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Science, technology and innovation for sustainable development

Report of the Secretary-General

Summary

The present report, submitted pursuant to General Assembly resolution 74/229, provides information on the implementation of the resolution, in particular through the work of the Commission on Science and Technology for Development, the United Nations Conference on Trade and Development and other relevant United Nations organizations. In the report, the Secretary-General discusses the role that science, technology and innovation play in the response to the coronavirus disease (COVID-19) pandemic; analyses the impact of new and emerging technologies on sustainable development; showcases lessons learned and good practices from developing countries in strengthening their capacity in the area of science, technology and innovation; highlights findings from research and high-level policy discussions on science, technology and innovation as an enabler of sustainable development at the national, regional and global levels; and highlights initiatives to strengthen the science-policy interface within the United Nations and enhance global support mechanisms for science, technology and innovation.

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I. Introduction

1. The present report is submitted pursuant to General Assembly resolution 74/229. It highlights findings from research and high-level policy discussions on ways to harness science, technology and innovation for the achievement of sustainable development; lessons learned and good practices from developing countries in strengthening capacities for science, technology and innovation; and initiatives to enhance global support mechanisms for science, technology and innovation.

II. Science, technology and innovation for mitigation of the impact of the coronavirus disease (COVID-19) pandemic and increased resilience

2. The present report covers the period from 2019 to 2021, which coincides with the outbreak of the coronavirus disease (COVID-19) pandemic. In that regard, science, technology and innovation have played a critical role in building resilience and combating and recovering from the pandemic. Science has been crucial in better understanding the disease, its symptoms, how it is transmitted, preventive measures and, above all, in finding diagnostic methods, treatment medicines and vaccines. New technologies have empowered people to absorb and adapt to shocks, allowing physical distancing while connecting to family and friends and giving each other support in a way that would have been unimaginable before the pandemic. Innovation has been critical in enabling economies to adapt and self-organize to continue functioning at this time of crisis.

3. More importantly, the COVID-19 pandemic has accelerated technological change. The pandemic and the resulting need for social distance and lockdowns have sped up the adoption of digital tools in many areas of life, from work to leisure. Digital tools for remote work, which were already available and considered a regular feature in some sectors, have become widespread and are now part of the new normal. There has also been a significant push for digitalization in developing countries, focusing on the digital economy and e-commerce.

4. However, such technological change is not without its challenges. With half the people in the world still not connected to the Internet,[1] the risk that digital divides become development divides is real and severe. Existing inequalities along the lines of income, gender, age, education and health, among others, affect people's access to the benefits of new technologies and risk further exacerbating social divides. Those digital divides reinforce existing inequalities in a vicious cycle. Technical solutions using digital technologies can benefit marginalized groups and those who are further behind and can benefit even more those who already have an advantage in certain social and economic dimensions, such as wealth, education and health). Digital inequality is a consequence and a subset of broader economic and social inequalities.

5. Many factors affect the dynamics of economic inequality, including wars, epidemics and the effects of trade and globalization. One of those factors is the impact of technological revolutions. As highlighted in the 2021 *Technology and Innovation Report* by the United Nations Conference on Trade and Development (UNCTAD),[2] the great divides between countries today manifested after the industrial revolution. Since that time, every wave of progress has been associated with sharper inequality.

[1] International Telecommunication Union, *Measuring digital development: Facts and figures 2020* (Geneva, 2020).

[2] United Nations Conference on Trade and Development (UNCTAD), *Technology and Innovation Report 2021: Catching Technological Waves – Innovation with Equity* (Geneva, 2021).

Consequently, the gap in the average income per capita between developed and developing countries is now $40,749.[3]

6. Currently, there is not one, but two waves of technological change. The first wave is the digital revolution of Web 2.0 technologies, which is at its peak. The second wave is highly data-driven and involves artificial intelligence, robotics, the Internet of things, gene editing, blockchain and other frontier technologies associated with Industry 4.0. That wave is in its initial stage in the technological revolution paradigm. Such technologies represent a $350 billion market, which could grow to more than $3.2 trillion[4] by 2025. Many of the major providers of the technologies are from the United States of America and China, which are responsible for between 30 per cent and 60 per cent of patents and journal publications.[5]

7. While very few countries create the technologies that are driving that change, all countries will be affected. However, almost none are well prepared for the consequences. That is a critical issue that requires urgent attention, in particular to ensure that outcomes are consistent with sustainable development objectives.

8. From the production perspective, each wave of technological change results in new forms of inequality. A major concern today is that artificial intelligence and robotics will reduce employment. However, the most alarmist estimates of large displacement of workers and reduction in jobs do not take into account that not all tasks in a job are automated and, most importantly, that new products, tasks, professions and economic activities will be created throughout the economy.

9. The impact of artificial intelligence on inequality between countries will depend on the type of input data. If artificial intelligence uses primarily big data generated by users, that will benefit mainly the United States and China. Their competing digital platforms receive massive amounts of user data. If artificial intelligence uses mainly big data generated by the Internet of things, it may also benefit other countries with strong manufacturing bases, such as the European Union countries, Japan and the Republic of Korea. If computers learned more like humans by recognizing patterns and generalizing from a few examples, that would still require resources and capabilities more likely to be found in the developed countries, leaving developing countries behind.

10. Another concern is job polarization, namely, the expansion in high-wage and low-wage jobs and the contraction in middle-wage jobs. However, not all job polarization can be attributed to technological change; much of the polarization is also an outcome of trade and international competition. In developed countries, from 2000 to 2020, job polarization was associated with a 4 per cent reduction in medium-skill jobs, but in lower-middle-income developing countries, there was an increase of 6 per cent during the same period.[6] It is therefore expected that low-income and lower-middle-income developing countries will be less exposed to the potential negative effects of artificial intelligence and robots on job polarization.

11. To prepare for the frontier technology revolution, countries must promote the use, adoption and adaptation of such technologies. The developing countries, however, face many challenges, the first being the change in demographics. By 2050, most of the increase in population will be in sub-Saharan Africa, with an increase of 1 billion people.[7] Firms in Africa may have fewer incentives to use automation as a form of saving labour costs. Another challenge is the technological gap. For example, in the past 30 years, the gap in output per worker between low-income and

[3] Ibid.
[4] Ibid.
[5] Ibid.
[6] Ibid.
[7] Ibid.

high-income countries increased from approximately $60,000 to almost $90,000.[8] The risk is that lower-income countries will also fall behind in the adoption of Industry 4.0, widening the technological gap. Yet another challenge is the slow diversification of many developing economies that are dependent on commodities instead of manufacturing. Common technologies used in manufacturing helps firms to adopt and adapt new technologies. Further, the developing countries and the least developed countries in particular have fewer public and private resources to fund research and innovation. For instance, the African Union established a target of one per cent of gross domestic product (GDP), but on average, the sub-Saharan African countries are still at 0.38 per cent.[9] In addition, stringent intellectual property rights are likely to reinforce existing technological divides.

12. Developing countries need to adopt frontier technologies while continuing to diversify their production bases by mastering existing technologies. Accordingly, many national and local governments are stimulating the growth of new industries and services in frontier technologies. To be fully effective, they need to align innovation and industrial policies, keeping the national industry competitive. That will require better access to patented technologies and opportunities for technological learning through public-private research and development. Finance for innovations can come from official sources and alternative funding, including impact investment, venture capital, crowdfunding, and innovation and technology funds. At the same time, policymakers need to anticipate the impacts on the workforce, which will need competencies in science, technology, engineering, mathematics and design, management and entrepreneurship. There is also a renewed importance of the role of labour unions to protect the rights of workers in the digital economy. Workers should also be able to rely on stronger social protection mechanisms and different forms of income redistribution.

13. From a user perspective, frontier technologies have enormous potential to improve people's lives and protect the planet. There are several examples of developing countries using frontier technologies to track diseases, create early warning systems for pandemics and natural disasters and monitor crops and droughts. In that regard, one of the most critical channels of the impact of technology on inequality is access, including availability, affordability, awareness, accessibility, and capability for effective use. Access to technology also can be restricted by social norms for women, minorities and other groups, even within the same household.

14. Another aspect is the design of the technology and the goods and services using the technology. All technology needs to be designed carefully if it is to help, rather than produce unintended side effects. A major concern today is related to the biased design and unintended consequences of artificial intelligence and the inequalities and ethical considerations of gene editing. Biases within artificial intelligence systems can arise because they employ biased algorithms or biased data for training. Gene editing also raises ethical questions such as what constitutes an ideal human being. That could result in an underclass of people who cannot afford genetic treatment.

15. To overcome those challenges, the international community needs to guide frontier technologies to support sustainable development and leave no one behind. It is crucial to establish coherent ethical frameworks, in particular for artificial intelligence and gene editing deployment. There are already many initiatives in that area, 167 of which are listed in the 2021 *Technology and Innovation Report*. Similarly, there is a need for a broad consensus on the ethical and societal issues of gene editing.

16. A whole-of-government approach is critical to direct science, technology and innovation towards inclusive and sustainable development. There is a role for

[8] Ibid.
[9] Ibid.

policymakers, the private sector, academic institutions, civil society organizations and other stakeholders in steering the effects of frontier technologies towards positive outcomes. In that regard, civil society participation is essential in shaping more equal and sustainable technological paths. It is also critical to strengthen international cooperation to facilitate technological learning in developing countries.

17. Section III below highlights findings from high-level policy discussions on ways to harness science, technology and innovation to achieve sustainable development. Section IV presents the work of the United Nations system in strengthening science, technology and innovation capacities and section V contains conclusions and recommendations.

III. Promoting strategic and inclusive debate on science, technology and innovation for the achievement of sustainable development

18. The Commission on Science and Technology for Development, as the United Nations focal point for science, technology and innovation for sustainable development, acts as a forum for strategic planning, sharing lessons learned and providing foresight regarding trends in science, technology and innovation in key sectors of the economy, as well as drawing attention to emerging technologies. At its twenty-third session, the Commission considered the priority themes of "Harnessing rapid technological change for inclusive and sustainable development" and "Exploring space technologies for sustainable development and the benefits of international research collaboration in this context". At its twenty-fourth session, the Commission considered the priority themes of "Using science, technology and innovation to close the gap on Sustainable Development Goal 3, on good health and well-being" and "Harnessing blockchain for sustainable development: prospects and challenges".

A. Harnessing rapid technological change for inclusive and sustainable development

19. There is a need to guide rapid technological change towards an inclusive and sustainable future and a particular need for breakthrough innovations designed to address the Sustainable Development Goals. Mission-oriented approaches are a practical way to provide directionality to innovation activities. The GAVI Alliance is a good example of such an initiative. Setting priorities and defining appropriate missions is vital, but that remains challenging for policymakers, especially in the case of versatile technologies that could affect many Goals.

20. There are five channels through which rapid technological change can result in unintended consequences. First, automation and digitalization can have positive returns for people with the right skills, but the net effect on employment remains unclear. Second, the winner-takes-all nature of digital technologies can increase inequality through market concentration. Third, the design of technology and how it is used can perpetuate inequalities. For example, if artificial intelligence uses biased data to learn how to make decisions, it can replicate old causes of inequalities such as gender and racial discrimination. Fourth, unequal access to essential technological infrastructure, lack of affordability and disparities in skills create wider inequalities. Almost half the world population remains offline and, consequently, out of reach of digitally enabled innovations. [10] Fifth, frontier technologies may increase the technological gap between countries because technologies are applied first and more

[10] International Telecommunication Union, *Measuring Digital Development: Facts and figures 2020*.

intensely in industries, services and segments of value chains in which more industrialized economies have a comparative advantage.

21. There are four priority areas for governments to shape rapid technological change. First, policies to create an enabling environment for frontier technologies, including infrastructure, and low-cost technology-based services need to be developed. Second, skills development for innovation must be promoted, given that frontier technologies require literacy and digital skills as well as entrepreneurship training that can support the adaptation of new technologies. Third, it is important to scale up businesses through improved policies for financing, better collaboration between researchers and the private sector, and wider dissemination of successful innovations. Fourth, there is a need for technological foresight to better understand the technological paths and potential long-term social, economic and environmental impacts.

22. International collaboration in research cooperation, capacity-building and official development assistance, which are all critical to ensuring that emerging technologies are developed with inclusiveness and sustainability in mind, must be fostered. The levels of official development assistance must increase to build the critical science, technology and innovation capacities.

23. While the impact of frontier technologies will be felt by all, not all are participating equally in defining the path such technologies will follow. There is a need for a global, inclusive dialogue on all aspects of fast technological change and its impact on society, including its normative dimension.

B. Exploring space technologies for sustainable development and the benefits of international research collaboration in that context

24. Space technologies have the enormous potential to contribute to the achievement of numerous Sustainable Development Goals and to the COVID-19 response. For example, earth observation data are being used to map land cover areas, develop crop yield estimates and support early warning for drought and other disasters. Remote-sensing technologies are used to monitor and forecast disease patterns and spread. In the context of the COVID-19 pandemic, public health officials across the world are using aggregated, anonymized Global Positioning System data (based on the global navigation satellite systems) to understand how communities are complying with social distancing and stay-at-home orders.

25. The increasing availability of open data and new technological developments such as machine learning, big data and cloud computing are lowering the costs of using, adopting and adapting space technologies. In that regard, there are numerous promising applications and technological developments.

26. Space-based applications can be utilized by all countries regardless of their spacefaring capabilities. Satellite data are increasingly being made available for free or at low cost. Countries, regions and the international community can build the human and technological capabilities necessary to transform Earth observation and other space-derived data into intelligence, for example, early warning for disasters and disease outbreaks and monitoring of crop health.

27. At the national level, countries need to invest in awareness-building, physical and data infrastructure, human capacity, research and development, and innovation capabilities of firms. Some regions are supporting the development of regional policies and spatial data infrastructure to strengthen national efforts.

28. International cooperation is essential to help countries to effectively share access to space-based physical infrastructure, data, digital assets, and services. Such

collaboration can help countries to pool human, physical, financial and other resources to create global public goods that accelerate progress on the achievement of the Sustainable Development Goals and respond to the COVID-19 pandemic.

C. Using science, technology and innovation to close the gap on Sustainable Development Goal 3, on good health and well-being

29. A range of COVID-19-related interventions clearly illustrated the importance of science, technology and innovation, from genome mapping, diagnostics, contact-tracing applications and disease monitoring to treatments and vaccines. Using breakthrough technologies, researchers and pharmaceutical companies developed COVID-19 vaccines at a remarkable speed in less than a year.

30. Telemedicine, remote care and mobile health, including the home monitoring of vital signs and medication adjustments, have reduced costs and improved safety in health-care delivery.[11] The application of big data and artificial intelligence is enabling complex clinical decision-making and the identification and reporting of health emergencies. In addition, the development of medical and assistive devices and services, such as 3-D printing, has revolutionized the manufacture of devices and equipment.[12]

31. However, health-care innovation ecosystems that are essential in adapting those technologies to local conditions face enormous challenges in developing countries. Innovation systems lack enabling policies, funding, skills, physical infrastructure and information and communication technologies (ICTs). Internet access is a key infrastructure for digital health, but it also requires reliable access to electricity access. In his report on using science, technology and innovation to close the gap on Sustainable Development Goal 3 (E/CN.16/2021/2), the Secretary-General called for a whole-of-government and multisectoral approach to ensure that science, technology and innovation policies were consistent with national health priorities and sustainable development strategies.

32. Diseases that disproportionately affect poor people, especially in developing countries, should not be forgotten. The number one leading cause of death in low-income countries is neonatal conditions, with diarrheal diseases, malaria, tuberculosis and HIV/AIDS among the top 10 causes.[13] Every year more than 5 million children die before the age of five years as a result of preventable or treatable diseases.[14]

33. International collaboration on science, technology and innovation should be based on equitable relations between the partners involved, including in respect of intellectual property rights. Several flexible approaches could be adopted, including the issue of licences (paid or unpaid), patent pools, voluntary pledges, waivers of intellectual property right barriers or the enabling of open access for scientific collaboration during global health challenges. Other areas in which international collaboration is needed as the health sector is being transformed by digital technologies are privacy and data protection, cybersecurity, and ethical frameworks for frontier technologies such as artificial intelligence and gene editing.

[11] World Health Organization Regional Office for Europe, *Future of digital health systems: report on the WHO symposium on the future of digital health systems in the European region* (Copenhagen, 2019).

[12] UNCTAD, *Technology and Innovation Report 2018: Harnessing Frontier Technologies for Sustainable Development* (Geneva, 2018); and UNCTAD, *Technology and Innovation Report 2021: Catching Technological Waves – Innovation with Equity*.

[13] World Health Organization, "Global Health Estimates 2020: Deaths by Cause, Age, Sex, by Country and by Region, 2000–2019" (Geneva, 2020).

[14] Ibid.

D. Harnessing blockchain for sustainable development: prospects and challenges

34. Blockchain technology was invented to create bitcoin and to serve as the base technology for cryptocurrency, enabling open (peer-to-peer), secure and fast transactions that are recorded in a distributed ledger. Second-generation blockchain records computer code in the ledger. Instead of only registering that a payment has been made, the blockchain can store "smart contracts" that are executed automatically when their conditions are met. The most recent advances in blockchain have tried to address the shortcomings of the previous generations of the technology, such as performance, scalability and interoperability.

35. Like any technology, blockchain can be applied in solutions for the Sustainable Development Goals. Many examples of such use are still in the pilot phase or have been deployed but no impact assessment is available.

36. There are five visions attributed by society to blockchain that could play out. The first is blockchain overtaking centralized applications. That would result in lower transaction costs, but it is not clear whether blockchain applications would be more affordable than the centralized ones that they would replace. Second, some people see blockchain as a tool for financial inclusion. Decentralized finance could contribute to financial inclusion, but inclusiveness is not one of the drivers of innovation in that domain. Third, some consider that the main role of blockchain is to increase efficiency in international transactions. Increasing trade and transport efficiency and reducing costs have the potential to increase trade, but who benefits from that increase still depends on many other factors, such as the productive structure of countries and the policies in place to harness trade for development. Fourth, cryptocurrencies could replace fiat money. At present, cryptocurrencies have a negligible impact on the money supply and therefore do not challenge sovereign currencies. Fifth, blockchain could become the "new Internet". In that scenario, blockchain is in the installation period of a technological revolution.

37. Potential unintended consequences of blockchain technology that require attention include high energy consumption, money-laundering and money-hacking, inequality and privacy.

38. For low-income and lower-middle-income developing countries, harnessing blockchain will require the development of digital infrastructure and skills. Governments should encourage innovation and create opportunities for skills development, for example through pilot projects, that could kickstart the diffusion of blockchain. National blockchain associations and laboratories could play a relevant role in the innovation and development of blockchain.

39. Upper-middle-income developing countries are more likely to have the technical foundation and the human resources for rapid technological adoption. The challenge for many of them is to connect the domestic innovation system and the global ecosystem of innovation, including through incubators and networks. That calls for strategic and concerted efforts to build capabilities in the blockchain-related areas.

40. High-income-countries have made important inroads not only in increasing the technological potential of blockchain, but in creating an environment that can support blockchain applications. They should develop legal and policy frameworks so that the real economy and the public benefit from blockchain while minimizing its risks and protecting users.

41. Four areas for international collaboration on blockchain include sharing knowledge and information and conducting research; helping to set guidelines, norms and standards; helping to build the capacity of governments to play their role in the

blockchain ecosystem, including oversight; and using blockchain in United Nations operations.

E. Considerations in applying science, technology and innovation in sustainable development

1. Applying a gender lens to science, technology and innovation

42. Promoting women's contribution and leadership in science, technology and innovation continues to be a challenge. Digital technologies, digital-based information, and apps are not reaching women to the same extent as men, and the differential effects of new technologies on women and girls need to be better understood. At the same time, new technologies can offer opportunities to improve women's status, equality and empowerment. COVID-19 has endangered some of women's productive and innovation capabilities. The pandemic has exposed women and girls to vulnerabilities, but it has also opened up opportunities to rethink science, technology and innovation systems and promote action to close the gender gap and move closer to attaining Sustainable Development Goal 5.

43. In moving forward, UNCTAD research presented to the Commission on Science and Technology for Development offers five key recommendations. First, there is a need to mainstream gender at the level of technological design to address more comprehensively and consistently the potential of technology to respond to women's needs, perspectives and priorities. Second, there is a need for more research on the implications of new technologies such as robotics, artificial intelligence and blockchain for women. Third, while there is a need to train women for occupations in which they are underrepresented, it is equally important to ensure that job positions for women are available in high levels of governance systems in those sectors. Fourth, there is a need to identify barriers and opportunities for scaling gender and socially inclusive innovations. Fifth, multi-partner, multi-level and multi-stakeholder programmes are needed to mainstream gender into policy and action in various sectors in a coordinated manner. Partnerships among government, civil society organizations, the private sector and academic institutions are all important facilitators in gender inclusion and sustainable development.

44. As part of the Generation Equality Forum in 2021, the United Nations Entity for Gender Equality and the Empowerment of Women is convening the action coalition on technology and innovation for gender equality, an innovative, multi-stakeholder partnership that mobilizes governments, civil society, international organizations and the private sector to catalyse action, drive investment and deliver concrete, game-changing results for gender equality. The action coalition aims to drive commitments towards specific tactics to accelerate progress towards four priorities: (a) bridging the gender gap in digital access and competence; (b) investing in feminist technology and innovation; (c) building inclusive, transformative and accountable innovation ecosystems; and (d) preventing and eliminating online and technology-facilitated gender-based violence and discrimination. The vision of the action coalition is to ensure that women and girls have equal opportunities to safely and meaningfully access, use, lead and design technology and to steer the digital transformation of societies. All the members of the action coalition will commit to helping to widen innovation ecosystems and to embedding transparency and ethics in digital technology, so that building inclusive digital economies is at the core of all the COVID-19 recovery efforts.

2. Access to digital infrastructure

45. Following the mandate of the Economic and Social Council and the General Assembly, most recently in their resolutions 2020/12 and 75/202, respectively, the

Commission on Science and Technology for Development serves as the focal point in the system-wide follow-up to the outcomes of the World Summit on the Information Society.

46. In 2020 and 2021, the Secretary-General issued reports on the progress made in the implementation of and follow-up to the outcomes of the World Summit on the Information Society at the regional and international levels (A/75/62-E/2020/11 and A/76/64-E/2021/11). In the reports, the Secretary-General highlighted that access to ICT services had grown rapidly, but not rapidly enough to ensure that everyone could benefit, with high inequality in accessing ICTs remaining between and within countries, between women and men and between people who live in different areas or who have different life experiences. They also stressed the transformative impacts of new applications and services, including mobile devices, social media and cloud computing, on progress towards achieving the Sustainable Development Goals while recognizing the new challenges in digital governance such as cybersecurity. The reports noted the important roles that digital technologies played in the COVID-19 pandemic, such as in public health interventions through big data and artificial intelligence and in remote work and study through Internet and videoconference platforms, while also highlighting challenges such as misinformation and disinformation as well as privacy and data protection.

47. At its twenty-third and twenty-fourth sessions, the Commission on Science and Technology for Development discussed developments and trends related to the World Summit. During those sessions, the Commission noted that despite the continuing progress, approximately half the world had no access to the Internet, with affordability still falling short of the target of the Broadband Commission for Sustainable Development. It also noted the new challenges in the information society, such as cybersecurity, evolving roles of platforms, global data management, energy consumption by ICT ecosystems and electronic waste, and stressed the need for coordinated efforts by governments, the private sector, civil society organizations and international organizations. It also welcomed the report of the Secretary-General entitled "Road map for digital cooperation: implementation of the recommendations of the High-level Panel on Digital Cooperation" (A/74/821), which provides a response to complex changes and rapid developments in digital technology and their impacts on economies and societies and highlights the convening role of the United Nations.

3. Finance for science, technology and innovation

48. It is important, even during the economic hardship wrought by the pandemic, that countries provide stable and predictable funding for activities related to science, technology and innovation. Investment in science, technology and innovation should constitute a key component of post-pandemic recovery packages.

49. As countries strengthen the budgetary commitments to support science, technology and innovation activities, it is critical to set funding targets and to establish and communicate the disbursement trajectory towards them. In that manner, governments can not only treat science, technology and innovation spending as "protected funding lines", but also ensure and signal the continuity and predictability of government support to relevant stakeholders.

50. Investment by developing countries in science, technology and innovation remains much lower than that of developed countries, and their innovation systems are much weaker and more fragile. Hence, international cooperation in funding, including through increased earmarked official development assistance, designing and delivering solutions, and ensuring that scientists and innovators from developing countries can participate in global research and development networks are essential.

IV. Building capacity for science, technology and innovation

A. Integrating policies on science, technology and innovation within national development strategies

51. Between 2019 and 2021, UNCTAD completed the science, technology and innovation policy reviews of the Dominican Republic, Ethiopia, Panama, Uganda and Zambia and advanced in its review of Botswana.[15] The reviews provided recommendations to orient science, technology and innovation investment and capacity development to take advantage of the opportunities created by the Sustainable Development Goals. That is particularly relevant concerning digital technologies and their interaction with mainstream sectors such as light manufacturing and agriculture.

52. The findings of the reviews include the need for development strategies to leverage science, technology and innovation in the development of productive capacities for industry, manufacturing and services and in the development of competitive higher-value-added activities and more complex export products. It is critically important that science, technology and innovation efforts be intensified and that policies and resource allocation shift their focus towards the entrepreneurial innovation end of science, technology and innovation processes, strengthening links between government and the private sector and between the private sector and academic institutions. There is a need for policy coherence across major areas of development policy, including science, technology and innovation policy and industrial policy, to accelerate development. In that regard, science, technology and innovation issues should be brought closer to the centre of national development policy. Capacity-building is an important element during the science, technology and innovation policy review processes and remains a crucial need for the countries reviewed. In that regard, and considering the possibility of online training, UNCTAD is preparing an e-learning platform to be launched in the fourth quarter of 2021.

53. The science, technology and innovation policy reviews have often ignited a renewal in science, technology and innovation, raised its profile in national development strategies and facilitated the inclusion of related activities in international cooperation plans. A key feature of the reviews is the systematic effort made to involve a broad range of stakeholders. That participatory process can mobilize networks of actors towards transformation through policy experimentation and learning. The activities under the reviews have enabled policymakers and other science, technology and innovation stakeholders in the countries reviewed to reach a better understanding of the key strengths and weaknesses in their science, technology and innovation systems, policies, institutions and capacities and to identify strategic priorities and policy options for improving science, technology and innovation capacity and becoming more innovative.

B. Aligning intellectual property and development strategies

54. Intellectual property is a critical component for innovation and technological development, given that it helps to set the incentive structure for the world's innovators who create the new technologies and processes that improve lives.

[15] Science, technology and innovation policy reviews are undertaken by UNCTAD at the request of member States. Through the review, the science, technology and innovation stakeholders in a country can identify the key strengths and weaknesses of their innovation systems and establish strategic priorities for their development. For additional information, see https://unctad.org/topic/science-technology-and-innovation/STI4D-Reviews.

55. The World Intellectual Property Organization (WIPO) assists Member States in developing, formulating and implementing national intellectual property and innovation strategies that address countries' specific needs, priorities, challenges and level of development, with due attention paid to the requirements of the least developed countries. WIPO also plans to strengthen its support to countries to build their capabilities and expertise in technology transfer, including addressing global crises such as the COVID-19 pandemic.

56. The WIPO Access to Research for Development and Innovation programme[16] provides free or low-cost access to some 9,200 subscription-based scientific and technical journals and 52,000 e-books and reference works to more than 2,115 registered institutions in 125 developing countries and least developed countries through a public-private partnership with some of the world's leading publishers. Similarly, the WIPO Access to Specialized Patent Information programme[17] provides free or low-cost access to commercial patent search and analytical services to more than 151 registered institutions in 43 developing countries and least developed countries through a public-private partnership with leading patent database providers.

57. The WIPO Index of Specialized Patent Information Reports (WIPO INSPIRE) platform was launched in November 2020 and comprises a detailed repository of reports on patent databases and search systems from around the world. It has an interactive world database coverage map that allows users to determine, at a glance, the patent databases that offer coverage of a specific jurisdiction.

58. The *WIPO Technology Trends* report is a new publication addressed to industry, academic institutions and policymakers, and general readers interested in innovation. Based on patent and non-patent data, it shows trends in various technologies, contextualizing them with case studies, insights and perspectives from leading experts, and includes policy considerations essential to understanding the complete technology landscape and ecosystem. The first *WIPO Technology Trends* report, published in 2019, covered artificial intelligence. The second report, published in 2021, covered assistive technology to support persons with functional limitations in participating in all aspects of life.

59. In 2020, WIPO published two new guides offering a step-by-step approach and several practical tools to help determine whether specific inventions are protected by patents or are in the public domain and help use and integrate public domain information and knowledge in product design and development.

C. Developing statistics, indicators and data for innovation

1. Development of indicators on science, technology and innovation

60. The United Nations Educational, Scientific and Cultural Organization (UNESCO), through the UNESCO Institute for Statistics, has been actively engaged in the development of indicators on science, technology and innovation concerning the Sustainable Development Goals. As the custodian agency for two global indicators to monitor target 9.5, the Institute currently focuses on collecting and disseminating research and development statistics. It is also defining and establishing a set of core science, technology and innovation data and indicators, which it will compile and maintain. The Institute also continues to collaborate with the Organisation for Economic Co-operation and Development (OECD) in maintaining the main methodological guides on measuring research and development (OECD Frascati Manual) and innovation (OECD/Eurostat Oslo Manual).

[16] For additional information, see www.wipo.int/ardi/en/.
[17] For additional information, see www.wipo.int/aspi/en/.

61. The Institute continues to contribute to capacity-building activities in the collection of science, technology and innovation data and indicators and to participate in other meetings organized by regional partners. It has successfully concluded its technical assistance to the Gambia on the implementation of research and development and innovation surveys, an online training seminar on measuring research and development expenditure in the United Arab Emirates and several other virtual meetings.

62. The UNESCO Natural Sciences Sector, with the support of the Institute, is in the process of establishing a global baseline data set on science, technology, engineering and mathematics education, as well as information on science, technology, engineering and mathematics education governance (policies and strategies) within UNESCO member States. The overall objective of the project is to compile information and data on science, technology, engineering and mathematics education that will help to inform the organization's strategic planning, decision-making and targeted interventions for strengthening such education within its member States.

2. Big data indicators for sustainable development

63. The United Nations Global Pulse initiative is aimed at accelerating discovery, development and scaled adoption of big data innovation for sustainable development and humanitarian action. The initiative functions as a network of innovation labs where research on big data for development is conceived and coordinated. Current projects include collaboration with the Office of the United Nations High Commissioner for Refugees to analyse anonymized call detail records provided by telecom operator Turk Telecom in order to understand refugee integration in Turkey; and a partnership with IBM Science for Social Good and the Pompeu Fabra University in Spain to develop a taxonomy and build an initial corpus of terms related to online hate speech targeting Muslim communities in English-speaking countries.

3. Frontier technology readiness index

64. To assess national capabilities to equitably use, adopt and adapt frontier technologies, UNCTAD introduced a frontier technology readiness index in 2021. The index comprises five building blocks, namely, ICT deployment, skills, research and development activity, industry activity and access to finance. Based on the index, in general, the economies most ready for the equitable deployment of frontier technologies are in North America and Europe. The least ready countries are in sub-Saharan Africa and in the developing countries in general. However, there are clearly many outliers, namely, countries that perform better than their per capita GDPs would suggest. The greatest overperformer is India, ranking 65 positions higher than expected, followed by the Philippines, which ranks 57 positions higher. The countries that outperform have promoted and invested in innovation and technological learning through domestic research and development. They also have been more successful in diversifying their economies, which has created opportunities for innovation and the deployment of new technologies. However, overall, the top overperforming developing countries have lower rankings for ICT connectivity and skills. Developing countries therefore need to work towards universal Internet access and ensure that all their citizens have opportunities to learn the skills needed to be more ready for frontier technologies.

4. Global Innovation Index

65. The WIPO Global Innovation Index captures the most recent global innovation trends and tracks the innovation ecosystem performance of some 130 economies. Since its inception in 2007, the Index has had an impact on two important fronts. First, policymakers have frequently referred to innovation and the Global Innovation Index when formulating economic, innovation and intellectual property policy

strategies. Second, the Index has fostered the collection of better innovation metrics. More recently, the United Nations flagship *Financing for Sustainable Development Report 2021* referenced the Global Innovation Index in underlining the risks to financing innovation as a result of the COVID-19 crisis.

D. Enhancing global support mechanisms for science, technology and innovation

1. Technology facilitation mechanism

66. The Technology Facilitation Mechanism was established in 2015 by Member States as the key science, technology and innovation instrument to support the achievement of the Sustainable Development Goals (see General Assembly resolutions 70/1 and 69/313). The fully multi-stakeholder Mechanism has engaged thousands of scientific and technological stakeholders. Moreover, participation in the activities of the Mechanism has continuously increased and widened, including among policymakers, entrepreneurs, academics and young people.

67. All three components of the Technology Facilitation Mechanism are operational. The UN inter-agency task team on science, technology and innovation for the Sustainable Development Goals currently comprises 45 United Nations entities and has more than a hundred active staff members. The activities of the task team are carried out through primarily working-level cooperation among expert staff and the task team has been a catalyst for cooperation on science and technology issues in the United Nations system. Non-United Nations entities, such as OECD and the Joint Research Centre of the European Commission are also very active in selected areas. For example, in 2021, an inter-agency task team sub-working group has brought analytical expertise across the United Nations system and tapped into the perspectives of hundreds of experts and stakeholders to publish an inter-agency report on emerging science, frontier technologies and the Sustainable Development Goals.[18] The sub-working group has also synthesized state-of-the art findings from integrated assessments and scenario and technology studies to identify promising technology scenarios and high-impact digital technology solutions for the Goals.

68. The inter-agency task team has addressed science, technology and innovation issues related to COVID-19, in line with the COVID-19 response by the Secretary-General. That includes, for example, a call for COVID-19 technology solutions, the results of which are featured on the 2030 Connect platform, several events on science, technology and innovation for the Sustainable Development Goals and recovery from COVID-19 and a related Department of Economic and Social Affairs policy brief entitled “The COVID-19 pandemic: a wake-up call for better cooperation at the science-policy-society interface”.[19]

69. The Partnership in Action,[20] initiated by the Department of Economic and Social Affairs, will serve as a platform to strengthen the development and implementation of science, technology and innovation for Sustainable Development Goals road maps, through the global pilot programme first launched at the 2019 high-level political

[18] Department of Economic and Social Affairs of the Secretariat, “Emerging science, frontier technologies and the Sustainable Development Goal perspectives from the United Nations system and science and technology communities”, advance report by the inter-agency task team for the science, technology and innovation forum in New York.

[19] Richard A. Roehri, Wei Liu and Shantanu Mukherjee, “The COVID-19 pandemic: a wake-up call for better cooperation at the science-policy-society interface”, Policy Brief, No. 62 (Department of Economic and Social Affairs, New York, 2020).

[20] For more information on Partnership in Action, see https://sdgs.un.org/blog/partnership-action-science-technology-and-innovation-sdgs-roadmaps-draft-consultation-24893.

forum on sustainable development. Road maps are currently being developed in six pilot countries, namely, Ethiopia, Ghana, India, Kenya, Serbia and Ukraine. The Department has prepared an operational note for implementing science, technology and innovation for Sustainable Development Goals road maps[21] to further assist governments in several pilot countries in the development of national science, technology and innovation road maps for the Goals.

70. From November to early December 2020, the capacity-building workstream of the inter-agency task team delivered a series of pilot online training workshops on science, technology and innovation policy and instruments on the Goals, attended by mid-level science, technology and innovation policymakers from developing countries. The online sessions drew more than 70 participants from 28 countries and 40 representatives from various United Nations bodies. In April and May 2021, the workstream delivered two online training workshops on current approaches to science, technology and innovation policymaking in the context of the Goals targeting Latin American countries, with more than 200 policymakers and government officials from the region.

71. In the period 2020–2021, members of the gender working group co-sponsored and participated in the celebration of the International Day of Women and Girls in Science, held in February 2021 at United Nations Headquarters, and contributed to a number of panels and sessions promoting science, technology and innovation studies and careers to women and girls. The working group also organized an event entitled "Gender equality in science, technology and innovation: Towards an inclusive science, technology and innovation ecosystem and connectivity for all" during the 2021 science, technology and innovation forum.

72. The sixth annual multi-stakeholder forum on science, technology and innovation for the Sustainable Development Goals was held in May 2021 with support from the United Nations 10-Member Group to support the Technology Facilitation Mechanism, which is composed of eminent experts, after a hiatus of one year owing to the pandemic. The forum deliberated on lessons learned from the COVID-19 pandemic regarding a better science-policy-society interface, a resilient recovery and rapid responses to global challenges. It identified science, technology and innovation solutions for building back better and accelerating progress towards the achievement of the Goals, emphasizing the Goals under review at the 2021 high-level political forum on sustainable development. Discussions also focused on promoting inclusion in innovation and transformations enabling science, technology and innovation by connecting across global conferences and events, such as the United Nations Food Systems Summit, the high-level dialogue on energy and the second Global Sustainable Transport Conference. The promises and potential risks of emerging technologies, as well as technological and capacity divides, were also discussed. Government representatives reported progress in science, technology and innovation for Sustainable Development Goals road maps and the related Partnership in Action, which helps spur coherent science, technology and innovation action towards the achievement of the Goals. Key topics were capacity-building, gender and next steps for the Technology Facilitation Mechanism, including its online platform 2030 Connect.

73. The 2030 Connect online platform became fully operational in July 2020, supported by the Department of Economic and Social Affairs and the Office of Information and Communications Technology working as part of a 45-member consortium of United Nations offices known as the inter-agency task team, advised by of the 10-Member Group. The Department of Economic and Social Affairs and the Office of Information and Communications Technology have undertaken a

[21] Available at https://sdgs.un.org/sites/default/files/2021-06/Operation%20Note%20STI%20for%20SDG%20Roadmaps_final_Dec_2020_rev.pdf.

comprehensive needs assessment to help shape 2030 Connect into a tool that can be truly useful for a wide range of stakeholders. The target audience of 2030 Connect includes private and public entities, decision-makers, global technology users, international development organizations, entrepreneurs, academics and researchers, civil society organizations and intermediaries. Mandated by Member States in the Addis Ababa Action Agenda and the 2030 Agenda for Sustainable Development as part of the Technology Facilitation Mechanism, the online platform will be free of charge and open to all. However, in order to offer relevant, up-to-date resources, 2030 Connect will require significant investment to maintain and expand its operation and services to cover costs for licencing, hosting and upgrades.

2. Technology Bank for the Least Developed Countries

74. In 2020, the Technology Bank for the Least Developed Countries concluded the technology needs assessments in Bhutan, the Gambia, Guinea, Timor Leste and Uganda. In 2021, the Technology Bank will initiate technology needs assessments in 16 least developed countries, namely, Afghanistan, Bangladesh, Benin, Cambodia, Djibouti, Kiribati, Lesotho, Liberia, Malawi, Mozambique, Nepal, Rwanda, Sao Tome and Principe, Sierra Leone, the Sudan and Zambia.

75. In May 2020, in response to the COVID-19 pandemic, the Technology Access Partnership, a platform aimed at facilitating access to health technologies by least developed countries, was initiated as an incubation partnership among the World Health Organization, the United Nations Development Programme, UNCTAD and the Technology Bank as core partners. The Technology Bank has recently initiated discussions with several organizations in the United States to acquire access to a global development technology platform for innovations, funding and insights called the “Global Innovation Exchange” platform. In April 2021, the Technological Bank, the Scientific and Technological Research Council of Turkey and the Industry-University Collaboration Centres Platform of Turkey signed a memorandum of understanding to facilitate access to technology and to improve science, technology and innovation capacity development for the least developed countries.

76. During 2020, the science, technology and innovation capacity programme supported 43 least developed countries in enhancing research capacity through two massive online courses, in partnership with the Food and Agriculture Organization of the United Nations and Research4Life, in which 36 per cent of the participants were women. In January 2021, a joint partnership with the UNESCO/World Academy of Sciences for the advancement of science in developing countries and the International Centre for Genetic Engineering and Biotechnology was launched to provide an opportunity for building productive capacities for young researchers and research institutions in least developed countries.

77. Through the World Academy of Sciences programme, the Technology Bank partnered with the Network of African Science Academies towards the launch of four academies, in Angola, the Democratic Republic of the Congo, Lesotho and Malawi, from December 2020 to May 2021. During 2021, the programme will result in the launching of academies in Cambodia, the Central African Republic, Chad, Liberia, the Niger, Mauritania, Sierra Leone and the Pacific Region.

V. Conclusions and recommendations

78. **Technologies are not deterministic, and they can be directed towards the achievement of sustainable development. Governments in developing countries have a major role to play in creating an enabling environment that includes universal Internet access, skills development, social protection and appropriate**

regulations. That requires a whole-of-government approach and the coordinated mobilization of a broad range of social and economic actors. Through concerted international efforts, governments and other stakeholders need to guide the development and deployment of new and emerging technologies so that they support sustainable development and leave no one behind. In that regard, developing countries should be able to rely on technical and financial support through international cooperation to build stronger national capacities in science, technology and innovation and promote an inclusive debate on how new technologies affect people and society and how they can promote the achievement of the Sustainable Development Goals.

79. **Member States may wish to consider the following recommendations:**

(a) **Design and implement science, technology and innovation policies to foster national innovation systems that direct rapid technological change towards inclusive and sustainable outcomes, including by adopting a mission-oriented and grand challenges approach to achieve the Sustainable Development Goals;**

(b) **Encourage a whole-of-government, multi-stakeholder and multisectoral approach to ensure that science, technology and innovation policies are consistent with national priorities and development plans, including in the area of health;**

(c) **Develop national readiness frameworks and early warning systems that incorporate science, technology and innovation to detect and address complex shocks such as pandemics;**

(d) **Develop national innovation strategies concerning frontier technologies such as artificial intelligence, gene editing, blockchain and space technologies to give policy direction for the development of national innovation systems that promote inclusive and sustainable innovation using those technologies, while minimizing risks and protecting users;**

(e) **Promote policies for skills development relevant to rapid technological change in terms of lifelong learning, entrepreneurship training, upgrading of skills for innovators and capacity-building for researchers;**

(f) **Strengthen national innovation systems, including for health, by investing in infrastructure, institutions and human capital, sharing knowledge within and across Government and other sectors, connecting domestic systems with the global system of innovation, including through incubators and networks, and making innovation systems an integral part of long-term strategies for building back better;**

(g) **Encourage educational collaboration through university networks to build capabilities in technological learning and innovation for the achievement of the Sustainable Development Goals;**

(h) **Provide support to firms and research and development institutions in turning research and development into products and services that address development needs, such as health care, and in commercializing those products and services;**

(i) **Foster innovation through entrepreneurship by strengthening funding mechanisms for innovation;**

(j) **Promote a pragmatic and cross-cutting public-sector approach for innovation to render legal and regulatory frameworks more responsive to rapid technological change and prioritize innovations as a way of solving current societal challenges;**

(k) **Continue the development of digital infrastructure and skills, especially among vulnerable groups, young people and women and girls, and create opportunities for skills development to kick-start the diffusion of frontier technologies.**

80. **The international community may wish to consider the following recommendations:**

(a) **Strengthen research cooperation and science and policy interfaces to ensure that frontier technologies are harnessed for inclusiveness and sustainability, including by shaping scientific networks and research and development for frontier technologies for health-care innovation;**

(b) **Promote North–South, South–South and triangular cooperation on science, technology and innovation through joint research programmes and the development of new knowledge and technologies for local needs;**

(c) **Promote and develop international technology assessment and foresight mechanisms to help countries to assess the challenges, including the unintended consequences of a technology, and opportunities of rapid technological change for inclusive growth;**

(d) **Support the efforts of countries in strengthening their national innovation systems for inclusive and sustainable development;**

(e) **Work towards more equitable access to scientific knowledge, technologies, and information on successful and innovative business models that harness rapid technological change to support inclusiveness and sustainability;**

(f) **Address the need for consistent normative frameworks and ethical principles relevant for rapid technological change for inclusive and sustainable development;**

(g) **Promote the development of standards, recommendations and regulations on frontier technologies to harness their potential, including by promoting security and privacy;**

(h) **Promote inclusive debate on frontier technology for achieving the Sustainable Development Goals. Developing countries, in particular the least developed countries, that are not engaged in the development of frontier technologies but are likely to be affected by their consequences need to be part of the international debate.**