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Science, technology and innovation as catalysts for the Sustainable Development Goals

Note by the UNCTAD secretariat

Executive summary

Science, technology and innovation are critical to the achievement of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals. Given a strong effort to upgrade the related capabilities of developing countries, science, technology and innovation can drive productivity improvement and economic growth, promote social inclusion and enable environmental sustainability. This note addresses the potential of several emerging technologies to contribute to the Goals and links them to examples of innovation in developing countries. The note also includes considerations of possible policy frameworks that leverage science, technology and innovation for inclusive and sustainable development, and suggests points for further discussion by the Investment, Enterprise and Development Commission.

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I. Introduction

1. The Sustainable Development Goals are one of the most transformative projects that the global community has embarked on in decades. Given the evidence of the ability of science, technology and innovation to drive economic and social change, harnessing them for the Goals should feature high on policymaker agendas. Their key role is reflected in the Nairobi Maafikiano adopted at the fourteenth session of the United Nations Conference on Trade and Development, which requests UNCTAD to promote effective international and national policies to help developing countries harness science, technology, innovation and entrepreneurship as an effective means of implementation of the Goals, through policy analysis, sharing of experiences and policy-oriented capacity-building.[1]

2. This note focuses on how the implementation of the social, economic and environmental dimensions of the 2030 Agenda for Sustainable Development may be oriented by the unfolding industrial revolution. Chapter II presents some features of new and emerging technologies and considers their potential to contribute to the implementation of the Goals. Chapter III provides examples of Goals-relevant innovation in developing countries that illustrate market opportunities for the private sector to drive innovation for the Goals. Chapter IV presents some considerations related to the design of public policies for inclusive and sustainable science, technology and innovation. Finally, the note suggests areas for further discussion by the Investment, Enterprise and Development Commission.

II. 2030 Agenda and emerging technologies

3. The 2030 Agenda articulates a universal programme of action aimed at radical change in the global development trajectory, in response to the aspiration of enabling all people to enjoy life in dignity and equality as members of more prosperous communities, while ensuring that environmental degradation is minimized. Revitalizing the Global Partnership for Sustainable Development (Goal 17), which involves Governments, civil society, the private sector, the United Nations system and all other development actors, is central to this programme. Science, technology and innovation are the key means of implementing the Partnership and, beyond their generic enabling role, their application is a necessary condition for progress in resolving most of the specific development problems addressed by the Goals; they are directly addressed in Goal 9.

4. The science, technology and innovation context in which the international community is starting to implement the 2030 Agenda is one of quick and profound transformation driven by several fast-evolving and oft-converging technologies, with a strong link to the ability to gather, store, transmit and process vast amounts of data and information. In the more advanced economies and several developing countries, such technological developments are transforming the operation of production systems, the role of various actors along value chains and the definition of sectors and industries.

5. There is no definitive list of key emerging technologies, yet discussions include most of the following fields: artificial intelligence; big data analytics; robotics (linked to artificial intelligence); autonomous vehicles; the Internet of things; additive manufacturing (three-dimensional printing); virtual and augmented reality; materials science and nanotechnology; synthetic biology; genetic sequencing; genome editing (such as the Clustered Regularly Interspaced Short Palindromic Repeats associated protein 9 genome-editing technology); genetic medicine; and neuroscience.[2] In this note, new and emerging technologies refer to those in these fields.

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[1] TD/519/Add.2.

[2] There are many different innovative applications in these fields; for a mapping of innovations against the Goals, see Institute for Globally Transformative Technologies, Lawrence Berkeley National Lab, 2014, *50 Breakthroughs: Critical Scientific and Technological Advances Needed for Sustainable Global Development* (Berkeley, United States of America).

6. The deeper interaction between several new technologies, with information and communications technologies playing a central role, are the key reason for the recent evolution in science, technology and innovation and the opening up of new possibilities for solving long-standing problems in areas of concern in all sectors covered by the Goals, from providing better employment opportunities in increasingly diversified economies, particularly for women and youth, to improving energy efficiency and promoting sustainable production and consumption patterns. Common features of new technologies relevant in the context of Agenda 2030 are considered in this chapter, and chapter III provides examples of experiences in developing countries.

A. Fast change and short adaptation cycles

7. The first feature that distinguishes current technological progress from earlier experiences is an extremely fast pace of change. In some areas, such as digital technology, performance, cost and applicability across various sectors is improving at exponential rates.

8. Another feature is that the disruptive potential of such technologies is stronger, due to their possibilities for innovative combinations with each other. Knowledge flows across areas of scientific and technical endeavour are greatly enhanced due to new digital platforms and networks; traditional disciplines converge, new disciplines emerge and cross-fertilization and collaboration become stronger and transformative. This presents an opportunity to generate new knowledge, products and services and social, economic and governance processes to greatly improve capacity to implement the Goals. The increasing importance of multiple technological combinations also means that the ramifications of changes may be disruptive in many social and economic domains and that changes will take place in often unpredictable ways and in several sectors at the same time or spread across sectors and countries at a significantly faster pace than in the past. This unprecedented rate of change is a challenge, as the understanding of social and economic implications, and the capacity of most societies to adapt to them, tend to move at slower rates. Similarly, faster changes in key new technologies remain contemporary with slower changes in more mature fields, and a limiting factor affecting the overall impact of technological changes on achieving the Goals is the ability of firms and sectors to absorb and diffuse technology and apply it effectively. Equally important is the role of the overall economic environment in encouraging and facilitating the emergence of new and innovative firms. In this regard, there are concerns that new technology may be improving overall productivity growth more slowly than in the past because of the increasing challenges that firms not operating at the technological frontier face in catching up with cutting-edge, innovative firms.[3]

B. Lower costs and wider choices

9. The cost structures of many new and emerging technologies, particularly those based on or enabled by information and communications technologies, offer a strong potential for a rapid decline in the cost of products and services. The marginal cost of digital products is essentially zero and many web-based services can be accessed at no additional cost by those with an Internet connection. Cost reduction extends beyond digital technology; the cost of sequencing a human genome, for example, decreased fivefold in 2001–2015.[4] Similar developments have taken place in renewable technologies, particularly solar and wind energy; the cost of solar panels decreased in the last 40 years from around $100 per watt to less than $0.50 per watt at the end of 2016, and continues to decrease.[5]

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[3] A Bergeaud, G Cette and R Lecat, 2017, Total factor productivity in advanced countries: A long-term perspective, *International Productivity Monitor*, 32:6–24.

[4] See https://www.genome.gov/sequencingcosts/.

[5] Bloomberg New Energy Finance, 2016, Solar panels now so cheap manufacturers probably selling at loss, 30 December, available at https://about.bnef.com/blog/solar-panels-now-so-cheap-manufacturers-probably-selling-at-loss/. See http://pvinsights.com/ for data on global spot market prices for solar cells and related goods.

Note: All websites referred to in footnotes were accessed in September 2017.

10. Such changes create possibilities for providing consumers with better quality goods and services at lower prices, thereby making them available to broader segments of the population and enabling the introduction of new ranges of products and services, including offerings more adapted to the specific needs of people living in poverty, as well as enabling public sector agencies to do more and better with smaller and more flexible investments.

C. More open science, technology and innovation

11. New technologies tend to develop through operational modes that rely more on open standards and collaborative networks enabled by information and communications technologies. Global platform technologies such as the Internet, as well as electronic commerce, cloud computing and social media, play a considerable role in this regard. Such technologies create opportunities for not only top-down but increasingly bottom-up innovation processes. More open environments in science, technology and innovation also include a less limitative role for geographical distance. Researchers, social activists, communities and entrepreneurs are increasingly able to engage in innovative collaboration at the international level. Innovative firms, including relatively small firms in developing countries, can benefit from easier access to international markets.

12. With regard to the democratization of innovation, additive manufacturing in particular can significantly reduce the cost in value and time of all steps (conceptualizing, designing, prototyping, tooling, manufacturing, marketing and distributing) in the process of bringing a product from the mind of an inventor to the hands of a consumer. This changes the ways in which individuals and groups may develop cheaper, customized solutions, and introduces the possibility for such innovative outcomes to materialize in many more diverse economies.

D. New forms of work and inclusiveness

13. Another key feature is the strong labour-saving trend in most current technological change, which may result in reduced demand for low-skilled labour, with potential implications for employment, equality and inclusiveness. In addition, and contrary to earlier labour-saving technologies applicable to non-cognitive tasks, artificial intelligence, a central technology of the new industrial revolution, enables the automation of cognitive tasks. The challenge of adapting the workforce to the automation of production may thus extend to a larger segment of the workforce than it has in the past. Different social groups have different capabilities to adapt to technological change; inequality may therefore increase as a result of technological change in the absence of adequate policies. For example, artificial intelligence and automation have the potential to augment the productivity of suitably skilled workers performing certain tasks by amplifying their ability to use data and information in innovative ways. One result of such changes may be increased labour market polarization between high-skilled and low-skilled workers.

14. Another Goals-relevant dimension in which new technologies may have significant implications is gender, as a larger share of women tends to be employed in low-skilled routine occupations most subject to automation. Women also tend to be underrepresented in the occupations that are most likely to benefit from the spread of new technologies and that rely on qualifications in science, technology, engineering and mathematics.

15. Increased concerns about job losses tend to emerge in times of profound technological change. Following transition costs, the net impact on jobs has always been positive in the past, even if the jobs that were created differed from those that were lost. As economies become more productive due to technological change, they become able to support more and better paying jobs in new occupations. Current claims about the net effects of new technologies on employment remain speculative, particularly with regard to developing countries, as, given their wage levels, the economic incentives for labour-saving technologies should be less significant.

III. 2030 Agenda and innovation and entrepreneurship

16. This chapter provides examples of how the deployment of new technologies in developing countries can result in socially, economically and environmentally sustainable outcomes, and the most relevant Sustainable Development Goals for each.

A. Precision agriculture: Goals 1, 2, 9, 12 and 15

17. Moving towards innovative agricultural production systems is fundamental for accomplishing the 2030 Agenda, as current production methods impose high environmental costs given population growth projections and the global decrease in available arable land per capita.[6] Precision agriculture involves using digital and other technologies such as drones to better manage areas under cultivation though improved data collection on the field-level performance variations of crops. The objective is to increase yields while optimizing inputs and preserving resources. Precision agriculture is mainly used in developed countries, yet there are examples of its application in a development context, such as the Government-sponsored precision farming project implemented by Tamil Nadu Agricultural University, India, in 2004–2007, involving the installation of a drip-irrigation and crop-production system and the testing of five crops; registration by farmers increased following the success experienced by the first 100 farmers to use the system and given the high market rate of the produce.[7] The technical results were positive and an independent evaluation concluded that the main obstacle to such sustainable innovation and commercialization was the lack of financial support beyond that available for the project funding, namely, farmers did not have the means to invest in precision agriculture.[8]

B. Water management, wastewater treatment and nutrient recovery: Goals 6, 9, 11 and 15

18. Technologies in this area include membrane filtration and oxidization processes for pollutant elimination; micro-level irrigation, to increase crop intensity and economize water use in agriculture; wastewater nutrient recovery, to reduce pollution and increase fertilizer resource availability; zero liquid discharge; off-grid desalination using solar power; and water remediation, often linked to extractive industries. An example of sustainable innovation in the latter is in the Nimr oilfield in Oman, which generates nine barrels of water for every barrel of oil; deep water disposal below the producing reservoir had been used to manage the excess water, a wasteful practice given the aridness of the region. Since 2010, a reed bed-based water processing system has been designed and implemented through a partnership between Bauer Environment and Petroleum Development Oman, with evaporation ponds extending over a surface of 3 million m^2 in an overall wetland area of 3.8 million m^2. The ponds are used for salt recovery, with the salt reused in oilfield drilling operations, and the reed beds produce biomass used in biosaline agriculture. The project generates job opportunities and new business prospects for Petroleum Development Oman and associated firms. Compared with deep disposal wells, the reed bed approach has no energy requirements and a significantly smaller carbon footprint.[9]

C. Transformative technologies: Goals 3, 4, 8, 9 and 10

19. Transformative technologies are a common term for technologies with exponential growth and impact due to strong linkages and dependencies on digital and information and communications technologies. They encompass developments such as virtual and augmented reality, the Internet of things, robotics (linked to artificial intelligence),

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[6] Food and Agriculture Organization of the United Nations (FAO), 2017, Strategic work of FAO for sustainable food and agriculture, available at http://www.fao.org/3/a-i6488e.pdf. See http://data.worldbank.org/indicator/AG.LND.ARBL.HA.PC.

[7] SK Mandal and A Maity, 2013, Precision farming for small agricultural farm: Indian scenario, *American Journal of Experimental Agriculture*, 3(1):200–217.

[8] A Velkar, 2008, Tamil Nadu precision farming project: An evaluation, London School of Economics.

[9] UNCTAD, 2014, *Science, Technology and Innovation Policy Review: Oman* (United Nations publication, Geneva).

autonomous vehicles, additive manufacturing and blockchain technology. For example, fab labs, a global network of local technical facilities, enable innovation by providing individuals with computers and computer-controlled tools – including computer-aided design, computer-aided manufacturing, additive manufacturing, computer numerical control and virtual and augmented reality – to design and prototype technology-enabled products. A fab lab was established, for example, in Rwanda in 2016, through the cooperation of the Ministry of Education, Rwanda; Rwanda Development Board; Chamber of Information and Communications Technology, Private Sector Federation, Rwanda; Gasabo 3D, Rwanda; Japan International Cooperation Agency; Centre for Bits and Atoms, Massachusetts Institute of Technology; and Solid Works Corporation. The United Nations and the International Committee of the Red Cross use the facilities to design spare parts and elements of equipment delivering supplies to refugees, and Sustainable Health Enterprises uses the facilities to prototype sanitary products. In addition, individual researchers develop the production of smart farming sensors to detect whether crops need water and the design of locks for a food delivery service.[10]

D. Innovation and entrepreneurship

20. New and emerging technologies can act as catalysts for accomplishing the 2030 Agenda by driving innovative entrepreneurship. This section provides examples of innovations that combine technologies, processes and business models in ways unique to their locality, including the specific Goals they help to address. All are for-profit ventures and illustrate the notion that commercial interest, entrepreneurship, innovation and sustainable development can be complementary and mutually reinforcing elements.

1. Algramo, Chile: Goals 1, 2, 9 10 and 12

21. Local grocery stores may sell food at prices that are up to 40 per cent higher than those in large supermarkets, which do not generally have branches in poorer neighbourhoods outside Santiago. Since 2013, Algramo has aimed to provide affordable food in these areas by buying staples such as rice, lentils, sugar and cleaning supplies in bulk from suppliers and distributing them, without the costly marketing and packaging processes of supermarkets, to local stores through vending machines with sustainable and returnable plastic tubs; hundreds of vending machines have since been installed. This results in considerably cheaper products for consumers.[11]

2. Digikala, Islamic Republic of Iran: Goals 8 and 9

22. Trusted online vendors that aim to provide unbiased information about complex and expensive consumer products are common in the developed world. Digikala, an online electronic commerce platform, was founded in the Islamic Republic of Iran in 2006; the company also includes a review site that employs a 100-member content creation team which tests products and records and edits video reviews. Digikala, valued at an estimated $150 million and having already achieved a significant market share of online retail in the country, plans to expand to rural areas and establish a mentoring scheme for startups. Affordable commercial delivery services and a functional national debit card system, usable online, were important facilitators for the success of Digikala.[12]

3. Jibu, Kenya, Rwanda and Uganda: Goals 6 and 9

23. This company franchises clean water vending stations, including water purification equipment, refillable bottles, packaging, point-of-sale systems, branding and business training. Entrepreneurs enter into a franchise agreement requiring a $1,000 co-investment.

[10] UNCTAD, forthcoming, *Science, Technology and Innovation Policy Review: Rwanda* (United Nations publication, Geneva).

[11] G Banks, 2016, This Chilean startup wants to change the way Latin America shops for food, *Forbes*, 5 February, available at https://www.forbes.com/sites/gracebanks/2016/02/05/this-chilean-startup-wants-to-change-the-way-latin-america-shops-for-food/#41bf66e5c17e.

[12] H Sharif, [Islamic Republic of] Iran's digital start-ups signal changing times, BBC, 12 October, available at http://www.bbc.com/news/world-middle-east-34458898.

However, the company loans entrepreneurs an amount for initial capital expenses, to be repaid over five years through business revenue. Refillable jugs of purified drinking water are sold at each station, to be returned by customers and refilled. Water purchased through a Jibu station is usually lower in price than the cost of boiling water and is affordable for about 70 to 80 per cent of the population in target areas. Jibu is a low-profit venture pioneering microfranchising in a sustainable development context, and its work helps mitigate carbon emissions and respiratory illnesses caused by boiling water over wood and charcoal fires.[13]

4. Safe Motos, Rwanda: Goals 3, 8 and 9

24. This company has two objectives, namely to reduce the number of preventable road accidents and deaths and to emulate the model of Uber for motorcycle taxis in Africa. Global positioning system coordinates, speed, acceleration and gyroscope data are logged and analysed and combined with customer feedback, as well as a booking system that includes driver evaluations, in order to reward safe and responsible driving. Drivers with at least three years of experience are eligible to join the scheme; for consumers, the application includes an electronic wallet that can be connected to mobile money and credit cards, to enable cashless payments. The company's model provides an example of the importance of knowledge of local conditions and a readiness to experiment in locally relevant business models. For example, as many motorcycle drivers cannot read maps, the company has developed a landmark-based navigation system. In addition, the company uses an information and communications technology incubator facility in Kigali to interact with other entrepreneurs, mentors, coders and developers. The continuously improving information and communications technology infrastructure and connectivity in Rwanda, a direct result of policy that reflects the transformative nature of digital technologies, has been a key supporting factor in the success of Safe Motos.[14]

5. Northwood Environmental, Zambia: Goals 8, 9 and 12

25. This company, based in Kitwe, collects plastic waste materials from areas in the Copper Belt, including townships, parks, public areas and manufacturing facilities, and sorts, processes and recycles the waste into feedstock for products for construction and agriculture industries. Collection and recycling activities started in 2015 at 150 kg per day, and increased to 1,000 kg per day before the end of the year. Purchases from the public and communities reach out to about 1,000 families, many of which are among the poorest in the region. To date, about 1,700 tons of plastic waste have been recycled into granules that would otherwise have cost $2.2 million in imports. Easing the burden on landfills and reducing the presence in the environment of plastic material with long degradation periods are additional environmental benefits.

IV. Policy responses

26. In order to effectively use new technologies in accomplishing the 2030 Agenda, policies should not only aim to adapt economic conditions and structures but also to guide social changes. Policies to support the diffusion, appropriation and financing of technology should be complemented by policies to address inclusion and sustainability, at both national and international levels. Several countries, many among advanced economies but also some among developing economies, are actively addressing such challenges and positioning themselves ahead of the curve of technological change. Several developing countries are making efforts to establish and nurture the scientific and technological capabilities required to enable them to address new technologies.

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[13] Jibu, 2013, Jibu launches new social enterprises in East Africa, available at https://coloradospringschambered c.com/library/Economic_Development/Economic_Development_Updates/Jibu.pdf.

[14] UNCTAD, forthcoming; A King, Safe Motos Rwanda: The tech startup taking on Africa's second-biggest killer, *Huck*, 10 March, available at http://www.huckmagazine.com/perspectives/ reportage-2/safemotos-rwanda-tech-startup-taking-africas-second-biggest-killer/. See http://klab.rw/public/startups/startup/59.

27. However, other countries may be left behind unless a concerted effort is made to build the necessary science, technology and innovation capabilities and to adapt societies and economies to the challenges of emerging technologies. In developed countries, new technologies may present risks of social exclusion and industrial obsolescence that should be proactively addressed by Governments and social actors. Based on the experiences of earlier technological revolutions, there are potential social and environmental downsides to applying science, technology and innovation to development. Ensuring that science, technology and innovation work in favour of the Goals depends on policy choices with regard to the technological trajectory to be followed.

A. Policy fundamentals

28. Success in implementing science, technology and innovation-driven strategies to achieve the Goals depends on establishing the basic foundations of related policies, which remain weak in many countries.[15] Such fundamentals include policies to stimulate the emergence of both technology absorptive capacities and innovative capabilities in an economy. They target the establishment of an enabling environment that promotes public and private sector investment in human capital and technological learning. They also include investment in general infrastructure such as for electricity, connectivity and transport. Securing high-quality Internet connectivity for all is critical. Facilitating investments to make broadband mobile Internet accessible and affordable, establishing regulatory environments conducive to trust online and building digital skills among the population are also necessary. Another essential area for investment is the development of science, technology and innovation infrastructure, including research and development facilities. Such hard infrastructure should be complemented by soft infrastructure such as basic engineering and related services (such as metrology, standards, testing and quality), which are needed to adapt technologies and build adequate absorptive capacity. Fundamentals also include fair and balanced regulatory regimes for intellectual property, and taxation, investment and competition policies. Finally, efforts to design appropriate governance mechanisms to guide national science, technology and innovation efforts, and to link and coordinate stakeholders, are essential (see box).

UNCTAD work on science, technology and innovation policy for development: Lessons learned

UNCTAD experience in supporting developing countries in the field of science, technology and innovation policymaking, including through its science, technology and innovation policy reviews and the work of multi-year expert meetings, have helped to confirm certain notions regarding the role of science, technology and innovation policy in development, as follows:

(a) Variability in economic structure, priorities, endowments, institutional frameworks, history and culture means that science, technology and innovation policy remains highly context specific. At the same time, there are important common characteristics of innovation in developing countries, including the need to consider innovation in traditional sectors and to incremental innovation rather than radical innovation. In addition, science, technology and innovation policy in developing countries should reflect the much larger role of small enterprises and the informal sector, given their limited capacity to adopt new technologies; invest heavily in research and development, training and innovation; and introduce major technological innovations. Investment in research and development and innovation is generally low among both the private and public sectors. In the least developed countries in particular, scaling up investment in science, technology and innovation capacity requires significant external financial support.

(b) Finding effective institutional frameworks for science, technology and innovation management remains critical. Institutional governance weaknesses are common, with inadequate coordination, short-term horizons and a lack of sustained policy support. There is a need for high-level political support with a focus on longer term development rather than short-term deliverables.

[15] See TD/B/C.II/MEM.4/5 and TD/B/C.II/25.

(c) Countries have difficulties in establishing priorities and identifying the most relevant areas in which the use of public resources can provide wider benefits for the economy. Insufficient effort or a lack of political strength to prioritize results in a list of priority actions that spread resources too thinly make it difficult to accumulate critical mass and, given implementation weaknesses, undermine the overall credibility of science, technology and innovation policy.

(d) Achieving coordination across ministries, and among the Government, industry, research institutes and universities, is critical to improving innovation performance. In many countries, there is a need to extend the scope of policy beyond a narrow focus on research, as well as a need to develop a better understanding of science, technology and innovation policy tools, design and measurement, monitoring and evaluation. Some tools are rarely used in many developing countries, such as technology foresight and innovation funds rather than research and development funds, while others require more support and better capacity to manage, such as intellectual property rights.

(e) There is a need to improve the implementation of science, technology and innovation policy and plans. Not all countries have a related policy or strategy and many that do lack funding for the implementation of policies and programmes. There remains in many countries, therefore, a limited degree of integration of science, technology and innovation into development policies and strategies. Attention should be paid to the linkages between science, technology and innovation policy and other key development policies such as industrial policy and policies on foreign direct investment, trade, competition, education and training, entrepreneurship and small and medium-sized enterprises.

UNCTAD advice on science, technology and innovation policy plays a useful role in raising awareness and understanding among policymakers and in promoting the mainstreaming of such policy in development policies. Challenges remain in fully mainstreaming such policy and, in particular, in implementing policy actions and programmes. The latter requires the achievement of buy-in from diverse stakeholders that support innovation, in particular from leading policymakers.

Source: TD/B/C.II/MEM.4/11.

B. Supporting the development of innovative firms

29. Adapting science, technology and innovation policy frameworks to the Goals may require broadening the scope of relevant actors. However, the development of related capabilities among firms and farmers should remain a fundamental focus of attention for policymakers. Dynamic networks of firms, often operating in spatial clusters, remain a key feature of the most innovative territories that dominate innovation in developed economies and advanced developing economies. In most developing countries, large cities account for a greater part of recorded national innovation. Such concentration of innovation and related knowledge infrastructure contributes to inequality between urban and rural populations in terms of income, education, health and opportunities. Pursuing a balanced upgrading of capabilities across urban areas and in rural areas is a goal for policymakers.

30. Supporting firm-level and farm-level innovation capacity includes two areas of policy action, namely supporting the development of innovative new firms, through measures such as the establishment of accelerators and incubators and innovation spaces and/or science and technology parks; and improving the innovation performance of established firms and farmers by promoting a higher degree of technology diffusion and capability-building among more firms, in order for firm productivity to rise across a larger group of firms and raise the growth rate of productivity at the national level.

31. A key aspect of the support policy needs to provide for, to enable the emergence of more innovative firms is financing. The availability of financial capital and the organization of financial markets strongly influence the way new technologies are deployed. Innovation often involves significant capital investments and is an uncertain,

risky undertaking, which makes it more difficult to mobilize the necessary resources. Lack of access to finance by firms is among the most serious constraints for innovation in all countries.[16]

32. Instruments such as tax incentives, the promotion of venture capital, angel investors and the establishment of innovation funds have been deployed in developing countries to facilitate the financing of innovation. For example, the science, technology and innovation policy review of Peru covered a variety of projects, including fellowships, internships, innovation projects by private firms, academic research and projects to strengthen linkages and coordination within the innovation system. UNCTAD identified several factors that contributed to the success of the programme of Peru in developing collaborative networks among enterprises, universities and research centres, leading to more firms carrying out product innovation, as follows: efforts to identify good practices in other countries prior to designing the programme; a light administrative programme structure, allowing for shorter time frames more adequate to the promotion of innovation activities; and continued support to encourage and facilitate the participation of firms in the programme.[17]

C. Strengthening education and training

33. Education systems are another fundamental component of strategies to harness science, technology and innovation for the Goals. The availability of a broad range of technological and managerial skills in the workforce is essential for the dissemination, adoption and application of technology, particularly emerging technology. Efforts to upgrade education in science, technology, engineering and mathematics are needed in many countries, with a special focus on nurturing related talent among girls and young women. There is broad agreement that emerging technologies make it necessary to develop education and training systems into lifelong learning systems that enable people at various stages of life to acquire the changing skills needed to deal with fast-moving technologies. The role of technical and vocational training, including in science, technology, engineering and mathematics, may become more important than in the past. Learning to learn, and developing creativity and entrepreneurial and managerial skills, are increasingly important. Given the crucial role of digital technologies as enablers and multipliers of other emerging technologies, education should prioritize ensuring adequate levels of information technology-related skills.

D. Building domestic and international linkages

34. Policies should take into account a critical lesson from the experience of the most innovation-effective economies, namely the importance of promoting strong linkages among actors in the Government, industry and research organizations, both nationally and with international networks. Such linkages are generally weak in developing countries. Instruments may be implemented as follows: to strengthen the geographical dimension of learning and innovation, for example through programmes in support of clusters or the establishment of science and technology parks, innovation centres and incubators;[18] to connect academia and industry, for example through funding schemes, the establishment of technology transfer offices and incentives for staff mobility between academia and industry;[19] and to enforce international linkages, for example through research collaboration or programmes to develop linkages between national and international firms, through global value chains or by leveraging foreign investment.[20]

35. Among instruments to promote linkages within an innovation system, science, technology and innovation parks are among the most widely used, in particular to foster collaboration between enterprises and universities and research centres. One reason for

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[16] For a discussion of policy issues related to financing innovation for development, see TD/B/C.II/21.

[17] UNCTAD, 2011, *Science, Technology and Innovation Policy Review: Peru* (United Nations publication, New York and Geneva).

[18] For a discussion of policy instruments to promote collaboration in national innovation systems, see TD/B/C.II/30.

[19] Ibid.

[20] TD/B/C.II/MEM.4/5.

their perception as important targets for support and public funding is that such parks provide a highly visible means of signalling a commitment to support technological innovation leading to better competiveness and increased employment. There is a strong link between economic diversification and national innovation capacity and successful park projects.[21] The experiences of several developing countries, as noted in several science, technology and innovation policy reviews, suggests that success in this area requires the existence of knowledge and technology leaders in the form of universities, research and development institutions and private firms or the ability to attract foreign technological firms.[22] A national policy formulated as an innovation system strategy, with appropriately developed cooperative linkages and incentives attracting and supporting high-technology firms, is another key condition. Such conditions are not easy to meet in developing countries. For example, a review of such parks in Latin America shows that most need to increase their size, strengthen their base of advanced knowledge institutions or high-technology firms and increase their efforts to encourage technological cooperation among the firms located therein.[23]

36. With regard to international linkages, global value chains are attracting considerable attention because of the role they can play in technological learning and the transfer of technology. However, such benefits depend on the linkages developed with other agents in a chain and the efforts made to learn through such linkages. Participation in global value chains may be associated with the upgrading of firms, which can take place as follows: process upgrading, through more efficient production; product upgrading, through the introduction of products with higher value added; functional upgrading, through the acquiring of new or superior roles in a value chain; and intersectoral upgrading, allowing local companies to apply acquired competences in other sectors of the economy.[24] The participation of smallholding farmers in a global value chain can produce process upgrading; for example, with regard to banana exports from East Africa. The association of local producers could generate economies of scale and facilitate their participation in international markets.[25] Leveraging value chains in the agricultural sector as an innovation policy instrument is particularly important given the significance of this sector for food security and employment and as the basis for diversification and growth in most developing countries. At the same time, the interaction between global value chains and the innovation systems of developing countries can influence whether and how firms in developing countries learn and innovate through such interaction.[26] However, evidence of knowledge spillovers through contacts between foreign affiliates and local suppliers is ambiguous. Domestic capacity-building in this regard requires strong support for the development of firm-level and system-level science, technology and innovation capabilities.[27]

E. Demand-side innovation policy

37. Demand-side innovation policy aims to create new demand for innovation or aggregate existing demand and make it more easily identifiable by firms and entrepreneurs, in order that risks may be reduced and incentives created for firms to engage in more

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[21] D Rowe, 2014, *Setting Up, Managing and Evaluating European Union Science and Technology Parks: An Advice and Guidance Report on Good Practice* (European Commission, Brussels).

[22] For examples of various conditions in and roles of science, technology and innovation parks under different national innovation systems in developing countries see UNCTAD, 2012, *Science, Technology and Innovation Policy Review: Dominican Republic* (United Nations publication, New York and Geneva); UNCTAD, 2014; and UNCTAD, 2015, *Science, Technology and Innovation Policy Review: Thailand* (United Nations publication, New York and Geneva).

[23] A Rodríguez-Pose, 2012, *Los Parques Científicos y Tecnológicos en América Latina* (Inter-American Development Bank, Washington D.C.).

[24] UNCTAD, 2007, *The Least Developed Countries Report 2007: Knowledge, Technological Learning and Innovation for Development* (United Nations publication, Sales No. E.07.II.D.8, New York and Geneva).

[25] UNCTAD, 2010, *Technology and Innovation Report 2010: Enhancing Food Security in Africa through Science, Technology and Innovation* (United Nations publication, Sales No. E.09.II.D.22, New York and Geneva).

[26] C Pietrobelli and R Rabellotti, 2011, Global value chains meet innovation systems: Are there learning opportunities for developing countries? *World Development*, 39(7):1261–1269.

[27] UNCTAD, 2013, *World Investment Report 2013: Global Value Chains – Investment and Trade for Development* (United Nations publication, Sales No. E.13.II.D.5, New York and Geneva).

innovative activities.[28] This type of policy includes initiatives such as public procurement, regulation, standards and consumer policy, as well as user-led and lead-market innovation initiatives. Public procurement has the longest record of successful application, and can be a particularly appropriate instrument for strategies to promote the technological development of small and medium-sized enterprises. However, it is necessary to consider its limitations, such as the fragmentation of public demand and the need to provide value for money. For example, in Sri Lanka, the use of transparent and competitive tender procedures stimulated the technological development of local small and medium-sized enterprises in the information and communications technology sector; one of the mechanisms used was the allocation of preferential marks for local firms that stimulated joint ventures between local and international firms and fostered capacity development among local firms.[29]

38. Coordination among the Government, industry and other stakeholders is critical to the success of demand-side policies. It is necessary to implement efforts to enhance administrative and organizational capabilities within the public agencies involved. It is also important to address coordination between industrial and innovation policies.

39. The previous sections describe some broad characteristics of the basic policies needed to enable countries to capture the benefits of science, technology and innovation, supported by experiences in countries that have been successful in this field. However, there is no single path or blueprint for building technological capabilities, and finding the appropriate national path requires a degree of experimentation and learning by doing for policymakers. This implies the need for sufficient policy space, including in international regimes applicable to science, technology and innovation.

F. International collaboration

40. However vital, national-level science, technology and innovation efforts may be insufficient to accomplish the 2030 Agenda. National policy should be supported and complemented by global collective action, failing which scientific and technological change may widen science, technology and innovation gaps among and within countries. As the world is in the early stages of the economic and social transformation that new technologies are expected to deliver, there is an opportunity for international cooperation and partnership in science, technology and innovation to shape future trajectories before path-dependency effects prevent countries from accessing the benefits of the technological revolution. Although the potential benefits of deploying new technologies for the Goals are considerable, uncertainty about the evolution of technology represents a risk that developing countries may not be able to address given current resource levels. International collaboration involving multiple partnerships among public, private and civil society actors is necessary to deploy science, technology and innovation to accomplish the 2030 Agenda.

41. Several global science, technology and innovation initiatives are already in place, including the Technology Facilitation Mechanism and Technology Bank for the Least Developed Countries. Focusing on innovation capabilities, a recent mapping exercise by the United Nations Inter-agency Task Team on Science, Technology and Innovation for the Sustainable Development Goals showed that around one third of United Nations initiatives are aimed at addressing Goal 9 at local, national and global and international levels.[30] Such initiatives range from supporting research and capacity-building for building local scientific and technological capabilities to advising on technology and innovation strategies and policies and establishing technology centres in different knowledge areas. Private international initiatives include public–private partnerships for infrastructure

[28] TD/B/C.II/MEM.4/5.

[29] UNCTAD, 2013, *Promoting Local [Information Technology] Sector Development Through Public Procurement* (United Nations publication, New York and Geneva).

[30] Inter-agency Task Team on Science, Technology and Innovation for the Sustainable Development Goals, 2017, Landscape of science, technology and innovation initiatives for the Sustainable Development Goals, available at https://sustainabledevelopment.un.org/content/documents/147462017.05.05_IATT-STI-Mapping.pdf.

technology and collaborations to support small and medium-sized enterprise development and research and development in developing countries.

42. The mapping exercise shows the importance of international exchanges of knowledge through scientific and technological collaboration, networking and capacity-building. This is a reflection of the increasingly important role of global science, technology and innovation networks, particularly in research, and the growing participation of some developing countries, such as China, in global science. Such changes are not necessarily the result of explicit policies but rather the outcome of internal dynamics in scientific collaboration, global linkages and increasingly open data sharing. Global policy should find mechanisms to influence the dynamics of global science, technology and innovation networks in ways that maximize positive outcomes for developing countries and respond to Goals-relevant research problems.

43. The financial dimension of international science, technology and innovation collaboration should be considered. New technologies create opportunities for efficiency gains, yet the implementation of the Goals requires the mobilization of financial resources at a scale that has not yet materialized. UNCTAD estimates that the gap in investment required in developing countries to accomplish the Goals by 2030 is $2.5 trillion per year.[31] Mobilizing finance and investment that targets the social and environmental dimensions of the 2030 Agenda is a significant challenge, and developing models of engagement between international finance, including private investors, and science, technology and innovation for development stakeholders, is important. New forms of partnership may help improve access to financial resources and change mindsets in the financial community with regard to the priority assigned to the need for investment in science, technology and innovation for social and environmental purposes.

G. New policy frameworks for Goals-relevant innovation

44. Development policy, including UNCTAD policy advice, has stressed the role of science, technology and innovation in raising productivity, generating economic growth and promoting structural economic transformation. In the context of the 2030 Agenda, the challenge is how to maintain economic growth while ensuring that the social inclusiveness and environmental sustainability dimensions of the development process are fully addressed. This will not be possible under a business-as-usual mode. New approaches to innovation policy may need to be developed in order to change the direction of innovation towards more inclusive and sustainable outcomes. The following five approaches were explored at the twentieth session of the United Nations Commission on Science and Technology for Development:[32]

(a) Mission-oriented innovation that seeks to provide a solution to a specific high-priority problem;

(b) Pro-poor and inclusive innovation that involves poor people in mainstream processes of technology development and innovation;

(c) Grass-roots innovation that originates from grass-roots actors in local communities;

(d) Social innovation, which refers to social relationships, practices and structures primarily aimed at addressing social needs and improving human well-being;

(e) Digitally enabled open and collaborative innovation, which allows knowledge and technology to be produced across a multiplicity of factors and institutions, drawing on both formal and informal knowledge.

45. The need for such new innovation approaches is emphasized by a line of research in science, technology and innovation policy that proposes that currently dominant policy frameworks based on an innovation systems approach are no longer appropriate in

[31] UNCTAD, 2014, *World Investment Report 2014: Investing in the [Sustainable Development Goals] – An Action Plan* (United Nations publication, Sales No. E.14.II.D.1, New York and Geneva).

[32] E/CN.16/2017/2.

addressing current global multidimensional challenges such as inequality, unemployment and climate change.[33] Proponents of a new innovation policy framework, entitled Innovation Policy 3.0, suggest that the concept of innovation should be broadened beyond traditional notions and support for research and development. Through the notion of sociotechnical system change, this approach seeks to support the emergence of new products and services and organizational models to meet social and economic challenges. Innovation policy under the new framework would also provide direction to innovation, in order to better address the needs, interests and perspectives of poorer, marginalized communities and better target social and environmental aims to achieve the Goals. An assumption of Innovation Policy 3.0 is that both developed and developing countries will be in a position to contribute equally to sociotechnical system change and that mutual learning will be beneficial. Efforts to broaden the notions underlying science, technology and innovation policy for development, and to ensure that the direction given to innovation is supportive of the Goals, are relevant. However, the full implications of new innovation approaches are not well understood. There is a need for further research and the exchange of experiences about how policy frameworks such as Innovation Policy 3.0 can interact with policy practices under more established models. In this regard, evolving knowledge could benefit from and inform UNCTAD policy, technical assistance and intergovernmental work in science, technology and innovation for development.

V. Questions for consideration

46. This note presents an optimistic outlook of the potential of science, technology and innovation, in particular of new and emerging technologies, to contribute to accomplishing the 2030 Agenda. However, it seems unlikely that current efforts, at both domestic and global levels, are leveraging science, technology and innovation for the Goals to their fullest potential. This is a cause for concern, considering the speed at which conditions are changing and the risk that science, technology and innovation gaps may become unmanageable.

47. The Investment, Enterprise and Development Commission may wish to discuss the following questions related to policy responses at all levels that may be relevant to step up current efforts in science, technology and innovation for the Goals to the required level:

(a) What is the experience of member States with adopting advanced technologies in national contexts? What key challenges, benefits and practical lessons can be identified at this stage?

(b) What is working and what is not working in international collaboration to help developing countries improve their local science, technology and innovation systems and benefit from new technologies? What may be the appropriate role of public–private partnerships in this regard?

(c) Who are the main stakeholders that need to be involved in making science, technology and innovation systems more supportive of inclusive and sustainable development? What good practices can be proposed to involve them more effectively?

(d) How can international organizations, UNCTAD in particular, support better policies for harnessing science, technology and innovation for the Goals? What are the main ways in which the policy frameworks applied by UNCTAD in its science, technology and innovation policy work should be adapted in order to be more supportive of science, technology and innovation development strategies relevant to the Goals?

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[33] The Transformative Innovation Policy Consortium involves academic and science, technology and innovation policy bodies from Colombia, Finland, Norway, South Africa, Sweden and the Science Policy Research Unit of the University of Sussex, United Kingdom of Great Britain and Northern Ireland. See http://www.transformative-innovation-policy.net/.