United Nations E/CN.16/2022/3

Economic and Social Council

Distr.: General
17 January 2022

Original: English

Commission on Science and Technology for Development
Twenty-fifth session
Geneva, 28 March–1 April 2022
Item 3 of the provisional agenda
Science and technology for development

Science, technology and innovation for sustainable urban development in a post-pandemic world

Report of the Secretary-General

Summary

This report explores the contribution of science, technology and innovation to mitigating the sustainability challenges facing urban sociotechnical systems in a post-pandemic world. It also assesses urbanization trends and the impact of the coronavirus disease (COVID-19) pandemic on sustainable urban development. It identifies 10 key urban sustainability challenges in relation to energy, circularity, water, mobility, economic prosperity, housing, gender-related empowerment and equality, urban planning, safety and security and protection from natural disasters. Under each category, a selection of practical science, technology and innovation solutions and case studies from around the world are presented. Finally, the need for action at the national and international levels to seize the innovation momentum from the pandemic and to use the transformative power of science, technology and innovation to deliver on the commitment to sustainable urban development are emphasized. International cooperation efforts are needed to further pool, formalize and transfer available knowledge of effective science, technology and innovation solutions.

Introduction

1. At its twenty-fourth session, in May 2021, the Commission on Science and Technology for Development selected "Science, technology and innovation for sustainable urban development in a post-pandemic world" as one of its priority themes for the 2021–2022 intersessional period.

2. At its sixteenth session, in 2013, the Commission examined the theme of science, technology and innovation for sustainable cities and peri-urban communities, including environmental sustainability. Since then, accelerating technological change in renewable energy, artificial intelligence, machine learning and big data have opened new possibilities for addressing urban problems innovatively, at a lower cost and more sustainably. The international landscape in which science, technology and innovation and urban development policies interact has also changed since 2013, with the adoption of the following: Sendai Framework for Disaster Risk Reduction 2015–2030; Addis Ababa Action Agenda of the Third International Conference on Financing for Development; 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal 11; Paris Agreement under the United Nations Framework Convention on Climate Change; and New Urban Agenda adopted by the United Nations Conference on Housing and Sustainable Urban Development (Habitat III).

3. In addition to accelerating technological change and a new international landscape, the COVID-19 pandemic and its effects on urban life provide a third strong reason for the Commission to take a fresh look at the issue of urban development and its social, economic and environmental dimensions. With an estimated 90 per cent of all reported COVID-19 cases, urban areas have become the epicentre of the pandemic,[1] and this can have significant negative effects along all dimensions of sustainable development. However, cities have also provided crucial sustainability lessons that combine some optimistic notes with strong warnings: much more intense efforts are urgently needed to ensure transitions to inclusive, productive and more environmentally sustainable urban communities.[2] For example, social distancing and lockdown measures, which have modified patterns of energy and transport demand worldwide, have demonstrated that a greener urban future is possible. At the same time, other pressing environmental challenges have been exacerbated, showing the need for more innovation in urban sociotechnical systems. For example, the intense use of disposable plastics has led to a significant increase in urban plastic pollution and of inappropriate waste management practices. The pandemic has also led to a global economic crisis and job losses, particularly in many developing countries and the least developed countries. As a result, existing economic inequalities have been exacerbated and the level of poverty has increased. The economic hardship has pushed millions of informal workers in developing countries out of urban areas due to the inability to afford basic urban services, including housing.[3] Urban areas have become the physical space in which the pandemic has worsened existing deep-rooted inequalities due to gender, age and place of residence. Many urban sociotechnical systems have broken down under the pressure, leaving people and places behind. Of particular concern are education systems, in which adults and children without Internet access have been left behind. On the other hand, the pandemic has served to show the importance of science, technology and innovation systems in contributing to equipping society with the instruments and capabilities required to direct innovation efforts towards improving sustainable urban development and the resilience of urban systems. Scientific knowledge production processes, digital technology adoption and innovations in organizational and institutional settings have contributed to mitigating the impact of the

[1] United Nations, 2020, Policy brief: COVID-19 in an urban world, available at https://unsdg.un.org/resources/policy-brief-covid-19-urban-world.
Note: All websites referred to in footnotes were accessed in December 2021.

[2] See Organisation for Economic Co-operation and Development, 2021, *Science, Technology and Innovation Outlook 2021: Times of Crisis and Opportunity*, Paris.

[3] United Nations Human Settlements Programme, 2021, *Cities and Pandemics: Towards a More Just, Green and Healthy Future*, Nairobi.

pandemic, helping many urban sociotechnical systems to continue to function during the crisis.

4. This report is based on the issues paper prepared by the secretariat for the intersessional panel meeting convened from 17 to 19 November 2021, the findings and recommendations of the panel and country case studies contributed by Commission members, as well as relevant literature and other sources.[4]

I. Urban sustainability challenges

5. Sustainable urban development, as framed under Sustainable Development Goal 11, involves rethinking urban development patterns and introducing the means to make urban settlements more inclusive, productive and environmentally friendly. In this regard, access to and the sharing of knowledge of science, technology and innovation are critical in the implementation of the New Urban Agenda. Several global challenges undermine the sustainability of urban sociotechnical systems. The challenges discussed in this chapter cover key areas under the green-productive-inclusive triad with regard to sustainable urban development, particularly in view of the impact of the pandemic on urban systems.

Inefficient and polluting energy systems

6. Urban energy systems, which are highly dependent on fossil fuels, consume up to 75 per cent of global energy and account for over 50 per cent of total greenhouse gases.[5] Urban areas also face an energy accessibility issue. Despite increases in global access to electricity, in 2019, approximately 760 million people, 75 per cent of whom were in sub-Saharan Africa, lacked access to electricity.[6] Public financial flows with regard to renewable energy continue to be concentrated in a few countries, making it difficult for many developing countries and the least developed countries to sustain urban energy transitions. In addition, the pandemic has led to a substantial decline in renewable energy investments, with a 34 per cent decrease in the first half of 2020 compared with the same period in 2019.[7]

Unsustainable production and consumption patterns

7. In 2020, most of the global material footprint was generated in urban areas. Based on current trends, by 2050, the equivalent of almost three planets will be required to provide the natural resources needed to sustain current lifestyles.[8] Cities are responsible for producing an estimated 60 per cent of the plastic that reaches marine waters. However, the global recycling rate remains between 14 and 18 per cent.[9] This issue has been exacerbated during the pandemic, which has led to the increased use of plastic goods, especially single-use plastics. The extent of food waste is equally critical, representing 44 per cent of global

[4] Contributions from the Governments of Belarus, Belgium, Brazil, the Dominican Republic, Egypt, the Islamic Republic of Iran, Kenya, Latvia, Peru, the Philippines, Portugal, Romania, the Russian Federation, South Africa, Switzerland, Thailand, Turkey and the United Kingdom of Great Britain and Northern Ireland, as well as the Economic and Social Commission for Western Asia, the Food and Agriculture Organization of the United Nations, the International Telecommunication Union, the United Nations Human Settlements Programme, the United Nations Industrial Development Organization, the United Nations Office for Outer Space Affairs and the World Tourism Organization are gratefully acknowledged. For all documentation from the intersessional panel meeting, see https://unctad.org/meeting/cstd-2021-2022-inter-sessional-panel.

[5] See https://unhabitat.org/topic/energy.

[6] International Renewable Energy Agency, 2020, *Global Landscape of Renewable Energy Finance 2020*, Abu Dhabi.

[7] Ibid.

[8] See https://www.unep.org/news-and-stories/press-release/un-report-time-seize-opportunity-tackle-challenge-e-waste.

[9] Organisation for Economic Co-operation and Development, 2018. Improving plastics management: Trends, policy responses and the role of international cooperation and trade, Environment Policy Paper No. 12.

waste; annually, over 17 per cent of global food production may be lost.[10] Electronic waste (e-waste) is an additional challenge. Despite content that includes highly hazardous substances, less than 20 per cent of e-waste is formally recycled and 80 per cent ends up in landfills or is informally recycled.[11]

Water scarcity

8. More than 60 per cent of urban areas in sub-Saharan Africa do not have access to water and sanitation services.[12] One study estimates that the global urban population facing water scarcity will increase significantly; by 2050, between 1.7 billion and 2.4 billion people will live in water-scarce regions and 292 of 526 large cities worldwide as well as 19 megacities are expected to experience perennial or seasonal water scarcity issues.[13] Additionally, natural disasters, increasing levels of surface water and groundwater pollution, population growth and urbanization are increasing the demand for clean water, amplifying levels of water stress.

Traffic congestion and vehicle emissions

9. Urban mobility presents some of the greatest obstacles to urban sustainable development. Among the most relevant issues are dependence on fossil fuels, increasing rising private ownership of polluting vehicles, road congestion due to growing levels of urban traffic and access to public transportation that is increasingly unaffordable for the poorest groups of urban populations. Transport activities are responsible for generating approximately 25 per cent of energy-related carbon emissions from fuel combustion worldwide and most of this pollution comes from urban areas.[14]

Limited access to decent employment

10. Urbanization and economic development go hand in hand. Overall, countries with a higher per capita gross domestic product (GDP) tend to be more urbanized, especially in terms of metropolitan populations. The share of the population living in metropolitan areas of above 1 million people is roughly four times greater in high-income countries, at 47 per cent, than in low-income countries, at 12 per cent, and in middle-income countries, GDP per capita in the most metropolitan regions is twice as great as per capita income in the least metropolitan regions.[15] As a result, urban areas contributed about 80 per cent of global GDP before the pandemic.[16] They are expected to become the main driving force of the post-pandemic economic recovery. Due to substantial differences in the roll-out of vaccinations and in the distribution of State aid, urban areas in developed countries have tended to recover faster than those in developing countries and the least developed countries. Urban unemployment rates in Latin America and the Caribbean had already reached an average of 10 per cent in 2017 and the figure doubled in January 2021.[17] In South Africa, already high unemployment rates have been exacerbated during the

[10] United Nations Environment Programme, 2021, *Food Waste Index Report 2021*, Nairobi.

[11] World Economic Forum, 2019, *A New Circular Vision for Electronics: Time for a Global Reboot*, Geneva.

[12] D Mitlin, VA Beard, D Satterthwaite and J Du, 2019. Unaffordable and undrinkable: Rethinking urban water access in the global south, World Resources Institute working paper.

[13] C He, Z Liu, J Wu, X Pan, Z Fang, J Li and BA Bryan, 2021, Future global urban water scarcity and potential solutions, *Nature Communications*, 12(1).
Note: Large cities are urban areas with a population of over 1 million and megacities are those with a population of over 10 million.

[14] International Energy Agency, 2019, *Carbon Dioxide Emissions from Fuel Combustion: Highlights*, Paris.

[15] Organisation for Economic Co-operation and Development, 2020, *Cities in the World: A New Perspective on Urbanization*, Paris.

[16] F Estrada, WJW Botzen and RSJ Tol, 2017, A global economic assessment of city policies to reduce climate change impacts, *Nature Climate Change*, 7(6):403–406.

[17] See https://www.cepal.org/en/publications/42251-employment-situation-latin-america-and-caribbean-transition-young-people-school and https://www.bbvaresearch.com/en/publicaciones/colombia-effects-of-covid-19-on-employment-in-january-2021/.

pandemic, particularly among youth, at 46.3 per cent.[18] The global decline in job opportunities in urban areas indicates a fragile economic system with a low level of resistance to exogenous shocks. One of the main causes of this weakness is the widespread presence of informal working conditions; 1.6 billion informal workers worldwide have little or no social protection.[19] Informal economies have been significantly impacted during the pandemic and, even as the global unemployment rate has grown, already existing gender-related discrepancies in job opportunities have been exacerbated.[20]

Unaffordable and poor-quality housing

11. Central and Southern Asia, Eastern and South-Eastern Asia and sub-Saharan Africa account for 80 per cent of the global population living in informal settlements,[21] in which residents experience overcrowded and low-quality housing conditions. Based on current urbanization trends, approximately 3 billion people may require quality and affordable housing by 2030, augmenting an existing housing deficit.

Gender-based inequalities and violence against women and girls

12. Women living in urban areas are more likely to be subject to occupational segregation, which prevents them for accessing many urban employment opportunities. Gender inequality also appears in the form of a technology-related bias and in urban planning practices. Consequently, the needs of women and girls are not adequately addressed. Often, this is a result of design processes that have been developed using a men-centred approach. There is also a strong correlation between urbanization and gender-based violence and abuse against women and girls. Data collected since the outbreak of the pandemic has shown that violence against women and girls has intensified in many countries during the pandemic.

Inadequate planning practices

13. Difficulties in regulating the growing demand for land in a fast-urbanizing world create urban sprawl and uncontrolled peri-urbanization processes. A common reaction among municipal governments has been to attempt to regulate peri-urban areas with traditional urban planning instruments. However, such tools have proved incapable of dealing with the complexity of fragmented space distribution processes, which in turn affect socioeconomic and environmental sustainability. The result is uneven development between centrally located urban spaces and those positioned in peri-urban interfaces.

Violence and insecurity

14. About 83 million people worldwide live with the consequences of armed conflicts and violence.[22] Approximately 54 per cent of urban resident homicides are carried out with firearms, many of which enter urban spaces through illicit trafficking.[23] At least 150 million people worldwide are also confronted with forced evictions, that is, involuntary removal from a home or land without access to legal and judicial processes.[24] This problem has been amplified during the pandemic. Significantly impoverished living conditions have left millions of urban households without the means of achieving land tenure security.

[18] Contribution from the Government of South Africa.

[19] International Labour Organization, 2020, *Issues Paper on COVID-19 and Fundamental Principles and Rights at Work*, Geneva.

[20] See https://unhabitat.org/World%20Cities%20Report%202020 and https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_813449/lang--en/index.htm.

[21] United Nations, 2021, *The Sustainable Development Goals Report 2021*, New York.

[22] Ibid.

[23] United Nations Office on Drugs and Crime, 2020, *Global Study on Firearms Trafficking 2020* (United Nations publication, Sales No. E.20.IV.1, New York).

[24] Office of the United Nations High Commissioner for Human Rights, 2020, Prohibition of evictions, COVID-19 Guidance Note.

Vulnerability to natural disasters

15. The sustainable development of many urban areas in developed and developing countries is also permanently threatened by natural disasters. Direct losses from natural disasters were $2.9 billion in the period 1998–2017.[25] Beyond economic damages, natural disasters also have negative impacts on urban social stability and significantly affect the lives of people in urban areas. In China, for example, in 2020, extreme seasonal weather displaced 744,000 people across 26 provinces and cities.[26] In Peru, people have been displaced and lost jobs in areas at risk of mudslides and flash floods caused by torrential rains in the Andean Mountains.[27]

II. Applying science, technology and innovation to sustainable urban development

16. Science, technology and innovation solutions can help mitigate the most pressing urban sustainability challenges and harness the value embedded in global population growth while ensuring sustainable urbanization processes. This analysis does not aim to cover all possible science, technology and innovation solutions to urban sustainability challenges. Rather, the objective is to highlight notable cases of technological and non-technological innovations that have created a robust environment, in order to support the identification of relevant lessons and practical implications and the subsequent formulation of policy measures. Under the framework of this analysis, over 100 science, technology and innovation initiatives were examined.

A. Energy

17. Urban sociotechnical systems for energy production and distribution are highly dependent on fossil fuels. A transition to low carbon and sustainable renewable sources is urgently needed, especially considering the steep increase in urban energy demand that an expanding population will progressively lead to. The use of renewable sources has gained momentum in the last two decades. However, the share of such sources has remained limited in comparison with that of fossil fuels. This gap has triggered significant investments in research and development activities, which have resulted in notable technological and non-technological advancements. Examples of science, technology and innovation solutions to challenges related to unsustainable urban energy systems include solar, wind, hydropower, biomass and geothermal energy systems that leverage available natural resources and local climate conditions to produce green energy, green hydrogen technology and energy efficient buildings. Most such solutions have already been embedded in urban settings and others serve urban areas by providing clean energy produced beyond administrative boundaries. Offsite renewable energy production, however, may be undermined by potential market and policy-related barriers, and the diffusion of green energy production models may benefit urban areas at the expense of rural territories. For example, wind farms can negatively impact the welfare of rural populations. It is important for policymakers to devise mechanisms to arbitrate such potential conflicts between public policy goals and to ensure sustainable outcomes that do not unfairly externalize the costs of urban energy transitions to rural populations.

Solar photovoltaic systems

18. Technologies using solar photovoltaic systems to produce urban energy are used in many different contexts, such as buildings and waste management systems. Ground

[25] Centre for Research on the Epidemiology of Disasters and United Nations Office for Disaster Risk Reduction, 2018, *Economic Losses, Poverty and Disasters 1998–2017*, available at https://www.undrr.org/publication/economic-losses-poverty-disasters-1998-2017.

[26] See https://www.scmp.com/news/china/society/article/3090854/after-coronavirus-flooding-hits-southern-china-14-million.

[27] Contribution from the Government of Peru.

mounted panels are among the most common applications, together with rooftop and floating installations. Rooftop solar photovoltaic installations have significantly increased in recent years and can easily sustain energy production in urbanized territories in which energy is not available or power interruptions and outages occur regularly. For example, in Egypt, in 2018–2019, following the opening of Benban Solar Park, one of the world's largest solar power plants, electricity produced through solar energy increased by 177 per cent, from 0.529 billion kW to 1.465 billion kW.[28] In Zambia and Zimbabwe, the United Nations Development Programme is working with various stakeholders to install rooftop solar panels on national medical warehouse and health-care facilities, providing the capability to autonomously produce green energy.[29]

Energy efficiency in the construction sector

19. Mandatory standards are a powerful policy instrument with which to stimulate demand for innovation. Many developing and developed countries have introduced regulatory systems requiring new construction and renovations to comply with minimum energy performance standards, such as energy rating systems, performance certification schemes, building and construction codes and standards, solar thermal ordinances and design for sustainability approaches. Such solutions help firmly embed sustainable development principles in the building and construction sector, while providing supply chain actors with regulatory frameworks that include local, national and international sustainability-related expectations. For example, solar thermal ordinances are legal provisions that require the minimum share of heating demand of a building to be covered through the installation of solar thermal systems. Thermal insulation is key to attaining energy efficient buildings, as heating and cooling operations account for approximately 50–60 per cent of total energy consumption.[30] Digital solutions can be used to track inefficiencies by monitoring the overall energy performance of buildings and evaluating the performance of single components.

B. Circularity

20. Addressing production and consumption patterns has become a priority in many urban regions because they place a significant strain on the world's limited natural resources. Science, technology and innovation solutions in this area focus on decreasing material footprints per capita, preventing excessive waste production and increasing the rate of recycling and reuse of different types of waste. For example, in Thailand, with a view to evenly distributing the benefits of prosperity to the wider community, a bio-circular-green economy model has been adopted that integrates the bioeconomy, circular economy and green economy through the use of science, technology and innovation to capitalize on the rich biodiversity and cultural diversity of the country, ranging from food and agriculture, health and medicine and bioenergy, biomaterials and biochemicals to tourism and the creative economy.[31]

21. Governments are developing matchmaking platforms to manage waste. For example, the Islamic Republic of Iran has introduced a matchmaking platform as part of national smart waste management systems to make the outsourcing process more transparent and allow for start-ups and entrepreneurs to cooperate with municipal administrations.[32] In addition, companies are adopting business-to-business matchmaking platforms to exchange resources, allowing them to return unused products, materials and waste back into the market and help other companies find resources while reducing waste. Another strategy is to make customers in urban areas aware of the environmental costs of buying habits by

[28] Contribution from the Government of Egypt.

[29] See https://www.un.org/en/un-chronicle/solar-health-five-ways-solar-power-can-make-universal-healthcare-reality.

[30] International Renewable Energy Agency, 2021, *Renewable Energy Policies for Cities: Buildings*, Abu Dhabi.

[31] Contribution from the Government of Thailand.

[32] Contribution from the Government of the Islamic Republic of Iran.

providing detailed information through environmental labelling and information schemes, which are voluntary methods of providing environmental performance certifications.

22. Food can easily become waste along its production and distribution channels. Digital traceability and tracking systems can enable the earlier detection of inefficiencies along food supply chains. For example, the improvement of locally produced food safety and traceability measures is the focus of the Ambrosia platform developed by the European Space Agency, the main output of which is a digital system that helps municipalities track points of origin and shipping processes by recording all transactions, the status of foods during transportation and environmental conditions.[33]

23. The recycling of e-waste is a complex process and poses a significant threat to urban life, thereby requiring regulatory intervention. For example, in the European Union, new eco-design legislation, including right-to-repair standards, requires manufacturers to ensure that appliances last longer. Responsible production principles may be complemented by new recycling techniques such as urban mining, that is, the extraction of rare metals embedded in discarded electronic equipment. For example, China is an emerging leading contributor to the urban mining of e-waste, and the volume of material recovered and reused has been growing significantly since the 2000s; the practice is also becoming significantly cost efficient.[34] With regard to monitoring e-waste, the International Telecommunication Union has published *Global E-Waste Monitor 2020* and the *Policy Practices for E-Waste Management* toolkit.

C. Water

24. Improving water use efficiency, demand management and leakage control is one of the most urgent actions needed in urban contexts. Smart technologies can provide the necessary support. For example, in India, a smart metering and automated leakage prevention system has been installed across 40,000 households, helping to save, on average, approximately 35 per cent of water consumption.[35] Digital solutions for water protection can also increase the efficiency and effectiveness of water treatment, enabling real-time water monitoring and the more rapid detection of possible pollutants.

D. Mobility

25. Congestion and air pollution are some of most significant mobility-related problems in urban areas globally. Science, technology and innovation solutions to such urban sustainability challenges can be grouped into three main categories, namely, low-emission vehicles; policies, regulations and financial schemes to incentivize the use of more sustainable transport solutions; and intelligent transportation systems. The electrification of urban transportation systems is growing in both developed and developing countries as a result of more favourable policy settings, financial incentives and continuous research and development efforts that increase vehicle performance while reducing overall costs.

26. In Belarus, the National Academy of Sciences, together with other stakeholders, has developed a comprehensive programme for the development of electric transport in 2021–2025. It includes more than 40 activities, ranging from research and development to work on the development of charging infrastructure. In addition, under the Electric Mobility Europe programme, the National Academy of Sciences supports planning processes and tools for the step-by-step conversion of bus fleets to the use of 100 per cent electric buses.[36]

27. Intelligent fast-charging solutions are emerging in cities to address issues related to congestion at recharging stations and slow charging rates. For example, in Amsterdam,

[33] See https://business.esa.int/projects/ambrosia.

[34] X Zeng, JA Mathews and J Li, 2018, Urban mining of e-waste is becoming more cost-effective than virgin mining, *Environmental Science and Technology*, 52(8), 4835–4841.

[35] See https://blogs.worldbank.org/water/future-water-how-innovations-will-advance-water-sustainability-and-resilience-worldwide.

[36] Contribution from the Government of Belarus.

Flexpower, the largest public smart charging network for electric vehicles in the city, combines faster charging with the use of locally generated renewable electricity and helps to ensure the more efficient use of electric grid capacity.[37]

28. Real-time traffic management systems automate operations such as vehicle detection, traffic density estimation, traffic accident identification and traffic light control. For example, in Bengaluru, India, the Electronics City Township Authority is testing a prototype traffic management solution that fully automates traffic control and monitoring operations.[38] The Government of the Philippines has developed traffic simulation software designed to be used by road and traffic engineers as a decision support system in traffic management.[39]

29. Mobility as a service refers to a multimodal approach to addressing urban mobility, including by allowing users to pay for tickets for a wide range of public and private transport options and to obtain real-time information on transport functioning. For example, in Helsinki, the system integrates information on bicycle-sharing systems, taxis, car-sharing services and conventional rental cars, together with public transport data, and allows for payments to be processed through mobile applications.[40]

E. Economic prosperity and decent jobs

30. Implementing science, technology and innovation solutions could help policymakers foster entrepreneurship, promote economic prosperity and support financial stability among urban residents. During the pandemic, such solutions have become imperatives for the smart, sustainable and people-centred recovery of urban economies.

Dedicated urban zones for the development of science, technology and innovation

31. Several countries have established dedicated zones to nurture the sustainable development of science, technology and innovation, which promote job creation and the advancing of industrialization in urban areas. Such dedicated spaces support local urban innovation ecosystems, improving the ease of doing business, providing access to finance and tax support and creating demand for new job profiles. Examples of this approach are the technological hub in the Dominican Republic, science and technology parks in Kenya, innovation zones in Latvia, hubs of innovation and entrepreneurship in Portugal, high-technology parks in the Russian Federation and technology development zones in Turkey.[41] By encouraging investment in high technology and promoting innovation and entrepreneurship, usually through government support, including tax incentives, such dedicated zones create job opportunities and contribute to the development of cities.

Electronic commerce platforms

32. E-commerce platforms have proved important for boosting business development in urban areas. They help microenterprises and small and medium-sized enterprises by providing online spaces to sell products or services and expand market opportunities beyond geographic boundaries. In addition, demand for e-commerce from urban areas triggers labour absorption in the logistics sector to meet this demand. This relationship has been amplified during the pandemic as, due to mobility restrictions, people have switched to the use of e-platforms to meet their daily needs. UNCTAD data based on national sources show a significant increase in e-commerce during the pandemic; in 2020, the share

[37] See https://www.elaad.nl/projects/flexpower-amsterdam.

[38] See https://new.siemens.com/global/en/company/stories/research-technologies/folder-future-living/reducing-congestion-with-deep-learning.html.

[39] Contribution from the Government of the Philippines.

[40] See https://www.cerema.fr/fr/actualites/maas-europe-enseignements-experiences-helsinki-vienne.

[41] Contributions from the Governments of the Dominican Republic, Kenya, Latvia, Portugal, the Russian Federation and Turkey.

of online retail sales grew, from 16 to 19 per cent of total retail sales.[42] For example, in Uganda, the United Nations Capital Development Fund collaborated with the main ride-hailing company in Kampala to launch a digital e-commerce platform for home deliveries during the pandemic, which has helped 18,000 people keep their jobs, 800 vendors to maintain revenue streams during lockdown measures and thousands of customers to continue to receive deliveries of food and other essential goods.[43]

Information and communications technology-related education and training programmes

33. Industrial sectors have been experimenting with the technological advancements enabled by information and communications technology, such as robotics, that is leading to a higher degree of automation. In certain sectors, automation processes may lead to reductions in workers, yet such technology can also unleash productivity gains. Many local and national authorities promote innovative education and training programmes that aim to increase information and communications technology skills among youth. Such upskilling opportunities are offered to ensure a better alignment between education systems and growing markets; such an alignment is indispensable in leaving no one behind and ensuring sustainability-oriented system changes in urban areas. For example, in South Africa, the Oliver Tambo Research Chairs initiative builds on existing continental frameworks and interventions geared towards the development of high-end skills, the recruitment and retention of excellent researchers and the provision of incentives to support research that contributes to socioeconomic and transformative development in Africa.[44]

Cash transfer schemes and programmes

34. Innovative cash transfer schemes can ease financial burdens on poorer workers and help them access secure financial services, limiting the widespread adoption of informal loans. To induce behavioural change in low-income populations and improve their financial situations, local authorities can initiate conditional cash transfer programmes that provide payments in return for fulfilling specific conditions. For example, in Brazil, a programme initiated in some municipalities offers cash transfers to families meeting certain conditions, such as the compulsory attendance of children at school.[45] In Sabang, Indonesia, a locally funded social protection programme aims to provide poor households with the monthly cash-based assistance required to meet the health and nutritional needs of children.[46]

Smart technologies to address child labour

35. Science, technology and innovation solutions can provide effective means to address child labour, the rate of which increased by 8.4 million in 2016–2021, to 160 million,[47] as well as modern slavery, human trafficking and migrant smuggling, which are critical urban phenomena. For example, remote monitoring tools addressing forced and child labour make use of mobile telephone-based technologies, real-time tracking systems and other networked technologies to determine the presence of illegal working conditions in a workplace. Some of these real-time monitoring tools also use satellite imagery to oversee the movement and loading of boats and web scraping to search for data on child abuse that can lead law enforcement agencies to children in need. Such technologies can also be used to stop human trafficking operations.[48]

[42] UNCTAD, 2021, Estimates of global e-commerce 2019 and preliminary assessment of COVID-19 impact on online retail 2020, Technical Notes on ICT[Information and Communications Technology] for Development No. 18.

[43] See https://www.uncdf.org/article/5577/uncdf-and-safeboda-with-support-from-sida-launch-an-e-commerce-platform-for-home-delivery-amid-covid-19.

[44] Contribution from the Government of South Africa.

[45] See https://www.worldbank.org/en/results/2020/04/22/strengthening-conditional-cash-transfers-and-the-single-registry-in-brazil.

[46] See https://sdgs.un.org/partnerships/delivering-results-children-through-locally-funded-social-protection-programme.

[47] See https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_800090/lang--en/index.htm.

[48] See https://www.unicef.org/reports/accelerating-results-children-technology-and-digital-innovation-2020.

F. Housing

36. The development of more affordable and quality housing solutions is highly dependent on science, technology and innovation efforts. Many countries have placed cross-sectoral partnerships and industrial alliances for research and development at the centre of national development agendas for the housing construction sector, alongside the establishment of international standards to facilitate collaboration.

Digitalization of operations and manufacturing processes

37. Science, technology and innovation solutions to support sustainable development in the housing construction sector focus on the digitalization of operations and manufacturing processes. The wider use of digital fabrication techniques relying on information technology-controlled production environments can help improve efficiency while increasing production rates. For example, in China, a 57-floor skyscraper was built in 19 days using digital fabrication technologies and offsite manufacturing techniques; the use of traditional building techniques would have required more than one year of onsite construction.[49] Additive manufacturing technologies can also be used in building new houses. For example, the non-profit organization New Story is introducing three-dimensionally printed homes in the Plurinational State of Bolivia, Haiti and Mexico; a 600-square-foot (56m^2) home can be produced in one day at an overall cost of $4,000.[50]

Digital twin technology

38. Through the use of digital twin technology, virtual models can be created to predict the functioning of an object. This insight can be used to inform decision-making processes in the housing construction sector.[51] Engineers and designers across manufacturing industries are increasingly using this technology to experiment with different design solutions and civil engineers use it as a supporting tool in the design, construction and monitoring processes of transport infrastructure assets.[52] In addition, in housing construction, digital twin technology allows for the collection of information during the entire life cycle of a building and can help improve maintenance operations while facilitating data-sharing operations.

G. Gender-related empowerment and equality

39. Sustainable and inclusive urbanization cannot be realized without the introduction of safeguards against existing gender gaps, biases and discrimination. Science, technology and innovation solutions in this area range from new digital tools to non-technological interventions that support awareness-raising activities, community mobilization actions, educational programmes, legal and policy-related reforms and changes in institutional settings.

Online anti-violence services

40. In many cities worldwide, women and girls do not have acceptable levels of safety. By some estimates, women are twice as likely to be victims of violent aggression as men.[53] In response to this lack of safety in public and private urban spaces, technology-related grass-roots innovations are spreading, some of which aim to enhance the capability of

[49] Y Chang, X Li, E Masanet, L Zhang, Z Huang and R Ries, 2018, Unlocking the green opportunity for prefabricated buildings and construction in China, *Resources, Conservation and Recycling*, 139:259–261.

[50] See https://unfoundation.org/blog/post/3d-printing-for-good-how-one-nonprofit-is-printing-homes-for-families-in-need/.

[51] See https://www.arup.com/perspectives/publications/research/section/digital-twin-towards-a-meaningful-framework.

[52] See https://www.oecd-ilibrary.org/sites/ee2a2c2f-en/index.html?itemId=/content/component/ee2a2c2f-en.

[53] United Nations Human Settlements Programme, 2006, *State of the World's Cities 2006/7*, Nairobi.

women, girls and other city users to report abuses and help instigate reactions from the public and from public authorities. For example, in Kenya, the company Ushahidi collects reports of violence submitted through an electronic platform and verifies and maps them, making all data publicly available.[54]

Awareness-raising measures and education

41. Innovative gender-equality measures are urgently needed to rethink urban safety. For example, in Ecuador, educational material on gender-based discrimination and stereotypes has been piloted in some schools. In India, public service announcements along subway lines and open discussions have been introduced to raise awareness. In Marrakech, Morocco, under a programme on sexual violence prevention, over 1,500 drivers of a city-wide bus network have been trained in responding to sexual harassment episodes in buses and around bus stops.[55] In Papua New Guinea, a multi-channel campaign has been launched, reaching thousands of urban residents by combining social media, television and radio networks and social interactions in schools, churches and public spaces. In Rwanda, a campaign has been launched to enhance the capacities of public transport workers to prevent sexual harassment in public spaces.[56]

H. Urban planning

42. To ensure that central urban areas and peri-urban interfaces provide all residents with equal access to urban services, facilities and opportunities, local authorities and urban planners can use different science, technology and innovation solutions. Their adoption leads to a more detailed understanding of sustainable development issues and more efficient and inclusive decision-making processes. Such technologies help leverage collective intelligence and create the open, inclusive and highly collaborative environments required to ensure that urban planning processes take control of peri-urbanization processes and make urban spaces accessible to all people.

43. Studies of peri-urban planning and management have led to new approaches that respond to the specific needs of peri-urban interfaces. For example, in New Zealand, an innovative participatory process called spatial group model building has been piloted, which helps combine the expectations and knowledge of a wide range of actors into peri-urban planning processes by inviting them to co-design a group model building that connects the flows, processes and collaborative relationships among actors within a complex system. The participatory process is supported by geographic information system technology, which helps stakeholders visualize the physical space and connect the information on the building on digital maps.[57] In Zambia, a study used the spatial group model building framework to investigate how East Coast Fever, a disease of cattle and buffalo, oscillated over time and to identify context-specific interventions that could mitigate the impact on the local economy.[58] Spatial group model building has also been applied in Jashore District, Bangladesh; the state of Bihar, India; and Tanintharyi Region, Myanmar.[59]

44. Different digital support tools are currently available to allow local authorities, urban planners and other stakeholders to jointly develop and assess alternative development

[54] See https://journals.openedition.org/factsreports/4316.

[55] See https://www.unwomen.org/en/news/stories/2017/11/feature-marrakech-safe-cities.

[56] United Nations Entity for Gender Equality and the Empowerment of Women, 2017, *Safe Cities and Safe Public Spaces: Global Results Report*, New York.

[57] KM Rich, M Rich and K Dizyee, 2018, Participatory systems approaches for urban and peri-urban agriculture planning: The role of system dynamics and spatial group model building, *Agricultural Systems*, 160:110–123.

[58] C Mumba, E Skjerve, M Rich and KM Rich, 2017, Application of system dynamics and participatory spatial group model building in animal health: A case study of East Coast Fever interventions in Lundazi and Monze districts of Zambia, *Plos[Public Library of Science] One*, 12(12).

[59] KM Rich, J Berends and GS Cooper, 2021, Enriching value chains through maps: Reflections from spatial group model building in Myanmar and India, *Development in Practice*.

strategies. For example, under its Block by Block initiative, the United Nations Human Settlements Programme introduced the use of Minecraft in the framework of public space planning, whereby the video game is used as a participatory tool for stimulating the co-production of regeneration projects for neglected public spaces; the methodology is freely available to all and provides residents of urban areas with access to a virtual environment in which they can collaboratively design, build and discuss virtual urban landscapes and architectural models that have the potential to improve the quality of existing urban spaces. The Block by Block methodology for co-created public spaces was piloted in India and Kenya and has been used extensively in urban areas worldwide, in particular in developing regions, in which it has served to mobilize community engagement. An enhanced version of the methodology using virtual reality has been tested in Stockholm.[60] Virtual reality can also be used to create urban digital twins, that is, virtual models of entire urban systems. For example, in New Zealand, a company specializing in three-dimensional visualizations of urban infrastructure has created a digital twin of Wellington, building on a combination of smart city technologies that connect streams of urban mobility data that describe the real-time functioning of urban infrastructure and provide different types of urban mobility and transportation statistics; local authorities, using the digital twin, can acquire data to support decision-marking.[61]

I. Safety and security

45. Efforts are being made worldwide to sustain urban safety and security, primarily based on the use of innovative policy interventions and the increasing availability and performance of technological solutions. For example, in Doha, the local government, in collaboration with the United Nations Office on Drugs and Crime and its Line Up, Live Up initiative, aims to break the chain of violence by inducing behavioural change in at-risk youth by promoting sports as a means to learn tolerance and respect and to develop positive behaviours that could help youth avoid criminal activity and violence.[62]

46. Technologies for the spatial identification of crime hotspots have been implemented in cities worldwide. Crime mapping through geographic information system analysis, for example, is an effective measure that local police forces can adopt in urban areas to develop timelines and map locations of crime events. For example, in London, the police force used crime mapping with randomized controlled trial designs to examine the effects of increased visible patrols at bus stops; crime mapping can help the police predict crime patterns and reduce victim-generated calls for emergency and bus driver incident reports.[63] In Mexico, maps are created by local authorities to identify areas prone to violence against women.[64] In South Africa, researchers at the University of Pretoria have showcased the usefulness of crime mapping by developing a robbery risk model for the city of Tshwane, based on geospatial analysis in which commuter nodes and urban public facilities form points of interest.[65]

47. Some innovative solutions for addressing forced evictions in urban areas rely on predictive profiling techniques, of which machine learning algorithms are a key component. A variety of machine learning models can be used to identify buildings in which tenants are at risk of harassment from landlords. For example, in New York, a machine learning model has been used to analyse historical data to predict harassment and create risk scores; local

[60] See https://unhabitat.org/the-block-by-block-playbook-using-minecraft-as-a-participatory-design-tool-in-urban-design-and and https://unhabitat.org/using-mixed-reality-technology-for-inclusive-and-participatory-planning.

[61] See https://www.dezeen.com/2021/07/09/digital-twins-develop-cities-digital-design-architecture/.

[62] See https://www.unodc.org/dohadeclaration/topics/crime-prevention-through-sports.html.

[63] AA Braga, B Turchan, AV Papachristos and DM Hureau, 2019, Hotspots policing of small geographic areas effects on crime, *Campbell Systematic Reviews*, 15(3).

[64] MG Royo, P Parikh and J Belur, 2020, Using heat maps to identify areas prone to violence against women in the public sphere, *Crime Science*, 9(1):1–15.

[65] N Kemp, GD Breetzke and A Cooper, 2021, Modelling the risk of robbery in the city of Tshwane, South Africa, *Cartography and Geographic Information Science*, 48(1):29–42.

government agencies can harness this data to prioritize inspections of high-risk buildings and better organize outreach activities for vulnerable tenants.[66]

J. Protection from natural disasters

48. Science, technology and innovation solutions contribute to protecting urban areas and populations from natural disasters by empowering and giving a voice to people, including the most vulnerable; extending access to education services; making possible the monitoring of environmental risks; connecting people; and enabling the development of early warning systems.[67] Data analytics capability is critical in urban regions facing natural disasters. To develop this capability, many local and national governments are increasing their efforts towards building integrated data management systems that pool critical information on urban infrastructure assets. For example, cities in Latin America and the Caribbean, following a series of natural disasters, have invested in developing the capacity to build a data management platform for supporting disaster management, by conducting activities that help connect heterogeneous data on critical infrastructures, and this integration process is already helping local governments model risks related to infrastructure in the areas of mobility and transportation.[68]

49. Nature-based solutions is an umbrella term that groups different types of ecology-based technical solutions, innovative actions and policies, the objective of which is to help protect, govern and recover urban ecosystems, build up their resilience to natural disasters and protect biodiversity. For example, in South Africa, the uMngeni Infrastructure Partnership aims to use nature-based solutions to help rehabilitate natural ecosystems, such as river areas and dams that serve urban populations.[69] The Government of Switzerland spends 0.6 per cent of GDP on protection against natural hazards, including the construction of elaborate protective structures to prevent damage; knowledge regarding the continual intensification of land use is a key prerequisite for minimizing risk and work on analysing land use risk is therefore ongoing.[70]

III. Suggestions for consideration

50. The pandemic has led to many new forms of innovation for sustainable cities and communities. It has also triggered a level of research, development and experimentation that countries may struggle to implement in non-crisis conditions. The pace at which local and national leaders and stakeholders have reorganized urban sociotechnical systems in many regions by introducing innovative science, technology and innovation solutions to the challenges imposed by the crisis have been significant. It is now necessary to seize this innovation momentum and use its transformative power to ensure that urban areas can deliver on their commitment to sustainable urban development.

51. Member States may wish to consider the following suggestions:

(a) Adjust pre-pandemic priorities and resource allocation strategies: Review and redefine any existing sustainable urban development priorities to take into account the impact of the pandemic; identify and invest in suitable science, technology and innovation solutions to alleviate unemployment and financial issues experienced among low-income households and smaller firms; ensure that priority is given to the science, technology and

[66] T Ye, R Johnson, S Fu, J Copeny, B Donnelly, A Freeman, M Lima, J Walsh and R Ghani, 2019, Using machine learning to help vulnerable tenants in New York City, in J Chen, J Mankoff and C Gomes, eds., *Compass 19: Proceedings of the 2019 Conference on Computing and Sustainable Societies*, New York.

[67] See UNCTAD, 2021, Issues paper on science, technology and innovation for sustainable urban development in a post-pandemic world, Presented at the intersessional panel meeting, 17–19 November 2021.

[68] See https://publications.iadb.org/en/technology-climate-action-latin-america-and-caribbean-how-ict-and-mobile-solutions-contribute.

[69] See https://www.youth4nature.org/blog/nature-based-solutions-cases-in-african-cities.

[70] Contribution from the Government of Switzerland.

innovation actions that offer value for money and more efficient spending, focusing on activities that boost urban resilience; and capture, formalize and share positive and negative practices at different stages of development and experiences in using various science, technology and innovation solutions in urban sustainability enhancement;

(b) Cultivate and empower local ecosystems for urban innovation: Frame an enabling institutional and regulatory environment that promotes the development of an open innovation culture in urban spaces and facilitates cross-sectoral and multi-stakeholder collaboration, for example by facilitating citizen participation through online platforms;[71] and expand incubation services to facilitate the transformation of business sector research in science, technology and innovation that actively helps solve urban development challenges;

(c) Build local capacity to deal with the complexity of urban digital transformation: Provide local actors with the knowledge resources necessary to benefit from and participate in sustainable urban digital transformation; and raise awareness among municipal governments, particularly mayors, and other local stakeholders of the complexity of technology-related urban development strategies (such as smart cities[72]) and the importance of integrating consideration of local context conditions with a people-centred focus in urban sustainability actions;

(d) Introduce new and more equitable financing mechanisms: Facilitate cross-sectoral collaborative ventures with heterogeneous actors to increase the financial capacity of cities and urban communities to support the research and development actions required to embrace science, technology and innovation solutions; and strengthen institutional settings to ensure that public investment management in cities and communities is supported by policy coherence across multiple levels of governance;

(e) Rethink urban areas as data infrastructures: Transform existing data governance structures to ensure a more human-centric, systemic, cross-collaborative and privacy-preserving approach to the management and development of urban data infrastructures; and ensure that cross-sectoral and multi-stakeholder collaborative ecosystems support data governance structures;

(f) Take an integrated approach to policy setting for sustainable urban development: Help local development actors embrace the integrated approach to urban sustainability enhancement in the 2030 Agenda for Sustainable Development and the New Urban Agenda; and adjust institutional frameworks to integrate urban sustainability policy settings, horizontally and vertically, and ensure the coordination needed to maximize synergies among science, technology and innovation actions and minimize fragmentation and trade-offs;

(g) Build capacity in digital mindsets, skills and technology acceptance: Build consensus and strengthen collaboration in digital education strategies; increase innovation and investment in digital technology for learning and teaching; and close digital skills and knowledge gaps to engage citizens not yet connected, to sustain a truly inclusive sustainable urban development (preliminary work through feasibility studies is important before developing smart city processes).[73]

52. The international community may wish to consider the following suggestions:

(a) Introduce financial measures that can help reinstate the financial stability of private and public sector organizations, especially in developing economies; and enhance international support by mobilizing additional financial resources for developing countries from multiple sources;

(b) Support cross-country collaborative research efforts by establishing common strategies for data collection and analysis that can facilitate benchmarking; and mobilize the

[71] Contribution from the Government of Belgium.

[72] For example, the feasibility study of the smart city in Piura. Contribution from the Government of Peru.

[73] Contribution from the Government of the United Kingdom.

resources required to increase the international availability of urban disaggregated data to obtain localized knowledge on the functioning of urban sociotechnical systems and prepare appropriate science, technology and innovation solutions;

(c) Ensure the cross-sectoral harmonization of urban sustainability policies across government levels, from local to global; and establish a virtual environment to facilitate international knowledge transfer and ensure that a global body of experience is available for all;

(d) Assist developing countries in structuring long-term collaborative efforts that extend beyond single projects and consider multi-year developments; and provide countries with guidance on how to develop effective local and national regulatory frameworks;

(e) Enhance capacity-building support to increase the availability of resources for scaling up research development capacity in response to an emergency condition; mobilize resources for supporting more research exploring the non-technological dimensions of urban digital transformations for urban sustainability; and ensure that research and development efforts towards sustainable urban development receive adequate financial support in all regions, especially those with the greatest need;

(f) Develop operational tools that consider the place-based and sociotechnical components of technology-related sustainability transitions to stop the spread of one-size-fits-all mentalities;

(g) Strengthen scientific cooperation in the field of digitally enhanced teaching and learning to provide government leaders and local authorities with more guidance; and encourage the reframing of national education systems to ensure that digital literacy and digital technologies become a central component of existing and future school curricula, at all levels, from pre-primary schools to universities.