Chapter 6

Innovation, Technology and the Value of Sustainable Urbanization

The world is firmly entrenched in the Information Age. Technology continues to reshape economies and societies amidst the fourth industrial revolution, or the exponentially paced disruption caused by the possibilities of billions of people connected by mobile devices, with unprecedented processing power, storage capacity and access to knowledge. These possibilities will be multiplied by emerging technological breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing.

Cities are at the centre of these changes as the concentration of people and human activities encourage technology and innovation talent to co-locate. Even amidst the COVID-19 pandemic, cities are where the main health facilities are located and the home of the research institutions that are working assiduously to develop a vaccine. They are the home base for the technology companies that have produced the tools for millions to work from home. The interplay of technology and innovation has already influenced urbanization patterns and is poised to further shape the future of cities.

Quick Facts

1. Cities are rapidly deploying technology to address a wide range of urban challenges.
2. New technologies and innovation provide opportunities for cities to meet the SDGs and generate immense value from the process of urbanization.
3. The COVID-19 pandemic is accelerating the deployment of innovation and technology in urban areas.
4. The global demand for smart cities is growing rapidly, from US$622 billion in 2017 to US$1 trillion in 2019; this is expected to reach US$3.48 trillion by 2026.
5. Problems of digital exclusion in access to the benefits of new technologies persist, potentially deepening inequalities

Policy points

1. Cities must work to promote effective policies to protect citizen data and empower citizens to understand how to protect their personal data.
2. Clear, ethical frameworks and institutional arrangements for data collection and data sharing should be put in place.
3. Technology is most effective when coupled with institutional innovation and is not a substitute for improving governance.
4. Results of smart city experiments are mixed and particularly poor when these efforts are technology- rather than people-driven.
5. Technology cannot displace citizen engagement in community and city affairs.

As centres of art, science and idea exchange, cities have historically played a key role in catalysing "innovation," a term broadly defined as novel ideas, methods, approaches and knowledge.[1] Development of new technologies, production methods, institutional arrangements and knowledge are important elements that explain how cities have grown and continue to serve as centres of wealth, opportunity, diversity and creativity.[2]

At this current moment of rapid urbanization and fast-paced technological change in the context of ecological and public health crises amidst deep social inequalities, cities remain the linchpin to achieving sustainable development and meeting our climate goals. Hence, more than ever, it is critical to leverage the opportunities that urbanization presents "as an engine of sustained and inclusive economic growth, social and cultural development and environmental protection."[3] Innovation is the lubricant that facilitates this engine.

Cities are comprised of diverse populations living in intricate webs of cooperation and coordination. As a result of this proximity, density, diversity and sheer numbers, cities give rise to a set of complex problems around challenges like health, education, mobility, logistics, food security, consumption, waste, poverty and inequality. These issues, in turn, make cities prime stages to develop innovative solutions to global challenges. Cities are well poised to address these pressing problems by leveraging the very strengths of urban life. Indeed, cities that are open, inclusive and diverse encourage creative responses and vibrant neighbourhoods that result in higher human

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productivity[4] and innovation.[5] Cities, as the unit of government closest to citizens, act as "civic laboratories" to foster innovation for sustainable development that can be replicated and scaled up.[6]

Cities are at the centre of the technological changes occasioned by the fourth industrial revolution, namely the move towards big data, quantum computing, the Internet of Things (IoT), automation and artificial intelligence. Technology companies are attracted to cities because of their specialized and diverse talent pools as well as clusters of likeminded firms. Consequently, some cities are reaping the direct and indirect benefits of technological innovation while also addressing new problems such as e-waste,[7] surveillance,[8] labour disruption[9] and digital and spatial exclusions that can exacerbate inequalities and environmental problems.

Large technology, architectural and engineering firms with financial interests in urban development are also promoting their own notions of how cities should innovate under the rubric of "smart cities." Thus, cities must navigate how to manage, regulate and sometimes resist pressures to adopt technologies that are being actively promoted by multinational corporations. Instead they must facilitate bottom-up innovation and technology that benefit residents and address pressing problems while protecting privacy and citizen data.[10] These technological frontiers are just one of the domains in which cities are waging critical battles for sustainable human development with impacts far beyond their boundaries.[11]

This chapter will explore how cities across the globe are addressing challenges through innovation and technology and in doing so, meeting the demands of the New Urban Agenda, SDGs and Paris Agreement on climate change. It explores how cities are creatively experimenting to generate economic, social, cultural and environmental value (Chapter 2). The chapter will discuss the ways cities have enhanced and strengthened the deployment of innovation and technology in urban areas for the benefit of residents. However, it will also discuss the threats to inclusive, safe,

Operators work in road traffic control centre, Moscow, Russia. © Anton Gvozdikov/Shutterstock

sustainable and resilient urban development brought about by technological change and problematic concepts and dynamics around how technology should be used. Concerns include serious disruptions in labour markets, potential deepening inequality and social segregation (Chapter 1), as well as increasing surveillance and the danger that the overall pace of change is outstripping the ability of regulatory systems and municipal capacities to manage the risks associated with new technologies. Some of these concerns emerge from the rise of "smart cities" and contrast with successful urban innovation that prioritizes people over technology. Finally, this chapter offers some recommendations for the way forward for cities to innovate and leverage technology in ways that unleash the full value of sustainable urbanization and help us solve our global challenges.

6.1. What is Innovation and Why Does It Matter?

Some have cautioned that innovation has become so frequently used in such a wide range of contexts that it is now a meaningless buzzword.[12] This accusation makes it even more important to be clear on its meaning. Broadly, innovation refers to novel ideas, methods, approaches and knowledge that are applied to solving problems. These problem-solving measures can include the development of new technologies, but it is important to note that this definition goes beyond new technologies and inventions to include changes in production methods and institutional, ecological, social and political arrangements. As one historian of the idea of innovation notes: "today people expect innovation to be societal, environmental and ethical, rather than strictly economic."[13]

At a time when the world is rapidly urbanizing in the context of serious climate, resource, public health and ecological challenges,[14] the need for innovation broadly understood takes on particular force. In the face of the need for rapid transition to decarbonized, sustainable urban economies and development (Chapter 2), cities need to innovate to develop novel pathways and solutions to persistent and emerging challenges. This urgency makes innovation fundamental to attaining a better urban future for the planet that captures the full value of sustainable urbanization.

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For this reason, the New Urban Agenda stresses the importance of creating "an enabling environment and a wide range of means of implementation, including access to science, technology and innovation and enhanced knowledge-sharing."[15] Innovation is also explicitly part of SDG 9, which requires Member States to build "resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation." Innovation is thus seen as both a critical means to the end of delivering on the international development agenda related sustainable urbanization and as a desirable end in and of itself that brings improvements through new tools, products and ways of working. In this context, innovation offers a notion of human progress and creativity in light of the societal challenges that span the SDGs, NUA and Paris Agreement.

In the contemporary moment, innovation is often associated with start-up businesses and technology entrepreneurs pursuing narrower economic goals of efficiency and productivity. The OECD, for example, defines innovation "as the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations."[16] In this definition, innovation is largely seen as emerging from within the private sector, with the role of government being that of an enabler. This definition is too narrow for discussions of the value of sustainable urbanization because urban innovations take place within complex networked forms of governance where cities and national governments play a key role in partnership with the private sector, over which they maintain oversight. Governments can help by judiciously channelling public investment[17] and creating networks with other key actors, thus driving change towards the public good. These steps include innovations in delivering municipal services, reducing carbon emissions, improving the urban environment and fostering more liveable cities.

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A growing recognition exists that while cities can serve as platforms of innovation, creativity and knowledge generation, city governments can also be innovators drawing on, and in some cases creating, new technologies as well as developing legal and institutional innovations to improve and transform government processes and service delivery. Cities can also draw diverse actors into collaborative networks and support innovation ecosystems that drive needed change in specific areas by supporting competitions, convening meetings and leveraging procurement power to incubate social innovation for sustainable urban development. This underscores the critical importance of innovative cities for unlocking the full value of sustainable urbanization.

6.2. Civic Technology for Urban Innovation

Urbanization is occurring within the context of rapid technological change including the exponential rise in computing power that permits the storage and analysis of big data along with a whole suite of related developments such as artificial intelligence, IoT, nanotechnologies and blockchain. One key aspect of this change is automation as machines increasingly take over functions once performed by humans. Hence, we see the rise of robots[18] and the automation of decision-making more generally with algorithms that can be taught (machine learning) and which draw on massive amounts of data to "think" (artificial intelligence). These technological advances create both new tools and problems as they raise a number of profound ethical and social questions.[19] Technology is not neutral and moral values like bias and discrimination are often embedded in the very design and workings of these innovations.[20]

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As with past technological innovations, these components of the fourth industrial revolution are likely to be highly disruptive to urban labour markets, especially with the rise of more "automated thinking"[21] and "connected machines that will interact, visualize the entire production chain and make decisions autonomously."[22] For example, many companies are working on autonomous vehicles and mobility solutions. While such an innovation could reduce traffic congestion and carbon emissions, it would also displace jobs for taxi, ridehail and public transport drivers. Moreover, if realized, the advent of autonomous vehicles raises profound social and urban planning issues in cities that are trying to minimize car-centric development patterns.[23] The emerging and potentially profound shifts in work and labour stemming from these new technologies are likely to exacerbate inequalities even more without adequate social policies (Chapter 1). Cities, where both technological innovation and economic activities are concentrated, are the places where this increasing inequality will be most evident.

6.2.1. What is civic technology?

Cities, often in collaboration with the public, civil society and businesses, are innovating how to use new technologies to address a wide range of urban challenges. Local governments are increasingly purchasing patented technologies like cheaper and more effective sensors to monitor and share information on water, air, solid waste, infrastructure, energy, traffic and public transport, among other areas, all in the name of building a smart city. With these investments, companies are trying to capture and shape ideas about smart cities from the top down. In contrast, civic technologies are a more people-centred concept that aims to support stronger participatory and democratic processes from the bottom up.

Smart city technologies include smartphone apps, city data dashboards, information screens in public spaces, intelligent operations centres and public-facing websites with critical information and feedback mechanisms. These platforms rely on physical hardware, from publicly owned sensors that monitor vehicular traffic flow to citizen-owned mobile phones that call a ride or order food

Smart car (HUD) , Autonomous self-driving mode vehicle on metro city road iot concept with graphic sensor radar signal system and internet sensor connect. © Zapp2Photo/Shutterstock

delivery. These kinds of services tend to produce "big data," or quantities of data so massive that traditional techniques and software cannot analyse them, instead requiring large-scale computing power, algorithms and data science to uncover trends and patterns. Big data analysis, real-time monitoring and automation of various municipal services from streetlights to complaint systems are extremely useful for city planning and service delivery. Hence, leveraging these technologies appropriately is one way to make the city smart in terms of being more efficient, responsive and able to provide better and new services critical to meeting the SDGs and the NUA. The everyday citizen end user in turn benefits with the opportunity to view the city's progress via public data portals.

Another aspect of some of these technologies is that they allow for more decentralized, local data collection at the city level, to some extent democratizing computing and data collection. This decentralization enables civil society and citizens to potentially become more involved in data collection on their own, monitoring service delivery and participating in governance and decision-making.

Cities can work to create systems that enable citizens to deliberately use their phones to collect data. For example, the 311 system started in North America and now operating all over the world allows complaints to be routed immediately to the appropriate city department and has proven effective at responding to problems identified by citizens while reducing costs (Box 6.1).

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6.2.2. Civic technology for urban mobility

Other applications use passive mobile phone data to track urban mobility patterns. The Digital Matatus project in Nairobi, Kenya, uses GPS-enabled mobile phones to trace out minibus routes and stops to create critical public transport data and passenger information where none existed before (Box 6.2). Transport is a popular sector for these types of initiatives. In India,

Box 6.1: How citizen reporting for municipal response evolved from "Dial 311" to SeeClickFix to civic apps

In 1996, Baltimore, US, launched a three-digit non-emergency phone number, 311, that residents could call to report municipal issues like potholes, illegal dumping, graffiti and abandoned vehicles. The system coincided with a sentiment among government that the public sector can and should be more closely connected with citizens and their needs. At the same time, 311 had the additional impact of collecting reams of data about government operations.

Its back-end system, Customer Relationship Management software, captured details about every phone call, query, complaint and request, generating insight into how workers delivered city services. The system was so useful that OpenPlans, a US non-profit dedicated to making cities work better, facilitated the development of Open311 software in 2010 to help other cities adopt the system as a free tool rather than buying proprietary software.

These apps enable communication for all types of people. One study found that lower-income residents and young, college-aged individuals were more likely to use Boston's 311 app than the traditional phone number or website. For certain disabled residents, app-enabled engagement can help leverage services in a way that wasn't possible before.

Mobile 311 apps gave way to online services like SeeClickFix, which attempt to sell cities access to a platform that falls somewhere between a 311-call centre and a social network. SeeClickFix allows citizens to identify a problem with their smartphone and click on a map with their location. That geo-located information is then conveyed to the appropriate city government departments. Some city governments monitor what SeeClickFix users are saying about the places they live, while others take things a step further, integrating the platform into the city's back-end systems. Some cities also have bespoke apps, like San Francisco's water quality app for its beaches and Calgary's pet adoption app.

Today, things have gone a step further. Seeing how well mobile reporting apps work for citizens has made governments realize that if it works for citizens, it can work for internal operations too. From SeeClickFix to custom purpose-built reporting apps, what began as a humble call centre has evolved into a nimble and reliable way for government to target scarce resources on its most vexing problems.

Sources: Wood, 2016; Snow, 2017.

the Delhi government began providing transit data from GPS trackers on state-run buses to researchers and app developers, including Google, to develop useful tools like real-time schedules.[24] In Abidjan, Côte d'Ivoire, IBM researchers used anonymized data from mobile phone users to discover the most frequented bus routes and then came up with 65 network improvements that would save passengers an estimated 10 per cent travel time.[25] In these cases, data was generated without deliberate citizen action but through so-called "digital exhaust," or the data trail from online activity, which can be aggregated and analysed to reveal useful patterns about urban flows.[26]

Not all urban innovations require high-end technology skills or equipment. Ecosandals is a social enterprise in the poor Nairobi neighbourhood of Korogocho that improves upon the common practice in many African cities of turning rubber tires into sandals and creates youth employment in the process. Similarly, in Morocco, the small company Upcyclemo employs youth to create outdoor furniture and plant pots out of tires. In Uganda and Kenya, social entrepreneurs are converting plastic bottles into bricks and

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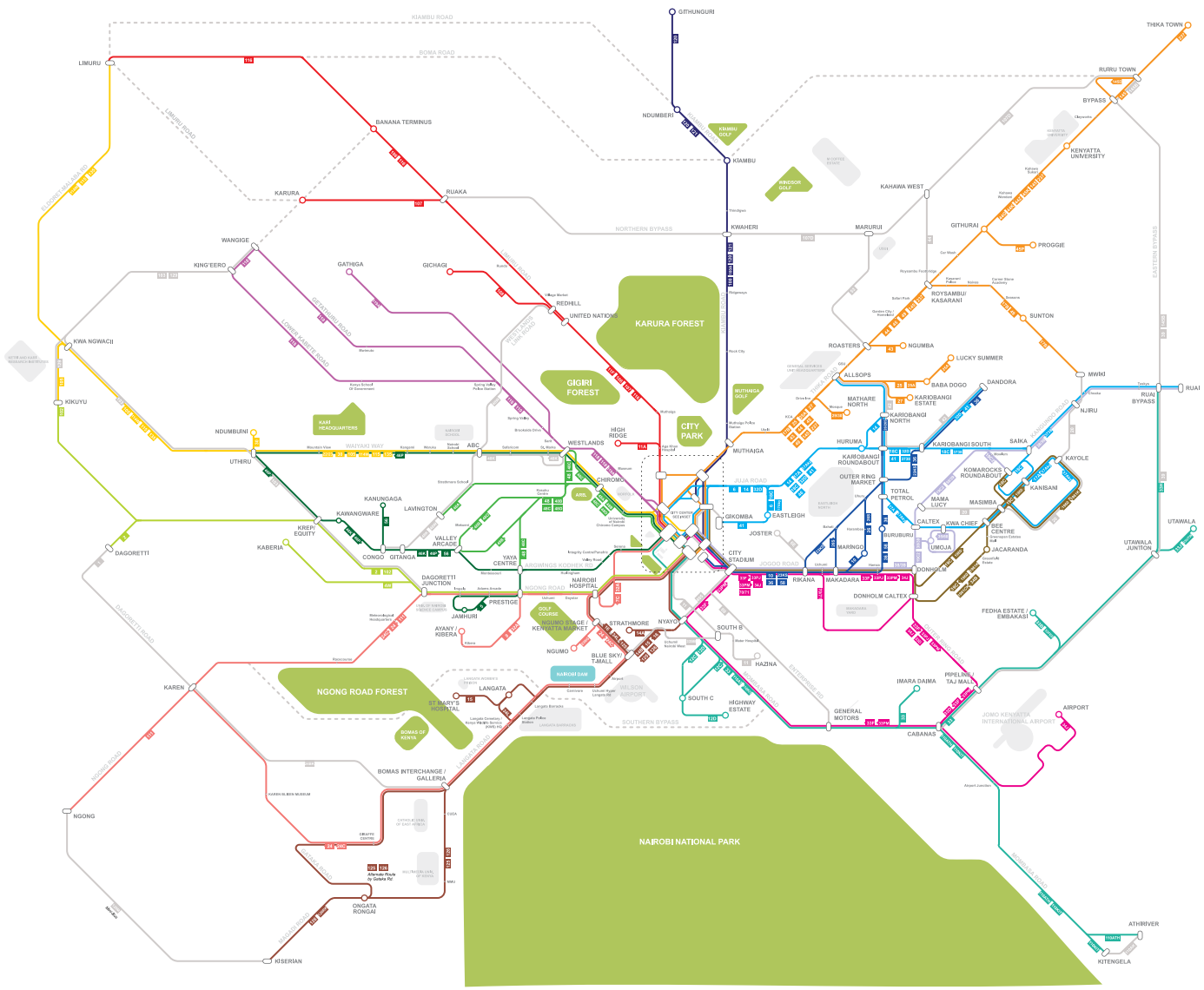
paving stones, solving two problems at once: both plastic waste and the need for sustainable building materials.[27] Software engineers in Lilongwe, Malawi used cast off computers to develop a highly effective electronic health records system to improve care for HIV patients.[28] While outside technology providers bring skills and expertise, locally-developed innovation often faces challenges in accessing capital and support, suggesting cities need to recognize and support homegrown innovation systems that creatively solve problems with context-sensitive solutions.

Figure 6.1: Public transport map for Nairobi

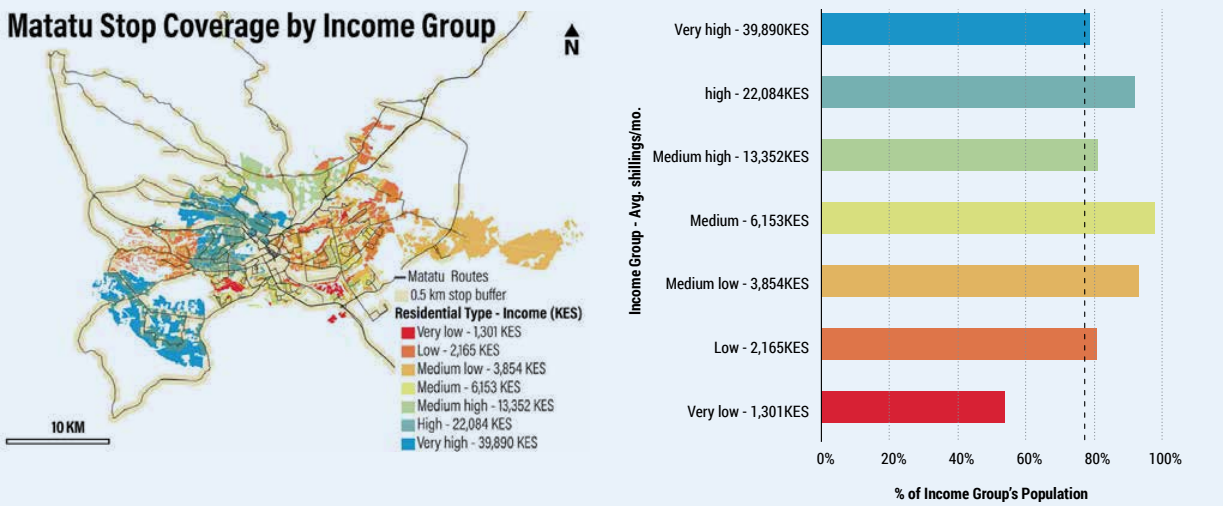


Source: Civic Data Design Lab/Digital Matatus Project (*www.digitalmatatus.com*).

Box 6.2: Digital Matatus project maps minibuses in Nairobi

In cities where informal transport systems are the primary form of urban mobility, local authorities do not have basic data on their transit systems because these systems are run by many different private actors who do not collect or share data on routes, passengers and frequency. Digital Matatus was a pioneering mapping project that helped catalyse ongoing efforts to map informal transport systems in African and Latin American cities.[29] This collaboration between the University of Nairobi, Columbia University, MIT and the small US design firm Groupshot mapped out Nairobi's *matatu* (minibus) routes and stops using GPS enabled mobile phones in 2013.[30] The team used this data to create a schematic map in 2014 that proved popular in the absence of an official public transport map for the city. The regularly-updated data is open source and the routes have been integrated into different apps including Google Maps. This data is also being used to measure access to health facilities[31] and green spaces as well as to measure the proportion of the population with access to frequent public transport, which is the indicator for SDG target 11.2.[32] Many cities across Africa and Latin America are similarly collecting bottom-up data for their transit systems.[33] In Addis Ababa, Ethiopia, software developers came up with the idea of putting a simple QR code on buses that contain the map for that route and in Maputo, Mozambique, a company developed an information screen for the public.

Measuring the SGD11.2 target



Source: Fried et al., 2020.

6.2.3. Tracking COVID-19

The latest frontier for mobile technology and big data is understanding and managing the spread of COVID-19. In East Asia, national governments have partnered with software developers to create smartphone apps that geolocate people's movements in relation to the COVID-19 status of other geolocated users.[34] This exercise provided information to citizens to help them avoid places where they might get infected. For example, Corona 100m is a tracking app from Republic of Korea that alerts users if they are within a 100-metre radius of the latest tracked location of a coronavirus patient. The app appears to be popular in the Republic of Korea and was downloaded over 1 million times within 10 days of being launched.[35] Australia and

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Singapore have launched contact tracing apps—CovidSafe and TraceTogether, respectively—that facilitate contact tracing in the event of COVID-19 infection by individuals whose mobile phones are linked.

These apps enable governments to dampen infection rates, which simultaneously protects public health and inspires consumer confidence to spur economic activity. As with most technologies, however, these apps must be supplemented by well-functioning public health policies and programmes such as rapid testing, in-person follow-up contact tracing and mandatory isolation. Despite these apps' relative success, there are clear trade-offs between public health and privacy, which exist alongside other data security concerns.[36]

Contact tracing apps are just the tip of the iceberg in technological trends sparked or accelerated by the COVID-19 pandemic. These innovations have been crucial in keeping people safe, productive and connected when they are physically apart while simultaneously ensuring that society remains functional during lockdowns.[37] It is important to note, however, that in many of the world's cities substantial numbers of people cannot transition to remote learning and also face exclusion from these technologies. Some COVID-19 impacts of these technologies are likely to endure in the post-COVID-19 era and have potential long-term implications for urbanization processes (Box 6.3).[38]

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Box 6.3: Ten technology trends accelerated by COVID-19

The coronavirus disease (COVID-19) pandemic has accelerated key technology trends, including digital payments, telehealth and robotics, which can help reduce the spread of the disease while helping businesses stay open. These technology trends can help make society more resilient in the face of pandemics and other threats, as well as considerations about their effects on business, trade, work, production of goods and services, education, health care and entertainment.

Online shopping and robot deliveries

COVID-19 has transformed online shopping from a nice-to-have to a must-have around the world. Online shopping needs to be supported by a robust logistics system. In-person delivery is not virus-proof. Many delivery companies and restaurants in the US and China are launching contactless delivery services where goods are picked up and dropped off at a designated location instead of from or into the hands of a person. Chinese e-commerce giants are also ramping up their development of robot deliveries. However, before robot delivery services become prevalent, delivery companies need to establish clear protocols to safeguard the sanitary condition of delivered goods.

Digital and contactless payments

Cash might carry the virus, so central banks in China, US and the Republic of Korea have implemented various measures to ensure banknotes are clean before they go into circulation. Contactless digital payments, either in the form of cards or e-wallets, are the recommended mode of payment to avoid the spread of COVID-19. Digital payments enable people to make online purchases and

payments of goods, services and even utility payments, as well as to receive stimulus funds faster. The availability of digital payments relies on internet availability, internet-equipped devices and a network to convert cash into a digitalized format.

Working remotely

Many organizations have asked their employees to work from home. Remote work is enabled by technologies including virtual private networks, voice over internet protocols, virtual meetings, cloud technology, work collaboration tools and even facial recognition technologies. Working remotely poses challenges to employers and employees. Information security, privacy and timely tech support can be big issues. Working remotely can also complicate labour law issues, such as those associated with providing a safe work environment and income tax issues. If remote work becomes more common after the COVID-19 pandemic, employers may decide to reduce costs and hire people from regions with cheaper labour costs. Not all jobs can be done from home, which creates and reinforces disparity. Well-educated, white-collar workers are more likely to have jobs that allow them to work from home unlike informal sector workers and those employed in service jobs deemed essential during lockdown.

Distance learning

As of mid-April 2020, 191 countries announced or implemented school or university closures, impacting 1.57 billion students. Many educational institutions started offering courses online to ensure education was not disrupted by the lockdown. Technologies involved in distant learning are like those for remote work and include virtual reality, augmented reality, 3D printing and artificial-intelligence-enabled robot teachers. Concerns about distance learning include the possibility that the technologies could create a wider digital divide in terms of readiness, availability, affordability and income level.

Telehealth

Telehealth can be an effective way to contain the spread of COVID-19 while providing essential primary care. Wearable personal IoT devices can track vital signs. Chatbots can make initial diagnoses based on symptoms identified by patients. However, in countries where medical costs are high, it is important to ensure telehealth will be covered by insurance. Telehealth also requires a certain level of tech literacy to operate, as well as a good internet connection.

Online entertainment

Although quarantine measures have reduced in-person interactions significantly, creativity has brought entertainment online. Cloud raves and online streaming of concerts have gained traction around the world. Chinese film production companies also released films online. Museums and international heritage sites offer virtual tours. There has also been a surge of online gaming traffic since the outbreak of COVID-19.

Supply chain 4.0

The coronavirus pandemic has created disruptions to the global supply chain. With physical distancing and quarantine measures, some factories are completely shut down. Heavy reliance on paper-based records, a lack of visibility on data and lack of diversity and flexibility have made existing supply chain system vulnerable to any pandemic. Core technologies such as big data, cloud computing, IoT and blockchain are building a more resilient supply chain management system for the future by enhancing the accuracy of data and encouraging data sharing.

3D printing

3D printing technology has been deployed to mitigate shocks to the supply chain and circumvent export bans on personal protective equipment. 3D printing offers flexibility in production: the same printer can produce different products based on different design files and materials. However, massive production using 3D printing faces a few obstacles. First, there may be intellectual property issues involved in producing parts that are protected by patent. Second, production of certain goods is subject to regulatory approvals, which can take a long time to obtain. Other unsolved issues include how design files should be protected under patent regimes, the place of origin, impact on trade volumes and product liability associated with 3D printed products.

Robotics and drones

COVID-19 has made the world realize how heavily it depends on human interactions to make the economy work. The pandemic provided a strong push to rollout the use of robots, which have increasingly been used to disinfect areas and deliver food to those in quarantine. Drones have walked dogs and delivered items. While there are some reports that predict many manufacturing jobs will be replaced by robots in the future, at the same time, new jobs will be created in the process. Policies must be in place to provide sufficient training and social welfare to the labour force to embrace this change.

5G and information and communications technology

All these technology trends rely on a stable, high-speed and affordable internet connection. While 5G has demonstrated its importance in remote monitoring and healthcare consultation, the rollout of 5G is delayed at a time when the technology may be needed the most. The adoption of 5G will increase the cost of compatible devices and the cost of data plans. Addressing these issues to ensure inclusive access to internet will continue to be a challenge as the 5G network expands globally.

Source: Xiao and Fan, 2020.

6.2.4. Measuring air and water quality

Besides mobile phones, other kinds of sensors like air or water quality monitoring devices are also becoming less expensive and more widely available, allowing cities and their citizens to monitor environmental conditions more cheaply and frequently. This trend can also enable wider participation in citizen science initiatives that create better informed citizens who will advocate to reduce air and water pollution.[39] Such monitoring can also contribute toward achieving SDG11.6: "*By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management*." These monitoring devices can track measurements for SDG11.6 indicators like mean urban air pollution of PM_{10} and $PM_{2.5}$ particulate matter. Technology in the hands of cities and their citizens can subsequently help move towards more sustainable urbanization that addresses climate change and its impacts (SDG 13).

While lower cost monitors can be profoundly useful and potentially cut costs, they do not obviate the need for cities to build continuous and stronger air and water quality monitoring systems. Supporting local university and scientific communities is also critical to be able to interpret data from these devices, help properly calibrate the sensors to local conditions and ultimately implement air and water quality solutions in alignment with the New Urban Agenda (Box 6.4).[40] Such efforts can also help

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collect currently missing data to monitor SDG 3 (good health and wellbeing for all) as well as look at inequalities across neighbourhoods that can spur demand for change. In Nairobi's Mukuru slums, for example, residents created art inspired by air quality measurements to speak out about the unfair distribution of air pollution and health burdens in their community.[41]

Box 6.4: Measuring air pollution with low-cost air quality monitoring networks

In 2012, poor air quality was responsible for seven million premature deaths, making it the world's single largest environmental health risk. Air pollution is a major problem in cities across the globe and it requires a data-driven approach. But a large gap exists in the abilities of different cities to measure and model air pollution and relatively few have air quality monitoring systems in place. Low-cost air quality sensors have the potential to bridge this data gap. UNEP in partnership with the company Alphasense, the University of Cambridge, the NASA-GLOBE citizen science programme, the Wajukuu Arts Collective and the Kibera Girls Soccer Academy conducted an experimental deployment of six low-cost air quality monitors in schools across Nairobi.

Despite technical limitations, this experiment showed that sensors can provide indicative measurements of air quality that are valuable to local communities. It also found that such a sensor network can play an important role in engaging citizens by raising awareness about the importance of addressing poor air quality. Sensors are clearly a potentially important complement but not a substitute for high quality and reliable air quality monitoring systems as problems of calibration, certification, quality control and reporting remain to be solved. However, when carefully interpreted, data from low-cost monitors can be useful and this experiment helped inform Nairobi's air quality management plan. Increasingly, African governments are supporting their cities to measure air pollution. Both Ghana and Senegal, for example, have monitoring stations, air quality management plans and air quality indexes for citizens.

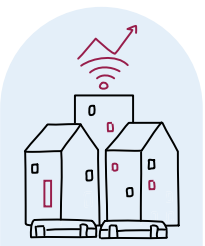
Low Cost Air Quality Monitor installed in a school in Nairobi

Source: deSouza et al, 2017.

6.3. Technology Firms and the Smart City

Digital technologies can help make a city "smarter" because the user of these technologies has a continual flow of data which, when analysed by algorithms, ideally helps see, think, intervene and make decisions more intelligently in and for the city. For example, a resident may look at an app to know which bus to catch for the shortest travel time or whether to go outside depending on the air quality. A traffic light can see a bus coming and turn green to give public transport priority over private vehicles. At its most optimistic, a smart city might best be defined as an "innovative city that uses information and communication technologies and other means to improve quality of life, efficiency of urban operation and services and competitiveness, while ensuring the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects."[42]

Technology firms are increasingly offering to sell smart city products and services to city governments, other companies and even directly to citizens. Estimates vary widely on the global smart cities market size. The global demand for smart cities is growing rapidly, from US$622 billion in 2017 to US$1 trillion in 2019. It is expected to reach US$3.48 trillion by 2026 (Chapter 1).[43] These figures indicate an important and growing sector that is seen as an enormous opportunity for technology companies.



The global demand for smart cities is growing rapidly, from US$622 billion in 2017 to US$1 trillion in 2019

The most ambitious smart city approach involves local governments partnering with technology companies to develop whole new experimental neighbourhoods or exurban developments sometimes conceptualized as entirely new cities. While the specifics of each smart city or smart neighbourhood project varies, they typically involve technology like sensors, wireless networks, IoT and smart meters. Using these technologies, smart cities automate services like communicating with citizens to receive feedback. In households, these technologies reduce energy costs by automatically turning lights and other appliances off when people are not around and through smart meters that talk to smart appliances and turn them on and off to reduce costs, for example, cleaning dishes in the middle of the night when energy demand is low.[44] Given the way that technology is leveraged to reduce energy demand and encourage low emissions living, these cities are also sometimes called "eco cities", an idea that has a much longer history reaching back into the 1970s.[45]

New Songdo City on reclaimed tidal wetlands on the outskirts of Incheon, Republic of Korea was one of the first smart city developments. The national government spearheaded the idea for a new city built from scratch that would strive for simultaneous economic prosperity and environmental sustainability through cutting-edge technology that would attract private sector tenants and build a new national business and innovation centre. The government engaged with local and foreign companies to develop a top-down master plan. Architects designed the city with sustainability principles reinforced by ubiquitous information sharing through wireless networks, digital technologies and devices that communicate with one another. A steady stream of data is continuously being computed and sent to adjust services and infrastructures aiming to create a more efficient urban metabolism and service experience for residents as well as businesses.

Despite US$40 billion of investment and technology that has attracted a wide array of companies, the city remains only partially populated and lacks the social quality of an organically grown city.[46] It is, in effect, a low-density, car-centric, high-end, exclusive US-style suburb that some residents describe as lonely.[47] As a testbed or showcase for the new international city-building industry, Songdo points to the limitations of having neighbourhoods, much less whole cities, designed by "partnerships of real estate developers, institutional investors, national governments and the information technology industry"[48] rather than by and for people from the bottom up.

Songdo also illustrates the problems with new city developments that focus on making a more efficient urban metabolism without maintaining broader climate and ecological goals like carbon neutrality, biodiversity,

Central Park, Incheon, South Korea. © PKphotograph/Shutterstock

wetlands preservation and coastal zone management in the face of sea-level rise.[49] Often designed and serviced by the same international architectural, engineering, and technology firms, variations on the Songdo model has proven somewhat impervious to criticism and spread across the globe (Box 6.5).[50] In other cases, like the Eko-Atlantic City on an artificial island in Lagos, Nigeria, or Konza Technology City outside of Nairobi, the vision is largely in favour of social exclusion through high-end real estate development.[51] These real estate development schemes are the very opposite of socially-inclusive urbanization as envisioned in the New Urban Agenda.

Box 6.5: Google's Sidewalks Lab encounters resistance to Toronto Tomorrow

Tech giant Google and its spinoff urban development company Sidewalks Lab is a prime example of the growing smart city business model. Sidewalk Labs describes itself as a firm that "imagines, designs, tests, and builds urban innovations to help cities meet their biggest challenges."[52] In 2017, Sidewalks Lab reached an agreement with the City of Toronto to redevelop a 12-acre (4.9-hectare) waterfront industrial parcel into a futuristic neighbourhood. The company's experimental master innovation and development plan, Toronto Tomorrow, was unveiled in 2019 and envisioned self-heating sidewalks, underground trash chutes, flexible streets and cross-laminated timber skyscrapers, all collecting copious amounts of data to ensure optimum energy and mobility efficiency.[53]

While the conditions of Sidewalk Labs' agreement required actively negotiating with municipal entities to ensure that the planned neighbourhood fit into the city's vision, citizen groups argued that the wealthy tech outsider was circumventing public oversight and citizen engagement processes.[54] They were also wary of the degree of surveillance that Toronto Tomorrow would entail and how much data the tech giant would ultimately control.[55] In July 2020, Sidewalk Labs ended the project citing economic uncertainty due to the COVID-19 pandemic.

Source: Sidewalk Labs, n.d.; Summers, 2019; Weiditz, 2020.

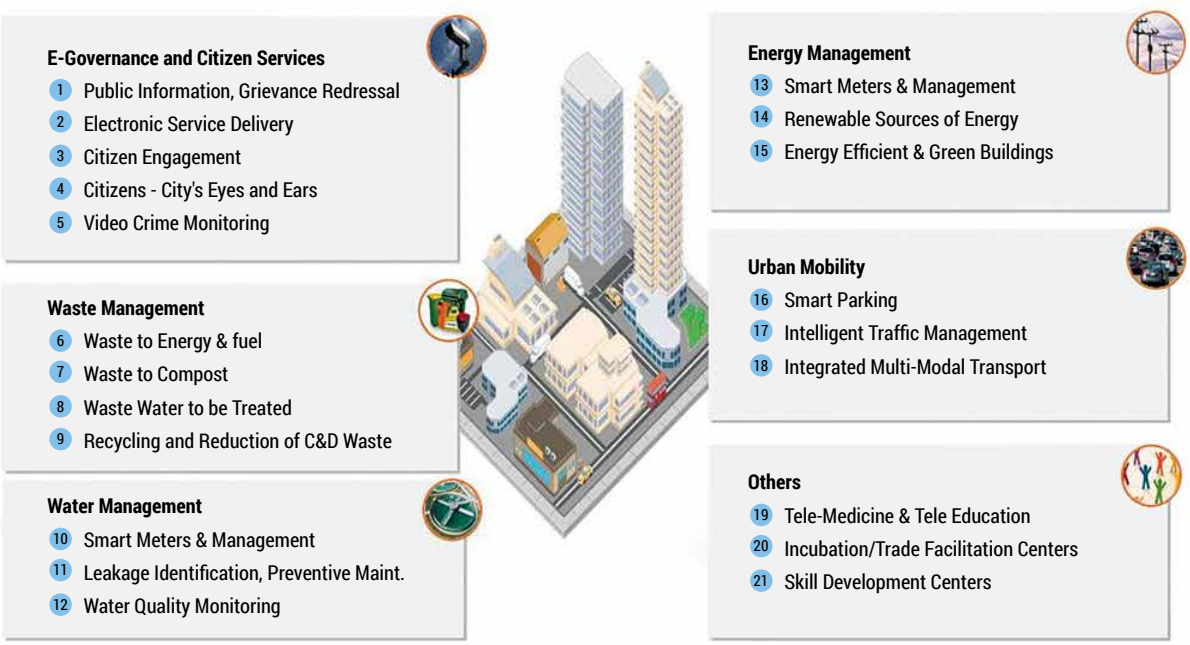
Another smart city approach involves cities, rather than national governments, more centrally in the driver's seat in creating smart city projects. In some cases, however, these kinds of projects are incentivized by national governments. For example, in 2015, India launched the Smart Cities Mission "to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions."[56] This national programme applied technology to a wide variety of urban problems from wastewater treatment to telemedicine (Figure 6.2). The programme selected 100 cities and approved their smart city plans for partial funding.[57] However, it is important to note that progress has been slow, with some cities making faster progress than others, which reveals uneven local capacity to finance and implement smart city initiatives.[58]

Another smart city approach involves cities, rather than national governments, more centrally in the driver's seat in creating smart city projects.

Even with the excitement over the power of new civic technologies for urban innovation, many limitations exist. First, technology cannot displace citizen engagement in neighbourhood and urban affairs. Digital platforms are not a substitute for civic meetings, dialogue and institutional reform. Efforts to displace these gatherings or move them online are often problematic. For example, the institutional innovation of participatory budgeting developed by the city of Porto Alegre, Brazil, gives citizens a say in how the city budget is spent. It is effective in part because of the dialogue it generates, which gives the poor a bigger voice and creates citizen monitors who watch to ensure the projects they voted for are implemented.[59] When this process is taken online, it loses some of its effectiveness. At its worst, it can generate more distrust in government.[60]

Additionally, technology is most effective when coupled with institutional innovation and is not a substitute for improving governance. Many smart cities projects are led astray by their emphasis on technology over engagement with existing governance processes. In the case of Toronto Tomorrow, citizens were deeply concerned about the power of a large wealthy technology firm to distort democratic

Figure 6.2: Government of India's smart city mission



politics and violate their privacy rights. The potential exists for cities to use governance frameworks, regulation and tools such as public procurement to take a more proactive approach to the ongoing digital transformation and ensure that projects that involve technology are more closely aligned with the goals of cities and citizens.

6.4. The Bottom-up Smart City: Urban Labs, Open Data and the Open-Source Movement

Cities and the people who live in them are increasingly finding bottom-up ways to innovate in order to make their cities better places. These strategies include forging links with local universities; leveraging local, civic-minded software developers, tech companies and collectives; building, encouraging and sharing anonymized open data; and leveraging open source software. Cities are also increasingly developing regulatory mechanisms for urban tech companies to rein in their disruptive power with mixed results.

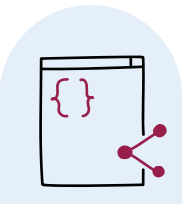
Ultimately, citizens are a city's greatest resource. They provide new ideas for innovation, act as the eyes or ears of the city, help monitor conditions on the ground and engage the city more actively in setting priorities, for example through participatory budgeting and voting for elected officials or on specific policies and programmes. Whether through texting or apps, citizens with mobile phones and other monitoring devices like low-cost portable air monitors or medical records systems can help generate important data. Cities also generate data from their own systems, whether buses with trackers, utility meters on public housing, sewage pipes equipped with sensors or financial information about city budgets.

6.4.1. Cities and open data

A growing number of cities are working to standardize such data and make it public through open data portals.

Cities and the people who live in them are increasingly finding bottom-up ways to innovate in order to make their cities better places

The so-called "open data" or "open government" movement seeks to make as much information as possible about city operations available to the public both to inform the everyday citizen and to inspire those who might create a useful tool, application or analysis from that data. This movement is gaining momentum as cities recognize that they can create a lot of value in terms of technological innovation that improves service delivery, public trust and analysis to feed into better policy.[61]



Open data and open source software contribute to increased economic development as well as resilience in planning and service provision.

Open data and open source software contribute to increased economic development as well as resilience in planning and service provision. These low-cost alternatives to proprietary software allow entrepreneurs in the region to build up new businesses that improve services and planning as well as researchers and analysts to develop new, context-specific knowledge to guide decision-making. For example, software developers in Lilongwe were able to build lower cost medical record software for health clinics by drawing on OpenMRS, an open source enterprise electronic medical record system platform that shares and builds open code, thereby reducing the costs of developing software. Recognizing the importance of these benefits, the international development community has developed principles for digital development (Figure 6.3).[62]

Open data is defined as "data that can be freely used, re-used and redistributed by anyone subject only, at most, to the requirement to attribute."[63] According to the Open Data Institute, good open data should have four attributes: be linked to the internet so that it can be easily shared and talked about; be available in a standard, structured format, so that it can be easily processed; have guaranteed availability and consistency over time, so that others can rely on it; and be traceable, through any processing, right back to where it originates, so others can work out whether to trust it.[64]

Figure 6.3: Digital principles for development

Source: www.digitalprinciples.org.

One clear example of where open standardized data has made a large positive impact is in the transport sector. In 2015, TriMet, the public transit agency in Portland, US, agreed to make its proprietary data about routes and schedules available to Google, which integrated that information into its popular mapping app using a transit data format that eventually became an open source platform.[65] The open transit data movement has since spread with great positive effect. The United States National Academies of Sciences, Engineering and Medicine surveyed 67 transport agencies across the globe on their experience with open data and found evidence that significant benefits emerge from making public transport data open including that the public was more aware of public transport services.[66]

Open data also allows third-party innovation around passenger information systems. This innovation is most evident in the "ecosystem of third-party apps being developed for the dominant smartphone platforms."[67] Open public transport data thus can also help foster business development, and some app developers are able to generate income from innovative apps they create using open data. Indeed, the cost of developing apps in-house was a key factor in the decision by Transport for London (TfL) to move towards an open data strategy.[68] Allowing the private sector to develop diverse quality products on top of the data can be highly cost effective. TfL calculated that apps powered by its bus data will deliver £83 (US$106) million of customer benefit over 10 years, at a cost to TfL of £820,000 (US$105,000) per year.[69] By 2012, 5,000 registered developers had produced over 362 apps powered by TfL data. The apps reached 4 million people with an estimated £15–58 million (US$19–74 million) value in time saved by users.[70]

Some of these companies are also able to generate more data as apps gain users who, in turn, feed back into data creation, which can even lead to new transit provision. For example, CityMapper, a London-based company, used its data to discover demand for missing bus links and launched a bus-taxi hybrid service on these routes.[71] TransitScreen, Inc. uses open data from public transit agencies to develop informational screens for building lobbies and public spaces. Overall, many of these businesses develop services that make shared mobility and public transport more attractive. These efforts help build a rich ecosystem in support of the global agenda of improving public transport and reducing individual car use, a critical part of addressing climate change and air pollution in cities. Evidence speaks to the power of developing ecosystems around open data, not just in the transport sector but in all areas. Indeed, with climate change, cities should be building open environmental and demographic data for climate resilience planning.[72] This approach also addresses the question of how to reach SDG targets 17.6 (enhancing international cooperation on and access to science, technology and innovation and enhance knowledge sharing) and 17.7 (promoting the development, transfer, dissemination and diffusion of environmentally sound technologies) by making technology available at fair terms and encouraging knowledge transfer and learning across cities.

To leverage open data as a resource, cities have to develop their own ICT capabilities to help build and organize data as well as portals to share this data in a standardized format

Box 6.6: Hackathons leverage open data to build city tech tools

The idea of running a hackathon to leverage new ideas for how to use open data in cities has caught on across the world. One of the first city-run competitions in the US was Apps for Democracy, held in Washington, DC in 2008 to leverage the city's 200 opened datasets as catalogued by a third-party company. The city found sponsors to provide US$50,000 in prize money for the top three apps. The hackathon resulted in 47 successful designs, which helped raise an estimated US$2.3 million for the city itself. But this value is only created when cities have the resources to make data available in a useful form and requires an existing civic-minded tech community. In addition, many of the innovative ideas do not get developed and hence are not sustained requiring a more iterative and collaborative approach. Communities of "civic hacktivists" are growing across the world and cities increasingly are finding ways to partner with them to provide services or understand problems better.

Source: Smith, 2017.

To leverage open data as a resource, cities have to develop their own ICT capabilities to help build and organize data as well as portals to share this data in a standardized format; many cities are now sharing a wide variety of anonymous data and creating app competitions or "hackathons" to encourage new applications to address urban problems (Box 6.6). Open data portals also have the added benefit of increasing collaboration among departments and promoting more interaction and trust between residents to solve challenges.[73]

Another strategy for cities is the innovation challenge. This approach hopes to draw on the diverse ideas, talent and people in the city and beyond to tackle a specific challenge. For example, ThinkCity, a social purpose organization in Kuala Lumpur, Malaysia, created the "climathon" in 2019 to solicit ideas to address the serious challenge of climate change resilience. The winner of the first climathon in Penang developed a prototype for a smart flood warning system for the city of Pulau Pinang which is highly vulnerable to flooding. Using sensors and artificial intelligence to transmit data on water levels in real time, the system would model hydrological problems in advance, enable early detection of flooding risk and generate a public alert system. ThinkCity with its partners from George Town, in turn, won the EIT Climate-KIC Climathon Global Awards for nature-based solutions to prevent flooding including planting climate-resilient species of trees that can help cool communities.[74]

In a similar vein, after Hurricane Sandy wreaked havoc on the New York City metropolitan area in 2012, the US Department of Housing and Urban Development in partnership with the non-profit and philanthropic sector organized Rebuild by Design, a design competition to foster and fund innovative solutions to climate resilience. This collaborative public-private process continues to work in different cities across the globe.[75]

6.4.2. Urban labs

Cities with institutions of higher education can also develop so-called "town and gown" partnerships with universities (Box 6.7). Many universities are in urban areas and are increasingly looking to collaborate with local communities and tech companies in urban labs to address a wide range of urban problems. The MIT Senseable City Lab and University of Chicago's Urban Labs are examples in the developed world. Other collaborative urban tech initiatives like the Hyderabad Urban Lab or C4D Lab (University of Nairobi) and iHub in Nairobi are supported by foundations, civil society and multilateral aid. Still others are housed within city government, like the Laboratorio de Innovación Quito (LINQ), LABcapital in Bogotá and the Laboratorio para la Ciudad in Mexico City, which closed in 2018. These kinds of urban tech collaborative networks and spaces are growing globally, and cities can encourage them by providing affordable space, open data and collaboration. Research is a critical building block for urban innovation systems that spawn new civic-oriented tech companies.

Box 6.7: New York City's "Town and Gown" programme

Created in 2009-2010, Town+Gown is a city-wide university-community partnership programme, resident at the New York City Department of Design and Construction, that brings academics and practitioners together to create actionable knowledge in the built environment.

Town+Gown is an open platform research program that uses service (experiential) learning and faculty-directed research to facilitate partnerships between academics and practitioners on applied built environment research projects through the collaborative inquiry model of systemic action research.

Town+Gown aims at increasing evidence-based analysis, information transfer, and understanding of the built environment, using, in many instances, New York City's built environment as a laboratory for practitioners working in the city's physical spaces, and academics in the built environment disciplines, with the ultimate objective of making changes in practices and policies based on research results. The programme involves city departments partnering with university teams sharing data and insights on problems that university teams work on. The city then organizes for events where the projects are presented and discussed in public. Joint solutions to city problems emerge out of this dynamic.

Source: https://www1.nyc.gov/site/ddc/about/town-gown.page

6.5. Cities and the Uneven Geography of Technological Innovation

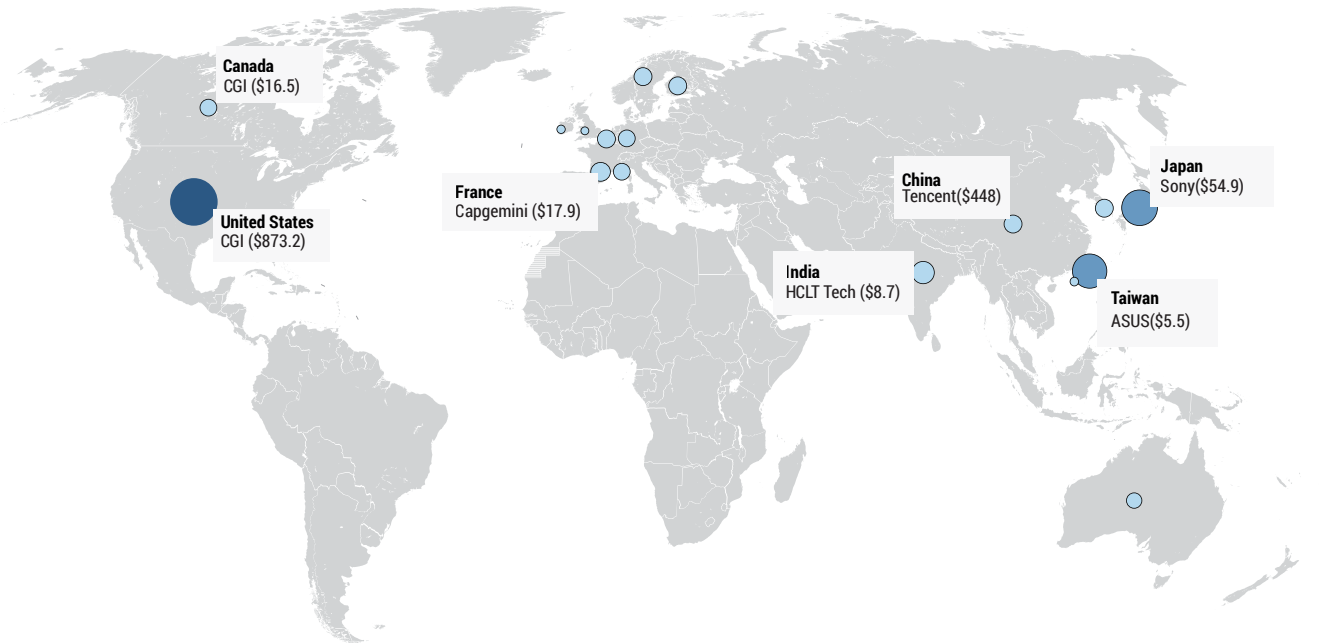
Technological innovation requires public investment in research and development (R&D) and venture capital, or funding that goes into risky new projects or ventures. These components are unevenly distributed across the world. Large technology innovation networks and the companies within them are almost always located in global cities that can also attract young well-educated workers, many of whom are immigrants, while less globally connected cities are left behind.[76] These workers are sometimes called the creative class, a term that encompasses artists and entrepreneurs of all kinds that work in lucrative creative industries.[77] In 2015, creative industries generated over US$2.2 trillion with more than 29.5 million jobs worldwide, which is equivalent to three per cent of the world's GDP.[78] While creative industries are open to people of all ages and backgrounds, they offer significant pathways to youth employment and connect the formal and informal sectors, generations and regions, bearing a largely untapped potential to improve urbanization by 2030.

Although it is hard to measure precisely, some estimates suggest that the digital economy alone in 2016 was worth US$11.5 trillion globally, equivalent to 15.5 per cent of global GDP, and is projected to grow to 24.3 per cent of global GDP by 2025.[79] If the Silicon Valley region were a country, it would be one of the richest in the world with annual production valued at US$275 billion.[80] As technology and related knowledge spreads, which happens quickly in the digital age, innovation supports other economies both directly and indirectly through productivity gains.[81]

The geography of current technological innovation, however, is riven with inequalities, with many profound implications for society

The geography of current technological innovation, however, is riven with inequalities, with many profound implications for society that express themselves at different levels: within and between these metro areas, between metro areas and rural areas, and across cities and countries around the world. Currently, the San Francisco Bay Area in the US is the largest tech innovation ecosystem in the world. Many of the largest tech companies, like Google, Facebook, Uber and Airbnb, are based there and have outsized impacts locally because of the wealth they generate and globally because of their impact on rental housing markets, the taxi industry, political advertising and data privacy. It is important to understand these dynamics because most cities are now impacted by these giant technology firms that are, in many cases, wealthier

Figure 6.4: Global distribution of top 100 digital companies and market capitalization (US$ billion)



Source: Murphy, 2018.

and more powerful than many countries and have wide-ranging impacts, including on city governance.

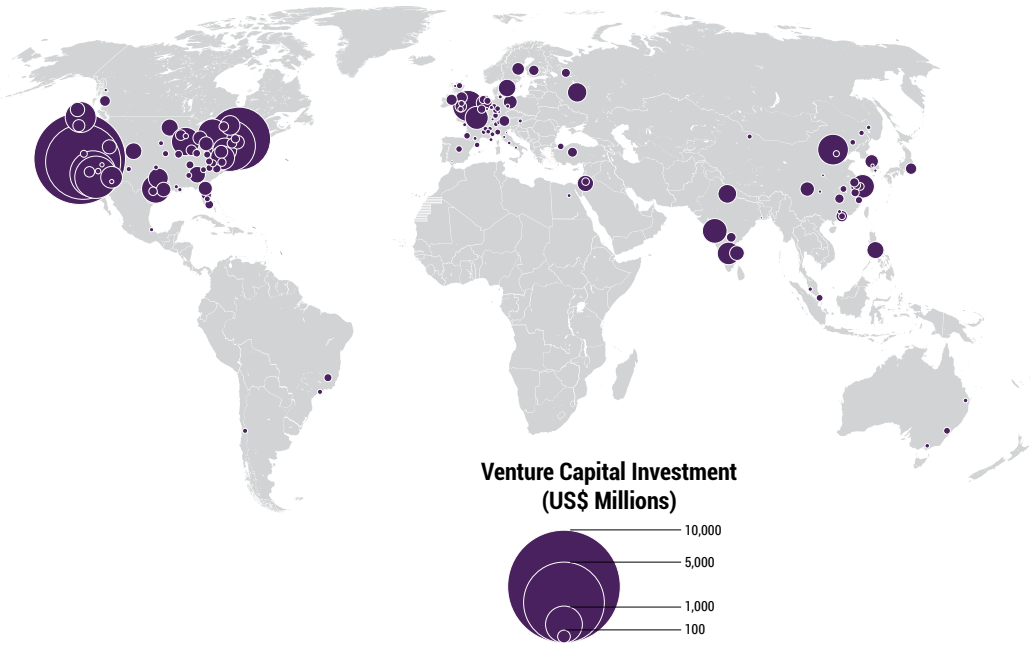
Venture capital supports technology companies by lowering the barriers to taking products to market. This financing also tends to be concentrated in the US, especially in the San Francisco Bay Area and the Northeast Corridor (Boston-New York-Washington), with most venture capital-backed high-tech start-ups found in global cities like London, Paris, Toronto, Beijing, Tel Aviv, Shanghai, Mumbai and Bangalore, among some others (Figures 6.4 and 6.5).[82] While much of this venture capital goes into investment in local technological innovation, some of it is exported to support technology companies globally,[83] sometimes creating conflicts between more locally funded and developed technology firms and global players that make for a very uneven playing field and what some term "tech or digital colonialism."[84]

Public sector investment in scientific, engineering and technology research that forms the basis of much of the core of technological innovation is also very unevenly distributed globally, which raises a problem for the enabling environment envisioned in the New Urban Agenda and SDGs: "access to science, technology and innovation and enhanced knowledge-sharing."[85] According to UNESCO, while global spending on R&D has reached a record high of almost US$1.7 trillion, only 10 countries account for 80 per cent of spending which consists of both private and public sector support.[86] Part of this public sector R&D support makes it into universities that either incubate or spin off start-ups or provide breakthroughs in science that enable further technological advances.

Public sector investment in scientific, engineering and technology research that forms the basis of much of the core of technological innovation is also very unevenly distributed globally

Even though some of the benefits of improved technology spread across the globe, the spatial distribution of venture capital and public sector R&D along with the technology

Figure 6.5: Global distribution of venture capital



Source: Martin Prosperity Institute, 2016

companies that draw on them is profoundly concentrated. One implication is that large technology firms are players in many cities across the globe, creating new power dynamics as was the case of Sidewalks Lab in Toronto.

As the technology sector can generate employment and economic dynamism with the production of new services and increased efficiencies, many cities strive to foster conditions for these kinds of businesses to flourish. Witness the dozens of cities around the world that have attempted to brand themselves with the moniker "Silicon," from the Silicon Wadi of Tel Aviv to the Silicon Savannah of Nairobi. However, cities also are highly unequal in the extent to which they can develop policies to encourage technology firms as an economic strategy. Some cities with more resources are investing in innovation districts, incubator and accelerator spaces, knowledge centres and universities, as well as providing land or tax breaks to tech companies. Other cities simply host technology firms but are not focused on building innovation systems. Overall, a great diversity exists among cities in terms of their orientation towards the innovation and technology firms that increasingly dominate the world's most economically dynamic cities.[87]

A great diversity exists among cities in terms of their orientation towards the innovation and technology firms that increasingly dominate the world's most economically dynamic cities

One of the most dramatic examples of the ambivalent relationship cities can have toward the technology sector is San Francisco. In 2015, the mayor faced a budget deficit and created tax breaks for tech companies to move into the city. The incentive created a dynamic hub that boosted city employment and generated substantial revenues, but the influx also raised rents and property prices feeding a housing crisis that has made San Francisco one of the most unequal cities in the US.[88] In 2018, city voters responded to the changes in their city by approving a tax on tech companies to fund housing for the homeless over strenuous opposite from the tech industry.[89] But Silicon Valley is more than just a single city's policies. A detailed analysis of the Bay Area's innovation ecosystem by the Bay Area Science and Innovation Consortium (BASIC), which brings together local government, companies and universities in

an innovative form of cooperative networked governance, shows a whole set of complex public and private actors that interact to produce the region's wealth, including universities, accelerators, big companies and venture capital (Figure 6.6).[90]

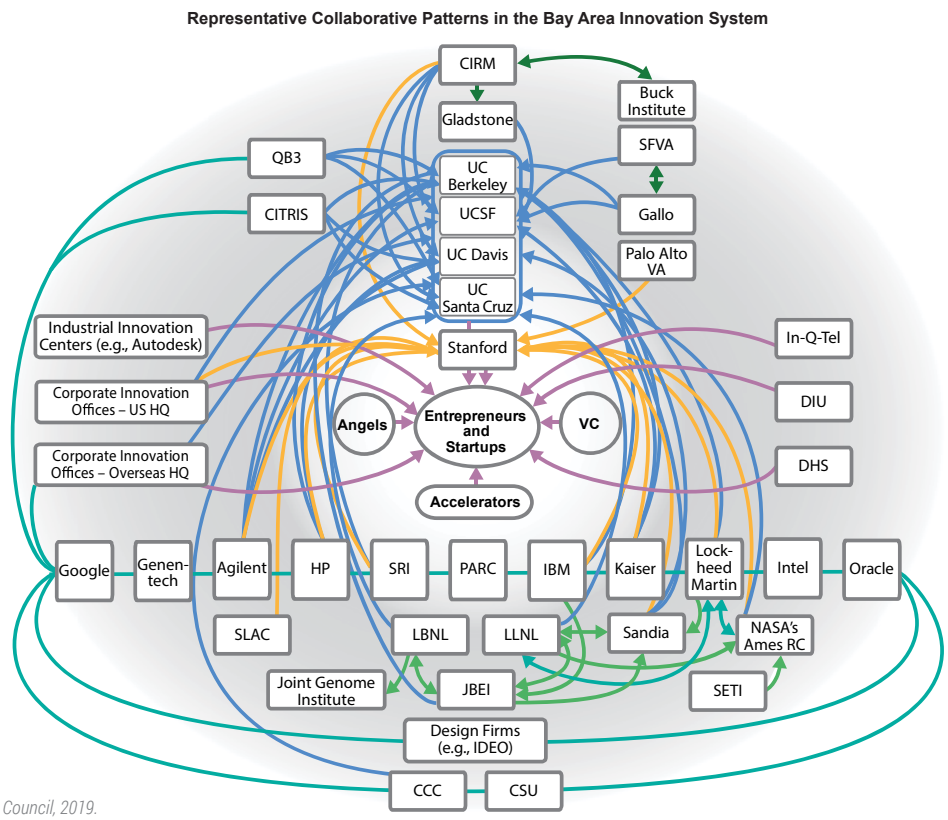
So far efforts to kickstart innovation systems in other metropolitan areas have brought mixed but usually lower than expected success.[91] This outcome is because it is hard to nurture a complex ecosystem that involves a form of networked collaborative governance, which is in and of itself a kind of institutional innovation. This conclusion reinforces the insight that innovation in the broad sense lies both in scientific and technological developments, but also in the creative actions of governments and citizens that strive to use new institutional arrangements to address economic as well as social and environmental challenges. However, even if a city is not actively trying to build local innovation systems, we have seen many ways for cities to leverage new technologies from the bottom up to become "smarter."

6.6. Digital Exclusion, Data Privacy and the Perils of New Technologies

Historically, every set of profound technological changes has led to transformations in labour, social and political relations. This section systematically examines some of the perils of the movement towards ever more automation and digitization. These include digital exclusion, questions of data control and digital colonialism, privacy and surveillance concerns, political misuse of social platforms and impacts on labour, poverty and inequality.

The problems of digital exclusion and inequality in access to the benefits of new technologies persist. Despite the fact that internet use and mobile phones are expanding rapidly, with approximately one million people going online each day for the first time and with two-thirds of the global population owning a mobile device, about half of the world's population (3.9 billion) do not have internet access,[92] with a majority of these being rural dwellers, low-

Figure 6.6: The San Francisco Bay Area innovation system



Source: Bay Area Economic Council, 2019.

The problems of digital exclusion and inequality in access to the benefits of new technologies persist

income, elderly, illiterate and female. The offline population faces four kinds of barriers: low incomes, affordability, user capability and infrastructure.[93] While digital exclusion is a clear problem in rural areas, urban areas with increasingly large populations of poor residents face serious problems of digital exclusion, even in wealthier countries.[94]

This disparity means that cities need to have digital inclusion strategies if they want smart city or citizen programmes and outreach to work in an equitable way for all residents. Several strategies exist from providing free wi-fi in public places like plazas and public transit to sponsoring municipal broadband as a utility to promoting digital literacy, especially among women and children, by distributing low-cost devices or integrating coding into school curricula. However, many cities across the world are themselves slow to digitize data and take advantage of the new technologies available to them, which means they are also slow in addressing digital inclusion problems.

Another key challenge is privacy. Cities must work to promote good policies to protect citizen data that get collected via these new services and empower citizens to understand how to protect their personal data. While static open data like the number of light posts or housing locations raise few legal problems, profound concerns exist around making health or real-time data open.[95] This concern is applicable to many of the emerging apps associated with tracking and contact tracing COVID-19 cases. More work needs to be done to develop data protection laws, education programs and policies especially in contexts where such laws are currently weak or underdeveloped.[96] Some cities are hiring staff tasked with managing open data portals and protecting privacy. Big tech firms offering services in cities use private data often in ways that leave citizens unaware. As cities embrace and promote digital technologies by partnering with tech companies, they need to act to protect user data, especially at a moment when profound ethical and political questions exist around the use of tech for surveillance and manipulation to undermine democratic processes.[97]

Cities must work to promote good policies to protect citizen data that get collected via these new services and empower citizens to understand how to protect their personal data

Another problem is how to regulate technology companies providing new types of services that lead to problematic impacts, particularly in the realm of labour disruption, regulation and city planning. Cities, for example, are being inundated by new mobility services from ride hailing cars and vans to scooters, with big tech firms also testing autonomous vehicles. By claiming to be a technology company and not a transport company, new mobility companies often attempt to evade regulations, and many cities need to update their legal frameworks and policies to address these kinds of new services and experiments.

How to manage and regulate technology companies is a major challenge

How to manage and regulate technology companies is a major challenge. For example, Uber and its many equivalents provide a service connecting passengers with a ride through an e-hailing app that uses geolocation and algorithms to calculate costs. In many cities like Johannesburg, South Africa, Uber has displaced low-income workers in the taxi sector with immigrant drivers who are still nevertheless paid poorly,[98] triggering violent strife and raising questions about unfair competition.[99] Evidence is also accumulating that in some cities, Uber is causing additional traffic congestion by creating an incentive for many more vehicles circulating on the road.[100] Thus, cities need to find ways to manage these new services and ensure they complement existing mobility paradigms.

Whether these powerful tools will be used to improve urban life depends on "who controls the technology, who has access to the data, who interprets them, and of course, what they are used to achieve."[101] With data and analysis an increasingly lucrative business, a scramble exists for urban data collection with many firms offering services but keeping both the data and the software they use as

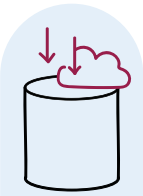
private property. This tendency creates a strong data and tech dependency, which some call "digital colonialism" that stifles potential innovation and spinoffs from the data. Hence, developing strong governance frameworks built on digital rights is key to ensure that technology is deployed in a way that improves public life in cities and feeds into the value of urbanization.

6.7. The Importance of Governance and Digital Rights

Given the concentration of power in technology companies and the pace of technological change, governments are under pressure to play a more active role in enhancing the positive aspects of technology while safeguarding against its negative effects. Governments must ensure that there is a comprehensive and functioning regulatory environment that builds citizen trust and sets clear rules for technology companies.

To realize this goal, governments need to put in place regulations and policies that govern technological development, addressing issues such as interoperability, procurement, public-private partnerships and issues to do with privacy and security raising from the use of digital platforms and data collection. To build trust, governments need to enact privacy laws that respond to the concerns of citizens, businesses and civil society in relation to security breaches, the handling of personal data and surveillance.

Clear, ethical frameworks and institutional arrangements for data collection and data sharing should be put in place, especially in relation to data collected from different sources as well as around algorithms and the use of artificial intelligence, which have in-built biases.[102] These governance frameworks need to set out ethical standards, including who has the right to data, access and ownership, and who should enjoy the benefits from the data. Here, it is important that the public sector, as the custodian of citizens' rights, assumes its full governance responsibility. For many local governments, this is a completely new area, and as such, digital policy and governance capacity need to be significantly strengthened or built from scratch.



Clear, ethical frameworks and institutional arrangements for data collection and data sharing should be put in place

Municipal data is increasingly becoming a strategic resource that enables local governments to carry out their mission and programmes effectively

Municipal data is increasingly becoming a strategic resource that enables local governments to carry out their mission and programmes effectively. Appropriate access to municipal data significantly improves the value of the information and the return on the investment in generating it. As discussed in relation to civic technologies, well-governed municipal data ensures accountability and transparency, promotes openness and public participation in government, and provides actionable insights. Cities and local governments are realizing their responsibilities when it comes to digital governance, data and upholding citizens' digital rights.

In 2018, the Cities Coalition for Digital Rights was launched as a network of cities committed to upholding digital rights and supported by the Office of the United Nations High Commissioner for Human Rights, UN-Habitat, Eurocities and UCLG. The coalition is a global initiative that puts citizens' digital rights at the centre of policies relating to data and technology. The coalition shares best practices and coordinates common initiatives and actions. Inspired by the Internet Rights and Principles Coalition, the work of 300 international stakeholders over the past ten years, the Cities Coalition for Digital Rights is committed to the following five evolving principles:

i. *Universal and equal access to the internet and digital literacy*: Everyone should have access to affordable and accessible internet and digital services on equal terms, as well as the digital skills to make use of this access and overcome the digital divide.

ii. *Privacy, data protection and security*: Everyone should have privacy and control over their personal information through data protection in both physical and virtual

places, to ensure digital confidentiality, security, dignity and anonymity, and sovereignty over their data, including the right to know what happens to their data, who uses it and for what purposes.

iii. *Transparency, accountability and non-discrimination of data, content and algorithms*: Everyone should have access to understandable and accurate information about the technological, algorithmic and artificial intelligence systems that impact their lives, and the ability to question and change unfair, biased or discriminatory systems.

iv. *Participatory democracy, diversity and inclusion*: Everyone should have full representation on the internet, and the ability collectively to engage with the city through open, participatory and transparent digital processes. Everyone should have the opportunities to participate in shaping local digital infrastructures and services and, more generally, city policymaking for the common good.

v. *Open and ethical digital service standards*: Everyone should be able to use the technologies of their choice, and expect the same level of interoperability, inclusion and opportunity in their digital services. Cities should define their own technological infrastructures, services and agenda, through open and ethical digital service standards and data to ensure that they live up to this promise.

The coalition and its principles are the start of a global movement of cities that are taking digital rights seriously to ensure that the new digital economy is having a positive effect on urban life. Barcelona, for example, whose residents have been experiencing major increases in rents and neighbourhood displacement in recent years, has banned landlords from renting out properties without a tourism licence on Airbnb. However, this regulation proved difficult to enforce because officials would need to scroll through thousands of listings and check them against the register of tourism apartments. In 2018, applying the principle of data transparency and accountability, the Barcelona City Council signed an agreement with Airbnb in which the city was given full access to properties being listed; thus, enabling officials to easily corroborate the data against the tourism apartments database. This successful enforcement demonstrates how a concerted effort from cities can assert regulatory power to correct the negative impacts of companies working in the digital economy.[103]

6.8. Concluding Remarks and Lessons for Policy

Advances in digital technology and innovation are unleashing the underdeveloped potential to make maximum use of local resources and assets and address profound urban challenges. New technologies can also boost economic growth and prosperity, but whether they will be harnessed to the benefit of the majority is an outcome firmly in the hands of cities and their national governments. Decisions made by cities around how to use and regulate rapid technological change within an innovation strategy will have profound impacts and determine how much we capture the value of urbanization to fulfil the aspirations for a sustainable future.

New technologies and innovation provide opportunities for cities to meet the SDGs and generate immense value from the process of urbanization

New technologies and innovation provide opportunities for cities to meet the SDGs and generate immense value from the process of urbanization. Serious challenges also exist, and regulatory and legal tools need to be applied to steer needed innovation and manage new technologies that can harm as well as help. It is also important to reiterate that not all innovation is about technology. Cities themselves are innovators and incubators of innovation.

Cities are exploring new ways to engage with residents to ensure equity and justice including access to and regulation and management of new technologies. They are developing

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and fostering new ways to provide high-quality services to address the SDGs and New Urban Agenda as well as confront the growing threats of climate change and the ongoing threat of the COVID-19 pandemic. Technology is most effective in unleashing the value of sustainable urbanization when it supports city governance and innovation including in operations, management and citizen engagement and democracy.

Cities have become highly adept at sharing and adapting new innovations on their own, accelerating the diffusion of good ideas and speeding global learning

It is most critical for cities to build capacities to manage potentially tumultuous changes[104] and to find pathways towards national and global cooperation when confronting these challenges especially as the impacts of technological and climate change are often highly uneven, creating deeper inequalities in the absence of mitigation measures.[105] Fortunately, cities have become highly adept at sharing and adapting new innovations on their own, accelerating the diffusion of good ideas and speeding global learning. More must be done to support this trend.[106]

Several lessons emerge from the discussion in this chapter:

- New technologies and innovation provide opportunities for cities to meet the SDGs and generate immense value from the process of urbanization. Cities that encourage creative activities, neighbourhoods and people are best able to innovate.

- Open cities that welcome and leverage diversity and migrants and foster creative and collaborative networks between levels of government, universities, the private sector and citizens tend to build productive innovation systems that enhance economic, social and cultural value.

- Developments in big data, quantum computing, networked IoT, automation and artificial intelligence have the potential to reshape social relations, labour, politics and city life in profound ways. Cities must build regulatory and policy capacities to address these challenges and negotiate what is in the public interest, ideally adopting strong frameworks for digital rights and development.

- Technology firms are increasingly focusing on cities as markets for smart city technologies. Results of smart city experiments are mixed and particularly poor when these efforts are technology- rather than people-driven. Cities should focus on their existing problems, apply their own civic technology and encourage innovations to address these problems before pursuing private sector technology products.

- Technology cannot displace citizen engagement in neighbourhood and city affairs. Technology is most effective when coupled with institutional innovation and is not a substitute for improving governance.

- Cities require data and data capacities and benefit from building open data and open source ecosystems. Developing open data portals, hackathons and innovation challenges and support for research and local science along with needed labour retraining will foster a healthy technology innovation ecosystem.

- Problems of digital exclusion in access to the benefits of new technologies persist, potentially deepening inequalities. In line with the New Urban Agenda and SDGs, cities must actively develop programmes and strategies to promote inclusion in technology development, use and education.

- Finally, the need for innovation in its ancient Greek philosophical meaning as "introducing change to the established order"[107] has perhaps never been more critical as we strive to build a new socio-ecological order on the foundation of the SDGs, New Urban Agenda and the Paris Agreement. Cities are the key places where intense technological, social and political experimentation is taking place to address the challenges of urbanization: inequality, the fourth industrial revolution and the climate crisis. The value of their work in realizing sustainable development in this context is immeasurable.

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