OECD Urban Studies

Smart City Data Governance

CHALLENGES AND THE WAY FORWARD

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BETTER POLICIES FOR BETTER LIVES

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Foreword

The rise of smart cities enabled by digital technologies holds the potential to help deliver faster and better public services. Digital technologies (e.g. sensor cameras, Internet of Things (IoT) infrastructure, geospatial technologies, digital twins, etc.) are being deployed to collect and analyse data for tackling urban challenges, such as making mobility management more efficient, improving vehicle and pedestrian safety, enhancing public security and emergency services, strengthening urban planning and design, and facilitating research and development. Cities therefore have access to large amounts of real-time data to monitor, manage and improve urban life.

At the same time, the way data are produced, collected, analysed and stored is critical to address public privacy and data use concerns and ultimately maximise the effectiveness of smart city projects. Good data governance can also help strengthen data quality and increase data collection capacity by defining the processes and stakeholders' responsibilities in managing data.

The OECD has long been assisting countries in harnessing the benefits of data and digital transformation for people's well-being while addressing related potential challenges. For instance, the adoption of the OECD Recommendation of the Council on Enhancing Access to and Sharing of Data in 2021 was the first international effort to agree on a set of principles and policy guidance on how governments can maximise the cross-sectoral benefits of all types of data while protecting the rights of individuals and organisations. At the local level, the OECD has also actively engaged in smart cities and data governance, notably through the elaboration of Group of 20 (G20) guidelines on leveraging digital technology and data for human-centric smart cities: the case of smart mobility and the G20 roadmap toward a common framework for measuring the digital economy.

In this context, *Smart city data governance* aims to guide policy makers at all levels on setting up effective data governance for smart cities, building on international experience.

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Smart cities aim to boost citizens' well-being, promote sustainable environments and optimise public service delivery by leveraging technologies, in particular digital technologies. Forecasts predict that the global Internet of Things (IoT) market in smart cities will grow from USD 300 billion in 2021 to over USD 650 billion by 2026. In the United States alone, cities are expected to invest USD 41 trillion over the next 2 decades to upgrade and benefit from digital technologies.

Digital technologies (e.g. artificial intelligence [AI], IoT, big data), innovations in robotics, drone technology as well as supporting digital infrastructure and devices (e.g. wireless broadband networks, smartphones and cloud computing) generate a vast amount of real-time data that can help both public and private sectors to innovate and deliver public services more efficiently and effectively. However, the amount of data generated is growing more rapidly than governments' capacity to store and process them. Only 2% of new data produced in 2020 was saved and retained in 2021, and estimates also suggest that only 1% of IoT data are utilised.

The success of smart city projects largely depends on the availability and effective use of data. This is why some countries have issued a national data strategy to unlock the power of data and guide their use in the development of smart cities (e.g. Japan and United Kingdom national data strategies). Open data are sometimes included as a core component of such national data strategies to ensure that data from public organisations are available to everyone in open, free and accessible formats (e.g. Spain's Platform for Data Intermediation; Sweden's National Geodata Strategy). Several countries have also issued guidelines and regulatory frameworks to ensure data privacy and security, as well as to build trust (e.g. Japan's Act on the Protection of Personal Information). Some countries are developing smart city standard frameworks aimed at providing a unifying ontology (the representation and definition of concepts and their relationships) across the board to handle data from different sources and fields (e.g. India's Data Exchange Platform the United Kingdom's standard for smart cities PD 8100).

At the local level, cities are adopting a human-centric approach in the use of data and digital technologies to place residents' needs at the centre of policy making (e.g. Vienna, Austria). Cities have also adopted a range of mechanisms to unlock the potential of smart city initiatives. For instance, some cities have appointed a local chief data officer to provide strategic leadership on data management (e.g. Barcelona in Spain, Paris, France, and Reykjavík, Iceland). Other cities have set up local data strategies at the core of decision-making processes with the objective of tackling practical data and urban challenges. For instance, Vienna's Data Excellence Strategy tackles data silos, unclear data responsibility and data acquisitions; in the United Kingdom, the outcome-oriented data methodology of the London Office of Technology and Information helps governments define the desired outcomes of local policy, barriers to achieving them, potential solutions and the data needed to design and implement them. Some cities, such as Paris, are making all structured data accessible by open license arrangements to promote their reuse and generate new applications. Other cities, such as Seoul, Korea, have developed data dashboards that centralise and visualise all urban data from different sectors to produce real-time indicators. Cities also contribute to

ensuring the privacy and security of data collected through digital technologies by setting ethics and security oversight committees (e.g. Seattle's Privacy and Cybersecurity Committee in the United States), adopting ethical guidelines for data management to generate trust (e.g. Bilbao's Data Manifesto in Spain) and defining opt-out procedures as part of data collection (e.g. the city of Takamatsu, Japan). To strengthen cybersecurity, cities are setting up dedicated teams (e.g. Security Operations Centre, Madrid, Spain) and classifying data according to privacy risk levels to support data management (e.g. New York City, United States, privacy risk levels of IoT data).

Both national and local governments have been working to set up a data architecture that reflects data quality standards, semantics and interoperability for data processing and sharing. A range of national data interoperability frameworks seeks to foster collaboration and co-ordination among stakeholders to boost efficiency and effectiveness gains from data management (e.g. Argentina, France, Japan, Luxembourg). At the subnational level, interoperability is often ensured through agreements (e.g. Dutch Metropolitan Innovations initiative) or city platforms (e.g. Barcelona in Spain, Hamburg in Germany, Nantes Métropole in France, Seoul, Korea) for data sharing among local governments, between local governments and the private sector, or through the organisation of events or fora (e.g. Sketch Lab in Toyama, Japan).

Challenges and recommendations

Despite the wide range of local and national initiatives to enhance smart city data governance, urban data still raises a set of management, regulatory, access and security challenges for both national and city governments:

- **Insufficient financial resources** for smart city data strategies are a key challenge, which prevents cities from accessing the adequate technology to process and store data and from upscaling smart city projects. A possible way forward for city governments could be to combine different budget streams to build synergies among several investment programmes and to work with neighbouring cities to pool resources together towards common goals, as well as to partner with the private sector by building a business case on the value of data.
- **A lack of business models** for financing and refinancing data collection and transfer is also a primary concern for local and national government officials. The requirements to open public (national and local) data, generally free of charge, can limit the scope of public sector bodies unable to invest in innovative digital applications. One option is to build agreements among a wide range of stakeholders to facilitate data sharing through a data ecosystem where all co-operate for its maintenance and sustainability over time.
- **Access to skilled data management and analytics expert**s is also a recurrent problem for national and local governments. For example, the United Kingdom estimates that 90% of senior civil servants need to be upskilled in digital and data essentials. Organising regular workshops and networking events among data officers at all levels of government, using simple tools and interfaces for data usage, as well as creating partnerships between information technology managers and service providers to improve knowledge and co-operation and, with the help of educational institutions, could help upskill the public workforce.
- **The compliance of private companies** with the national legislation on data sharing and protection can also challenge smart city projects' implementation. In response, implementing audit mechanisms may assist in verifying that data sharing and portability requirements among stakeholders, as well as data reporting to public authorities, abide by the legislation on processing and retaining data.
- **Digital technologies are prone to data security and safety risks** related to leaks and cyberattacks. Governments at all levels need to invest in stepping up cybersecurity capacity and capability, by setting up digital security committees to discuss challenges and possible solutions

and developing agreements with the private sector to provide technical support and capacity building to local governments for example.

- **Smart city data are often stored in silos**, which often prevents interoperability. National and local governments should build data platforms that enable data sharing across city departments, sectoral policies and levels of government with relative ease and adopt data standards to facilitate common sharing and understanding while promoting open data policies.

1 Why does data governance matter for smart cities?

In the era of digitalisation, data-driven organisations and data quality are more relevant than ever. Data are a key asset of any organisation. Therefore, the adoption of governance frameworks to guide the use, storage and sharing of data is essential. This chapter discusses the relevance of data governance in the framework of smart cities. It begins with a discussion on the relevance of data governance. It then examines national efforts to enable smart cities and data governance. It concludes with a review of the main challenges to promoting smart cities and data governance.

Introduction

The uptake of digital technologies and infrastructure is accelerating. It is estimated that nearly two-thirds of the global population will have Internet access and the number of devices connected to Internet protocol (IP) networks will be more than 3 times the global population (29.3 billion networked devices) by 2023 (Cisco, 2020[1]). Increased urbanisation calls for an optimisation of the processes in urban space and digitalisation provides an opportunity to collect and analyse data more efficiently for effective decision making. Equipping cities with sensors and ubiquitous computers to generate data about city life (e.g. on traffic congestion, air pollution, water usage, potential natural hazards, public utilities such as roads, electricity and water) and using information about residents and urban communities to inform law enforcement, healthcare and other crucial public services are often at the heart of smart city projects. This chapter discusses the importance of smart city data governance. It explains the concept of smart cities, followed by different arguments on the relevance of smart city data governance. It then presents the international experience of promoting smart cities and the challenges countries and cities face to build smart cities and improve data governance.

Understanding smart cities and data

Digitalisation is paving the way for smart cities

Digital transformation allows for collecting and managing data, enabling governments and private sector companies to provide better public services. For example, Internet of Things (IoT) technology allows governments and enterprises to establish a more direct connection with citizens and collect new data that can feed into policies and eventually new and improved services. Digitalisation is also changing how people live by connecting machines, vehicles, infrastructure and buildings rather than users (WEF, 2020[2]). In Paris, France, digital technologies are used to simplify user interactions with public services by facilitating their use, saving time and personalising services as well as reducing energy use and the carbon footprint, understanding how outdoor spaces are used and how future developments may impact public areas (Mairie de Paris, 2020[3]). Digital technologies are helping cities prepare for more regular floods, heatwaves, droughts and other events that impact people's health, well-being and safety. Using smart technologies for construction design can also contribute to decarbonising buildings and construction to make cities and urban life more sustainable through energy efficiency improvements (OECD, 2022[4]).

The COVID-19 pandemic has accelerated digitalisation across the world. Between 2019 and 2020, broadband adoption grew by 4.8% across the world and even by 9.8% in Latin America (Jung and Katz, 2022[5]). However, innovating in digital technologies does not necessarily mean a country has embraced digitalisation. For example, despite a global reputation for impressive technological progress and citizen awareness of embracing digital technology, Japan's public sector – and a good portion of its private sector – has been slow to embrace the digital era.[1] Before COVID-19, central and local governments had their own strategy for promoting digitalisation, resulting in 1 700 systems procured and managed separately and with dispersed responsibility. This fragmentation made the response to the pandemic ineffective and the outdated and cumbersome administrative systems hampered policy responses (Makishima, 2022[6]).

Digitalisation is transforming the way cities are conceived and work, as the use of digital technologies covers almost every aspect of urban life. For example, smart meters and pipes are used to track water quality and leaks, smart grids to manage energy consumption, smart homes to manage energy demand, autonomous cars and car-sharing platforms to improve mobility and alleviate pressure on land use, smart sensors and videos to improve traffic flow and public safety, etc. (BrighterAI, 2023[7]).

Digital technologies were used to mitigate transmission risks during the pandemic. Non-traditional sources of data such as Internet search requests, mobility tracking from mobile phones and banking card activity became important means of monitoring the state of the economy and the impact of containment measures (OECD, 2021[8]). In November 2020, for example, the city of Yokohama, Japan, organised a baseball match to test whether crowds could gather safely in preparation for the Olympics and Paralympics in 2021. Monitoring devices in the stadium and a smartphone application were used to inform spectators about congestion in different parts of the stadium. During the pandemic, Tokyo, Japan, accelerated its efforts towards its digital transformation with the promotion of online learning, telemedicine, telecommuting and the digitalisation of public services. The city introduced a smart school project to enable all school children and students in Tokyo to study online (OECD, 2020[9]). India experienced an increase in digital payments across online grocery stores, small retail outlets and online pharmacies: contactless payments via quick-response (QR) codes, wallets or contactless cards surged as they provided ease, security and allowed users to maintain social distancing.[2]

The COVID-19 pandemic has triggered changes in the way of working in enterprises and government agencies. Teleworking has led managers to rethink how to organise their work, replacing face-to-face interactions by virtual interfaces. In OECD countries such as Australia, France and the United Kingdom, 47% of employees teleworked during lockdowns in 2020 while, in Japan, a country without a nationwide lockdown, the rate increased from 10% to 28% between December 2019 and May 2020 (OECD, 2021[10]). In Latin America, for example, 34% of the population was able to telework during the pandemic (Jung and Katz, 2022[5]). Online payments began to increase in countries where cash transactions dominated. In Japan, online payments increased by 11% in 2020 and by almost 20% in major cities compared to 2019, which was a remarkable change in a society where cash dominated consumer purchases (OECD, 2021[8]). The percentage of new online consumers experienced a significant increase in countries like Chile (94%), Colombia (113%) and Mexico (79%) during the pandemic in 2020 compared to the previous 2 years and electronic trade grew from 13% in 2017 to 23% in 2020 on average in Latin America (Jung and Katz, 2022[5]). COVID-19 also uncovered some weaknesses in digital transformation. For example, traditional work practices (i.e. physical presence in the workplace) and poor telecommunication infrastructure in some homes hindered the possibility of teleworking. In Japan, according to research, the productivity of employees working remotely during the pandemic decreased by between 30% and 40% compared to their productivity levels in the office (Morikawa, 2021[11]).

Smart cities as a vision to address urban challenges by utilising data

The term “smart city” and other related concepts, such as “smart communities” and “ubiquitous cities”, evoke societies that leverage technologies, mostly digital ones, to boost citizens’ well-being and deliver more efficient and sustainable public services. However, the term “smart city” is subject to different interpretations and debates across OECD countries (OECD, 2020[12]). In Japan, a smart city usually refers to the use of (digital) technology to provide services and solve city problems.[3] In Canada, authorities use the term “smarter communities” to refer to being innovative and using data and connected technology to strengthen communities and create opportunities for growth.[4] For Korea, a smart city is a sustainable city where several city services are provided based on city infrastructure constructed by converging and integrating construction, information and communication technologies to enhance competitiveness and liveability.[5] For Colombia, a city or territory is smart when it orients its actions towards sustainability and inclusion and connects and adapts to the challenges and expectations of the people, generates an environment of collaboration, innovation and constant communication, and uses technologies as tools that leverage social, economic and environmental transformation” (Government of Colombia, 2019[13]). For the city of Portland, United States, a smart city refers to “… the use of existing and innovative technologies, data collection and data management tools to enhance community engagement, improve delivery of public services, and address City goals around equity, mobility, affordability, sustainability, community health and safety, workforce development, and resiliency” (City of Portland, 2018[14]). In Japan, while the Tokyo

Metropolitan Government defines smart cities as "… a vibrant city that keeps growing, a city open to the world, a city leading the world in environmental policies, and a global financial and economic center" (2016, p. 21[15]), the Cabinet Office characterises smart city is "[a] holistically optimized, sustainable city or district where management (planning, building-up, management/operations, etc) is executed leveraging such advanced technologies as ICT for the resolution of various issues of the city" (Government of Japan, 2020, p. 3[16]).

Although definitions of smart cities vary from country to country and even across international organisations, the use of digital innovation to improve competitiveness and efficiency in urban services is a common element. In smart cities, local governments and/or private sector actors develop a system of technological solutions (e.g. smart technologies such as sensors and cameras) to advance city governance and development goals. Smart technologies are used to collect and analyse data to meet cities' particular needs, such as traffic congestion, public security, healthcare for the elderly, public transport provision, city planning and innovation (Johnson et al., 2022[17]). The OECD defines smart cities as "initiatives or approaches that effectively leverage digitalisation to boost citizen well-being and deliver more efficient, sustainable and inclusive urban services and environments as part of a collaborative, multi-stakeholder process" (2020, p. 8[12]).

However, what makes a city "smart" remains a pending question across the literature. Research suggests that a city becomes smart by using smart technologies in transport infrastructure, water systems, power supplies and public services (Thomas, 2019[18]) and this entails the interaction of technological components with political and institutional components (Fietkiewicz and Stock, 2015[19]). It also suggests that "[t]he smartness of a city is […] not about technology as such, but rather about how technology is used, as part of a wider approach, to help the city function effectively, both in its individual systems, and as a whole" (BSI, 2015, p. 6[20]). Smart cities not only provide better services and make better use of urban resources, they also guide how people govern and make decisions to ensure sustainable urban development through the use of digital technologies and urban data open to the public (Paskaleva et al., 2017[21]). For the OECD and the International Transport Forum (ITF), the term "smart" is often linked to notions of "how" (which are technological in nature and guided by industry actors) and to those of "what for" (which are the domain of public authorities and the mandates given to them by people) (ITF, 2020[22]).

Kitchin (2016[23]) has identified at least three broad concepts of smart cities that are not mutually exclusive. The first refers to smart cities as digitally instrumenting cities where networked, digitally enabled devices (e.g. digital closed-circuit television [CCTV], sensor networks, smart meters) embedded into the city's fabric change the configuration and management of infrastructure and services. The second refers to smart cities as an initiative aimed at improving urban policy, development and governance by using information and communication technology (ICT) to boost and improve innovation, sustainability, creativity, human capital and management. Under this conception, a smart city publishes open data and fosters an open data economy, encourages citizens' participation in planning, enables urban test-bedding and leverages digital technologies and data to create synergies and break down departmental silos, among other things. The third concept refers to smart cities as those that use digital technologies to promote a citizen-centric urban model of urban development and management, reducing inequality while enhancing transparency, accountability and civic engagement.[6]

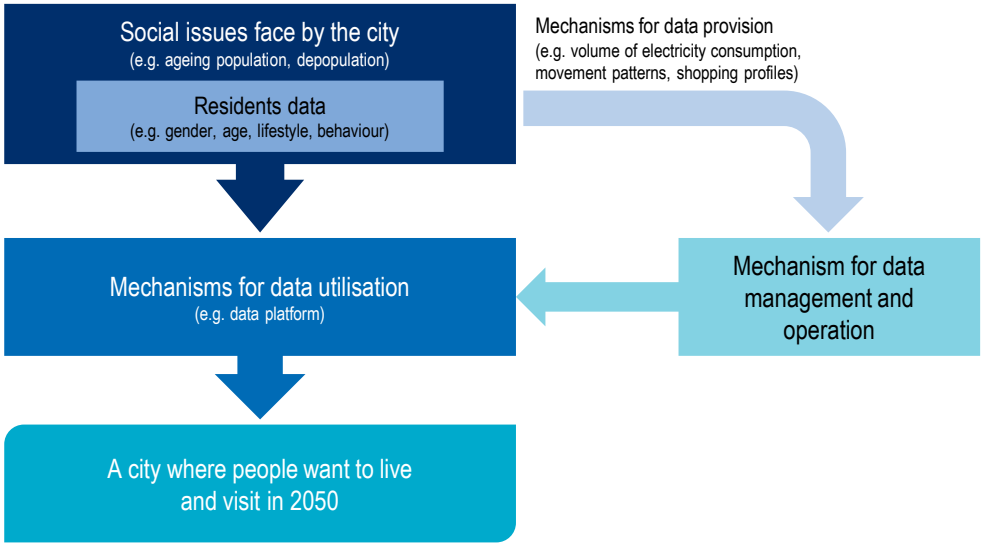
Ultimately, a smart city aims at solving urban and regional problems based on a human-oriented approach (Ishida, 2021[24]) through the use of information technology (IT) and data. Data are central to achieving the objectives of smart cities. Still, the critical issue is to ensure that data are of the right quality and volume and obtained at the right time and in full security to tackle socio-economic local and regional issues (Figure 1.1). Some OECD countries, such as Australia, Canada, Japan, Korea and the Netherlands, commonly refer to "data-driven" cities, projects and strategies. Data should not be the driver of decision making and policy formulation but the enabler of achieving a city's key priorities.[7] Technology and data are a means to an end rather than an end in itself.

For the OECD (2019[25]), a "data-driven public sector":

- Recognises data as a key strategic asset, defines its value and measures its impact.
- Removes barriers to managing, sharing and reusing data.
- Applies data to transform the design, delivery and monitoring of public policies and services.
- Values efforts to publish data openly and the use of data between and within public sector organisations.
- Understands the data rights of citizens in terms of ethical behaviours, transparency of usage, protection of privacy and security of data.

However, the London Office of Technology and Information (LOTI) in the United Kingdom suggests that cities should strive to be "data-enabled", rather than data-driven, which suggests that smart city initiatives and data use should focus more on outcomes.

Figure 1.1. How a city uses data to tackle social issues



Source: PwC (2021[26]), *Smart Cities in 2050: Rebuilding the Future of Japanese Cities*, https://www.pwc.com/jp/en/knowledge/thoughtleadership/assets/pdf/smart-city2050-en.pdf.

The value of smart city data depends on their application

Data and their application are key elements of smart cities. The New Leipzig Charter, a document that calls for fostering the common good using the transformative power of cities in Europe, states that cities should improve decision making and digital public services to shape digital transformation. To this end, "[d]ata should be used for the common good, with ethical and socially responsible access, use, sharing and management … [while] data usage should be carefully weighed against privacy issues" (German Government, 2020, p. 9[27]). Smart cities are undergoing an evolution process to focus on the needs of people living in urban areas through the application of the IoT. IoT is understood "… as a connected network of heterogeneous components that are sensing, collecting, transmitting, and analyzing data for intelligent systems and services" (Sarker, 2022, p. 1[28]). The total IoT market worldwide was estimated to be worth around USD 300 billion in 2021 and is forecasted to rise to more than USD 650 billion by 2026.[8] In the United States alone, cities are expected to invest USD 41 trillion over the next 2 decades to upgrade and benefit from digital technologies.[9] The IoT market revenue in China was projected to reach USD 4 517 million in 2022.[10] In Japan, the value of IoT technology for Japanese factories was estimated at JPY 636.2 billion (approximately USD 4.4 billion) in fiscal year (FY) 2021 and forecasts project it to reach

JPY 1 trillion in FY 2027 due to increasing government investment in smart public infrastructures such as smart parks and the launch of a wide range of IoT sensors and solutions.[11] Moreover, the growing adoption of IoT in various industries (e.g. agriculture, healthcare, manufacturing, etc.) is also propelling the growth of the Japanese IoT market.[12]

Managing and sharing data responsibly is critical to ensuring the benefits of smart cities. IoT provides critical building components for smart cities, such as data acquisition, data analytics and intelligent decision making. Connected smart devices in the IoT network can share and access authorised information to make informed decisions in the public and private sectors. From an operational perspective, there is a need to maintain data integrity to ensure the smooth delivery of public services. From a public policy perspective, data can help monitor compliance with and the enforcement of rules related to urban development, well-being and environmental sustainability. These data can also be useful for planning purposes, improving equity, promoting economic growth and contributing to people's welfare.

Digital technologies (e.g. IoT, big data analytics, artificial intelligence [AI], three-dimensional [3D] printing, machine learning, advanced energy storage and video technology) play a key role in service provision through the data collected. A smart city typically uses ICT to collect and share data, increase the efficiency of city operations, improve the quality of public services and raise quality of life standards. As Box 1.1 suggests, the use of ICT implies generating, collecting and using data. Public organisations, private companies and individuals require reliable, updated and easily accessible data for their decision making and innovation. However, citizens cannot use or analyse data by themselves; they need intermediaries and data providers to help them use and interpret data. City data collected from diverse sources, such as sensors, Internet-connected devices, or others, are used to obtain insights and hidden correlations to provide better services to citizens and improve decision-making processes (Sarker, 2022[28]).

Box 1.1. Defining "smart city data"

Smart city data may be defined as "data collected by sensors and other technologies deployed in a smart city project, as well as the insights derived from this data" (Chyi and Panfil, 2020, p. 2[29]). It can be classified into technologies for collection and technologies for use. The former involve software applications that collect data through sensors or recorders and process, store or send data using the Internet. The latter consist of software programmes/applications that use data as input and perform a certain function, such as classification and detection, by manipulating the data and performing calculations by applying present algorithms to the data. These software programmes/applications are likely to be installed in hardware devices that support Internet connection, such as IoT devices and more interactive smart devices, such as smartphones, tablets or computers.

Smart city data can be generated in either a passive or an active way. Data generated passively means that data are generated without intention, awareness or consent through sensors and cameras. For example, massive, diverse and fine-grained data on the size and patterns of mobility are collected through IoT devices installed on the roads and public transportation, while consumers are barely aware of being part of such data and do not give any explicit consent to being accounted for in this manner. Actively generated data refer to cases where the involved people actively opted to provide or generate data themselves. The public or private sectors can collect smart city data and it is becoming increasingly common to establish public-private partnerships (PPPs) for data governance.

Source: Chyi, N. and Y. Panfil (2020[29]), "A commons approach to Smart City data governance: How Elinor Ostrom can make cities smarter", https://www.newamerica.org/future-land-housing/reports/can-elinor-ostrom-make-cities-smarter/; OECD (2021[30]), *Innovation and Data Use in Cities: A Road to Increased Well-being*, https://dx.doi.org/10.1787/9f53286f-en.

National smart city frameworks emphasise the importance of accessing, producing and using timely and accurate data for decision making and public service (ITF, 2020[22]). For example, the national smart city frameworks of Germany, Turkey and the United Kingdom highlight the importance of ensuring high-quality geospatial data. Their aim is generally to enable interactive urban and landscaping planning, 3D modelling and digital land use planning. These data also enable smart mobility goals such as providing optimal routes, effective planning and land registration.

However, public and private sector stakeholders are generating more data than they are capable of handling and storing. According to estimates, every day, digital technologies generate more than 2.5 quintillion bytes of data; more than 50% of those come from IoT devices (Marr, 2018[31]) and less than 1% of IoT data has been fully utilised (McKinsey Global Institute, 2015[32]; WEF, 2022[33]). Moreover, only 2% of the data generated in 2020 was saved and retained into 2021, while the rest was either temporary (created or replicated for the purpose of consumption) or temporarily cached and then overwritten with newer data (Businesswire, 2021[34]).[13] To unlock the power of data generated as part of smart city projects, cities need governance protocols and regulatory frameworks that allow them to manage growing volumes of complex data while building trust between data providers, platform operators and data users (e.g. public and private organisations, citizens) and facilitating data sharing (WEF, 2022[33]).

The relevance of data governance for smart cities

Smart cities dovetail with the data revolution. Creating, processing, analysing and sharing vast amounts of data are central to smart cities. Digital technologies, which are intrinsic to smart cities, encompass digital devices, systems and resources that help create, store and manage data. These technologies are making cities' systems and services responsive to and reactive upon (real-time) data. Smart cities are thus part of the data revolution (Kitchin, 2016[23]; 2014[35]). Five features of the data revolution describe what smart cities are also experiencing: a wide-scale production of big data; the scaling of traditional small data into data infrastructures (digital repositories); the creation of linked data; the publishing of open data; and the development of new data analytics.

Several cities such as Dublin (Ireland), Rio de Janeiro (Brazil) (Box 1.2) and Tokyo (Japan) have adopted an urban operating system (or city OS) and dashboards to link together multiple smart city technologies to better co-ordinate city systems and link as much data together as possible to draw a profile of their city. Urban OS and dashboards exemplify cities' efforts to link different technologies and data to create new data and inform decision making.

Box 1.2. Rio de Janeiro Urban Operations Centre

In 2010, the city of Rio de Janeiro in Brazil opened the *Centro de Operações Rio* (COR). This purpose-built operations centre integrates all stages of the crisis management process, with immediate responses in emergency situations. It was built to create a command and control hub for managing city operations in the lead-up to and during three major sporting events: the Confederations Cup, the World Cup, and the 2016 Olympics. Its mission is to monitor the city and integrate actions to reduce the impact of emergencies 24 hours a day.

COR integrates data from 30 public agencies and concessionaires whose services directly affect the routine of the city of Rio de Janeiro. Among them are the Rio Alert system, the Integrated Centre for Urban Mobility (CIMU), CET-Rio, RioLuz, Comlurb, Geo-Rio (sirens), the Municipal Guard, the Departments of Social Assistance, Conservation, Health and Education, Civil Defense, Águas do Rio, among others. It employs 500 professionals that control 1 500 cameras around the city.

In 2023, COR will have a new datacentre capable of processing a high volume of data, such as the amount of rain, photos and videos of emergencies, and information captured by the new georeferenced sensors. In the same facility, the streaming of the new cameras will be processed, all connected by fibre optics. COR analysts, aided by various data analytics software, process, visualise, analyse and monitor live service data, alongside data aggregated over time and large volumes of public administration data that are released on a more periodic basis. The data are used for real-time decision making and problem solving. COR can use the data it processes to investigate particular aspects of city life and build predictive models with respect to everyday city development.

Source: COR (n.d.[36]), *Centro de Operações Rio*, https://cor.rio/ (accessed on 3 February 2023); Kitchin, R. (2016[23]), *Getting Smarter about Smart Cities: Improving Data Privacy and Data Security*, https://www.researchgate.net/publication/293755608_Getting_smarter_about_smart_cities_Improving_data_privacy_and_data_security.

There are no smart cities without comprehensive and agile data governance arrangements

Data governance is a key element in the development of smart cities. There are several definitions of data governance, for example as "…the process of managing the availability, usability, integrity, and security of the data … based on internal data standards and policies that also control data usage" (Stedman and Vaughan, n.d.[37]). For the OECD, data governance refers to "diverse arrangements, including technical, policy, regulatory and institutional provisions, that affect data and their creation, collection, storage, use, protection, access, sharing and deletion, including across policy domains and organisational and national borders" (2022, p. 13[38]). Box 1.3 provides an overview of the OECD data governance model. Rules regarding the collection of, access to and control over the use of data have implications on which goals are pursued in a digitalised urban environment. The complexity and large number of actors and the need to reconcile competing economic, social and environmental interests and values call for a revision of data governance frameworks. National governments need to offer an enabling environment that provides cities with regulatory structures, instruments and institutions to balance private and public interests regarding data access and use.

Box 1.3. Advancing data governance in the public sector

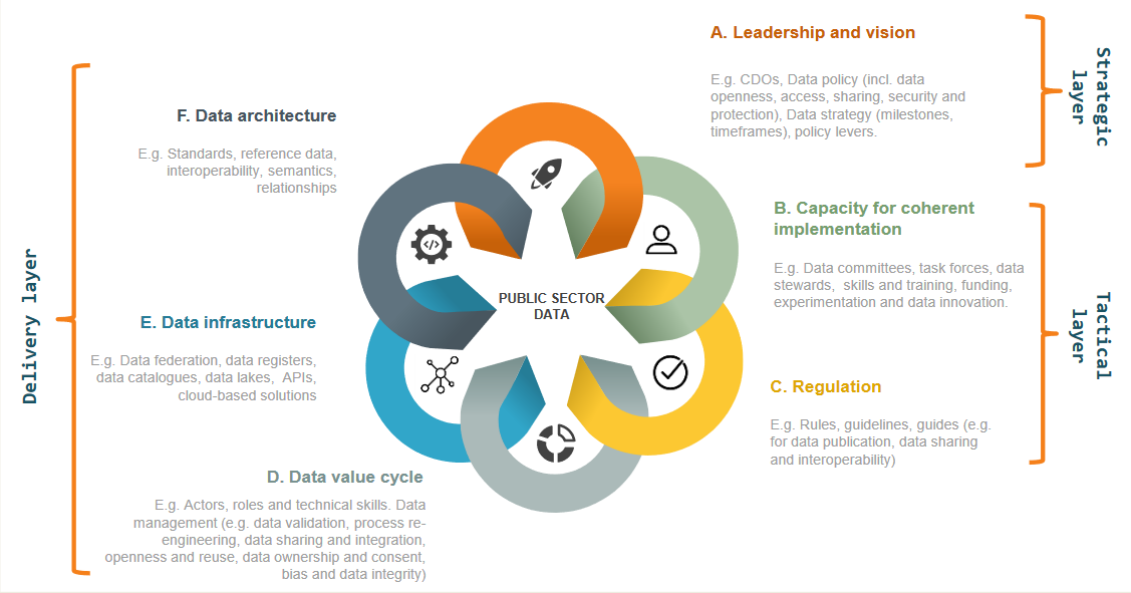
The OECD has developed a model for data governance in the public sector to showcase the core elements needed to design and deploy data projects and initiatives. The model highlights the equal and strategic relevance and value of all organisational, policy and technical aspects for the success of data governance. It identifies a range of non-exclusive data governance elements and tools grouped around three core layers of data governance:

- **Strategic layer**: Includes national data strategies and leadership roles, and considers data strategies as an element of good data governance. Data strategies enable accountability in relation to responsibilities and can help define leadership, expectations, roles and goals. This layer also highlights how the formulation of data policies and/or strategies can benefit from open and participatory processes integrating the input of actors from within and outside the public sector towards greater policy ownership.
- **Tactical layer**: Enables the coherent implementation and steering of data-driven policies, strategies and/or initiatives. Public sector skills and competencies, job profiles, communication, co-ordination and collaboration are used as instruments to improve the capacity of the public

sector to extract value from data assets. The layer highlights the value of formal and informal institutional networks and communities of practice as levers of public sector maturity and collective knowledge. Data-related legislation and regulations are considered instruments that help countries define, drive and ensure compliance with the rules and policies guiding data management, including data openness, protection and sharing.

- **Delivery layer**: Allows for the day-to-day implementation (or deployment) of organisational, sectoral, national or cross-border data strategies. It touches on different technical and policy aspects of the data value cycle across its different stages (from data production, openness and reuse), the role and interaction of different actors in each stage (e.g. as data providers) and the interconnection of data flows across stages. Each stage is interconnected but has specific policy implications in relation to the expected outcomes.

Figure 1.2. The OECD model for data governance in the public sector



Source: OECD (2019[25]), *The Path to Becoming a Data-Driven Public Sector*, https://doi.org/10.1787/059814a7-en.

Smart cities are a blend of institutions, processes, urban actors and technology. Thus, engaging in collaborative and co-ordinated processes is necessary to allow different stakeholders to generate and use the data necessary for developing smart solutions. Governance has a critical role in making cities smarter and sustainable. Inclusive stakeholder relations, the ability to co-operate and the structure of the collaborations are critical factors of governance that condition the success of smart city initiatives (Paskaleva et al., 2017[21]).

Data governance helps city governments make better and faster decisions with more certainty. Indeed, smart cities and the use of data represent or create opportunities for stakeholders to engage in decision-making processes in the pursuit of a better urban life. For this reason, many OECD countries (e.g. Canada, France, Japan, the United States) are using a citizen-centred approach to smart city initiatives in which citizens and different stakeholders (e.g. private sector companies, academics) are seen as key stakeholders for the design and implementation of smart city initiatives/projects. In the United States, for example, the U.S. Department of Transportation organises a smart city challenge through which cities develop proposals on how to overcome mobility challenges using new digital technologies. The

department, residents and private sector are all closely involved in work on project proposals in order to put their smart city vision into action. The winning city receives financial support from the department to support the implementation of its mobility project.[14]

In this context, what makes the governance of smart cities work is the cities' governance capacity, in other words access to highly skilled staff in the public and private sectors, the ability of the public sector to engage in long-term projects and the ability to fund and finance projects beyond the pilot phase. The governance of smart cities also requires strengthening their capacity to develop sustainable relationships among the different stakeholders and enhancing their organisational capacity to ensure co-ordination and communication.

A particular issue for the governance of smart cities is governing the exponential growth and access to greater data volumes. Smart city projects produce a large amount of data due to the use of IoT technology and other devices. Data governance can assist cities in collecting data in a cleaned, standardised and accurate manner to facilitate use and sharing. Energy consumption, mobility, health, environment, people's consumption or leisure are examples of areas where data are being collected and much of that data is open and easily accessible to citizens. The development of IoT, AI and the deployment of fifth-generation technology standard for broadband cellular networks (5G) technology have intensified and made it easier to generate data. Essential data for city life, such as data on demographics, housing, traffic, pollution, crime and health, are being collected and managed by local public authorities. Data come from different sources and domains, making data governance a key challenge for smart cities. A dilemma national and local policy makers face is what data are necessary and sufficient to make a smart city work.

Data governance for smart cities should be an inclusive and iterative process of data collection and management

In the development and implementation of smart city projects, many actors are engaged in collecting, analysing, managing and interpreting urban data. This means that data collection and management is a process of interaction among different stakeholders in which citizens may have the opportunity to participate. A central body in charge of the co-ordination of smart city projects and interaction among the different stakeholders may be set up. For example, in New York City, United States, the Mayor's Office of the Chief Technology Officer is responsible for implementing the New York City Internet of Things Strategy. In London, United Kingdom, the local government set up a Smart London Board composed of academics, entrepreneurs and business leaders to implement and monitor the Smart London Plan.

Promoting intersectoral, inter-organisational and governmental-non-governmental collaboration is one of the most important success factors for smart city initiatives (Paskaleva et al., 2017[21]). Many smart city projects are a collective venture of different public and private organisations, each with different rationales, ambitions and perspectives. Large corporations partner with the government and academia for the implementation of smart city pilot projects. In fact, research has shown that overlooking the challenges to partnership governance compromises the scaling up of smart city projects, which may then fade out after the pilot stage and fail to generate scalable solutions for urban problems across the whole city (Van Winden and Van Den Buuse, 2017[39]). Therefore, cities need to integrate data governance approaches into their smart city frameworks based on solid stakeholders' partnerships. Smart city project managers need to be aware that partners enter the projects for a variety of reasons, including testing new products, improving urban services, sharing and accessing data to enable innovative solutions and products, enhancing energy efficiency, etc. The case of the Energy Atlas in the city of Amsterdam in the Netherlands illustrates a case where a strong link between the pilot project team and the parent organisation and the explicit common interest and commitment move the project forward in a multi-stakeholder setting (Box 1.4).

Box 1.4. Amsterdam's Energy Atlas

Amsterdam's Energy Atlas project explores the use of urban data to improve energy management. The city government expects the project to stimulate the use of renewable energy, as citizens become more aware of their own energy usage and realise that there are gains to be made. Companies will be able to determine their own usage and that of others and find out where renewable sources of energy and the energy infrastructure are located.

The Energy Atlas is a platform type of smart city innovation in which key public and private players in the local energy system share their data and create an online interactive platform (the Energy Atlas) that reveals data on real energy, water and sewerage use at building-block level for the entire city. The Energy Atlas helps identify the geographic locations in the city with the highest potential for adopting new energy solutions.

Between January 2012 and August 2015, European funding from the Transform project supported the project initially. The Amsterdam city administration was the lead agency in the project, leading and managing the project from the outset and organising the process of partner engagement and data integration. Participating utilities and housing corporations in Amsterdam agreed to provide their data for free on the condition that the platform would be open and would not reveal energy use on the level of individual clients. This created a challenge for partners as they had to cluster information on clients in such a way as to keep anonymity. Despite these technical and legal challenges, partner organisations (e.g. Alliander, Gemeente Amsterdam, Liander, TNO, Vattenfall-Nuon, Waternet) decided to continue with the project as they realised the value and importance of sharing data.

The Energy Atlas gives up-to-date and real (rather than projected or estimated) data on a wide variety of energy consumption and production in the entire city. The atlas now operates without European cofinancing and the local partner management boards have committed to continuing to feed the platform with data and keeping it technically up to date.

Source: Van Winden, W. and D. Van Den Buuse (2017[39]), "Smart city pilot projects: Exploring the dimensions and conditions of scaling up", https://doi.org/10.1080/10630732.2017.1348884; Open Data Soft (2017[40]), "How Amsterdam uses urban data to build a more sustainable city", https://www.opendatasoft.com/en/blog/amsterdams-energy-atlas-using-urban-data-to-build-a-sustainable-city/; De Pater, M. (2016[41]), *Energy Atlas*, https://amsterdamsmartcity.com/updates/project/energy-atlas.

The cases of Amsterdam in the Netherlands, Copenhagen in Denmark and New Delhi, India, show that, through data governance, cities can tailor data to the specific needs of stakeholders in critical areas for the city's management and citizen well-being. The cities can also realise their sustainable development goals in urban sectors.

Data governance in smart cities could lead to more efficiency and inclusion

Data are the raw material of smart city initiatives. Therefore, how cities govern data largely dictates how effective and innovative governments are in tackling urban challenges. To that end, national and subnational governments must find a balance between bringing more value to the data (i.e. analysing and using it for decision making) and securing or protecting personal data provided by citizens. Here, data governance means the core mechanism of smart city operations, that is decision making and innovation on how to use data to solve urban/regional problems.

Data governance is often employed to generate additional revenue for the city. Milton Keynes Council in the United Kingdom, for example, runs the MK Data Hub, which requires the private sector to pay a certain amount of money to use their data for commercial purposes.[15] The data hub incorporates a vast amount

of data from various sources, such as key infrastructure networks for energy and transportation, sensor networks for weather and environment, and social media.[16] Therefore, the pricing structure depends both on the provider side (e.g. data accuracy, granularity, timeliness) and the user side (e.g. type of user and purposes). While selling (access to) data is the most straightforward way of monetisation, more complicated models are being adopted as well. For example, LinkNYC, a smart city project initiated by New York City to transform payphones around the city into smart kiosks called Links for Public Services, was funded by setting up a partnership with a private company called CityBridge.[17] Services provided by LinkNYC include Wi-Fi, telephone calls, an emergency button, phone chargers, maps, etc.[18] In exchange for the development, New York City granted CityBridge the rights to operate the kiosks as well as user data generated during the operation. Using the data and advertisements, both the city and the company were able to raise their own revenue continuously.

Data governance can also bring about significant intangible benefits. While many data governance projects aim to enhance the quality of life of all citizens, some are more dedicated to improving the lives of future generations, i.e. sustainability, or those of minorities, i.e. inclusion. Smart meters are a classic example of achieving sustainability through data governance. By collecting real-time data on energy usage and letting users monitor the status, smart meters induce savings and closer control of energy consumption. For example, the Japanese government has set the goal of installing 80 million smart meters by 2025 to improve energy efficiency. The Tokyo Electric Power Company (TEPCO) is deploying 27 million smart meters as part of a citywide energy management platform.[19] In the United States, nearly 107 million smart meters were deployed as of 2020, covering 75% of households, and the number of smart meters deployed grew to 111 million in 2021.[20]

The collection and use of data with smart technologies are also geared more toward fostering inclusion and well-being. In Japan, the city of Takamatsu, for example, piloted a project to use wearable vital sensors and cardiac rate monitors for the elderly. In particular, the COVID-19 pandemic has increased the relevance of real-time data. The East Japan Railway Company (JR East), the largest train company in the Tokyo area, used real-time data to inform passengers about overcrowding in trains and stations to avoid contagion. In the United Kingdom, the Greater London Authority (GLA) created a high streets data service and partnership to provide organisations with constant access to the best data on local high streets and town centres at a low cost. The partnership helped the local government access private companies' real-time data during the pandemic to track which areas of the city were recovering faster.

Data governance has a key role in scaling up smart city projects

Many smart city projects die after the pilot stage. Poor collaboration among stakeholders, limited municipal organisational and technical capacity, failings in the articulation of public needs at a citywide scale, low levels of social acceptance of new technologies and technological uncertainty are some of the main governance factors that prevent scaling up smart city projects around the world (Bundgaard and Borrás, 2021[42]). The lack of scalability makes many smart city projects mere social experiments as they remain at the stage of piloting. For example, in Japan, only 23 smart city projects were rolled out into actual mainstream service delivery in 2020. A possible explanation is that 43% of local government revenue comes from central government transfers and those resources are mostly earmarked despite attempts to limit this practice (OECD/UCLG, 2019[43]).

Sustaining smart city pilot projects is becoming a challenge for many cities around the world. Different factors account for this trend, such as: the failure to secure the necessary budgetary resources to transfer smart city pilot projects into actual public service delivery; a lack of incentives for scaling up; and a lack of mechanisms and incentives included in pilot projects to maximise scaling up potential (Van Winden and Van Den Buuse, 2017[39]). In some cases, policy makers and private sector stakeholders are not aware that smart city projects will take time to produce the desired change and will most probably require the accumulation of different projects. For example, the OECD has already pointed out that most smart city

projects in Japan are developed individually and are not interconnected, which may prevent their scaling up without a sharing knowledge mechanism (OECD, 2021[8]). However, through engagement with local communities and stakeholders, local smart initiatives can draw on the opportunities of urban data, (digital) technologies and networks to realise urban sustainable development goals. In other words, "…governance is in effect the landscape for understanding and driving processes and activities in data-sensitive issues related to sustainability in the smart city" (Paskaleva et al., 2017, p. 5[21]).

Another explanation is that stakeholders in smart city projects do not develop or prepare clear investment recovery models, which results in corporations seeing smart city projects as testing sites (PwC, 2021[26]). Pilot projects provide valuable information on how smart city initiatives may work but are not assessed regarding their possible pitfalls. A testing site cannot be considered a smart city as it does not spread the benefits of the project to the city as a whole. The lack of an investment recovery model makes it difficult for local governments to secure external financing due to the difficulty in making decisions regarding large-scale investments and revenue projections. The case of the Cargohopper in Amsterdam and Utrecht in the Netherlands exemplifies a case of replication of a smart city solution developed to address the particular needs of a city and then replicated in another (Box 1.5). Explicit knowledge needs to be transferred efficiently to new circumstances in order to facilitate replication. Data must be collected from different stakeholders processed within the IT system to scale up. To do so, trust needs to be established and an incentive to share data defined. Since several logistic providers interact with each other, the system must achieve data interoperability and thus must be designed to be capable of handling data from different sources. The case of Cargohopper also highlights that, to upscale a smart city project, there needs to be a minimum threshold of clients in a city using the service (or product) to develop a viable business model. Co-ordination of data sharing is essential to scale up smart city projects as it allows different stakeholders to take an active part in the project and benefit from the services or products.

Box 1.5. Cargohopper, environmentally friendly urban goods transport in Amsterdam

The Cargohopper project of Amsterdam is an inner-city delivery project using electric transportation. It was first piloted in the city of Utrecht and was then replicated in Amsterdam in collaboration with the local administration. The logistics company Transmission, with the support of various institutions across the Netherlands, was the initiator of the project, a response to the growing number of Dutch cities introducing bans of large diesel trucks in inner-city areas labelled "environmental zones" to limit pollution and congestion. The project consists of an electric freight vehicle and a smart distribution system. More than an appealing road train with separate carriages, Cargohopper is a complete logistics system.

In a distribution centre (located at a facility just outside the zone), shipments are processed, bundled and loaded onto the electric freight vehicle. These shipments are sorted by address in separate carriages, allowing efficient delivery to businesses based on the proximity of delivery addresses in the same area. Only through the establishment of data interoperability can the databases be harmonised and stakeholder collaboration become more effective. The local government allowed Cargohopper to operate and delivery goods within the city centre environmental zone and partially subsidised the development of the first electric vehicle.

Source: Van Winden, W. and D. Van Den Buuse (2017[39]), "Smart city pilot projects: Exploring the dimensions and conditions of scaling up", https://doi.org/10.1080/10630732.2017.1348884; Lechner (n.d.[44]), *Cargohopper (Environmentally Friendly Urban Goods Transport)*, http://okosvaros.lechnerkozpont.hu/en/node/232.

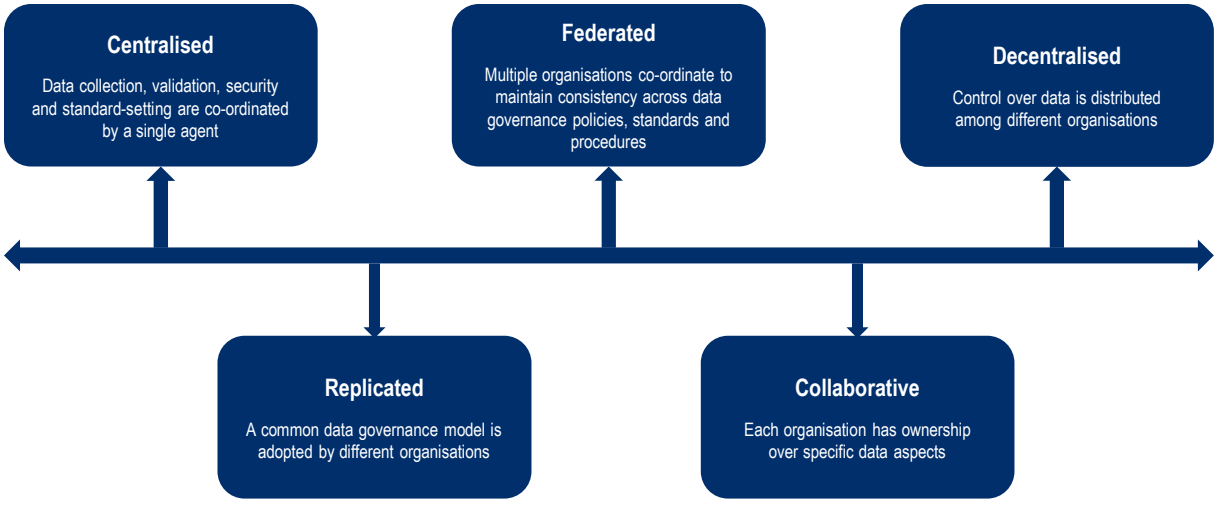
Knowledge transfer mechanisms among stakeholders in a smart city project are critical for scaling up. Replicating a successful smart city solution requires the know-what and know-how (tacit or explicit) to be transferred from place to place but also needs contextualisation of knowledge (Van Winden and Van Den Buuse, 2017[39]). Large companies often are able (and have financial incentives) to organise effective knowledge transfer mechanisms. But this option is not available to start-ups or small and medium-sized enterprises (SMEs) as they may not have the same network of partners as large companies. Thus, it is important that smart city projects include mechanisms for knowledge sharing and dissemination, and that the IT system is capable of managing an increasing number of interactions in terms of data.

There are different approaches to data governance for institutional needs

Research has identified at least five approaches to data governance: centralised, replicated, federated, collaborative and decentralised (González Morales and Orrell, n.d.[45]). They represent a continuum on which different models can be identified for different circumstances and needs (Figure 1.3). For example, a more centralised model of data governance could be used when a central office, such as the statistics office, oversees data collection, standard-setting, security and storage, while a more decentralised model may be used in cases when data control is distributed among several organisations.

There are pros and cons to the use of any of the extremes in the continuum. A decentralised model does not work when common standards and co-ordination are needed to facilitate data sharing, whereas a centralised model may create problems in an environment that needs to foster creativity, innovation and experimentation. A middle ground could be found in the replicated, federated or collaborative models but all of them require clear institutional rules and mechanisms for communication and co-ordination. A federated model, for example, allows multiple organisations to be part of a co-ordinated network of hubs, reducing the complexity of data exchange management, but allows for multiple representations of information based on the different needs and priorities of participating organisations. A collaborative model to data governance can be an effective way to engender a more multi-stakeholder, open and ecosystem approach to tackling interoperability problems (see Chapter 2). It allows greater adaptability and flexibility than other models.

Figure 1.3. A continuum of models of data governance



Source: Based on González Morales, L. and T. Orrell (n.d.[45]), *Data Interoperability: A Practitioner's Guide to Joining Up Data in the Development Sector*, https://www.data4sdgs.org/sites/default/files/services_files/Interoperability%20-%20A%20practitioner%E2%80%99s%20guide%20to%20joining-up%20data%20in%20the%20development%20sector.pdf.

How do countries promote a national enabling framework for smart cities and data governance?

There is no one-size-fits-all guideline or mechanism to promote data-enabled smart cities. However, a review of international experiences offers indications of how countries and cities could build a sound framework for smart city projects that enables more efficient and effective use of data.

A vision and a policy framework for smart cities and data

Setting a clear vision is the first step towards a smart city. The experience of many smart cities around the world shows the significance of a clear vision identifying current challenges and the ideal future that cities want to achieve. Indeed, challenges and visions depend on each city's particular history and priorities and no single smart city model can fit in all contexts. By clearly defining issues and goals, cities can manage to lead innovations and new technologies to face their challenges. The vision can be set both at the national and subnational levels. For example, in 2016, the Japanese government launched Society 5.0, a vision for the future society Japan should aspire to. This involves "[a] human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space" (Japanese Cabinet Office, n.d.[46]). The aim is to achieve a forward-looking society that breaks down the existing sense of stagnation through social reform (innovation). This approach highlights the organisational changes to leverage what is already happening at the micro level, such as smart cities, smart mobility and smart medicine, and roll them out across the economy and country. Cities also set their vision depicting their own identity. For example, the vision of the cities of Copenhagen, Denmark, and Helsinki, Finland, (Box 1.6) represent a "mission statement" or "development model" along different indicators or topics. The vision is generally based on the goals that a city or community has derived from current challenges and opportunities that it wants to grasp in the foreseeable future. The lesson from these experiences is that governments and citizens should debate the future of the city and what they want the city to be before engaging in smart city projects.

Box 1.6. Smart city vision – Copenhagen and Helsinki

Copenhagen, Denmark, aims to become the world's first carbon-neutral capital by 2025 and is implementing initiatives to rebuild the vision for the city in co-operation with the national government, as well as promoting smart city initiatives in different areas such as industry and tourism, disaster management and crime prevention, and public services. The city aims to be a clean and healthy city, a carbon-neutral capital, a green and blue capital and the world's best city for cyclists.

Helsinki, Finland, aims to become the most functional city in the world by turning the whole city into a testing site to support the creation of innovative services and products by applying digital technology as well as providing services under the concept of City as a Service.

Source: Copenhagen Connecting (n.d.[47]), *Copenhagen Smart City: The Challenge*, https://www.almanac.in-jet.eu/downloads/M2M_Workshop_Presentations/Session%204/Mia_Copenhagen_smart_city_2015.pdf; Helsinki Partners (2020[48]), "A smart city saves time and produces better services", https://www.myhelsinki.fi/en/business-and-invest/invest/a-smart-city-saves-time-and-produces-better-services.

A national policy framework may guide smart city strategies for development and facilitate the adoption of smart city initiatives at the local level. This could be an explicit smart city policy or an implicit objective immersed in broader policy objectives. In countries with explicit smart cities, a smart city national

framework (SCNF) in place would normally include a vision for the cities and a plan to maximise their potential through the use of technologies.

The SCNF may also incorporate a diagnosis of how the national government understands national and local challenges, the division of responsibilities across all levels of government contributing to the development of cities and how government action could promote investment and growth. The aim of an SCNF is to ensure co-ordinated action and approaches in public investment at the city level across levels of government. Even when there is no established national smart cities framework, the national government can provide resources or other kinds of support to regional and local governments and their stakeholders (ITF, 2020[22]).

Some countries do not have an explicit national policy framework for smart cities. In this case, countries need to leverage complementarities and co-ordination with other national policies. Building synergies and avoiding a duplication of efforts to ensure better efficiency and effectiveness is key in the implementation of smart city strategies, as smart city goals cut across different domains.

The existence of an SCNF may help empower and guide local governments in the identification of their main assets, needs and opportunities. The SCNF is not a way for national governments to prescribe policy or select needs and courses of action on behalf of local governments: it simply helps them to do so. In fact, subnational levels regularly inform national policy of government and, thus, the SCNF should reflect the diverse challenges that cities face (ITF, 2020[22]). In Italy, for example, the Strategy for Digital Growth was developed based on the capability of municipalities to identify social and economic challenges and smart city solutions to meet people's needs.

The SCNF may also include a comprehensive set of tools for cities to develop their smart city strategies, including principles, standards and guidelines. For example, Japan's basic concept of smart city initiatives is based on three "basic philosophies" and five "basic principles" (Box 1.7). Both highlight the importance of data in achieving the objectives of a smart city initiative. A critical element is the utilisation of data among cities, which requires governance frameworks to ensure the interoperability of data-sharing platforms for other cities to be able to access and use openly available data. Interoperability may be understood as the ability of organisations to interact in view of mutual goals, sharing information and knowledge through the exchange of data via their ICT systems (see Chapter 2). The development of smart cities in Japan depends on the co-ordination of strategy, a reference architecture, guidebooks, the development of standards and PPP platforms (Figure 1.4).

Box 1.7. Japan's basic concept of smart city initiatives

Three basic philosophies

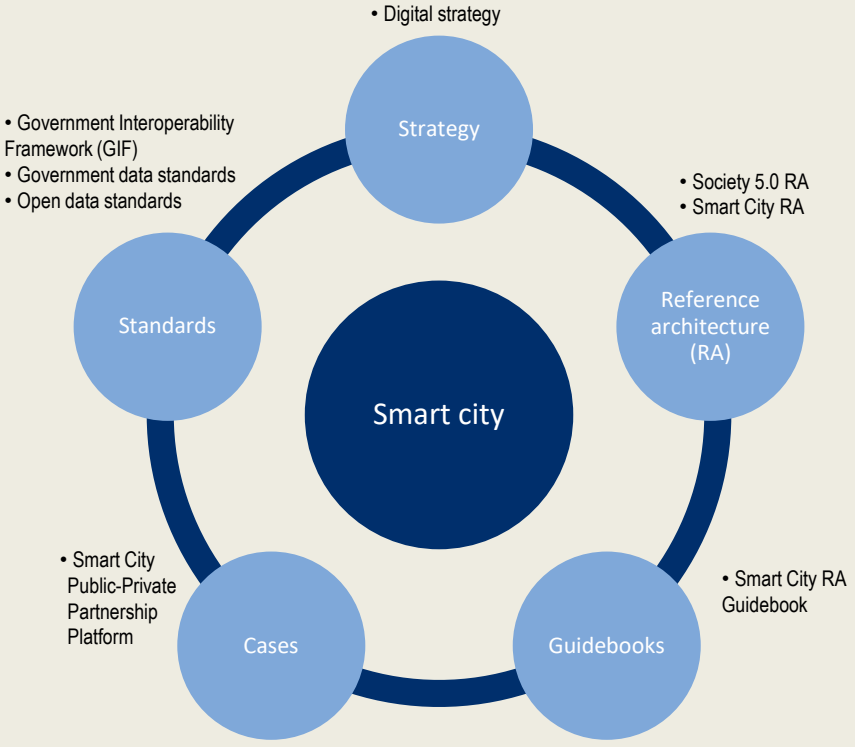
1. **Being resident (user)-centric** – Improve well-being, take the standpoint of residents and respect their independent activities.
2. **Being vision-challenged focused** – Attach importance to solving challenges and realising visions, going beyond the sole use of technology.
3. **Attaching importance to collaboration among sectors/cities** – Attach relevance to cross-sectoral data linkage and cross-regional collaboration to address compound or cross-regional challenges.

Five basic principles

1. **Ensuring fairness and inclusiveness** – To allow all residents to enjoy services equally and all entities to participate.

2. **Ensuring privacy protection** – To ensure the protection of residents' privacy in utilising their personal data.
3. **Ensuring operational and financial sustainability** - To realise a sustainable smart city that takes root in the community.
4. **Ensuring security and resiliency** – To protect privacy and prepare for emergencies, including natural disasters.
5. **Ensuring interoperability, openness and transparency** – To ensure the interoperability of the data platform, an open data distribution environment and transparency of the decision-making process.

Figure 1.4. Elements underpinning smart city development in Japan



Source (figure): Hiramoto, K. (2022[49]), "Smart cities in Japan", PowerPoint presentation given to the OECD team, Tokyo.
Source (box): Japanese Cabinet Office (2022[50]), "Japan's Smart Cities", Presentation to the OECD, Secretariat of Science, Technology and Innovation Policy.

Where it exists, an SCNF introduces an articulated public agenda for smart cities in a given country and provides a framework to index smart city initiatives. For example, in 2020, the Brazilian federal government adopted the Brazilian Charter for Smart Cities (*Carta Brasileira para Cidades Inteligentes*), the country's SCNF. Its main purpose is to support the promotion of sustainable urban development standards taking into account the Brazilian context of digital transformation in cities. For this, it seeks to integrate the urban development and digital transformation agendas under environmental, urban, social, cultural, economic, financial and digital sustainability perspectives. An innovation of the charter is that it introduces a definition of a smart city that considers the reality, diversity and complexity of the country's cities (Box 1.8).

Box 1.8. Brazil's Charter for Smart Cities

The Brazilian Charter for Smart Cities is a democratic political document that expresses a public agenda for the digital transformation of cities. It defines Brazilian smart cities as "[c]ommitted to sustainable urban development and digital transformation, in their economic, environmental, and sociocultural aspects that act in a planned, innovative, inclusive, and networked manner, promote digital literacy, governance, and collaborative management and use technologies to solve real problems, create opportunities, offer services efficiently, reduce inequalities, increase resilience and improve the quality of life of all people, ensuring the safe and responsible use of data and information and communication technologies" (Government of Brazil, 2021, p. 8[51]).

The charter constitutes a concept that guides, informs and supports subnational governments in the design and implementation of smart city projects and programmes. It is based on five guiding principles and six guiding directives.

Table 1.1. Guiding principles and directives of Brazil's Charter for Smart Cities

Guiding principles	Guiding directives
A systemic view of the city and the digital transformation	Stimulate community protagonism
Environmental conservation	Promote sustainable urban development
Public interest above all	Collaborate and establish partnerships
Respect for Brazilian territorial diversity in its cultural, social, economic and environmental aspects	Build up answers to local problems
Integration of urban and digital fields	Promote education and digital inclusion
	Decide based on evidence

The principles and directives structure 8 strategic goals implemented through 163 recommendations for action directed to key audience segments:

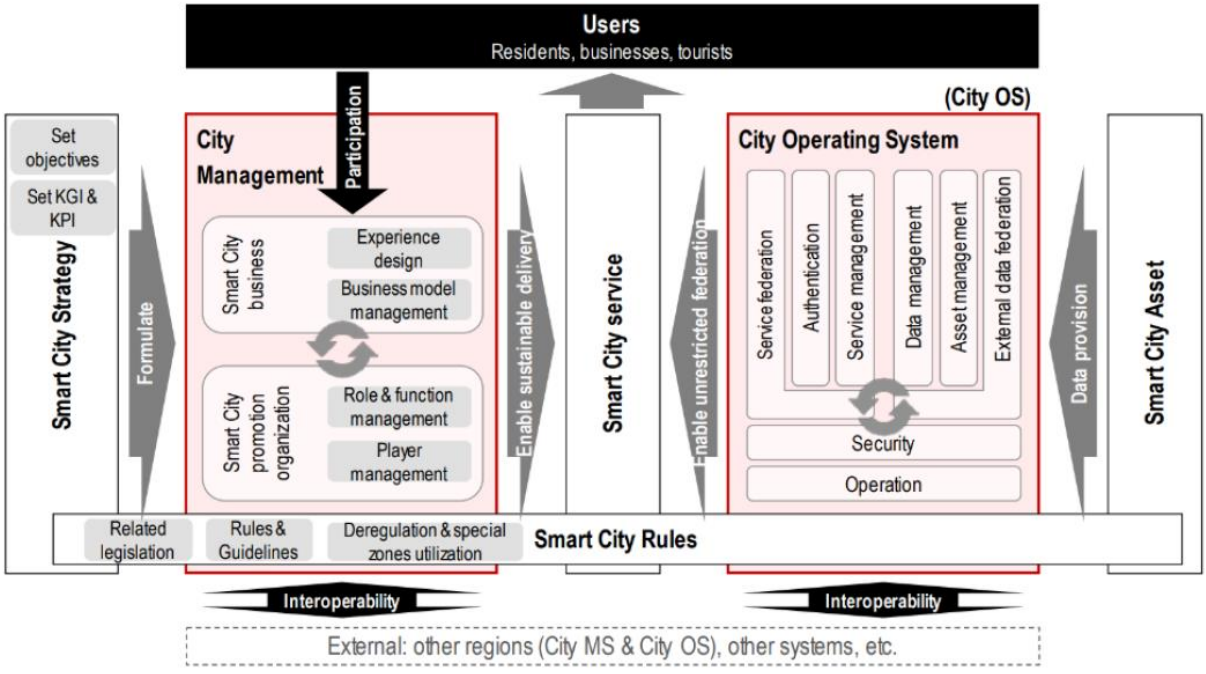
1. Integrate transformation into sustainable urban development policies, programmes and actions, respecting diversities and considering the inequalities present in Brazilian cities.
2. Provide equitable quality Internet access for all.
3. Establish data and technology governance systems with transparency, security and privacy.
4. Adopt innovative and inclusive models of urban governance and strengthen the role of public authorities as managers of the impact of digital transformation in cities.
5. Foster local economic development in the context of digital transformation.
6. Stimulate sustainable urban development financing models and instruments in the context of digital transformation.
7. Foster a massive and innovative movement in public education and communication for greater engagement of society in the process of digital transformation and sustainable urban development.
8. Build up means to understand and evaluate, continuously and systematically, the impacts of digital transformation in cities.

Source: Government of Brazil (2021[51]), *The Brazilian Charter for Smart Cities*, https://www.gov.br/mdr/pt-br/assuntos/desenvolvimento-urbano/carta-brasileira-para-cidades-inteligentes/The_Brazilian_Charter_for_SmartCities_Short_VersionFinal.pdf.

In Japan, the Smart City Reference Architecture (SCRA) guides the development of smart cities under a common structure (see Annex 1.A and Figure 1.5). This is to ensure a common framework for the development of smart cities, share experiences, provide guidance to areas with no experience and ensure data compatibility among systems to facilitate data sharing (Government of Japan, 2020[16]). The SCRA intends to provide a common ground for all of the different smart city initiatives across the country, facilitating interoperability.[21] This is of critical importance as private sector organisations may be reluctant to invest in smart city projects where there is restricted technology integration. Differences in technical standards among different local governments could prevent an expansive scale, that is the development of more smart city projects across the country.

All public and private stakeholders involved in the development and implementation of smart city initiatives in the country are encouraged to keep the four principles in consideration while working on their smart city projects. The SCRA in Japan was developed through the Cross-ministerial Strategic Innovation Promotion Program (SIP). The use of the SCRA is expected to prevent smart city initiatives from becoming standalone efforts, making it easier to enable the repurposing of outcomes and the interoperability between cities and between domains.

Figure 1.5. Foundational components of Japan's SCRA



Source: Government of Japan (2020[16]), *Smart City Reference Architecture White Paper*, https://www8.cao.go.jp/cstp/stmain/a-whitepaper1_200331_en.pdf.

One of the expected benefits of using a common architecture for the development of smart city initiatives in Japan is what is called a "cross-sectional data federation". By federating (or centralising) data from individual services for citizens, Japanese authorities expect to develop a one-stop service for citizens and private sector stakeholders. Cross-domain federation of data would facilitate linking and analysing the data of other cities to understand the characteristics of one's own community and lead to the creation of unique local businesses. Inter-domain federation of data would enable data use across different domains, making it possible to, for example, advance disaster prevention measures by combining government hazard maps, road traffic records in private sectors, satellite images, meteorological data, etc.

Cities establish specific strategies as a roadmap for becoming a smart city. Following national guidance, local governments tend to adopt a specific smart city reference framework that describes the landscape of IoT usage across the city and provides a long-term vision of the future of the city. A local strategy normally includes the governing principles that will guide the formation of the smart city and that must be observed by all projects implemented under this framework. The principles structure the city's approach to IoT usage and act as a guidepost for the analysis, recommendations and actions set in the strategy. The strategy should be based on a reflection of the city's challenges and opportunities and how the usage of (digital) technologies can help to meet the city's needs and its vision. For example:

- In France, the city of **Paris** developed a strategy entitled *Smart and Sustainable – Looking ahead to 2020 and Beyond* that presents the major opportunities and challenges of becoming a smart city but also the main objectives, projects and tangible actions (Mairie de Paris, 2020[3]). The strategy shows the city's main assets, the progress made so far and the action to transform Paris into an open, connected and sustainable city.
- In the United States, **New York City** developed the New York City Internet of Things Strategy that describes the efforts the city has made to increase local governance and co-ordination as well as the steps the city needs to follow to make the most of the IoT technologies to increase levels of well-being (Box 1.9).

Box 1.9. New York City Internet of Things Strategy

In March 2021, New York City, United States, published its Internet of Things Strategy to establish a set of critical near-term actions toward creating a healthy, cross-sector IoT ecosystem in the city – one that is productive, responsible and fair. The strategy is built around six key principles: governance and co-ordination; privacy and transparency; security and safety; fairness and equity; efficiency and sustainability; and openness and public engagement.

The strategy identifies a range of challenges and opportunities in fostering a healthy IoT ecosystem. For example, within city government, there is room for improvement in building the capacity to use and innovate with IoT, fostering collaboration among agencies, boosting partnership opportunities across sectors and strengthening governance and co-ordination throughout the city. In the private and non-profit sectors, the strategy has identified opportunities to support industry standards and best practices around IoT, co-ordinate emerging workforce and IoT literacy needs, and support local economies and communities. The strategy suggests there is greater potential for engagement and empowerment of residents in their interactions with IoT across society as consumers, residents or workers.

To address these issues and meet the development gaps, the strategy outlines five broad goals for near-term city action:

- Foster innovation by creating structures and programmes that support research, testing and experimentation with IoT technologies. Key actions include: the launch of a rapid IoT data collection programme and the development of a municipal testbed.
- Promote data sharing and transparency around city IoT use by engaging residents in IoT initiatives and aggregating information and data from the city's actions to make them available across agencies and for the public. Key actions include: the launch of a Smart City Catalog to share information publicly about city projects and request community's feedback on the strategy.
- Improve governance and co-ordination of the city's use of connected technologies through new policies and processes. Key actions include: the launch of a Smart City Collaborative for City agencies and a biannual IoT forum for city agencies; and a citywide IoT device inventory.

- Derive value from cross-sector partnerships by supporting and pursuing new opportunities for collaboration. Key actions include: setting up an online channel calling for expressions of interest from academic, community and industry partners, subject to city procurement rules.
- Engage with industry and advocate for communities by creating new channels for exchange and advocating for digital rights. Key actions include: conducting research to better understand the need for IoT skills among local employers.

Source: NYC Government (2021[52]), *IoT Strategy - The New York City Internet of Things Strategy*, https://www1.nyc.gov/assets/cto/downloads/iot-strategy/nyc_iot_strategy.pdf.

Private companies like Hitachi in Japan have developed their own vision of smart cities (Box 1.10). Hitachi is looking to build digital smart cities using data from people and cities. The company aims to ensure the secure exchange of data held by public and private institutions and link it with Japan's My Number identification system. The way Hitachi envisages digital smart cities as part of the infrastructure of society involves establishing both urban management and an urban OS for the appropriate handling and use of personal information.

Box 1.10. Hitachi – Creating digital smart cities through data

Hitachi, a manufacturing company in automotive systems, construction machinery and defence systems, seeks to create digital smart cities to improve quality of life using digital technologies (IoT and AI) for the co-creation of people-centric services that add value. Its vision of a resilient digital smart city entails the use of digital technologies to create a people-centric society that integrates the real and cyber worlds and maintains a stable economy and way of life.

The higher complexity of urban infrastructure and its maintenance, along with the shortage of human resources with equipment maintenance skills, has led Hitachi to focus on supplying expertise in IT and operational technology (OT) (e.g. elevators and escalators, surveillance cameras and air conditioning systems) through global businesses in the form of Infrastructure as a Service (IaaS). IaaS serves as a platform for digital services that provide people with places where they can live and work in comfort while maintaining economic viability taking the environment into account.

To create digital smart cities, Hitachi collects, analyses and utilises the various forms of data held by cities to provide services for improving people's quality of life and the services for urban management that underpin that way of life. The urban OS, developed by the national Cabinet Office, will be seminal in the creation and deployment of new services for overcoming societal challenges (e.g. ageing population). The OS facilitate the use of cross-industry data as it improves operational compatibility through system interconnectivity and the exchange of data held by government agencies and private sector businesses across different sectors and industries. Hitachi is testing smart city initiatives through co-creation with different stakeholders that include local and national governments, private sector businesses and academia.

Source: Nakano, H. et al. (2021[53]), "Hitachi digital smart cities featuring continuous value creation by people and digital technology", https://www.hitachi.com/rev/archive/2021/r2021_01/01a01/index.html.

Institutional arrangements for smart cities

A central body co-ordinates the implementation of the SCNF

The adoption of an SCNF requires specific governance arrangements for its implementation. One of these arrangements is the designation of a central administrative body responsible for co-ordinating the implementation of the SCNF (Table 1.2). According to OECD work on digital government, setting up an organisation in charge at the centre signals the highest political support for the digital government agenda and provides the opportunity to mainstream digitalisation in the public sector modernisation strategy (OECD, 2021[54]). There is no rule about who is better positioned to lead the SCNF; this depends on the particular administrative arrangements of every country and the main focus of the strategy. For example, the Swiss Federal Office of Energy (SFOE) leads the Smart City Switzerland strategy because it focuses on areas of smart environment and intelligent mobility. In Canada, Infrastructure Canada is the lead body for smart cities due to the large focus on infrastructure investments to build cities, promote innovation and enhance quality of life. In Japan, the Digital Agency may be considered the lead body as the focus is on strengthening the digitalisation of the country.

Table 1.2. Examples of administrative bodies in charge of SCNFs

Country	Smart city-related initiatives	Administrative body in charge	Other administrative bodies involved
Argentina	Services and Digital Country (*Servicios y País Digital*)	Under-Secretariat of Open Government and Digital Nation within the Office of the Chief of Cabinet	Ministry of Transport, Ministry of Environment and Sustainable Development, Ministry of Education
Australia	Smart Cities Plan	Department of Infrastructure, Transport, Regional Development, Communications and the Arts	
Brazil	Internet of Things Plan	Ministry of Science, Technology, and Innovation	Ministry of Economy, Ministry of Health, Ministry of Regional Development
Colombia	Sustainable Smart Cities and Territories	Ministry of Information Technologies and Communication	Ministry of Housing, City and Territory
Germany	Smart City Dialogue platform	Federal Ministry for Housing, Urban Development and Building	
Japan	Smart City Public-Private Partnership Platform	The Council for Science, Technology and Innovation (CST) in the Cabinet Office, Ministry of Internal Affairs and Communications, Ministry of Economy, Trade and Industry, Ministry of Land, Infrastructure, Transport and Tourism, Digital Agency	Ministry of the Environment, Local governments
Korea	3rd Smart City Comprehensive Plan (2019-2023)	Ministry of Land, Infrastructure and Transport	Ministry of Science and ICT, Ministry of Trade, Industry and Energy
Switzerland	Smart City Switzerland	Swiss Federal Office of Energy (SFOE)	
United Kingdom	Smart Cities	No one department leads	Department for Business, Energy and Industrial Strategy, Cabinet Office, Department for Digital, Culture, Media and Sport, Department of International Trade, Department for Transport, Ministry of Housing Communities and Local Government, Centre for the Protection of National Infrastructure

Source: Argentina: Argentinian Government (n.d.[55]) *Servicios y País Digital*, https://www.argentina.gob.ar/jefatura/innovacion-publica/servicios-y-pais-digital; Australia: Australian Government, (2016[56]), *Smart Cities Plan*, https://www.infrastructure.gov.au/sites/default/files/migrated/cities/smart-cities/plan/files/Smart_Cities_Plan.pdf; Brazil: Government of Brazil (n.d.[57]), *Decreto nº 9.854, de 25 de Junho de 2019*, http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2019/decreto/D9854.htm; Colombia: Government of Brazil (n.d.[58]), *Ciudades y Territorios Inteligentes*, https://gobiernodigital.mintic.gov.co/portal/Iniciativas/Ciudades-y-Territorios-Inteligentes/; Germany: German Government (n.d.[59]), "Smart Cities: Urban development in the digital age", https://www.bmi.bund.de/EN/topics/building-housing/city-housing/national-urban-development/smart-cities-en/smart-cities-en-node.html; Japan: Digital Agency (n.d.[60]), *Homepage*, https://www.digital.go.jp/en/, 25 January 2023; Korea: Smart City Korea (n.d.[61]), *Homepage*, https://smartcity.go.kr/en/, 26 January 2023; Switzerland: SwissCom (n.d.[62]), *Human Smart City*, https://www.swisscom.ch/en/about/innovation/smart-city.html; United Kingdom: Smart Cities UK (n.d.[63]), *Homepage*, https://smartcityuk.com/ 20 January 2023.

However, no single ministry or agency alone can implement the strategy. As Table 1.2 shows, in some countries, numerous national ministries contribute to smart city efforts. In the United Kingdom, no single department leads the implementation of the Smart City plan, as the implementation of the latter depends on the efforts of different departments across the national government that have a direct or indirect impact on the achievement of smart city goals. Some countries, such as Japan, have created specific agencies to lead digitalisation efforts, including by guiding the development of smart cities in co-operation with relevant ministries.

Countries use partnerships to strengthen their smart city initiatives

Smart city policy frameworks generally outline ways in which governments can build partnerships and co-ordinate activities and investments with the private sector, stakeholders from non-governmental organisations (NGOs), academia and the community as a whole. According to research, the private sector largely participates in smart city projects in a sort of PPP, which "…consist of mutual adjustments and long-term relationships aiming to define and achieve common goods, such as the reduction of carbon dioxide emissions, economic growth, and industrial development" (Pianezzi, Mori and Uddin, 2021[64]). For example:

- In 2019, the national government of **Brazil** introduced the National Chamber of Cities 4.0 as part of the Internet of Things Plan to bring together a wide array of stakeholders from the private sector, academia and governments to discuss the best technologies to serve people and cities. The Ministries of Regional Development (MDR) and Science, Technology and Innovations (MCTI) co-ordinate the Chamber. This forum aims to raise the quality of life in cities through the adoption of technologies and practices that enable the integrated management of services for citizens and the improvement of mobility, public security and use of resources (Government of Brazil, 2022[65]).
- In 2016, **Germany's** federal government set up the Smart Cities Dialogue Platform to address the opportunities and challenges of digitalisation for urban development and identify the opportunities and risks of digital technologies at the local level. The platform is composed of 70 experts from municipalities, district and local authorities, federal ministries, state ministries for urban development, research organisations and civil society. Participants developed a mutual understanding of the values and goals for smart cities comprised in the Smart City Charter and elaborated guidelines and recommendations for action supporting its members in their implementation (Government of Germany, n.d.[66]).
- In **Japan**, the Smart City Public-Private Partnership Platform was established in 2019 with the aim of accelerating smart city initiatives, with companies, universities and research institutions, local authorities and relevant ministries and agencies as members. As of 2022, there were 931 participating organisations. The platform is engaged in providing priority support for smart city projects by government agencies, organising subcommittees on issues and themes faced by members, supporting information sharing and matching among members such as companies, universities, research institutions and local authorities, and promoting the spread of smart cities

both domestically and internationally.[22] Moreover, the Smart City Institute Japan (SCI-Japan) is a private sector-led non-profit organisation founded by thinktank Mitsubishi UFJ Research and Consulting and newspaper company Nikkei in 2019. It was created as a knowledge and public-private-academic partnership platform to promote the expansion and advancement of smart cities in the country. Since its creation, SCI-Japan has expanded rapidly, showing that there is a high demand for smart cities in Japan. Currently, SCI-Japan has over 490 members and reached 500 members in 2022. Members of the institute are from various organisations, such as national government ministries, corporations, universities and non-profit organisations. Among its tasks, SCI-Japan collects, analyses and shares the latest information on the world's leading smart cities and know-how for promotion, formulates proposals and advice on the promotion of smart cities and facilitates the exchanges of knowledge and networking between various entities related to smart cities. For the promotion of smart cities, SCI-Japan develops training programmes for Smart City Architects, develops and promotes key performance indicators (KPIs) for liveability and well-being, and promotes the use of My Number Card (Smart City Institute Japan, 2022[67]).

- The **United States** federal government set up the Smart Cities and Communities Task Force to co-ordinate federal action and partnerships with academia, industry, local cities and communities to enable cities of all types to access networking and information technologies and services (ITF, 2020[22]).
- In 2023, in the **Netherlands**, the national government introduced an initiative called Dutch Metropolitan Innovations (DMI) as a PPP to facilitate the sharing and use of data in a responsible manner through mutual trust and open standards. The DMI ecosystem aims to accelerate the rollout of data-driven solutions for major societal challenges that currently beset the country, such as providing affordable housing, transport solutions and a sustainable environment. The partnership is composed of the Dutch business community, knowledge institutes, municipalities (including the 45 of the largest cities in the country), provinces and the national Ministries of Infrastructure and Water Management and of the Interior and Kingdom Relations under a joint set of agreements (see Box 2.29) (Government of the Netherlands, 2023[68]).

The experiences of Brazil, Germany and the United States suggest that building smart cities is a collaborative effort of different national-level bodies in co-operation with local governments, the private sector, academia and civil society. This requires sound governance arrangements that facilitate co-ordination, communication and the implementation of national policy across all levels of government.

Partnerships for smart cities are also created at the local level. Leading smart cities worldwide have designated a specific organisation to lead and co-ordinate the different stakeholders (e.g. local governments, private sector corporations, universities and research institutions, local businesses and residents) in smart city projects. These public-private joint councils or consortia are designed as permanent organisations with full-time staff. They not only arrange meetings but roll out smart city initiatives by utilising the funding and know-how of the public and private sector stakeholders participating in the project. Amsterdam Smart City is an example of an initiative to build partnerships for smart city projects in a wide variety of areas (Box 1.11).

Box 1.11. Amsterdam Smart City

Amsterdam Smart City is the innovation platform of the Amsterdam Metropolitan Area. It is a partnership between businesses, authorities, research institutions and residents. The city's residents have a central role in all projects and initiatives so that ideas and solutions for the city are created together. The Amsterdam Smart City initiative aims for sustainable economic growth, efficient use of natural resources and high quality of life. Amsterdam Smart City has grown to be a platform with over 100 partners active

in more than 70 innovative projects. It challenges companies, citizens, the municipality and knowledge institutions to submit and apply innovative ideas and sustainable solutions to urban challenges. Areas of interest for developing projects, ideas and new business models are smart housing, open data, smart grids, home energy storage, connectivity and smart mobility.

Source: Discover Amsterdam (n.d.[69]), *Amsterdam and Partners*, https://www.iamsterdam.com/en/our-network/municipal-government/amsterdam-smart-city#:~:text=The%20aim%20of%20the%20Amsterdam,storage%2C%20connectivity%20and%20smart%20mobility.

Data and standardisation for smart cities

For data to be shared effectively, a comprehensive common standard or a unified ontology (i.e. understood as a definition of concepts and their relationships) must be developed and adopted across the board to handle data from different sources and fields. The problem is that multiple service providers and government organisations oversee city management in cities. Separate programme offices and operation units generate data and use communication systems that are not connected by a common membership or structure. The different components of the smart city ecosystem are managed independently and evolve on their own, making it harder to share data and enhance policy co-ordination and pursue a common vision for the smart city. For example, it is common to find a surveillance system deployed by city police, an ambulatory system deployed by hospitals and e-governance systems developed by a municipal government, all developed and operating independently based on the specific objectives of their managing organisation. In Canada, for example, provincial governments have oversight of digital identification (ID) and rules governing data vary in each province and territory. This may complicate the sharing of information among jurisdictions (SCC, 2021[70]).

Countries are developing smart city standard frameworks to facilitate data sharing and management. In the United Kingdom, for example, the British Standards Institution (BSI) developed PD 8100 as the British standard for guiding the planning and implementation of smart city strategies and providing guidance on the applicability of smart city approaches to smart cities. It covers the role of data and technology in the development of smart cities. Standards are based on good practice from successful smart city initiatives. The BSI framework categorises standards into three main levels:

- **Strategic level (level 1)** – Standards at this level aim to provide guidance to city leadership (i.e. anyone in a strategic position within a city whose decisions have an impact on how the city functions) and other bodies on the process of developing a clear and effective overall smart city strategy. They guide the identification of priorities, the development of a roadmap for implementation and the monitoring and evaluation of the strategy.
- **Process level (level 2)** – Standards focus on procuring and managing smart city projects, particularly on those that cross organisations and sectors through best practices and associated guidelines.
- **Technical level (level 3)** – Standards cover the myriad technical specifications that are needed to implement smart city products and services and contribute to the general objectives of the smart city strategy and vision (BSI, 2015[20]; Lea, 2016[71]).

The PAS 181 Smart City Framework (SCF), developed by the United Kingdom (UK) Department for Business, Innovation and Skills, highlights good practices for city leaders to develop, agree and deliver smart city strategies that can help transform their cities' ability to meet current and future challenges. Current innovative practices are distilled into consistent and repeatable patterns that cities authorities can use to develop and deliver their own strategies. It does not present nor provide a one-size-fits-all model for the future of cities but stresses the enabling processes by which the use of data and technology together with organisational change can assist diverse cities to become more efficient, effective and sustainable.

The SCF emphasises the importance of leadership and governance, culture, business model innovation and how a diverse array of stakeholders can take part in the creation, delivery and use of city spaces and services (BSI, 2022[72]).

In India, the Bureau of Indian Standards (BIS) has developed a data exchange framework to facilitate data management and regulate their use. The Data Exchange Framework describes the data reference architecture, interfaces of data exchange components and the usage cases that are enabled in the smart city ecosystem. It constitutes a set of services that enables the consumption of resources, such as data by a consumer from one or more resource servers, based on explicit consent obtained from the provider of the resources (BIS, 2019[73]). It covers a catalogue of services that provides a framework to manage metainformation about resources, authorisation services to manage the authorisation to access resources and the service that provides a standardised way to access resources.

In Canada, the Standards Council of Canada (SCC) established the Canadian Data Governance Standardization Collaborative in 2019. The collaborative is a group of 220 actors across government, industry, civil society, Indigenous organisations, academia and standards development organisations. The purpose is to accelerate the development of industry-wide data governance standardisation strategies. Standardisation is regarded as a tool to support innovation and ensure companies remain competitive. In 2021, the SCC issued the Canadian Data Governance Standardization Roadmap (SCC, 2021[70]), which describes the current and desired standardisation landscape and makes 35 recommendations to address gaps in the field and explore new areas where standards and conformity assessment are needed. The roadmap intends to use standardisation to build trust and increase confidence in government's data management. This framework does not refer to the development of smart cities per se but provides valuable lessons on how standards can be developed and the issues that need to be taken into account, such as identifying key challenges and setting priorities.

In general, the case of Canada, India and the United Kingdom show that there should be increased standardisation of data rules to facilitate greater interoperability across the country, including cities. It is essential that standards are aligned across jurisdictions. Standards should be the result of a collaborative effort of actors from different domains and be built on the experience of national and local actors in developing standards as well as smart city best practices. Common terminology and definitions should be agreed upon to ensure that all actors speak the same language. Standards should also outline the roles and responsibilities of the various entities involved in the data exchange ecosystem. Data governance practices should be adapted to the different sizes and types of organisations and, in particular, cities. Standards should be updated regularly, adapting to changes in the context where smart cities operate.

Moreover, the International Organization for Standardization (ISO), a worldwide federation of national standards bodies, has developed a set of standards for smart cities and communities. The objective is to provide a series of evaluation axes and indicators to measure the state of cities worldwide. ISO 37122: "Sustainable cities and communities – Indicators for smart cities" provides a set of indicators for measuring the performance of cities across a number of areas.[23] It allows them to draw comparative lessons from other cities around the world and find innovative solutions to the challenges they face. ISO 37122 complements ISO 37120: "Sustainable cities and communities – Indicators for city services and quality of life", which outlines measurements for evaluating a city's service delivery and quality of life.[24] ISO 37122 and ISO 37120 also intend to assist cities in achieving the United Nations Sustainable Development Goals by assessing their performance.

ISO 37122, when used in conjunction with other indicators, intends to help cities implement smart city policies, programmes and projects to address challenges such as climate change, ageing populations and economic instability, among others. The indicators are designed to use data and digital technologies to improve public services and quality of life, and promote sustainability in a more innovative manner. ISO 37122 is composed of 15 sectors covering areas from economy, education, energy, environment and

climate change to housing, public transport, water and urban planning. Table 1.3 provides a summary of the indicators included in ISO 37122.

Table 1.3. Indicators for smart cities assessment - ISO 37122

Sector	Indicators
Economy	Data disclosure policies, new business continuity, workers in the ICT field, worker in the education, research and development (R&D) areas
Education	Expert, infrastructure for digital studies, higher education
Energy	Electricity and heat energy, the use of wastewater, the use of solid waste, electricity generated from a decentralised system, storage capacity of energy networks, existing lighting for streets, lights that have been damaged and renewed, buildings damaged, building with energy measuring device, electric vehicles charging stations
Environment and climate change	Buildings renovated, long-distance air quality monitoring stations, building with quality of air meters
Finance	Annual financial gain, electronic payment
Government	Online access data, online services, response time, IT infrastructure
Health	Integrated online health file, medical appointments, accessibility public warning system
Housing	Use of energy gauges, Use of water gauges
Population and social conditions	Building for special needs, budgeting for special needs, budgeting for the digital divide
Recreation	Recreational services
Security	Municipalities with digital monitoring cameras
Solid waste	Waste disposal centres, individual waste collection systems, waste for energy production, recycled plastic waste, waste disposal with sensors, electronic and electrical waste
Sports, culture	Online custom and cultural infrastructures, culture registered, publicity books and electronic book titles, member of a mass reading room
Telecommunication	Accessibility to broadband, areas with no telecommunications connectivity
Transportation	Traffic information and alerts for road users, use of transportation, transportation equipment, total number of bicycles, public roads with real-time system facilities, online public transportation services, public parking spaces, information about parking availability, traffic signals, area mapping, autonomous transportation facilities, bus mass transit, road facilities for autonomous driving purposes, motorised public transport
Urban/local agriculture and food security	Budget for agrarianism and food, leftover food, online food supplier mapping system
Urban planning	People involved in the planning process, building permits through the electronic delivery system, time required for building permit approval, population densities
Wastewater	Wastewater reuse, biosolids reuse, energy derived from wastewater, wastewater use, wastewater pipelines
Water	Drinking water, water monitoring stations, water distribution network, smart water meters

Source: Based on Kristiningrum, E. and H. Kusumo (2021[74]), "Indicators of Smart City using SNI ISO 37122:2019", https://doi.org/10.1088/1757-899X/1096/1/012013.

ISO 37150 series and other standards developed under ISO TC 268/SC 1 and SC 2 dealing with "Smart community infrastructures and transportation" are useful resources for smart cities investment and development, in particular as regards infrastructures. While ISO/37151:2015: "Smart community infrastructures – Principles and requirements for performance metrics" defines the metrics to evaluate the "smartness" of community infrastructures, ISO/37153:2017: "Smart community infrastructures – Maturity model for assessment and improvement" provides a methodology to assess smartness maturity of community infrastructures. Moreover, ISO 37155-1 and -2 provide a framework for the integration and operation of smart community infrastructures, which can be used for the lifecycle management of smart cities. ISO 37160:2020 is a unique standard that specifies measurement, reporting and verification (MRV) for low-carbon operations of power generation plants. Other types of standards cover IT infrastructure,

mobility and transportation, and resilience and disaster reduction for smart cities and communities. Table 1.4 provides a summary of the standards developed by ISO TC 268/SC 1 and SC 2.

Table 1.4. ISO standards on smart community infrastructures and mobility

Type of standards	Standards activities
Metrics and indicators	ISO/TR 37150:2014 Smart community infrastructures – Review of existing activities relevant to metrics
	ISO/37151:2015 Smart community infrastructures – Principles and requirements for performance metrics
	ISO/37153:2017 Smart community infrastructures – Maturity model for assessment and improvement
Smart mobility and transportation	ISO 37154:2017 Smart community infrastructures – Best practice guidelines for transportation
	ISO 37157:2018 Smart community infrastructures – Smart transportation for compact cities
	ISO 37158:2019 Smart community infrastructures – Smart transportation using battery-powered buses for passenger services
	ISO 37159:2019 Smart community infrastructures – Smart transportation for rapid transit in and between large city zones and their surrounding
	ISO 37161:2020 Smart community infrastructures – Guidance on smart transportation for energy saving in transportation services
	ISO 37162:2020 Smart community infrastructures – Smart transportation for newly developing areas
	ISO 37163:2020 Smart community infrastructures – Smart transportation for parking lot allocation in cities
	ISO 37164:2021 Smart community infrastructures – Smart transportation using fuel cell light rail transit (FC-LRT)
	ISO 37165:2020 Smart community infrastructures – Guidance on smart transportation with the use of digitally processed payment (d-payment)
	ISO 37167:2021 Smart community infrastructures – Smart transportation for energy-saving operation by intentionally driving slowly
	ISO 37168:2022 Smart community infrastructures – Guidance on smart transportation by Electric, Connected and Autonomous Vehicles (eCAVs) and its application to on-demand responsive passenger services with shared vehicles
	ISO 37169:2021 Smart community infrastructures – Smart transportation by run-through train/bus operation in/between cities
	ISO 37180:2021 Smart community infrastructures – Guidance on smart transportation with QR code identification and authentification in transportation and its related or additional services
	ISO 37181:2022 Smart community infrastructures – Smart transportation by autonomous vehicles on public roads
	ISO 37182:2022 Smart community infrastructures – Smart transportation for fuel efficiency and pollution emission reduction in bus transportation services
	ISO 37184 Sustainable mobility and transportation – Framework for transportation services by providing meshes for 5G communication
Development framework	ISO/TR 37152:2016 Smart community infrastructures – Common framework for development and operation
	ISO 37155-1:2020 Framework for integration and operation of smart community infrastructures – Part 1: Recommendations for considering opportunities and challenges from interactions in smart community infrastructures from relevant aspects through the life cycle
	ISO 37155-2:2021 Framework for integration and operation of smart community infrastructures – Part 2: Holistic approach and the strategy for development, operation and maintenance of smart community infrastructures
Power generation	ISO 37160:2020 Smart community infrastructure – Electric power infrastructure – Measurement methods for the quality of thermal power infrastructure and requirements for plant operations and management
Information sharing and exchange	ISO 37156:2020 Smart community infrastructures – Guidelines on data exchange and sharing for smart community infrastructures
	ISO 37170:2022 Smart community infrastructures – Data framework for infrastructure governance based on digital technology in smart cities
	ISO/TS 37172:2022 Smart community infrastructures – Data exchange and sharing for community infrastructures based on geographic information
	ISO 37166:2022 Smart community infrastructures – Urban data integration framework for smart city planning (SCP)
Resilience and disaster reduction	ISO/TR 6030:2022 Smart community infrastructures – Disaster risk reduction – Survey results and gap analysis

Source: ISO (n.d.[75]), *Standards by ISO/TC 268/SC 1: Smart Community Infrastructures*, www.iso.org/committee/656967/x/catalogue/p/1/u/0/w/0/d/0; ISO (n.d.[76]), *Standards by ISO/TC 268/SC 2: Sustainable Cities and Communities – Sustainable Mobility and Transportation*, www.iso.org/committee/8742800/x/catalogue/.

Table 1.5 shows that there is a wide range of standard activities related to smart cities. This list is not intended to be comprehensive but provides an overview of the different international standards that can be used for the development of smart cities and inform data governance. All these standards can be used to inform the process of developing a smart city and data strategy, guide the process of implementation of smart city projects and provide technical guidance on the implementation of smart city projects.

Table 1.5. Classification of standards activities related to smart cities

Type of standards	Standards activities
Strategic: Standards aimed at the process of developing a clear and effective overall smart city strategy	ISO/TC 268 Sustainable cities and communities. It includes indicators related to the development of requirements, frameworks, guidance and supporting techniques and tools for the sustainable development of smart cities considering smartness and resilience. It intends to help all cities and communities and their interested parties in both rural and urban areas become more sustainable (ISO, 2012[77]).
	ISO/37120:2014 Sustainable development of communities – Indicators for city services and quality of life. It defines and establishes methodologies for a set of indicators to steer and measure the performance of city services and quality of life. It is applicable to any city or local government that measures its performance in a comparable and verifiable manner, regardless of its size and location (ISO, 2014[78]).
	The World Council on City Data (WCCD) has developed three standards on city data known as the WCCD ISO 37120 Series on City Data. The series includes: • ISO 37120 - Indicators for Sustainable Cities, which provides cities with quantitative, globally comparable and independently verified local-level data to measure and compare their social, economic and environmental progress. • ISO 37122 - Indicators for Smart Cities, which provides indicators to measure progress, drive smart city investment, drive city-to-city learning and create tools for benchmarking. • ISO 37123 - Indicators for Resilient Cities, which intends to assist cities in preparing for, recovering from and adapting to shocks and stresses (WCCD, n.d.[79]).
	BS 8904:2011 Guidance for community sustainable development. It supplies guidance and recommendations to help communities of any size, structure and type to improve their sustainability (BSI, 2011[80]).
	ISO 37150 series and related standards cover infrastructures for smart cities, including indicators, mobility, power, IT and resilience.
Process: Procuring and managing smart city projects	PAS 181 – Smart city framework standard. Guide to establishing strategies for smart cities and communities. It focuses on the use of technology and data, together with organisational change, to build more efficient, effective and sustainable ways (BSI, 2022[72]).
	PAS 182: 2014 Smart City - Concept Model. Guide to establishing a model for data. It focuses on the implementation of smart city concepts, including the interoperability of systems and data sharing between agencies, and establishes an interoperability framework for smart cities. It describes how to define the meaning of data from many different sectors, such as health, education and transport, to facilitate sharing data and conduct data analysis across different sectors (BSI, 2014[81]).
Technical: Implementing smart city projects	ISO/IEC JTC 1 Information Technology. Smart Cities. It studies and documents the technological, market and societal requirements for the ICT standardisation aspects of smart cities as well as the technologies used to enable smart cities. It makes a proposal on how the standardisation process of smart cities should be addressed (ISO-IEC, 2015[82]).
	IEEE 802.11-2020/Cor 1-2022 Standard for Information Technology--Telecommunications and Information Exchange between Systems. It aims to define one medium access control (MAC) and several physical layers (PHY) specifications for wireless connectivity for fixed, portable and moving stations (STAs) within a local area (IEEE SA, 2022[83]).

Source: The classification of standards activities is based on Lea, R. (2016[71]), "Smart City Standards - An overview. Trying to make sense of Smart City standardization activities", https://urbanopus.net/smart-city-standards-an-overview/ (accessed on 16 January 2023).

Local authorities should review smart city and data projects systematically

To evolve and improve, smart city policies and programmes need continuity and regular updates. The case of Korea suggests that the development of smart cities requires experimentation and adaptation to be able to mature and evolve (Box 1.12). A key lesson is that the development of smart cities requires specific guidelines to facilitate more efficient implementation of high-technology facilities and systems in new towns. Moreover, the governance framework needs to be revised and adapted to make it fit for purpose. For example, sharing data and information across sectors and among cities may be constrained by regulations regarding privacy protection and, to facilitate this data-sharing process, it is sometimes necessary to explore different collaboration and co-operation instruments such as a memorandum of understanding (MoU). However, signing MoUs with individual agencies and local governments may be a long, complex process; therefore, the enactment of a specific law for this purpose could make co-operation for data and information sharing more effective. A legal framework mandating private actors, including citizens, to grant access to data of public interest to the government under conditions of privacy and security may be the way forward.

Box 1.12. The evolution of smart cities in Korea

Since the early 2000s, Korea has pursued smart city programmes and became a pioneer in the adoption of the concept of the smart city. Since then, smart city programmes have evolved and matured as the country gained experience from its pilot projects and reviewed its goals and legal framework. This evolution can be divided into three periods:

- **The construction stage** (2003-13) focused on creating a new growth engine by combining ICT with the construction industry. During this period, smart city development concentrated on new towns such as Dongtan, where ICT was incorporated into urban planning and the government enacted the Act on the Construction of Ubiquitous Cities (U-City Act) in 2008, focused on infrastructure, technology and services, aiming to competitiveness and quality of life.
- **The connecting stage** (2014-16) focused on connecting smart city services and building governance structures. This period focused on the integration of information and systems that used to operate independently from each other, public transport and crime prevention for example. For that purpose, the government developed smart city platforms through national R&D programmes, which provided the technical basis to integrate U-City solutions that local governments had been operating. Smart city governance and regulations were also revised. Korean government bodies signed a series of MoUs to facilitate sharing of information, institutionalise co-operation and build a smart city governance framework.
- **The enhancement stage** (2017-20) focused on innovative smart cities and creating a smart city ecology that incorporated concepts such as citizen participation, sustainable development and better governance into aspects of smart city projects. Moreover, smart cities were considered a key element for innovative job creation as part of the Fourth Industrial Revolution and not just as a way to solve urban problems. In 2016, the U-City Act was revised into the Law for Smart City Creation and Promotion of Industries (Smart City Act) to facilitate the participation of a wider range of stakeholders in smart city projects. Smart cities were not only used to build new cities but to revitalise deteriorating ones, which are now being transformed into smarter environments.

Source: OECD (2018[84]) *Housing Dynamics in Korea: Building Inclusive and Smart Cities*, https://dx.doi.org/10.1787/9789264298880-en; OECD (2020[12]) *Smart Cities and Inclusive Growth*, https://www.oecd.org/cfe/cities/OECD_Policy_Paper_Smart_Cities_and_Inclusive_Growth.pdf.

Stakeholders involved in smart cities and data governance

Smart cities and data governance involve the participation of multiple actors such as national and subnational governments, individuals, organisations and private sector companies that impact smart city projects and the way data are governed. All these actors are key players in the development of smart cities because they not only create and handle data but also benefit from well-governed data. The large number of actors involved in smart cities and, thus, data collection makes it necessary for national and local governments to be clear about the roles and responsibilities of every actor to deliver a successful smart city strategy and ensure the efficient and effective use of data. National and local governments need to address the "politics of data" as many actors may compete to govern data. The reason may be that each of the actors has multiple interests, goals, capacity and strategies. Data governance is not just a matter of rule making and enforcement. It requires social interaction, negotiation and co-operation among a wide range of public and non-public stakeholders (Micheli et al., 2020[85]).

Private sector companies are actively involved in building smart cities

Building a smart city requires the co-operation of many agencies, support by ICT infrastructures and the integration of sustainable development, green growth and collaboration between multi-stakeholders on multiple levels (Kaluarachchi, 2022[86]). Private sector companies are in some cases leading the way in the development and implementation of smart city projects and data collection and management. Their role in data governance tends to focus on protecting and classifying data, securing IT infrastructure, ensuring that data management follows the agreed standards, ensuring the protection of sensitive data and providing technical support for data quality, among others.

National and local governments tend to open up to private sector competition to unleash investment in smart cities. This shows that, in smart cities, the government does not have a leading role or a monopoly on the use of data and digital tools (Franke and Gailhofer, 2021[87]). For example, India's National Smart Cities Mission (NSCM), introduced in 2015, involves the participation of 100 cities. As part of this initiative, cities that complete their projects are intended to serve as demonstrative examples for their peers of the power of incorporating smart city innovations. However, the ultimate goal of these projects is to spark a wave of public-private investment in the further development of smart cities without the need for direct intervention from the central government and, by 2021, the NSCM had sparked USD 24.6 billion in tendered investment from public and private circles for its projects across participating cities (Bajpai and Biberman, 2021[88]).

The advantages of having private sector companies taking a leading role, together with local authorities, in smart city development are access to cutting-edge technology, funding and financial resources (Mirzaee and Sardroud, 2022[89]), highly skilled human resources (UK Government, 2020[90]) and their extensive experience in the technological development field. For example:

- In **Korea**, the central government is promoting smart city development as it is considered one of the major growth engines for the country's economy in the near future. Currently, there are two national test beds, Busan and Sejong, and smaller smart renewable city projects initiated by local and regional organisations (OECD, 2018[84]). The focus areas of the green field developments are water management and robotics in Busan and smart mobility and AI in Sejong. Both the private and public sectors are contributing to smart city projects and together invested approximately KRW 3.7 trillion (USD 3.29 billion) on smart city development in 2021.[25]
- In the **United Kingdom**, the central government acknowledges that collaboration with the private sector is critical in smart city projects, given their complexity (UK Government, 2020[90]). Thus, private technology companies, together with the public sector, lead smart city projects in cities across the country and even abroad due to the technological expertise of their human capital. Companies like Connected Places Catapult in London, Sensor City in Liverpool and the Open

Innovations institute in Leeds, combined with projects like Bristol is Open and testbeds like the Digital Health Living Lab in Brighton, support the UK government's continued investment in its national smart cities vision.

However, partnerships do not only include private companies. Mexico City, for example, is working with a non-profit organisation around earthquake detection.[26] Moreover, private companies alone will not be able to contribute to smart city development, as they require the participation of the public sector's knowledge of the city and of residents' needs. A potential issue is that most of these projects are prototypes and they are generating enough data to be scaled up and improved, but this begs the question of who owns the data generated by these projects.

In Japan, for example, private companies have been active in the promotion, building and implementation of smart city projects. For cities to attract private sector investment, they need to garner local support and this can be obtained when some clear social benefits and projects appeal to businesses' social responsibility goals, such as climate change and ensuring citizens' well-being. For example:

- In 2010, the Japanese government funded the Next-Generation Energy and Social Systems demonstration projects in cities. The cities of Keihanna District, Kitakyushu, Toyota and Yokohama received JPY 126.5 billion for these pilot projects, with two-thirds coming from the national government and one-third from the private sector. Private companies, endorsed by local governments, directed their proposals on energy efficiency projects to the national government (Pianezzi, Mori and Uddin, 2021[64]).
- In 2014, following the completion of these pilot projects, new smart city projects were launched under the FutureCity programme by the national government. The projects were carried out without a solid promise of funding from the central government. However, several projects were launched and, in 2019, the Cabinet Office, the Ministries of Internal Affairs and Communications, of Economy, Trade and Industry and of Land, Infrastructure, Transport and Tourism established the Smart-City Public-Private Partnership Platform. The platform has over 130 projects and more than 300 companies listed.
- Since the Ministry of Economy, Trade and Industry selected the city of Yokohama as part of the Next-Generation Energy and Social Systems Demonstration Area in 2010, the local government has been working with several private companies (e.g. energy-related operators, electronics manufacturers and construction companies) to promote the Yokohama Smart City Project (YSCP), aiming to optimise energy supply and demand balance in urban areas. In 2015, the Yokohama Smart Business Association (YSBA) was established as a public-private co-operation organisation to advance smart city projects and transform Yokohama into an energy-recycling city, resistant to disasters and economically strong, and expand its accumulated technology and experience both inside and outside Japan.[27]

Japanese private companies have also developed a smart city vision in co-operation with real estate companies and local governments. For example, Hitachi, a Japanese multinational conglomerate, aims to use digital technologies to create a people-centric society that integrates the real and cyber worlds and maintains a stable economy and way of life (Nakano et al., 2021[53]). Box 1.13 shows some examples where private companies have been involved in the development of smart city projects in Japan. Although local governments take part in all smart city projects, most of the current smart city projects are entirely initiated and almost entirely funded by private companies, for example the Fujisawa Sustainable Smart Town set up by Panasonic and the Hitachi Smart Industrial Town led by Hitachi (Pianezzi, Mori and Uddin, 2021[64]; Sakurai and Kokuryo, 2018[91]). A key message from those local experiences is that cities need to develop their capability to use technology to benefit from it.

Box 1.13. Examples of private sector involvement in building smart cities in Japan

In the Kanagawa prefecture, the **Fujisawa** Sustainable Smart Town (Fujisawa SST) is a joint project between 18 different businesses, universities, local governments and residential organisations, and opened in 2014. The main feature of the project is to develop a town underpinned by advanced technology-based infrastructure but based on actual lifestyles on a 100-year vision. Electronics company Panasonic targeted areas such as energy, security, mobility, wellness and community. The aim was to reduce carbon dioxide (CO_2) emissions by 70%, reduce water consumption by 30% and have renewable energy account for 30% of the total energy used. The homes were also tested against a magnitude 1.8 times stronger than the Great East Japan Earthquake of 2011.

In the Fukushima prefecture, Accenture, a professional service firm, and the University of Aizu have been working with the authorities of **Aizuwakamatsu City** since 2011 on smart city projects. The local government is promoting smart city initiatives in a wide variety of fields: mobility, commerce, education, healthcare, energy, agriculture, tourism, manufacturing, disaster prevention, government and infrastructure. Accenture, the University of Aizu and local authorities are also promoting horizontal deployment for smart cities in Japan, using the town case as a case study. The University of Aizu has been training data scientists and collaborating with private companies to address the problems of the city.

Near Mount Fuji, Toyota, a Japanese car manufacturer, is building a prototype "city of the future" called **Woven City**. It is set to be a fully connected ecosystem powered by hydrogen fuel cells and is expected to accommodate 2 000 residents and researchers who will test and develop technologies such as autonomous cars, robots, smart homes, etc. All homes will be equipped with the latest in human support technologies, from sensor-based AI that monitors people's health to taking care of basic needs and enhancing daily life. The project is an opportunity to deploy connected technology with security.

The Osaka prefecture faces challenges such as an ageing and shrinking population, the need to revitalise buildings and the threat of natural disasters. Plug and Play, a global venture accelerator, is helping the city of **Osaka** to tackle those issues. The company will carry out an accelerator programme focused on smart life and construction, travel and experiences, urban mobility and clean technology, hospitality and health and will be carried out at Knowledge Capital in Grand Front Osaka in co-operation with Osaka Prefecture and Osaka City.

In the Fukuoka prefecture, the messaging application LINE has been working with **Fukuoka City** to improve services such as residential tax payment, large garbage collection, natural disaster notifications and infrastructure reports; more recently, they introduced LINE Pay's QR code into public facilities and even an umbrella sharing scheme. The aim is to connect local government authorities, companies and residents to solve local problems and create new services through the use of technology.

In the **Takeshiba** district, the Tokyu Land Corporation and the SoftBank Corp. have been working since 2019 on a smart city model case that utilises cutting-edge technology. The project involves the creation of a data distribution platform that enables real-time utilisation of data such as people flows, user profiles, road and traffic conditions, water levels, etc. The aim is to improve mobility, reduce congestion and strengthen disaster prevention.

Source: For all cities: Tokyoesque (2022[92]), "Smart cities in Japan: Practical innovations for conscious future living", https://tokyoesque.com/smart-cities-in-japan/; Fujisawa: Fujisawa SST (n.d.[93]), *About Fujisawa SST*, https://fujisawasst.com/EN/project/; Aizuwakamatsu: Muroi (2021[94]), "Initiatives and vision for Smart City Aizuwakamatsu", Information provided by the government of Aizuwakamatsu City, Aizuwakamatsu, and OECD (2021[8]), *OECD Economic Surveys: Japan 2021*, https://dx.doi.org/10.1787/6b749602-en; Woven City: Toyota (2020[95]), "Toyota to build a hydrogen-powered city of the future", https://mag.toyota.co.uk/toyota-woven-city-hydrogen-power/; Osaka: PRNewswire (2020[96]), "Plug and Play Japan to open its new office "Plug and Play Osaka"", https://www.prnewswire.com/news-releases/plug-and-play-japan-to-open-its-new-office-plug-and-play-osaka-301103175.html; Fukuoka: LINE Fukuoka (n.d.[97]), *Line Smart City for Fukuoka*, https://smartcity.linefukuoka.co.jp/ja/project/smartcityproject?hsLang=ja-jp; Takeshiba: Smart City Takeshiba (n.d.[98]), *Homepage*, https://smartcitytakeshiba.com/ 4 September 2022.

At the national level, the Nippon Telegraph and Telephone Corporation (NTT Group) is participating in the development of smart cities working on urban digital twin computing (DTC) to provide new value by optimising services provided in cities. The objective is to capture environments, objects and people that are associated with each service provided in a community, create their digital twins and use DTC to link the twins across different industries. By combining urban DTC with the four-dimensional (4D) digital platform, which is being developed separately, NTT Group aims to create a data-driven and optimised smart city (Yamamoto et al., 2021[99]). In this way, the value of services made available by service providers in a district is enhanced and offers new services. An additional example is NEC Corporation, a Japanese multinational information technology and electronics corporation, which participates in the elaboration of the city OS platform of several smart city projects. NEC aims to contribute to the revitalisation of city management and resolve local issues by contributing to cross-domain data collaboration.

While countries and cities intend to build a demand-driven and citizen-based smart city ecosystem, they are encountering some barriers. For example, although the participation of private corporations in smart city projects has allowed cities to access their technology and expertise, generally, locally driven initiatives face issues of project scalability and sustainability. Private corporations might not be willing to invest in activities or projects with few prospects of short-term returns and may implement projects that only solve problems partially or focus on specific areas of a city. Certainly, private corporations have limited amounts of R&D budgets and governments must select projects based on available budgets; it is, however, important that each stakeholder consider the opinions and needs of all other stakeholders.

In countries like Japan, private sector corporations participate in smart city projects without the expectation of recouping their investments from the government. According to Pianezzi, Mori and Uddin (2021[64]), local governments' financial contribution to smart cities projects is rather limited in Japan, as their role is to encourage private companies to propose projects aligned with national agendas on issues such as carbon emissions and climate change, and to play a co-ordinating role. Local governments use their image to attract private companies to participate in smart city projects: it is indeed important for private companies to be associated with national and local governments. All smart city projects are experimental in character and revolve around areas such as energy management, transport, crime prevention, etc. Companies are therefore invited to experiment with innovative technologies in cities while contributing to national goals on energy saving and emissions reduction. Companies use this opportunity to test their technologies, establish a space for themselves in the future and sell their technologies on international markets with the central government's support.

Citizens' participation in smart city projects needs to be strengthened

To create value for citizens and society as a whole, governments must be able to access, aggregate and use data about their citizens, including data from private companies. A critical issue in data governance is that using data-based technologies and data analytics for urban public services often means handing over the data and governance of urban environments to private contractors, increasing surveillance of urban spaces and cutting off citizens from the control of and participation in urban planning and governance (Chawla and Divij, 2021[100]). This problem was exemplified in the case of Toronto's Quayside smart city project, where centralised decision-making processes to drive data collection and analysis and the predominance of collaborations with or outsourcing to private actors prevented residents from taking part in decision-making processes on how their data should be managed. This situation led to the project being cancelled. (Box 1.14). Toronto's experience shows the risks of having a weak communication strategy and centralised decision-making processes to drive data collection and analysis or just outsourcing to the private sector without including citizens' views.

Similarly, India's DataSmart Cities strategy (see Chapter 2) and city data policies promote highly centralised information systems, such as the Integrated Command and Control Centers for city surveillance. These initiatives generate data that are treated as the property of specific departments or

offices and executive officials are responsible for deciding what data should be made available, to whom and how but without citizens' involvement. There is no consideration about how city residents might have a say about how and what information about them is generated, processed and shared or how it should be commoditised. This begs the question of the values data governance seeks to promote.

Box 1.14. Toronto's Quayside smart city project

In 2017, Waterfront Toronto, the government agency in charge of developing 800 acres along the city's eastern seaboard, selected Sidewalk Labs, an urban planning and infrastructure subsidiary of Google, as the winner of a public bidding process with a project to develop a 12-acre lot on the waterfront called Quayside as a global hub for urban innovation. The project was intended to create 3 900 direct jobs and a one-time construction impact of CAD 1.6 billion for the Canadian economy. The project included digital technology deployments such as sensors to capture data to inform better decisions in housing and traffic policies, trash management and delivery of other city services, environmentally friendly public transit options including autonomous cars, biking and walking trails, high-speed public Wi-Fi, parks and recreation spaces, and more. It also promised a rigorous data privacy and governance regime and agreed not to sell citizen data without consent unless it was aggregated and anonymised. Sidewalk Labs' project had been selected due to its extensive engagement with local leaders, holding town halls and public roundtable meetings and setting up a residents' panel and advisory boards of local experts to help shape the project.

However, the Quayside project faced opposition because Sidewalk Labs had apparently planned to develop a larger area than that originally contemplated. Residents and local leaders became suspicious after the press reported in 2019 that Sidewalk Labs had plans that extended beyond Quayside to a much larger area estimated at 350 acres. That bigger plan included opportunities to generate revenues from real estate development and advisory services, financing for a light rail extension and underground infrastructure on that property. Press articles brought about concerns about how big companies could use their influence and power in a way that could damage democracy and public interest. As a result, a social media campaign against the project erupted. In June 2019, Sidewalk Labs released its Master Innovation Development Plan for the Toronto project to show full disclosure. The plan aimed to create an Innovative Design and Economic Acceleration (IDEA) District – not contemplated in the original agreement – in 2 phases over 20 years, including a 67-acre parcel called the River District, and trigger private investment of CAD 38 billion. The project promised some 93 000 jobs, including 44 000 full-time direct jobs, 34 000 housing units, of which 40% would be at below-market rates, CAD 4.3 billion in annual tax revenue and CAD 14.2 billion in annual gross domestic product (GDP) for Canada. However, after the publication of the plan, Waterfront Toronto's Digital Strategy Advisory Panel raised many concerns over the Sidewalk Labs project. In 2020, Sidewalk Labs decided to terminate its participation in the project.

In 2022, a new plan for Quayside, called Quayside 2.0, developed by a group of international architects, was published. The new project promotes a hybrid notion of an urban neighbourhood as natural and manmade.

Source: Sidewalk Labs (2017[101]), *Toronto Tomorrow: A New Approach for Inclusive Growth*, https://www.torontopubliclibrary.ca/detail.jsp?Entt=RDM3820301&R=3820301; Wachter, S. (2019[102]), "What's fueling the smart city backlash?", https://knowledge.wharton.upenn.edu/article/whats-behind-backlash-smart-cities/; Jacobs, K. (2022[103]), "Toronto wants to kill the smart city forever", https://www-technologyreview-com.cdn.ampproject.org/c/s/www.technologyreview.com/2022/06/29/1054005/toronto-kill-the-smart-city/amp/; Chown Oved, M. (2019[104]), "Google's Sidewalk Labs plans massive expansion to waterfront vision", https://www.thestar.com/news/gta/2019/02/14/googles-sidewalk-labs-plans-massive-expansion-to-waterfront-vision.html.

Moreover, citizens only provide and allow access to data when they trust actors in charge of data management. Citizens are wary about how city governments and big technology companies involved in smart city projects track and collect data about their daily activities and the selling of data without their consent. Big data are intrinsic to smart cities and, invariably, they create concerns over data privacy and security.

The experience of Vancouver, Canada, suggests that smart cities engage the broad public in the city-making process, leading to better answers and deeper public ownership of their future (Toderian and Glover, 2014[105]). Citizens not only use public services provided via the different applications and smart technologies: they are the main producers and providers of data (Franke and Gailhofer, 2021[87]). Citizens' participation could be promoted through the organisation of online town hall events to engage citizens via social media outlets (e.g. Facebook, X [formerly Twitter]) for scheduled time periods, allowing the use of smartphones to access city services such as waste collection schedules, recreation services and locations, and building inspections (e.g. Surrey in Greater Vancouver, Canada), the creation of participatory consensus-building platforms (e.g. the city of Kakogawa, Japan) and expanding online consultation.

Smart city governance frameworks need to be flexible enough to combine top-down policies with bottom-up initiatives on smart city development. So far, existing governance frameworks are, in general, rather rigid as local governments are largely executors of central governments' policies.

Living labs are being used to involve citizens in smart city projects. They are innovation ecosystems in real-life environments that use iterative feedback processes to create sustainable impact by focusing on co-creation, rapid prototyping, testing and scaling up innovations and citizens (Box 1.15).[28]

Box 1.15. Examples of living lab projects in OECD cities

- In **Milan**, Italy, the San Raffaele Hospital (HSR) has set up the City of the Future Living Lab as a virtual and real research environment and community. The lab is managed and organised by eServices for Life and Health, a department of HSR specialised in the application of ICT to health. The aim is to develop and deliver services to the hospital's infrastructure and foster innovation across numerous domains and disciplines. Several stakeholders and partners work together and share knowledge in a wide variety of ICTs, creating a fertile ground for innovation and cross-disciplinary research and communication.
- In the city of **Bodrum**, Türkiye, the Bodrum Living Lab aims to create economic and social value by developing, prototyping, testing and implementing innovative products and services related to agriculture, tourism, well-being, health and maritime verticals developed in co-ordination with its stakeholders.
- In **Saint Etienne**, France, the Design Creative City Living Lab involves users at an early stage of the development phase of the innovation process by creating a trusted environment where small and large business stakeholders can meet to test out innovative products, services and business models. It also provides a platform for exploring societal and policy goals related to ICT and human-adapted design innovation in an urban context.
- In **Copenhagen**, Denmark, the local government has authority over childcare, primary education, senior citizens' welfare, healthcare and public services. To facilitate dialogue with citizens and promote innovation, local authorities created the Copenhagen Solutions Lab as an incubator for smart city initiatives to develop smart city projects. The Copenhagen Solutions Lab identifies and co-ordinates smart city needs across the municipality's departments and matches them with existing knowledge and solutions on the market. In this way, the lab acts as a bridge between external partners and the local government's initiatives concerning smart city

development. Through collaborations with the research community and the market, the city gains access to the innovation power that is needed to create new and effective urban solutions.

Source: For Milan: Ospedale San Raffaele (n.d.[106]), *Advanced Technology in Health and Wellbeing*, https://research.hsr.it/en/search/index.html?q=eservices+; For Bodrum: Bodrum Living Lab (n.d.[107]), *Homepage*, https://bodrumlivinglab.com/en/home/, 8 December 2022; For Saint Etienne: Cité du Design (n.d.[108]), *Pôle Entreprises & innovation à destination des entreprises*, https://www.citedudesign.com/archives/fr/entreprises/; For Copenhagen: Nordic Smart City Network (n.d.[109]), *Copenhagen Solutions Lab*, https://nscn.eu/Copenhagen.

Challenges to promote smart cities and data governance

The development of smart cities provides an opportunity for the use of real-time data with the ultimate goal of solving critical urban problems. However, the effectiveness of digital solutions and technology-led innovations depends on access to data from a wide variety of sources, raising questions on data ownership, privacy, storage and security of data.

Governing data in smart cities may be fraught with regulatory and management challenges

With smart cities collecting massive amounts of generally heterogeneous data, local policy makers are challenged to determine what data are necessary and sufficient to ensure the functioning of smart city projects. Rules need to clarify how and when data can be collected and shared. Data management is subject to specific regulations and may vary depending on whether it is about personal or corporate data, data collected through digital technologies or data provided by citizens. Furthermore, smart city projects are subject to specific regulations depending on their domain of operation, such as transport, telecoms, water or energy supply. Moreover, smart city data prompted concerns about consent to capture, process and store data. Data that identify a particular individual (i.e. location, health records, daily activities) belong to that person but they can be legally shared or accessed if the entity receiving it has a legitimate reason. Local governments and private companies may act as data controllers or processors as part of their smart city projects but the challenge is to make sure they comply with the legislation to avoid breaching the law and being challenged on their data use.

National and local governments have enacted vast legislation to ensure adequate management of data and data safety. Technological innovations call for more guidance to clarify the reach of new technology developments and explain to individuals how they can protect their data more effectively. However, excessive regulation may hamper efforts to protect data and ensure privacy. Most countries have issued general regulations to protect data and personal information but this general regulation is also supplemented with secondary laws and guidelines that regulate data and information in specific domains. Data privacy protection and data security are particularly sensitive to excessive regulation, given that the latter may impact trust in data management practices and smart city projects. Appropriate regulation and the rule of law can strengthen trust but excessive regulation has the opposite effect when it makes it harder for public and private organisations and companies to comply with fragmented pieces of legislation. Over-regulation may also threaten the capacity of cities and their city OS to collect, store and share data. For example, regulations may require cities or partners to store large amounts of data that must be reported, which in turn will create a data overload and lead to high costs of maintaining large amounts of data.

The funding and financing mechanisms of smart city and data projects also largely impact their success. Funding is at the heart of any smart city investment project; the challenge is that cities rarely have enough resources to invest in smart city projects and require resources from other government and private sector

levels. Ensuring enough funding demands cities to be skilful in using different budget streams to build synergies among several investment programmes and to be flexible enough to collaborate with neighbouring cities to ensure sufficient financial resources. The experience of India's National Smart City Mission (NSCM) suggests that design flaws in the financing mechanisms have a negative impact on the capacity of the city to meet the deadlines in the implementation process and undermine the trust among partners (Box 1.16). A smart city requires clear rules about funding and flexible-but-solid budgetary practices that facilitate the movement of resources among programmes and across jurisdictions.

Box 1.16. Funding smart city projects in India

In 2015, the national government of India introduced the National Smart City Mission (NSCM) to fund smart city projects in 100 cities across the country. Cities were invited to submit smart city project proposals for funding. Once a city was chosen through a competitive process, it was required to set up a special-purpose vehicle (SPV) to co-ordinate financing and implementation.

To obtain funds from the national government and matching funds from the state government, the SPV was required to obtain the remainder of funding via other means: municipal bonds, land use conversion charges, user fees, synergies with other programmes, sale of government assets and private sector participation. However, the SPVs found managerial, technical and financial difficulties in implementing and completing projects according to the project timeline due to delays in the disbursement of funds from the national and state governments. Part of the reason for the delays was the failure of cities and states to mobilise the counterpart funding required according to the guidelines of the NSCM.

Moreover, the siloed competitive grant process prevented projects from building synergies within or between cities. The Urban Local Bodies (ULBs) in charge of developing the project proposals proposed projects that are more likely to obtain funding than those that respond to cities' development priorities. Another problem was that the definition of what constitutes a smart city was blurred, leading to inefficient use of resources.

Projects funded under the umbrella of the national smart city strategy do not necessarily fit into what is considered "smart" as they lack the technological and data elements. For example, In India, the city of Agra used the funds granted under the NSCM to build handicraft training centres for traditional embroidery; the city of Coimbatore invested in developing food kiosks, open plazas and fountains; and Prayagraj installed a plastic-to-diesel conversion plant. There was no metric to ensure that individual projects selected for funding met cities' needs apart from being aligned to the NSCM's goals.

Source: Bajpai, N. and J. Biberman (2021[88]), "India's Smart City program: Challenges and opportunities", https://csd.columbia.edu/sites/default/files/content/docs/ICT%20India/Papers/ICT_India_Working_Paper_62.pdf.

Across OECD countries and cities moving towards smart city initiatives, data, and in particular big data,[29] are expected to unleash innovation to solve social, economic and environmental challenges. However, a key challenge is that data are still often stored in silos. For example, data from sensors monitoring vehicles and pedestrian movements may not mean much unless they are combined with other types of data, such as weather and road conditions. Releasing data from silos and sharing them may enhance their value and produce social and economic benefits.

Governing and managing data require the involvement of different actors that might often have conflicting interests due to their different roles in creating positive outcomes. Citizens' concerns derive from their role as voters, consumers, employees, students, drivers, etc. City administrations perform the functions of a decision-maker, law enforcement body, data donor, etc. Private sector bodies (i.e. enterprises) have a role as job creators, investors, data generators and providers and business makers. All these different interests

must be reconciled to be able to benefit from data-enabled projects and manage possible risks that data management entails. Governing smart city data should thus focus on the co-ordination of all these actors on an organisational and technical level (von Grafenstein, Wernick and Olk, 2019[110]). In the public sector, the data strategies of the different levels of government may not always be sufficiently linked (e.g. those of national governments and those of local and regional governments), which may prevent the creation of synergies.

Sharing data and information across city departments and among cities is another challenge for smart data governance. In general, each government and each city agency typically have their own silo of confidential or public information. In some cases, they are reluctant to share what might be considered proprietary data. In addition, some data may be governed by certain privacy conditions that make them hard to share across different entities. The challenge for smart cities is finding ways to prevent or reduce the barriers to seamless information sharing and exchange among different stakeholders (Al Nuaimi et al., 2015[111]). Many countries, such as Germany and the Netherlands, face difficulties in combining and analysing data from the mobility, housing and urban planning domains, and the development of data-intensive applications is lagging behind. Moreover, it is not always easy to locate data sources and users. The experience of the city of Vienna, Austria, suggests that knowing what data are available and who is responsible for them is a key challenge in the implementation of the local data strategy (see Chapter 2). For this, the city government has set up a data catalogue, which includes technical data descriptions available on the intranet and is currently being developed into a data map.

In many cases, smart city applications use data from a variety of sources, including IoT devices as well as data from multiple industries or platforms and some require cross-industry data aggregation. Thus, smart city projects require governance protocols that facilitate sharing of data in a dynamic manner. Initiatives such as the LinkNYC programme in New York City, which focuses on replacing payphones with Wi-Fi-enabled kiosks, require inputs from three different companies to provide data, hardware and network capabilities.

Data sharing could uncover problems with refinancing. Public sector data tend to be open and made available for minimal prices or even free of charge, making it difficult for public sector bodies to refinance all of the processes of data collection, reproduction, transfer, dissemination and storage, limiting the possibilities of investing in innovative digital applications. The free transfer of data from public sector bodies to private companies may result in global companies benefitting from open data approaches, as they will be able to generate benefits without any need to co-operate with the public data holder. This discourages the establishment of viable data co-operation and corresponding business models. Moreover, making data available to third parties could be costly and administratively cumbersome due to the need for bilateral tailor-made agreements, or data sharing should be conducted via a central platform, which could lead to a loss of control over one's own data.

Adherence to traditional administrative processes may hinder the use of data and, in consequence, digitalisation. Japanese cities, for example, are shifting from a stage of competition for investment and recognition, working in isolation and short-term strategies, to one of co-operation and a long-term development vision. However, unwieldy procurement processes, fragmented administrative systems and dependency on legacy systems could hinder these efforts.

Equipping vulnerable groups (e.g. the elderly, low-skilled workers) with basic digital skills is becoming a key policy priority for countries and cities as it can boost their opportunities to benefit from services offered in smart cities. The reason is that digital skills are permeating societies and labour markets across all jobs ad sectors, not only ICT-related occupations. The *OECD Skills Outlook 2019* report found that 15% of adults lack basic digital skills and 13% lack basic digital, numeracy and problem-solving skills, while 14% of jobs on average are likely to be automated in the coming years (OECD, 2019[112]).

Smart city data are prone to security and privacy risks

A critical issue for smart cities and data strategies is to protect people's privacy, as data collection may disclose sensitive information. Protecting people's data privacy is a complex domain as several interrelated privacy forms need to be considered. For example, identity, bodily, territorial, locational and movement, communications and transactions privacy are some of the privacy forms that can be threatened and breached, producing different forms of harm to individuals (Kitchin, 2016[23]). In the context of smart cities, privacy may be understood as "…the preservation of the information that is collected, processed and disseminated that relates to an individual's person, behavior, habits, communication, location, associations or feelings" (Curzon, Almehmadi and El-Khatib, 2019, p. 78[113]). Data governance succeeds when data protection and action are both realised and balanced and when the benefits are equitably distributed.[30]

Smart city national frameworks (SCNFs) should enhance data protection. Smart cities need to access and use big data but the latter also raise privacy concerns. The SCNFs generally stress the importance of managing data with care, ensuring the security and privacy of individuals. Countries enact legislation on data protection that supports SCNFs and data strategies in their quest to protect the security of data and the privacy of individuals. In Canada, for example, smart city projects need to comply with the Personal Information Protection and Electronic Documents Act (PIPEDA) (Privacy Commissioner of Canada, 2019[114]). In the European Union, between July 2018 and April 2023, 1 616 fines amounting to around EUR 2.7 billion were handed out to different individuals (mostly large high-technology companies) for not complying with General Data Protection Regulation (GDPR) (CMS, 2023[115]). The most common violations have been the insufficient legal basis for data processing, not complying with general data processing principles, insufficient technical and organisational measures to ensure information security and insufficient fulfilment of data subjects' rights.

Across countries and the research community, a large part of discussions on data governance focuses on data sharing and access, considering that data keep flowing internally/externally in the process of collecting and using data. These flows necessarily entail issues of what is being shared and accessed by whom, which involve both the *source* of data (i.e. concerns about privacy, competitiveness, etc.) and the *destination* (i.e. openness and ownership). Table 1.6 summarises the risks of data sharing into four items. While trust/privacy and transaction costs concern difficulties and errors in realising data sharing due to technological and regulatory limitations, competitive concerns and lost financial opportunity are more fundamental scepticism about the usefulness of sharing data.

Table 1.6. Four risks of data sharing

Trust and privacy	Fear of data misuse and concerns about privacy and security
Transaction costs	Technological and procedural difficulties
Competitive concerns	Fear that surrendering strategic data will lead to loss of value or competitive advantage
Lost financial opportunity	Unrealised opportunity from not recognising downstream value, misallocating value among participants or neglecting opportunities to develop end-to-end data services

Source: Based on Candelon, F. et al. (2020[116]), "Simple governance for data ecosystems", https://www.bcg.com/publications/2020/simple-governance-rules-for-data-ecosystems.

Some of the data governance agendas focus on overcoming technological limitations in implementing control measures. For example, data anonymisation is considered an essential step to ensure privacy and security and needs to be done prior to sharing data. However, countries such as Australia have concluded that there is no such thing as anonymisation because there is no complete guarantee that individuals in datasets considered anonymised cannot be found. Research has also pointed out that complete anonymisation, to the extent that it does not harm the usefulness of data, is essentially impossible in many fields (von Grafenstein, Wernick and Olk, 2019[110]). Efforts to embed the anonymisation in the data

collection stage, i.e. anonymisation by design, could also be hampered (PwC, 2019[117]). A more accurate term than anonymisation would be de-identification of data according to the New South Wales, Australia, Government Data Strategy (NSW Government, 2021[118]).

To protect data privacy, smart city technologies request the notice and consent of users to collect their data. However, researchers argue that this could be an empty exercise due to issues of datafication, inference, repurposing and even opacity (Kitchin, 2016[23]). Citizens do not always have the time, knowledge and awareness to manage their own data in an informed manner. In many instances, citizens provide their consent for their data to be collected and used without realising the extent and consequences this may have for them and society as a whole. In general, privacy policies are more a liability disclaimer for businesses than assurances of privacy for citizens (Tene and Polonetsky, 2013[119]). Certain digital technologies, such as smartphones applications do not even request consent for data collection and application developers may even change the terms and conditions without notice.

The re-identification of anonymous data is another potential threat to privacy. Smart cities use digital technologies that promise the anonymisation of data using pseudonyms or aggregation. However, new computational techniques can make the re-identification of data a straightforward exercise. Inference and linking the pseudonyms to other accounts and datasets means that it is possible to re-identify individuals unless data are completely de-identified, which is rarely the case (Kitchin, 2016[23]). Research has shown that using a generative model of data re-identification, 99.9% of Americans would be correctly re-identified in any dataset using 15 demographic attributes, even in heavily sampled anonymised datasets (Rocher, Hendrickx and de Montjoye, 2019[120]).

Sharing and repurposing data in a way that was not originally intended are an additional threat to data privacy. In smart cities, data are collected for a specific purpose and use, and retained for only as long as needed but this cannot always be guaranteed. The reason is that data markets seek to generate large volumes of data to extract additional value (Kitchin, 2016[23]). Data can be repackaged, sold and repurposed in different ways that are different to the original purpose of the data collection exercise without the need for people's consent. Data repurposing is likely to breach data privacy laws and have an impact of citizens' life.

Data management should determine the extent and details of data control. While it is essential to prevent vulnerabilities, excessive control might undermine the usefulness and efficiency of data. Many factors may determine the relative benefits and loss of (loosening) control, such as domain characteristics, perceptions of the types of data (personal/impersonal), and technologies and tools used (van Zoonen, 2016[121]). The UK National Data Strategy acknowledges the risks of using data. When data are misused, it could harm people or communities, nurturing people's mistrust. Equally, misplaced government reluctance to securely share and use data undermines the performance of public services and risks causing harm by missing opportunities to help those most in need. Moreover, unnecessary barriers to technological innovation could drive inefficiencies and slow down growth (UK Government, 2020[122]).

The relative benefits and losses are also affected by situational factors. For example, the COVID-19 crisis has become a catalyst for loosening control of privacy for public interests. Many countries, including Australia and the United Kingdom, have initiated data-sharing practices between different departments of the public sector as well as between the public and private sectors to curb the spread of the disease (Hickman, Pierson and Comstock, 2021[123]). While the UK government has shared data from the National Health Service with technology companies to develop a COVID-19 database, in Australia, the New South Wales government has analysed the impact of the pandemic and benefitted from anonymised transaction data provided by a bank. Some countries have adopted trusted third-party systems that make decisions regarding the opening/closing of data on a case-by-case basis, rather than setting up a universal rule (Delcroix, 2017[124]). While this method can increase flexibility and maximise benefits, it may raise other concerns, such as who should constitute the party and where the party should be positioned within the hierarchy of decision-making entities (von Grafenstein, Wernick and Olk, 2019[110]).

Data governance also concerns data protection from rule violations and cyberattacks. The European Union implemented the GDPR, which entails severe penalties for data breaches – fines of up to 4% of annual revenue.[31] As a result, major companies such as British Airways, Google, H&M and Marriott were charged massive fines for personal data violations. For example, in Japan, the handling of personal information in smart city projects must comply with the 2003 Act on the Protection of Personal Information (APPI) (Government of Japan, 2003[125]) and other laws.

Each domain of smart cities has different cybersecurity concerns. For instance, Ma (2021[126]) has identified security-related challenges of smart buildings, which include concerns related to smart meter functions or vulnerabilities found in the process of communicating with smart grids, such as changing or repeating consumption messages. Other than domain-specific concerns, cybersecurity challenges derive from the integrative and communicative characteristics of smart cities. In other words, integration/communication between the physical and cyber worlds, between old and new systems/platforms, across various domains entails vulnerable intersections (Pandey et al., 2019[127]).

The lack of digital skills and capacity for data management at the national and local levels weakens data governance in smart cities

The shift to a digital society requires an increase in the capacity to use and manage data. More generally, public and private sectors' digital skills (i.e. the ability to find, evaluate, use and create content and value using digital devices),[32] capacity, talent and knowledge are core elements of good data governance and of broader public sector reforms, including digitalisation and fostering innovation. National and local governments need to ensure data literacy in relation to urban development as one of the required staff capabilities (BBSR, 2021[128]). Developing a digitally savvy public workforce requires a cultural change supported by a holistic strategy that encourages a more flexible and adaptable working environment; enables staff to adopt a more proactive approach to change and identifies and develops the necessary talent and skills needed for the proper functioning of the public sector (OECD, 2021[129]). The recruitment of data-savvy staff should be a key part of cities' recruitment and training strategies.

In countries like Brazil, Colombia, Estonia, India, Japan and the United Kingdom, a key problem in enhancing digitalisation and data management has been the lack of access to skilled, qualified experts in data management and analytics, particularly in small local governments. A part of the problem is competition with the private sector: people who are highly trained in data and technology may prefer to work there (i.e. banking, retail, etc.) for the more competitive salaries. The public sector, thus, must compete to access those skills.

In some countries, there is also an insufficient supply of smart city architects or experts. Cities need professionals who work as producers and co-ordinators of smart city development and have knowledge of digital technologies, regulation, business models and local government affairs (Valtasaari, 2022[130]). The lack of such professionals is preventing cities from guiding the development and management of smart city projects. Smart city architects should work with urban planners in close co-operation with subject matter experts, citizens and national and city authorities. In countries like Colombia, Japan, Mexico and many others, there is a lack of institutions that train and form a wider pool of smart city (data) experts and allow the creation of networks that help secure enough professionals for the future. In India, for example, cities did not invest in building the capacity of the different stakeholders to engage with the data flows generated by project infrastructure, diminishing the impact of the data (Bajpai and Biberman, 2021[88]). Bridging the capacity gaps would require setting up collaboration frameworks among cities and, in some cases, support from the national government would be needed.

According to estimates of the European Commission for 2019, the number of data professionals in the member countries of the European Union (EU27) plus the United Kingdom reached 76 million (3.6% of the total workforce), an increase of 5.5% over the previous year. However, there is an imbalance between the

demand and supply of data skills, with a data skills gap of 459 000 unfilled positions in the EU27 plus the United Kingdom, which amounts to 5.7% of total demand (EC, 2020[131]).

Digital skills are critical for enabling economic growth across all sectors of the national and local economies, not only the ICT sector. The lack of access to a workforce with the necessary digital skills is a problem for both the public and private sectors. In the United Kingdom, for example, 23% of employers consider their workforce lacking basic digital skills and 37% say they lack advanced digital skills (WorldSkills UK, n.d.[132]). In the public sector, the UK government estimates that 90% of senior civil servants need to be upskilled in digital and data essentials as the government lacks the digital skills to support digital transformation (Aldane, 2022[133]). In Japan, there are around 1 700 local governments of different sizes in the country and the small ones in particular do not have access to skilled specialists in data management. In large cities like Tokyo, the smart city industry provides large amounts of data that can be used by the numerous businesses installed in the metropolitan area. However, in smaller municipalities with shrinking populations, there are no businesses that could make use of data published by local governments. Access to technology is not necessarily a challenge for Japanese local governments but access to specialists is. According to the IMD World Digital Competitiveness report (IMD, 2022[134]), Japan has a low rate of digital talent (those who master technologies and transformation expertise), with only 1% of the workforce with adequate skills. And this limited digitalisation is also reflected in the digital maturity of the government, as Tokyo, for example, ranked only 84 in the IMD Smart City ranking in 2021 and the digital adoption rate is only 7.5% (Broeckaert, 2022[135]).

The OECD (2019[136]) has concluded that the lack of data-related skills is a challenge across all policy sectors and may prevent the effective reuse of data, even if made available via open access. While data skills refer to the full range of basic, technical, governance and other skills needed by practitioners to maximise the usefulness of data, technical skills range from programming, data visualisation, analysis and database management to core skills such as problem solving, project management and communication.[33] Investing in digital and data skills is more important than ever to build resilient and inclusive smart cities as well as to provide public and private organisations with the right workforce to adjust to an ever-changing world. Different actions have been taken to diagnose the problem and suggest solutions, for example:

- In **Japan**, a critical element of the Data Strategy is the human resource management aspect in all elements of the architecture to ensure capacity. Thus, Japan's strategy aims to develop the digital human "resoudigital" (resource and digital) transformation of local companies and industries, and ensure that all staff in government (national and local) have the fundamental digital skills and that there are sufficient professionals to analyse data and design.
- In **New Zealand**, the government requires skills for digital leadership, data analysis, cybersecurity specialists and architects (New Zealand Digital Skills Forum, 2018[137]). In 2017, the New Zealand Digital Skills Forum conducted a survey to understand the demand for digital skills in the public and private sectors. The results showed that both the public and private sectors underinvest in the development of digital skills of their staff due to the perceived available time and the difficulty of prioritising training above business-as-usual activities (New Zealand Digital Skills Forum, 2018[137]; OECD, 2019[25]). Estimates suggest that there is a need to double digital leadership capacity across government in the short term and additional investments are needed in critical skills such as cybersecurity and service delivery.
- **Estonia**'s Digital Agenda promotes innovation in the field of online governance, cybersecurity and information society; therefore, it includes actions and investments in the development of advanced ICT skills for the public sector and fosters digital literacy and lifelong learning for all citizens. The aim is to increase the ability of public sector institutions to capitalise on the benefits brought by innovative solutions in the ICT field.[34] The main goal of Estonia's Digital Agenda is to create a well-functioning, safe and secure environment which has the capacity to develop and create the innovative ICT solutions that Estonian society and economy need (EC, 2021[138]). To this end, the strategy puts emphasis on the development of digital skills for all citizens and for ICT professionals

(Box 1.17). This is of key relevance in a country where 99% of all government services are provided on line, 99% of the population has an electronic ID and 98% of medical prescriptions are issued digitally.[35] The message from Estonia's experience is that the government needs to focus not only on the skills of government officials but also on those of citizens who are the final intended beneficiaries of digital services. In addition, funding research and skills development of ICT professionals should be part of a national data strategy.

Box 1.17. Key actions for developing the digital skills of citizens and ICT professionals in Estonia

Actions for developing citizens' digital skills:

- Improving the quality of public services, together with user experience with the aim of facilitating access to public services and spread awareness of their advantage to build digital citizenship skills for everyone.
- Increasing the ability of public sector institutions to capitalise on the benefits brought by innovative solutions in the ICT field.
- Fostering lifelong learning and digital literacy and bridging the digital skills gap through increased awareness of ICT solutions' impact on quality of life, well-being, use of public services and others.
- Enhancing the uptake of digital identity and services amongst foreign nationals and expanding the national e-Residency programme.

Actions for developing the digital skills of ICT professionals:

- Organising networking events and workshops as well as partnerships between IT managers and service providers to improve knowledge and co-operation.
- Promoting the development of advanced digital skills in traditional sectors.
- Developing and implementing sector-specific ICT strategies and allocating additional state funding for IT development.
- Introducing measures to improve knowledge flows and skills transfer between mid- and top-level employees in the public and private sectors.
- Supporting the management and implementation of ICT development projects through the national government's guidance and quality requirements.
- Increasing funding for research in the field of connectivity, 5G technology, AI, cybersecurity and big data.

Source: EC (2021[138]), *Estonia - Digital Agenda for Estonia 2020*, https://digital-skills-jobs.europa.eu/en/actions/national-initiatives/national-strategies/estonia-digital-agenda-estonia-2020.

- **London**'s experience also suggests that one way of attracting talent and skills is to explain the social impact of working in certain roles in the public sector and to offer flexible working conditions such as teleworking. For skills in high demand, teleworking could be a particularly relevant solution as modelling and working with data can be done remotely.
- **Vienna**'s biggest challenge to implement its data strategy is the lack of staff trained in data analysis, preventing a deep understanding of the potential of data in the administration and the usage of that data. For this reason, the city administration uses data visualisation to tell stories and show the potential use of data while offering simple tools and interfaces.

- In **Italy**, the National Strategy for Digital Skills aims to bridge the digital divide that affects the entire population. It intends to do so by supporting digital inclusion and the development of e-skills through higher education and training cycles to increase the number of ICT specialists and ensure the working-age population has the basic digital skills to enter the job market (Box 1.18). Italy seeks to equip 70% of the population with at least basic digital skills, double the rate of people with advanced digital skills to reach 78% of young people with higher education, 40% of workers in the private sector and 50% of civil servants, and increase fivefold the share of the population using public digital services to reach 64% by 2025 (Jakobsone, 2022[139]).

Box 1.18. Italy's National Strategy for Digital Skills

In Italy, the National Strategy for Digital Skills has been drafted jointly with the collaboration of ministries, regions, provinces, municipalities, universities, research institutes, companies, professionals, the national public broadcasting company and several public sector organisations.

The strategy identifies four lines of intervention:

- **Higher education and training** – for the development of e-skills for young people within the mandatory education cycles.
- **Active workforce** – to ensure adequate e-skills in both the private and public sectors, including e-leadership skills.
- **ICT specialist skills** – to enhance the country's ability to develop skills for new markets and new jobs, with a specific focus on emerging technologies and key competencies for future jobs.
- **Citizens** – to develop the digital skills needed to exercise citizenship rights and promote active participation in democratic life.

For each line of intervention, there are associated priorities and 41 lines of action through 111 actions. A dashboard of over 60 indicators monitors the impact of the 4 lines of intervention. Each action also includes appropriate milestones, result indicators and target values.

Source: Jakobsone, M. (2022[139]), *Italy – National Strategy for Digital Skills*, https://digital-skills-jobs.europa.eu/en/actions/national-initiatives/national-strategies/italy-national-strategy-digital-skills.

- **India**'s DataSmart Cities strategy calls for building an ecosystem with a more capable city government, aware and engaged citizens as well as collectives of non-state actors to continue building mutual trust and collaborating to seek solutions to challenges associated with data. In India, the implementation of the DataSmart Cities strategy requires regular capacity building for data officers at all levels, such as city data officers, data champions and co-ordinators and members of the City Data Alliance (Table 1.7). The 2021 Salesforce-YouGov survey on digital skills in India found that 93% of managers in public and private sectors considered that the COVID-19 pandemic accelerated the need for digital skills in their organisations and that the skills in the most demand were in digital marketing (48%), social media (47%) and data analytics (37%) (Salesforce YouGov, 2021[140]). India's strategy suggests that capacity building for local government officers needs to be done in a peer-to-peer manner, where various stakeholders of the data ecosystem can collaborate, exchange data and learn. A 360-degree capacity-building mechanism needs to be put in place to ensure a learning system where a wide range of stakeholders can benefit from the content and strategies created in one place. India is using its National Urban Learning Platform (NULP), which can create a resource-rich ecosystem of learning and knowledge sharing for city managers and primary stakeholders in the national data ecosystem. The aim is to facilitate

information exchange and collaboration between city administration, professionals, industry, academia, researchers and start-ups striving to solve data challenges with state-of-the-art technologies. The key aspects of this strategy are to ensure that training is tailored to local needs, content is agreed upon through a discussion process, the use of online tools and a certification of new skills acquired.

Table 1.7. Capacity-building features of data officers in India

Open online learning platform	Local customised content delivery	Collaboration and engagement	Learning management	Certification
Open and free content on a platform for capacity building in the various domains.	Platform will support content delivery in local languages.	Collaboration and engagement feature to facilitate user discussions over content through the platform, which will also generate user insights to gauge the effectiveness of the content.	Learning management to track user statistics and generate user insights.	Users will receive a certificate at the end of their training which can get attached to their record.

Source: Based on Government of India (n.d.[141]), *DataSmart Cities: Empowering Cities Through Data*, https://smartcities.data.gov.in/sites/default/files/DataSmart_Cities_Strategy_Print.pdf.

The OECD (2021[129]) has developed a framework that proposes a series of pathways for developing a digital public workforce and supporting digital transformation in the public sector (Box 1.19). City governments could apply the actions suggested in this framework to guide their policies and strategies to acquire and develop the digital skills and competencies needed to design and implement smart city projects and enhance their data management strategies.

Box 1.19. The OECD framework for digital talent and skills in the public sector

Acquiring, developing and retaining the digital talent and skills needed for digital transformation in the public sector requires leaders and organisations to take action in three main areas:

- **Building the right environment** by:
  - Being aware of the workforce's digital skills requirements to keep pace with digital evolution.
  - Communicating a clear and understandable vision of the role of digital and the benefits of digital government.
  - Endorsing and actively participating in the rhythm of digital delivery, reducing hierarchical layers and delegating decision making.
  - Focusing on digital professions that are user-centred and have specific objectives and roles.
  - Developing a culture of learning that encourages and provides safety for employees to experiment.
- **Establishing the skills for a digitally enabled state** by:
  - Developing a broader digital skills strategy for society as a whole.
  - Equipping public servants with the digital user skills that support digital government maturity.
  - Setting diverse and multidisciplinary teams consisting of well-trained digital and non-digital professionals to design and deliver services with user needs in mind.
  - Ensuring leaders actively shape the environment to create a digitally enabled state.

- **Creating a path to a digital workforce** by:
  - Implementing proactive recruitment strategies promoting the public sector as an attractive and transparent employer.
  - Developing and implementing fair, trusted and attractive reward systems that support clear career planning.
  - Ensuring that managers promote multidisciplinary teams to promote job growth and professional development.
  - Offering regular feedback loops and mentoring programmes, and providing training through formal and informal mechanisms.
  - Ensuring job mobility is encouraged and public servants are offered a diversity of career choices.

Source: OECD (2021[129]), "The OECD Framework for digital talent and skills in the public sector", https://doi.org/10.1787/4e7c3f58-en.

SMEs have limited participation in smart city projects and data governance

Although SMEs constitute the backbone of the economy (they account for 60% of total employment and 50-60% of the national value-added),[36] their participation in smart city projects is still limited. Improving data governance arrangements could potentially help SMEs to scale up (OECD, 2022[142]). Governance arrangements that provide SMEs access to and facilitate the use of data and data-related technologies and skills could increase their capacity to innovate and their possibilities to scale up by achieving greater cost-efficiency. Innovative funding mechanisms for SMEs and start-ups are needed as well as training in data management. For cities to be better managed and more liveable for citizens, national and subnational governments and SMEs need to work together to develop smart cities. Governments have been implementing different strategies to support SMEs in the transition to the digital era (Box 1.20) (OECD, 2021[143]).

However, this transition is taking place at different speeds depending on the sector and size of the firms. Outdated data infrastructures, data silos and management practices that are not conducive to innovation are some of the barriers SMEs face in a data-driven economy (OECD, 2022[142]). Moreover, not all SMEs have the capacity to shift to digital services, particularly smaller ones, and they are more likely to limit their work to basic services. Certainly, the COVID-19 crisis heightened the importance of SME digitalisation and served as an accelerator, as firms had to move operations on line rapidly and implement smart working solutions during lockdowns to remain in business. OECD research has found that although countries are placing a stronger focus on reinforcing SMEs' internal capacity to use data (72% of 487 mapped policies), less attention is given to enabling SMEs access to external data (28% of mapped policies) through data-sharing infrastructure (OECD, 2022[142]).

Box 1.20. Governments' actions to support SMEs' digital uptake – Country examples

- In 2020, the **Australian** government announced a package of AUD 800 million to update the regulatory framework to boost the capability of small businesses and back the uptake of technology across the economy.
- In **Canada**, the government initiated the Go Digital Canada initiative in co-operation with Shopify to help small business sales grow on line through free training courses and the use of digital marketing channels.

- In 2020, the **French** government earmarked EUR 100 million to support small businesses in building up on line operations. The government platform FranceNum, intended to connect SMEs willing to digitalise with a network of specialised consultants, became a platform for live information on support initiatives from national and local governments and the private sector.
- In **Ireland**, authorities implemented the digital Trading Online Voucher Scheme for a total of EUR 3.3 million (USD 4 million). Micro enterprises can get a EUR 2 500 voucher for online training.
- The **New Zealand** government created a "revive and thrive" tool accessible from its business.govt.nz platform to give businesses access to tailored support and information on how to do commerce digitally.
- In **Slovenia**, the government supports SMEs through the Digitalisation and Digital Transformation Programme, which provides vouchers of up to EUR 10 000 for strategy formation, digital marketing development, enhancing digital competencies or digital security development.
- In **Türkiye**, the Small and Medium Enterprises Development Organisation (KOSGEB) has focused on the digitalisation of SMEs in the manufacturing industry. Projects aim to help SMEs in the sector adapt their production and business processes to digital technologies, such as data mining, the IoT, AI, etc. USD 38 million were provided to SMEs.

Source: OECD (2021[144]), *OECD SME and Entrepreneurship Outlook 2021*, https://doi.org/10.1787/97a5bbfe-en.

The emergence of smart cities means an exponential production of data, which involves considerable political, economic, commercial and technological stakes. The enormous production of data offers large companies and SMEs opportunities to better understand markets, competitors and clients. Although data can offer clear benefits for SMEs, not all of them produce data nor have the capacity to benefit from data as they lack the skills to conduct data analytics, for example. Moreover, it is still unclear to what extent SMEs are the leading actors of smart city projects. Preliminary findings suggest their role is limited but more research is needed. The COVID-19 crisis showed that most SMEs are agile, flexible and adaptable, as they can change rapidly depending on the circumstances. However, they lack the resources to initiate smart city projects and there are few examples where SMEs are part of the partnerships between governments and large corporations in the development of smart city projects. In particular, although SMEs can exploit big data, the difficulty lies in the capacity of knowing which data to exploit and the expertise to turn it into a competitive advantage (Rochdane and Hamdani, 2018[145]). Investing in human capital in SMEs will therefore be a key component in the transition to smart urban development and effective data governance and management.

Managing smart data involves technical challenges for cities

Smart city projects allow for collecting and utilising large amounts of real-time data for decision-making processes at the national and local government levels. This has potential benefits for cities and citizens as services and products can be tailored to specific needs. However, although the collection of different types of data from heterogeneous sources provides a more accurate profile of the city (or parts of it), this creates problems in collecting, standardising and storing large amounts of data.

Collecting smart data is a complex process in itself due to the multiple sources with different formats and types and different usages and access policies (Al Nuaimi et al., 2015[111]). The unstructured nature of data makes it difficult to categorise and organise it in a way accessible for stakeholders to use. For example, collecting data on traffic flows requires including smart traffic lights and signals as a part of a smart city

project. Analysis of data should take into consideration different factors, such as the city map, cars and smart signals as well as the distribution of the sensor and traffic light network.

Technical challenges in managing big data in smart cities are related to the volume, variety, velocity, variability and value of data (Al Nuaimi et al., 2015[111]). The emergence and use of cloud computing, IoT and location-based services has led to the challenge of storing large amounts of real-time data (Zheng et al., 2015[146]). Research suggests that there is no easy solution for smart cities to process mass quantities of sensor data as the infrastructure is not yet ready for increasing data at an accelerated rate (Schafroth, 2018[147]). There is no efficient model to stream data, as multiple systems that are not interconnected make it difficult to process and manage databases. Moreover, data collected from different sources, such as smartphones, computers, sensors, cameras, etc., may create a problem of heterogeneous data that are not interoperable. Moreover, knowledge about data quality, applications, scaling up and commercialisation possibilities are very limited across many cities and among stakeholders, and the knowledge on how to use data remains theoretical as practical experience often lags.

Ensuring the quality of data is a fundamental aspect of big data management and a challenge for smart cities. Data are captured by different agents through different sources under special regimes and stored in distinctive databases but without standard formats. Thus, relying on crowdsourcing and collaboration of multiple data providers may result in data that lacks structure and consistency, with high levels of disparity and heterogeneity (Al Nuaimi et al., 2015[111]). This is why earlier research warned that "[w]ithout a new generation of sensor data management platforms […] the adoption and benefits of the smart city will be substantially reduced. Particularly as challenges in collaboration and data heterogeneity breed an increasingly fragmented patchwork of systems and data unable to exploit the benefits of multi-resolution and multiscale data analysis compounded by the inherent disparity of data, its uncertainty and potential untrustworthiness" (Lee et al., 2013, pp. 101-102[148]).

Big data applications for smart cities require large processing capability to perform data analytics. For this purpose, cities need scalable and reliable software and hardware platforms. The challenge is to ensure access to software platforms that offer high-performance computing capabilities, that are optimised for the hardware being used, are stable and reliable for the different data-intensive applications and are supported by well-trained and capable civil servants and personnel from partnering agencies.

Collecting and storing data not only represent a technical problem but a financial one. For example, acquiring the technology to monitor energy use may force governments to use new systems, components or applications to monitor and record information, which may be costly. Moreover, if a project has not been implemented correctly from the beginning, even when devices to collect, share and store data may be affordable, this may result in very high costs and the image of the city and stakeholders being affected negatively.

Caveats on smart city data governance from international experience

The use of (digital) technology has its limits

In countries such as the United States, there has been some resistance to the use of smart city solutions. The use of biometrics, particularly facial recognition and 5G cell towers, has come under scrutiny in some cities due to concerns about privacy and law enforcement. For example, San Francisco banned the use of facial recognition technology due to concerns about potential abuse by the police and other agencies (Raval, 2019[149]).[37] Oakland (California) and Sommerville (Massachusetts) have also issued similar legislation[38] and other cities, such as Cambridge (Massachusetts), are considering similar moves. Civic leaders are also seeing escalating fears about AI because of its potential impact on jobs and data security, and since it may open their cities to cyberattacks. The takeaway from the United States experience is that local governments have a duty to set standards for new and upcoming surveillance technology on how to use it. National and local governments may need to decide on whether to add people's images to the facial

recognition databases with or without their knowledge and consent, for example. However, even providing detailed information on how personal data would be collected, there could be opposition. For example, the city of San Diego installed 3 200 intelligent sensors on streetlights that generate data to help with easing congestion, parking, public safety and environmental monitoring, among other benefits.[39] The local government detailed information on how the data gathered would be collected and used and the benefits it would produce for the city and its residents; but still, there has been considerable resistance from some residents.

Smart city projects should not merely focus on what technology can do but respond to identified social needs

With the emphasis on controlling and optimising every aspect of city life through technology, smart cities may be damaging city life. Research suggests that smart city projects should concentrate on priorities such as shortening commuting times, speeding up the construction of affordable housing, improving the efficiency of public transport and reducing carbon emissions (Jacobs, 2022[103]). The lesson from Toronto's Quayside project (Box 1.14) is that, although smart city projects are sometimes widely consulted with stakeholders, their solutions largely focus on what technology can do, when they should actually focus on *how* technology will respond to people's needs and produce benefits. This is why Japan's SCRA has adopted a human-centred approach. By leveraging technology and the services it enables, Japan seeks to satisfy the needs of an ageing and shrinking population.

Smart city projects should take into account the concerns of the local service industry

This is particularly the case in smaller cities where local businesses may fear being taken over by large corporations. Some central city areas are declining due to the disappearance of SMEs because of the expansion of large corporations. The protection and development of local commerce and industry should be part of a smart city project as an effort to contribute to regional revitalisation.

Smart city projects require an efficient communication strategy

Gaps in communication could potentially backfire in a smart city project, regardless of its thoroughness. The experience of Toronto's Quayside project in Canada shows how poor communication management could put an end to a smart city project (Box 1.14). The resistance to the Sidewalk Labs project in Toronto shows that residents may be sceptical about the involvement of large private companies in urban projects and express significant concerns about the government handing over significant amounts of money or resources to them to control the governance of public life. This could be a warning for other countries as large private companies are involved in several smart city projects, mostly as residents are wary about how city governments and large-scale technology companies involved in the projects will manage the data they collect on their daily activities.

Cities strive to be hyperconnected rather than just smart

To unlock the full economic, social, environmental and business value from technology, cities need to leverage technology to transform and securely interconnect key areas of their urban ecosystems: technology, data and analytics, cybersecurity and citizens (ESI ThoughtLab, 2022[150]). This means using the latest technologies to connect key areas from roads to cars, buildings to energy grids, citizens to government and cities to cities. A hyperconnected city facilitates real-time interaction among residents, businesses and government entities and services. An example is the city of Stockholm, Sweden, which has launched a strategy for a smart and connected city (City of Stockholm, 2017[151]). Based on its accumulated experience and in order to stimulate, guide and co-ordinate different digitalisation projects, the city of Stockholm has issued a strategy to become smart and connected (Box 1.21). However, to be hyperconnected, all new investments in the city must be based on the needs of residents and visitors, drawing on a wide variety of data to provide value to different stakeholders. This includes traditional data

gathered from city departments, local businesses and citizen surveys to new types of data from IoT, AI and social media. The experience of Stockholm suggests that data and technology should work in parallel and build synergies.

Box 1.21. Stockholm's strategy to become a smart and connected city

In 2017, the City Council of Stockholm adopted a strategy to transform Stockholm into a smart and connected city developed in collaboration with public employees, residents, businesses and academia. The aim of the strategy is to provide residents with the highest quality of life and build the best entrepreneurial climate. To achieve these objectives, the strategy aims to foster innovative solutions, transparency and connectivity. The strategy mainly focuses on the opportunities that arise from areas such as the IoT, big data and analysis. The smart city is made possible through connectivity and open data, integrated platforms, sensors and other technologies. The strategy concentrates on Stockholm as a physical place rather than the organisation of the city of Stockholm.

The strategy defines enabling factors divided into three main areas: operations, technology (including applications and services, digital platforms and IT infrastructure, information security and privacy) and principles for cost distribution. To guide the technology that enables the smart city, the strategy contemplates seven strategic enabling principles:

- Solutions are built on common digital platforms.
- Systems exchange data through central platforms.
- Technical solutions are based on open standards.
- Technical solutions are built modularly.
- Agreements enable development and innovation.
- Security and privacy protection is ensured.
- Data are made available internally and externally as open data.

The implementation of the strategy consists of three main angles: co-ordination and collaboration (internally and externally), communication (and dialogue with residents), and prioritised projects. To guide and co-ordinate the implementation of the strategy, the city developed eight principles for implementation:

- Initiatives are based on the needs of citizens.
- Development builds on what is already in progress.
- Prioritising is done in line with the target picture.
- Development is done through internal and external collaboration.
- Long-term perspective permeates all investments.
- Information is collected with regard to others.
- Digitisation is included in urban planning processes.
- Change is driven by internal and external communication.

Source: City of Stockholm (2017[151]), *Strategy for Stockholm as a Smart and Connected City - Summary*, https://international.stockholm.se/globalassets/ovriga-bilder-och-filer/smart-city/summary-of-the-strategy-for-stockholm-as-a-smart-and-connected-city.pdf.

Building and deploying successful big data applications will require addressing such challenges, having well-trained human resources and being well prepared and supported by the governing entities. With all success factors in place and a better understanding of their limitations, making a city smart through the use of data will be a sustainable goal.

Annex 1.A. Towards data-enabled smart cities in Japan

Japan's policy framework for smart cities

To guide the development of smart city initiatives across Japan and share the accumulated experience of existing initiatives, the Japanese government formulated the Smart City Reference Architecture (SCRA), which is a standard design framework of smart cities and the basic components they should have. The SCRA systematically organises the components of a smart city for it to contribute to resolving regional issues. In this sense, it enables the efficient construction of smart cities in each region based on standardised methods and rules.

The SCRA aims to ensure interoperability between the wide range of components that are expected to make up smart cities and facilitate the design of smart cities by researchers, industry professionals and city planners. The SCRA is built under four basic concepts considered indispensable for promoting smart cities in Japan:

- **User-oriented principle**, by which all stakeholders involved in a smart city project must be aware of the users (residents, visitors and businesses) of the services provided through the initiative.
- *Role* **of city management** refers to the overall and comprehensive management of the smart city project under holistic and comprehensive management. It states the need to maintain sustainable management of smart cities and develop citywide governance and management mechanisms.
- **Role of the city OS**, which states that data and services must be federated efficiently.
- **Interoperability** refers to the need to ensure interoperability with other regions and systems to make the development of smart cities more efficient throughout the country and ensure that data are shared seamlessly across regions.

According to the reference architecture, smart cities should have the following six foundational components:

- **Smart city strategy**. This describes the roadmap of how each region or city achieves its goals. Developing a strategy is mandatory and should present the key challenges faced in the city or region and set high-level goals. It should be based on a quantitative assessment in the form of key goal indicators (KGIs) and key performance indicators (KPIs).
- **Smart city rules**. Regulations on smart cities should include issues on privacy prevention as well as data utilisation. Region-specific rules are considered important in governing and managing region-specific services and regional collaboration councils.
- **City management**. Smart cities should be managed through a collaborative organisation composed of a wide number of stakeholders, thus enabling the sustainable management of the smart city that defines who does what. There should be a business management model led by a regional consortium composed of public and private sector stakeholders.
- **Smart city service**. This refers to what is provided to users by federating and/or integrating data and other services via the city OS. There should be clarity on the services to be deployed as part of the smart city initiative and that respond to the local needs.

- **City OS**. This is a set of system functionalities that enable access to a variety of data provided by smart city assets as well as external systems. It should be characterised by interoperability (connect), data exchange (flow) and scalability (future-proof).
- **Smart city assets**. These refer to the property and resources of the city, which could be converted into data required to solve issues and controlled via the city OS.

Japan aims to build data-enabled cities

Japan's national vision is for a data-driven, human-centric, next-generation society that uses AI, big data and IoT. Society 5.0 provides the foundations to use technology to enhance social cohesion. Japan aims to build smart (super) cities around an information co-ordination platform, which is expected to allow all citizens and businesses to participate in urban life. The platform will collect and manage all kinds of urban data, taking into account citizens' perspectives and providing complex and personalised services while ensuring data interoperability and distribution capability that can be extended to other cities.[40] The data-driven smart cities that Japan is working on involve a bottom-up approach achieved by integrating digital transformation (DX) that is underway in various policy fields while ensuring privacy and security.

Japan bases the building of data-driven smart cities on three pillars:

- **Eco-cities**, environmentally symbiotic cities which focus on low carbon, resource recycling and reduction of environmental burden.
- **Transit-oriented development** (TOD) aims to reduce traffic congestion and upgrade urban functions through urban development with a focus on public transport.
- **Building disaster-resilient cities** (disaster prevention) focuses on using technology for predicting and preventing disasters, building warning systems and using technology to minimise disaster damage in urban development.

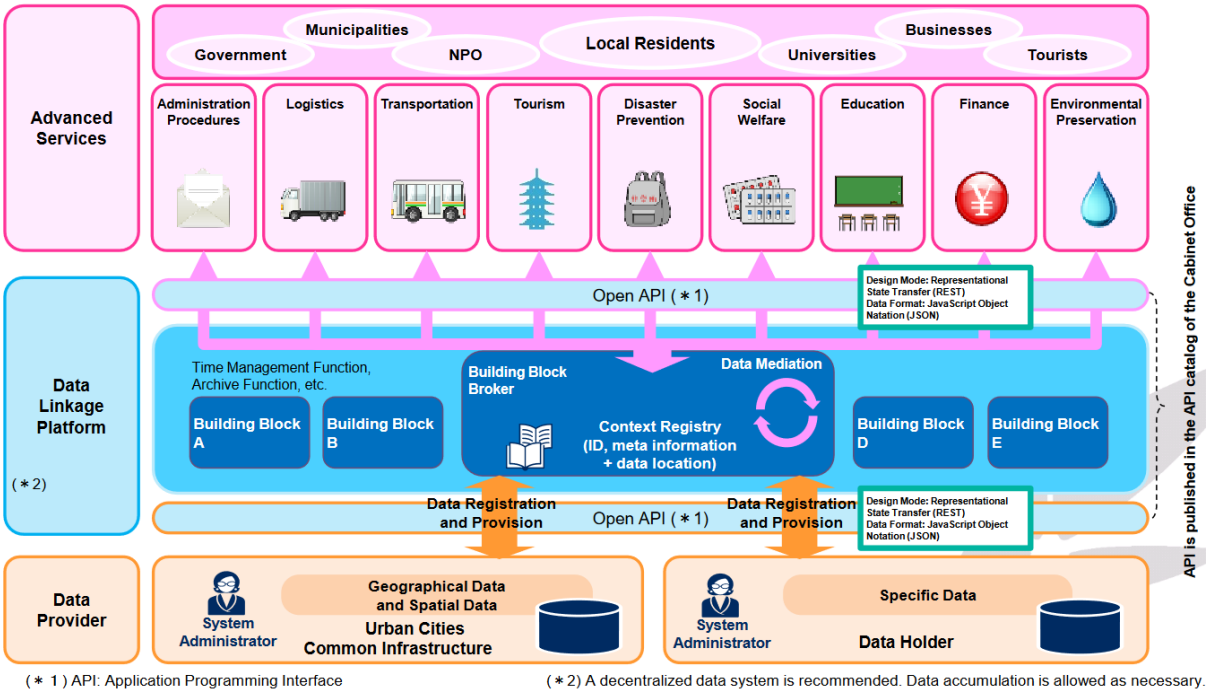
The difference between a "smart city" and a "super city" is that, in the former, the data combination will gradually change to a data linkage platform, while in the latter, the development of a cross-disciplinary data linkage platform is made all at once.[41] A super city covers at least five of these areas: mobility, logistics, payment, administration, healthcare and nursing care, education, energy and water, environment and refuse collection, crime prevention and disaster prevention and safety. The Society 5.0 initiative and a data-driven society aim to create super smart cities by integrating cyberspace and physical space through the maximum use of ICT while tackling economic and social problems through a human-centred approach. In a super smart city, data linkage platforms will promote data connection services between multiple fields (Annex Figure 1.A.1).

Japan and other OECD countries are now entering into a new "smart" society of sustainable and inclusive socio-economic systems that are powered by big data analytics, AI, IoT and robotics, where digital and physical spaces are tightly integrated. In this context, data take a central role as they could optimise entire societal and welfare systems to improve their quality of life by meeting people's needs at the time and place required, tailored to their particular needs. For Japanese authorities, smart city data refer to data from residents, public administration and service providers, among others, obtained from various IoT sensors via the network and include metadata, static data, dynamic data, geospatial data and personal data.

Japanese smart cities produce large amounts of data through the use of IoT. The central government is encouraging cities to use data to move towards Society 5.0 as trade, industrial production and societal functions depend more than ever on efficient access to data. OECD research has found that life satisfaction is positively linked to cities where stakeholders and residents are engaged in data collection and openly share their data (OECD, 2021[30]). However, not all city governments know how to or have the capability to transform data into inputs for decision making and, subsequently, into benefits for residents. This is an

issue that has to be addressed as tackling challenges such as pandemics and ageing societies requires open and trusted data flows for societies (WEF, 2020[2]).

Annex Figure 1.A.1. "Super city" according to Japan's National Strategic Special Zones system



Source: Government of Japan (n.d.[152]), *Japan's Smart Cities: Solving Global Issues Such as the SDGs, etc. through Japan's Society 5.0*, https://www.kantei.go.jp/jp/singi/keikyou/pdf/Japan%27s_Smart_Cities-1(Main_Report).pdf.

Data utilisation within a city is expected to: facilitate the optimal management of energy, water supply and sewerage and recycling within cities; build a cashless society; provide transport services anywhere and at any time; improve e-learning and long-distance education; enhance safety and security; extend healthy life expectancy; and ensure a prompt evacuation from and restoration of disaster zones by providing information in real time (Japanese Cabinet Office, 2022[50]). Cities like Aizuwakamatsu, Takamatsu, and Toyama have been working on projects to use IoT tools as part of their smart city projects to enhance disaster prevention, boost tourism and improve welfare and well-being. The city of Tsukuba is accelerating online medical services in collaboration with various start-ups.

In the case of Japan and several other OECD countries like Korea, Poland and Spain, data reuse and sharing among government entities across different levels of government can tackle an ageing society and public health challenges with more accurate preventive care, mitigating increasing costs. Data flows can help address pollution, climate change and other sustainability objectives by minimising waste and increasing traceability across sustainable supply chains (WEF, 2020[2]). Data are another critical element for enabling the delivery and tracking progress in achieving the United Nations Sustainable Development Goals.

Japan is promoting a human-centric approach to smart cities and data governance to manage the challenges brought about by digitalisation and data. These challenges are related to the use of digital technologies and may create or exacerbate digital gaps in society. For example, some residents may not have the digital skills to use the technological gadgets that are needed to access and benefit from these services.

Super cities are the next generation of smart cities in Japan

While Japanese cities are managing their transformation into smart cities, the central government has assumed a leading role to accelerate and co-ordinate the development of smart cities across the country. This is a welcome development because in the development of smart cities, even the most capable cities in the country, such as larger metropolitan areas, face challenges that they are not able to overcome on their own. For example, cities rely on central government funding to cover part of the whole of infrastructure projects, they are not equipped to develop interoperable systems to share data across their jurisdictional boundaries and they lack the resources to fund R&D for smart cities. Cities are responsible for making the main decisions and investments that lead to their smart city transformation. However, the central government, through the Ministry of Land, Infrastructure, Transport and Tourism and the newly created Digital Agency, has a role in addressing the problems cities cannot tackle on their own, provide a co-ordinated approach to the development of smart cities across the country and make the most of available resources. Moreover, the central government's participation in smart city projects would provide policy certainty that may incentivise more private sector participation.

In 2013, the government enacted the National Strategic Special Zones Act to establish the National Strategic Special Zones, where regulatory reforms and other measures such as tax incentives were promoted for projects carried out jointly by the central and local governments as well as the private sector with the aim of enhancing economic growth. In June 2020, Japan's government enacted the Act to Amend the National Strategic Special Zone Act, known as the Super City Act. The 2020 amendment enables governments to create another National Strategic Special Zone referred to as a super city. This new law aims to improve the collaboration between the public and private sectors for the digital transformation of cities. Cities selected as super cities will deploy AI and big data in medical care, education, energy, crime prevention and transportation, including the development and use of autonomous vehicles.

A super city is understood as a city that changes people's way of life by utilising AI, IoT and big data, allowing the provision of cutting-edge services (e.g. autonomous cars, cashless payments, remote medical care and distance education) (Hiramoto, 2022[49]). To establish a super city, Japan requires broad regulatory changes to ease the challenges of dealing with multiple government agencies. The 2020 amendment introduced a top-down approach by which if a municipality wins residents' approval for super city plans and applies to the central government, the national government can then direct agencies to make exceptions to the relevant regulations as needed. In super cities, data-linking platforms collect and organise various kinds of data from administrative organisations. The super city authorities appoint experts called "architects" to co-ordinate services and technology in their localities. Their task will be to ensure that siloed agencies co-operate and that systems are interoperable across different jurisdictions. A municipality that wishes to become a super city must organise discussion fora with private companies to discuss the super city development plans, draw up those plans and make applications to the National Strategic Special Zones Secretariat after obtaining approval from local residents.

Japan has very specific challenges that it seeks to address via smart city projects. While cities across the world are using smart city solutions to solve issues related to public safety, water and air quality, mobility and waste management, Japanese cities are mostly using smart city strategies to address the challenges of an ageing and shrinking population, the threat of natural disasters and the impact of COVID-19. If Japan fails to respond to these challenges, it may face economic contraction and problems in maintaining living standards and even infrastructure. Thus, national and local authorities are exploring the potential smart cities have to face those challenges. In this context, the Cabinet Office approved the Basic Policy on Economic and Fiscal Management and Reform 2021 (Grand Policies 2021), which proposes to build 100 diverse and sustainable smart cities by 2025 (Annex Box 1.A.1) (Government of Japan, 2021[153]).

Between 2017 and 2021, about 280 smart city demonstration projects were in approximately 170 geographic areas. Nowadays, almost 40 smart city pilot projects are being implemented across the country. For example, Aizuwakamatsu, a city with a population of 121 000 inhabitants, has a

comprehensive smart city strategy through which it provides a wide variety of services in collaboration with several stakeholders. The city of Maebashi, with a population of over 340 000 inhabitants, uses smart city projects for evidence-based policy making on issues such as urban regeneration, healthcare and community activities. Kakogawa, with almost 260 000 inhabitants, has a smart city strategy for disaster and crime prevention and resilience as well as looking after the elderly and children (Ishida, 2021[154]).

Annex Box 1.A.1. Four driving forces for economic and fiscal management and reform 2021 in Japan

The Basic Policy on Economic and Fiscal Management and Reform 2021 sets out four driving forces of sustainable growth in the post-pandemic period:

- **Realisation of a green society** to be achieved by stimulating private investment and innovation through a green growth strategy, promoting energy and resource policies toward decarbonisation and utilising carbon pricing that contribute to growth.
- **Acceleration of digitalisation by public and private sectors** by establishing the digital government, fostering the acceleration of DX in the private sector and promoting the development of digital human resources, elimination of digital divide and cybersecurity measures.
- **Revitalising Japan as a whole through the creation of vibrant local regions** by promoting the new flow of people to rural areas supporting the creation of dynamic mid-sized enterprises, SMEs microenterprises boosting economy through wage increases revitalising tourism turning agriculture, forestry fishery industries into growth industries including export growth, accelerating multicore co-operation based on smart cities.
- **Overcoming the declining birth rate and building a society that makes it easier to have and raise children** by forging a society that enables marriage and raising children and creating an environment to ensure the security of children who will bear the future and measures against child abuse.

Source: Government of Japan (2021[153]) *Basic Policy on Economic and Fiscal Management and Reform 2021*, https://www5.cao.go.jp/keizai-shimon/kaigi/cabinet/2021/2021_basicpolicies_en.pdf (accessed on 27 June 2022).

Rural areas in Japan are more deeply affected by a shrinking and ageing population, deterioration of public transport and industries than cities; some of them are even at risk of disappearing. Thus, those places are considered to need more smart city projects than large cities but authorities in many of those localities consider smart city initiatives to be only for large urban areas (Ishida, 2021[24]). In reality, many of the municipalities applying for support to become a super smart city are located outside metropolitan areas.

Investments in smart initiatives can be expected to continue rising in Japan and worldwide as public services, information and means of participation and cultural resources are digitalised. In the post-pandemic period, investment in smart projects like smart grids, intelligent traffic management, autonomous vehicles, smart lighting, e-governance services and data-enabled public safety and security, are gaining momentum. Technologies like AI and big data will be in high demand to combat future pandemics and other threats like climate change, with growing opportunities for crowd analytics, open data dashboards and online city services. This is a similar trend followed across the world as cities are investing more in digital technology to provide key public services and boost economic activity. According to estimates, by 2025, smart cities' spending on (digital) technology will reach USD 327 billion, 22.7% more than in 2019 (Valente, 2020[155]).

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2 Governing data in smart cities – A review of experiences

Creating effective data governance strategies, policies and frameworks to drive data quality while preserving security and privacy in a transparency framework is key to developing (smart) cities. Thus, this chapter provides an overview of the international practice in data governance to guide public sector efforts at the national and local levels in making more efficient use of data. It first discusses the importance of a strategy, reviews the strategies to enhance trust and examines the efforts to set data standards. It then takes up the issues of co-ordination for data sharing. It concludes with the case of data governance in smart mobility.

Introduction

As discussed in Chapter 1, smart cities hold the promise of helping cities boost economic growth and resilience and reduce costs while enhancing sustainability, improving public services and quality of life, and increasing citizens' engagement in a pragmatic, apolitical manner by using data-driven solutions. Data are the foundation of the digital society and play a critical role in the development of smart cities. Cities are facing increasing opportunities to leverage data and digital technologies to improve public services and resident well-being. However, cities must balance their data needs with concerns about privacy and data use. It is, therefore, critical to set robust data governance arrangements to manage and use the data that smart cities generate. Data governance understood as the "…diverse arrangements, including technical, policy, regulatory and institutional provisions, that affect data and their creation, collection, storage, use, protection, access, sharing and deletion, including across policy domains and organisational and national borders" (OECD, 2022, p. 13[1]) The relevance of data governance rests in that it provides the rules and parameters that govern data collection efforts aimed at producing more efficient interactions between city governments, their partners and citizens (Johnson et al., 2022[2]). If used and managed properly, data can help make smarter decisions, automate and accelerate processes, and improve communication between government, private companies and citizens.

According to international experience, how smart a city becomes, how fast and at what ratio of costs to benefits largely depends on how well public and private actors work together to govern and manage the data on which smart cities are built. Failing to govern and manage data responsibly and efficiently may hamper cities' competitiveness and productivity, and may damage citizens' trust in the government's capacity to manage data and meet their needs.

This chapter explores international experiences of good practices in terms of governing data in the context of smart cities, both at the national and subnational levels. It starts with a discussion on the importance of data governance and the different elements that have an impact on it, such as trust, transparency and data security. The chapter then turns to different practices to ensure data interoperability. It concludes with the case of data governance in smart mobility as an integral part of smart cities.

Building a data governance structure for smart cities

Effective data governance involves developing and implementing the foundational frameworks in terms of institutions, roles, rules, processes and technical structures to ensure that data access and sharing are reliable, trustworthy and deliver value (OECD, 2019[3]). It is also critical to ensure that sensitive data are protected while non-personal datasets are shared or opened for reuse within the limitations of available legislation and rules (OECD, 2019[3]). The governance of data sharing must address the overlapping purposes and needs that a wide range of stakeholders may have and ensure they abide by data sharing rules. For this purpose, local governments should develop frameworks that enable targeted data sharing that respects privacy and commercial sensitivities of people and companies, and meets operational needs. New regulations demanding stricter data control and the understanding of the risk of not complying with those new requirements to protect data have reinforced the need for more capacity and capability to manage data (Algmin and Zaino, 2018[4]). Data governance is one of the key factors for enhancing the regulatory capabilities of subnational governments, unlocking market opportunities for private enterprises and improving citizens' capacity for participation in decision-making processes (Franke and Gailhofer, 2021[5]).

As Chapter 1 highlighted, countries tend to adopt a general smart city national framework (SCNF) that guides the building and implementation of smart city projects and the provision of better services. At least three critical points can be stressed from international experience: i) the relevance attached to linkages across data from different sectors and regions; ii) the need to ensure privacy and protection of personal

data; and iii) the need to ensure interoperability of data platforms. To be effective, these elements need a governance structure that facilitates co-operation across levels of government, among cities and across policy sectors, involving a wide number of stakeholders from the public and private sectors and citizens.

Smart cities should use data purposefully through a tailored strategy

The experience of OECD countries suggests that data governance and management in smart cities must enable society to turn data into benefits while ensuring public support. According to the OECD, establishing a clear vision and strategy for data is an important element of data governance (OECD, 2019[3]), which can also be applied to the city level. Existing national-level data strategies may also explicitly or implicitly support smart city data governance, as is the case with the National Data Strategy of Japan (Box 2.1). The experience of Germany and the Netherlands suggests that before designing a platform, coding algorithms and acquiring and deploying digital technologies, national and local governments need to identify the challenges first and consider the value creation and broader outcomes of possible solutions. Those solutions should be tailored to the city's unique context and its specific social and cultural needs. Sometimes, solving a city's challenges does not require large investments in technology.

While cities aiming to make progress on digitalisation and become a smart city also develop their own data strategy, a national model or guideline can be a reference for local governments to tailor their own strategy in the framework of their smart city plans. For example, in Mexico's robust national statistical system, there are many opportunities to reinforce support and capacity building to local governments. However, in the absence of a national data strategy, there is a lack of concrete guidance on how the National System of Statistical and Geographical Information (SNIEG) should interact with local statistical systems, as well as on knowledge-sharing modalities between the Mexican National Institute of Statistics and Geography (INEGI) and chief data officers or CDOs (or equivalent) at the state or municipal levels (Marks, 2022[6]). Establishing a process of sustained knowledge sharing between state and municipality data officers and INEGI could foster a greater understanding of the use of data. It would inform better decision making at the local level and improve the production and data dissemination processes that support policy making and decision making at the subnational level.

National statistics offices (NSOs) lead data governance and data management within central governments and at the national scale. In some cases, NSOs may start discussions within the national government on the legal system required to enable the collection, processing, sharing and storing of data. NSOs have an advisory or leadership role in the elaboration of national data strategies and work closely with the international community in sharing experiences and good practices on data governance. Critically, NSOs have the necessary experience and expertise to advise other levels of government on ensuring data quality and complying with data management regulations. An important aspect is to develop analytical capabilities in areas such as data literacy, science and engineering across national government to ensure effective data management and support subnational governments in upgrading their data management capability.

Box 2.1. Japan's National Data Strategy

In 2020, Japan released a data strategy that proposed a basic structure of national strategy and is also intended to support data governance at the local level. The National Data Strategy is the basic policy tool to achieve the objectives of Society 5.0,[1] which sets Japan's future vision to build a citizen-centric society with efficiency and trust where anyone can access data easily, start a business quickly and use high-quality services. Data will emanate from base registries (e.g. legal entities, land), high-value datasets (e.g. public administration data), statistics and real-time sensor data (e.g. traffic and weather). Data will be available on a platform as open data and data from the private sector.

The Smart City Reference Architecture of the strategy regards data as one of the key components of smart cities and thus aims to use different types of data jointly to create new value. Data are to be fused in the Government Interoperability Framework. For example, the government expects to combine data on land, topography, nature and weather, transportation, traffic and operations, building and infrastructure, and area services (i.e. city services, events, etc.) to manage disaster risk.

Table 2.1. Principles of Japan's National Data Strategy – Data use

Control your data yourself	Connect	Use anytime, anywhere	Safe	Create together
• Controllability • Privacy	• Interoperability • Efficiency	• Availability • Quickness • Cross-border	• Security • Trust • Quality	• Co-creation • Creation of new value

Source: Government of Japan (2021[7]), *National Data Strategy*, https://www.digital.go.jp/assets/contents/node/basic_page/field_ref_resources/0f321c23-517f-439e-9076-5804f0a24b59/20210901_en_05.pdf

Table 2.2. Principles of Japan's National Data Strategy – Administrative action

Evidence-based administration	Data ecosystem	Maximising data value
• Priority area identification • Business transformation • Data management and open data • Cultural change	• Data engineering for data ecosystems • Data standards • Data quality management • List of data assets in the administration	• Rule management for data access • Channel management for the various data access • Open data

Source: Government of Japan (2021[7]), *National Data Strategy*, https://www.digital.go.jp/assets/contents/node/basic_page/field_ref_resources/0f321c23-517f-439e-9076-5804f0a24b59/20210901_en_05.pdf

Japan's National Data Strategy promotes smart city governance trying to ensure that local-level governments follow a common architecture and data standards. It also offers the basis to use data to promote trust and achieve Society 5.0 overarching goals. A particular challenge to be addressed is to foster cross-domain data use as, in most cases, data are collected, analysed and used in silos. This means that the administrative departments of national and local governments produce large amounts of data but their benefit is limited as they are not shared nor used to their full potential.

Source: Hiramoto, K. (2022[8]), "Smart cities in Japan", PowerPoint presentation given to the OECD team, Tokyo.

Local data strategies are a prerequisite for exploiting the potential value of data produced by the city for the benefit of its residents, businesses and academia. It should include all necessary measures to provide reliable data of the required quality in a timely manner. The city of Vienna's Data Excellence Strategy, for example, takes a human-centric approach to managing data and digital technologies, placing residents' well-being at the centre of decision making (Box 2.2).

Local data strategies must be tailored to the needs of each urban society. According to the experience of Germany, those strategies need to be understood and used as a tool to achieve local urban development goals and evolve continually and dynamically based on the needs and priorities of each city or community (BBSR, 2021[9]). For that purpose, all levels of government need to join forces purposefully for the use of data to achieve integrated and sustainable urban development.

Box 2.2. Vienna's Digital Excellence Strategy – Key aspects

The city of Vienna's Data Excellence Strategy intends to include all of the necessary measures that guarantee a timely provision of reliable, high-quality data to make the city a "data excellent" Data Capital City. It is based on three key elements:

- **Data governance**. The basis for company-wide co-ordinated data management, through rules, organisation and processes and the people involved at the professional and technical level.
- **Data quality management**. Refers to all quality-oriented organisational, methodological, conceptual and technical measures to manage data considered as an asset.
- **Enterprise data management**. Based on the city of Vienna's information and communication technology (ICT) strategy, the local government intends to use the city's modern and comprehensive enterprise data management to make innovative use of its data.

These principles intend to ensure that data are usable in key figures and data usages (reports, dashboards, open data). The experience of the city of Vienna suggests that it is essential to ensure a clean data landscape to ensure that the city management can retrieve evaluations based on quality-checked data at any given time and make informed decisions.

To ensure data quality, the city has defined performance indicators to assess and communicate progress. For a legally compliant use of data and the corresponding access rules, it is essential to classify data and to know which entity has the data responsibility. A data catalogue contains relevant information for all stakeholders.

Source: Information provided by the city of Vienna to the OECD Secretariat for this report. Further information can be found at https://digitales.wien.gv.at/en/data-excellence-strategy-of-the-city-of-vienna/.

Like Japan, the United Kingdom has adopted a National Data Strategy that may help strengthen data governance for smart cities. This strategy, issued in 2020, intends to facilitate the access, use and reuse of data to a wide range of stakeholders (Box 2.3). It leveraged the benefits and power of data to respond to the COVID-19 pandemic. A lesson from the United Kingdom (UK) experience that is relevant for the development of smart cities is that a data strategy should leverage existing digital strengths and installed digital capacity (infrastructure and organisational) to promote better use of data across businesses, government, civil society and individuals.

Moreover, the UK national experience suggests that for developing smart cities and setting a local data governance structure, a data strategy requires activity and focus beyond government. Working with local stakeholders to define how the city, businesses and other actors will co-operate across the wider data landscape is critical to ensure the functioning of smart cities.

Involving citizens from the early stages of data projects is also essential. Countries and cities use different mechanisms for this. For example, in the city of London, United Kingdom, the borough of Camden organised a citizens' consultation where the government provided different scenarios on how the borough could use its data and asked how they felt about sharing their data in each one. The results provided them with the relevant information to design a more socially acceptable scenario, where people would be willing to share their data. Other options for cities can be to use a citizens' jury methodology to develop a citizen's charter and a data ethics board to get external advisers to ask the right questions on data sharing and protection.

Box 2.3. The UK National Data Strategy

In 2020, the UK government issued a National Data Strategy that sets out how best to unlock the power of data. It defines core pillars and priority areas that could be used for the development of smart cities as a guiding framework. Data are expected to: boost productivity and trade; support new businesses and jobs; increase the speed, efficiency and scope of scientific research; drive better delivery of policy and public services; and create a fairer society for all.

To address the interconnected issues that currently prevent the best use of data, the strategy adopts four core pillars:

- **Data foundations**: To make data fit for purpose, they need to be recorded in standardised formats on modern, future-proof systems and held in a condition that means they are findable, accessible, interoperable and reusable. Ensuring high-quality data can lead to more effective use and drive better insights and outcomes.
- **Data skills**: A wealth of data skills is key to making the best use of data. That means delivering the right skills through the education system but also ensuring that people can continue to develop the data skills they need throughout their lives.
- **Data availability**: For data to have the most effective impact, it needs to be appropriately accessible, mobile and reusable. For this, it is necessary to ensure better co-ordination, access to and sharing of data of appropriate quality between organisations in the public, private and third sectors.
- **Responsible data**: As the use of data grows, it is essential to ensure it is used in a way that is lawful, secure, fair, ethical, sustainable and accountable, while also supporting innovation and research.

The strategy identifies five priority areas of action, called missions, to ensure better use of data:

- **Unlocking the value of data across the economy** – Setting the correct conditions to make data usable, accessible and available across the economy while protecting people's data rights and private enterprises' intellectual property.
- **Securing a pro-growth and trusted data regime** – Building a data regime that is not too burdensome for the average enterprise to use data.
- **Transforming the government's use of data to drive efficiency and improve public services** – Adopting a whole-of-government approach that ensures alignment around the best practice and standards needed to drive value and insights from data; and the creation of an appropriately safeguarded, joined-up and interoperable data infrastructure to support this.
- **Ensuring the security and resilience of the infrastructure on which data relies** – Ensuring that data and its supporting infrastructure are resilient in the face of established, new and emerging risks, protecting the economy as it grows.
- **Championing the international flow of data** – Promoting domestic best practices and work with international partners to ensure data are not inappropriately constrained by national borders and fragmented regulatory regimes to use them to their full potential.

Source: UK Government (2020[10]), *National Data Strategy*, https://www.gov.uk/government/publications/uk-national-data-strategy/national-data-strategy#data-1-2.

Strategic leadership at the local level is needed to guide the implementation of data governance in smart cities

Leadership on digitalisation and data management at the national and local levels is essential as it provides a body with official explicit responsibility for co-ordinating smart city and data management efforts, including in terms of policy definition, implementation and co-ordination.

OECD research shows that data-driven transformation requires more than technical skills, with countries such as France, Korea, New Zealand, the United Kingdom and the United States having attributed data leadership/stewardship to CDOs or bodies to support data governance at the strategic level (OECD, 2019[3]) (Box 2.4).

Box 2.4. Examples of chief data officers/stewards at the national level in Japan, New Zealand and the United States

In **Japan**, the National Data Strategy specifies that the Head of Data Strategy is appointed as the CDO of the Digital Agency, responsible for implementing the strategy and accelerating the digitalisation process of the national government. The CDO will co-ordinate the work of and collaborate with the CDOs appointed in every sectoral ministry.

In **New Zealand**, the Government Chief Data Steward (GCDS) supports the use of data as a resource across the government to help deliver better services. The GCDS leads by facilitating and enabling a joined-up approach across government and develops policy and infrastructure while providing support and guidance so agencies can use data effectively. Moreover, the GCDS: sets the strategic direction for the government's data management; leads the government's response to new and emerging data issues; co-develops a Data Stewardship Framework to enable agencies to manage data as a strategic asset and benchmark their data maturity; and leads the government's commitment to accelerating the release of open data.

In the **United States**, the responsibilities of the CDOs are defined in the Open, Public, Electronic and Necessary Government Data Act. Some of the responsibilities include: being in charge of lifecycle data management; co-ordinating with any official in the agency responsible for using, protecting, disseminating and generating data to ensure that the data needs of the agency are met; managing data assets of the agency, including the standardisation of data format, sharing of data assets and publication of data assets in accordance with applicable law; ensuring that, to the extent practicable, agency data conform with data management best practices; engaging agency employees, the public and contractors in using public data assets and encouraging collaborative approaches on improving data use.

Source: Government of Japan (2021[7]), *National Data Strategy*, https://www.digital.go.jp/assets/contents/node/basic_page/field_ref_resources/0f321c23-517f-439e-9076-5804f0a24b59/20210901_en_05.pdf; Government of New Zealand (n.d.[11]), *Government Chief Data Steward (GCDS)*, https://www.data.govt.nz/leadership/gcds/; United States Congress (2017[12]), *H.R.4174 - Foundations for Evidence-Based Policymaking Act of 2018*, https://www.congress.gov/bill/115th-congress/house-bill/4174/text.

At the subnational level, cities are also appointing officials to lead data and smart city strategies, i.e. local CDOs. They are in charge of the implementation of their respective initiatives for the management of data but this depends on the capacity of the local government, in particular municipalities, as they may not always have the staff with the right competencies and skills. Cities such as Barcelona and Bilbao (Spain), London (United Kingdom), Los Angeles and New York (United States), Paris (France), Reykjavík (Iceland) and Vienna (Austria) have created the city-level CDO.

In general, a local-level CDO requires both specific technical capabilities (e.g. cloud computing, data science analytics and data management, data collection and production processes, etc) and communications and interpersonal skills. Local CDOs need to be able to have an influence across organisational boundaries to improve data interoperability, for example, and to lead collaborations with a wide range of stakeholders (e.g. academia, private sector and citizens) (Marks, 2022[6]). Being able to engage with local civil society is of critical importance as CDOs need to demonstrate the value of sharing data and reassure them of data safety. Local CDOs need to have the ability to break down silos and explain the benefits of sharing data and open datasets (Marks, 2022[6]). This is a message that local CDOs should convey not only to the officials but to publicly elected officials. Working with the local private sector and encouraging them to share data is also a critical task. Local CDOs need to demonstrate the benefits of pulling data together from different public and private sources. In Barcelona, Bilbao and Sydney (Australia), the CDO (or equivalent) helps scale and sustain the implementation of their data strategies. The OECD (2019[3]) noted that it is important that countries do not misunderstand the role of the data leader and confine it to the information technology (IT) department when the role should be more strategic in achieving policy goals through better data management and sharing practices. Moreover, through existing research at the national level, the OECD has observed that "[p]ublic policies tend to overlook the benefits of data governance. There is a need for promoting data governance as a sublayer of policy arrangements. This can help to extract value from data for successful policy" (OECD, 2019, p. 27[3]). However, while there seems to be an acknowledgement of the importance of data for national and subnational governments (e.g. Barcelona, Bilbao, Bogotá, London, New York, Tokyo), research suggests that the private sector also considers data as a critical asset to achieve companies' core objectives but that this does not always translate into actions that make data deliver real advantages (Algmin and Zaino, 2018[4]). This could be to the detriment of smart city projects as private companies tend to lead such initiatives and collect large amounts of data. Although data are considered a valuable asset by the public and private sectors, it does not mean that partners in smart city strategies should gather more and more data and apply them indiscriminately. Instead, leadership is required to manage and be intentional in how data create value.

Having adequate institutional arrangements for the implementation of the smart city and data strategies is critical for data-driven cities. In Japan, for example, three central bodies are responsible for implementing digital and data strategies as well as providing guidance for the development of smart cities across the country (Box 2.5). At the local level, the city of Vienna provides an example of a data excellence organisation to implement the data strategy. To ensure the efficient and effective use of data, the government of the city of Vienna seeks to master the data lifecycle in all areas of administration, minimising the effort and generating the greatest possible added value through data. As Figure 2.1 suggests, the responsibility for this does not only lie in the IT department but in all departments. The local government has set up a data excellence organisation and defined specific roles such as data stewards, experts and users in the departments.

Box 2.5. Leadership for smart city data governance in Japan

Japan's **Cabinet Office** defines policy and priorities for the national-level government. It is in charge of policy planning and comprehensive policy co-ordination. It is composed of all ministries of the central government and supervises the work of the Digital Agency as well as the Reconstruction Agency. The Cabinet Office is responsible for the preparation of the Basic Plan for the Advancement of Public and Private Sector Data Utilization and for ensuring the necessary financial resources for its implementation.

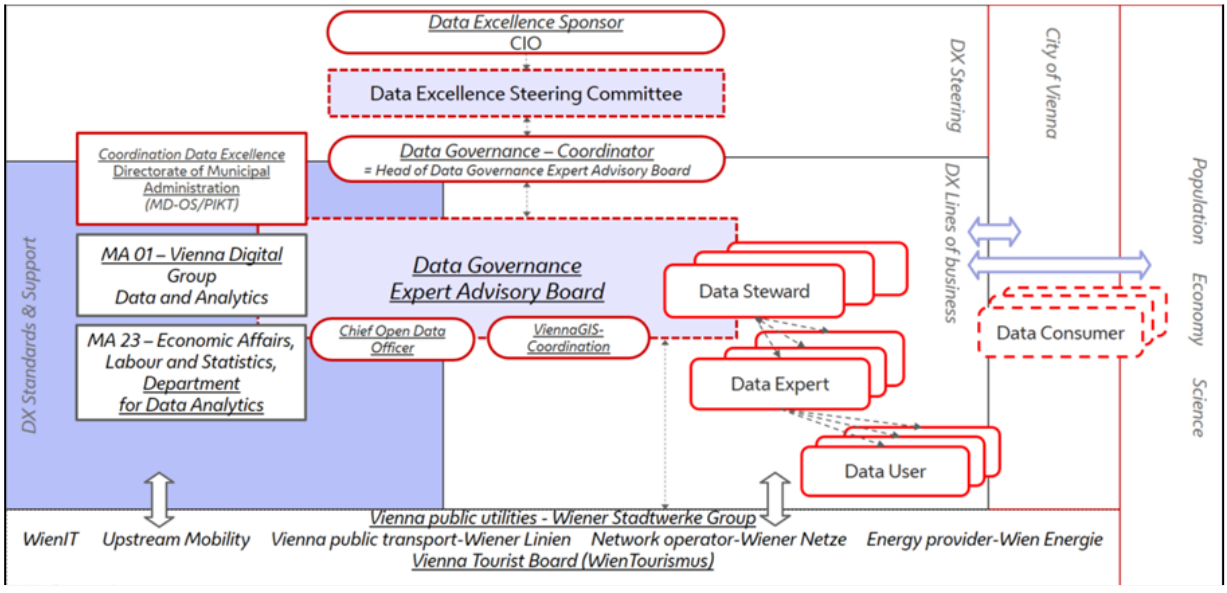
The Council for Science, Technology and Innovation in the Cabinet Office leads a Smart City team composed of representatives of the Regional Revitalisation Office in the Cabinet Office and the Digital Agency, as well as the Ministries of Land, Infrastructure, Transport and Tourism (MLIT), of Internal Affairs and Communications, of Economy, Trade and Industry and of the Environment.

In 2021, the central government created the **Digital Agency** to lead Japan's efforts on digitalisation. The Digital Agency is in charge of co-ordination for the implementation of the National Data Strategy and can make recommendations to other ministries and agencies at the central level of government. Its policy priorities include making online public services more user-friendly, implementing the National Data Strategy, building digital capabilities through training and education, conducting a regulatory reform to facilitate the use of new technologies, ensuring safety and security, promoting research and demonstration of digital innovations, and examining and evaluating digital programmes. Its mission, vision and values reflect a focus on human-friendly digitalisation.

MLIT also has a critical role to play in the implementation of the data strategy through the smart city initiatives. MLIT is responsible for the comprehensive and systematic use, development and conservation of the land, promotion of transportation policies, development of infrastructure, implementation of tourism policy and development and implementation of urban policy. It has a City Bureau that oversees works on urban renewal, urban planning, urban development and urban transport facilities.[2] As part of its work on urban policy, MLIT promotes urban renovation and compact, low-carbon cities.[3] Smart cities and digitalisation play a critical part in MLIT's work as it contributes to the national efforts to tackle depopulation and an ageing society and the achievement of the Society 5.0 vision.

Source: Government of Japan (n.d.[13]), *About the Cabinet Office*, https://www.cao.go.jp/en/about.html; Government of Japan (n.d.[14]), *About Digital Agency*, https://www.digital.go.jp/en/about-en/#mvv; MLIT (n.d.[15]), *Homepage*, https://www.mlit.go.jp/en/ (accessed on 27 September 2022).

Figure 2.1. Organisation of the city of Vienna for the implementation of the Data Excellence Strategy



Source: Information provided by the city of Vienna to the OECD Secretariat for this report.

Data strategies would benefit from incorporating the development of smart cities as a tool to achieve broader urban development goals

In some countries, data strategies make an explicit case for the development of smart cities to deal with national challenges such as demographic shifts, climate change, inequality and access to services. For example, India and Japan promote the use of data to inform policy decision making and boost innovation in service creation and delivery. In Japan, the government is boosting digitalisation to cope with the challenges of providing better services at higher levels of efficiency to an ageing and shrinking population and in turn boosting economic growth and competitiveness. The Smart City Reference Architecture advocates the use of smart city data for informed decision making. The National Data Strategy promotes an evidence-based administration that manages open data across all levels of government.

However, unlike Japan, India is using smart cities and data strategies to deal with the effects of a growing population and urbanisation that is placing a significant burden on civic infrastructure and services like sanitation, water, sewerage, housing, electricity and public transport. Like Japan, India launched a National Data Strategy focused on the development of DataSmart Cities. India aims to create data to ensure a move towards outcome-based planning in governance and build data-enabled cities (Box 2.6). India's strategy highlights that the power of data science and geographical information systems can be harnessed to exchange ideas, solutions and workforce across the country to fix local challenges (Government of India, n.d.[16]). The DataSmart Cities strategy intends to institutionalise a culture of data by putting in place formal mechanisms for data collection, management and use. For the government of India, there is a need for building on the "city-as-a-platform" concept that recognises the value of enhancing engagement among government, citizens, academia and industry, along with improvements in the internal workflow and decision-making processes of city governments. Equally, India's strategy promotes the development of a data maturity assessment framework, which is absent in the Japanese strategy.

Box 2.6. India's DataSmart Cities strategy to enable smart city data governance

India's federal government has developed its DataSmart Cities policy framework to help enable smart city data governance to solve complex urban challenges. It was developed with the assistance of city officials, academics and private sector leaders. It is based on the 2015 Smart Cities Mission that paved the way towards transforming urban management with the power of digital technologies. For the government, making cities DataSmart is essential to realise the full potential of technology interventions and innovation ecosystems in cities. DataSmart Cities are defined as those that have successfully integrated a culture of data awareness and data usage in its functioning. The expected outcome is to bring greater efficiency, accountability and transparency in city governance decisions while fostering civic engagement, co-creation and innovation in problem solving.

There are three foundational pillars of DataSmart Cities that are expected to support the creation of an open data culture, leading to greater data exchange for open innovation and co-creation:

- **People** – which refers to well-capacitated institutional structures across all tiers of governance along with the formation of networks and alliances. This includes the identification of responsibilities and actors for implementing the principles of data governance. The idea is to encourage cities to think through the "what" and "who" of an institutional mechanism.
- **Process** – which refers to process enablers, such as policies and standards. This intends to address the challenges of privacy, security, rightful use and potential bias through the creation of an appropriate policy along with regulatory and institutional instruments at the city level.

- **Platform** – which refers to technology platforms to support the implementation of policy intents. This builds on the guiding principles and architectural blueprint of the National Urban Innovation Stack. The objective is to guide cities in the adoption of open data platforms, along with a roadmap for evolution to a mature data marketplace.

The Ministry of Housing and Urban Affairs has also launched an open data platform to serve as a single source of open datasets from multiple cities and government agencies. The platform already contains around 3 566 catalogues with more than 5 135 sources of data and 242 application programming interfaces (APIs), with information from 100 smart cities. Every participating city must appoint a city data officer to facilitate data sharing and exchange through the platform. The goal is to unlock the potential of open data, open innovation and co-creation.

The DataSmart Cities strategy also lays down the foundations of a data maturity assessment framework to be implemented through self-assessment. The objective is to encourage cities to assess their readiness against the three foundational pillars while combining the dual objective of robust processes and intended outcomes.

Source: Government of India (n.d.[16]), *DataSmart Cities: Empowering Cities Through Data*, https://smartcities.data.gov.in/sites/default/files/DataSmart_Cities_Strategy_Print.pdf; Government of India (n.d.[17]), *Open Data Platform: India Smart Cities*, https://smartcities.data.gov.in/.

At the local level, the city of Vienna's Data Excellence Strategy aims to deal with the challenges encountered in the data lifecycle, such as data silos and redundant data, manage multiple data acquisitions and unclear data distribution of responsibility and elaborate evaluations and time-consuming reporting. Local authorities in Vienna intend to use data as the foundation for information and knowledge and the construction of the future digital twin[4] of the city. Vienna's future digital twin is expected to assist in monitoring existing processes in the city, generating new data, simulating planning in different scenarios and making better decisions based on data, offering high added value for internal tasks and co-operation with residents, businesses and the academic community.

Cities' data strategies should provide a methodology for data collection, defining the scope and purpose

Developing a data strategy aims to reflect real-life problems and how the strategy could help tackle and prevent them through data collection and use. In other words, while data sharing on the part of public authorities should build in minimising data requests, data collection and sharing are, in some cases, weakly linked to desired policy outcomes at the city level (e.g. improved environmental outcomes, liveable cities, etc.). In Japan, for example, the National Data Strategy does not stress or provide guidance to cities on how outcomes and methods of data collection and management should be better linked to conduct regulatory and planning actions, including the appropriate level of aggregation, data handling, data retention periods, auditability, etc. The strategy focuses largely on the methods and the need to enhance capacity but lacks an outcome-based assessment.

Regional (e.g. New South Wales [NSW], Australia; Hamburg, Germany) and local (e.g. London, United Kingdom) experience suggest that it is critical to focus on outcomes for citizens by putting data at the core of decision-making processes. This requires a collaborative, co-ordinated, consistent and safe approach to using and sharing data. The relevance of the NSW Government Data Strategy is that it embeds the data practices that delivered valuable data and insights during the COVID-19 pandemic (Box 2.7). It was developed through a cluster of collaboration of CDOs from different departments. However, the implementation of the strategy requires a regulatory reform to strengthen data-sharing laws to facilitate the work of agencies in the creation of high-value datasets. For example, the review of the Data Sharing

(Government Sector) Act revealed the need to provide "legislative teeth" to the Data Analytics Centre to meet its full potential and provide actionable insights.[5] Similar to the case in Japan, the NSW Government needs to streamline how the data-sharing legislation works, particularly when it intersects with other privacy legislation. A lesson from this experience is that a data strategy should be accompanied by a revision and amendment of the regulatory framework to facilitate the operationalisation of the strategy.

Box 2.7. NSW Government Data Strategy

In 2021, the NSW government in Australia published its new Data Strategy. The strategy aims to harness the power of data to execute the government's policy priorities, respond to emerging issues and deliver better services to the public while maintaining privacy, security and ethical standards. It is built around four complementary themes:

- **Accelerating actionable insights**: This involves increasing the speed at which data can be translated into actionable insights to guide government decision making, including in emergency situations. To ensure insights are actionable, the government links them to strategic priorities aimed at improving community outcomes.
- **Treat data as an asset**: This is done by: aligning standards and practices to increase the visibility, usability and value of data; identifying the data that matters for delivering better customer outcomes, governing and managing it effectively across the data lifecycle; and using and sharing it across government and as open data to generate insights that support decision making and innovation.
- **Strengthen transparency and trust**: This involves maintaining privacy, ethical and security standards, taking a "by design" approach to data projects and consolidating whole-of-government data policies to accelerate the safe use and sharing of data across the government.
- **Foster culture, leadership and capability**: This involves ensuring that government employees understand the importance of using data to inform decisions that impact the community and that they have the skills needed to use data effectively and safely in their role. Fostering strong data leadership through the CDOs (and appointing a CDO in departments that do not have one) and the NSW Data Leadership Group (NDLG).

Each theme is supported by a set of principles and sector-wide actions.

Source: NSW Government (2021[18]), *NSW Government Data Strategy*, https://data.nsw.gov.au/sites/default/files/inline-files/NSW%20Government%20Data%20Strategy_0.pdf.

Although some data strategies have a complex structure, including the adoption of technical standards and common approaches while unlocking the value of cities working together to gather, analyse and act upon their data, many of them lack a clear methodology on how this data collection should be done. Poor problem definition can lead to data being analysed in a way that does not add value and therefore diverts time and resources. The experience of London, United Kingdom, shows that it is important to have not only standards for data quality but also a clear methodology for data collection and analysis. The London Office of Technology and Innovation (LOTI) has developed a methodology that intends to prevent organisations from wasting time collecting data that they may not even need, as it adds no extra value to their decision making and does not enable new actions (Box 2.8). All smart city stakeholders need to know: what is being gathered; who is collecting it; and the purpose behind any generation, collection, storage or sharing of data. Moreover, when it comes to sharing data, it is essential to be clear about the exact uses to which the data will be put to facilitate access to information. Local governments need to understand that

they should be the primary users of the data they produce. They have access to an enormous amount of data but figuring out the uses of existing data and identifying data gaps is a step that many governments tend to miss. The LOTI methodology recognises that while digital technologies and data provide a powerful set of tools and approaches with which to innovate, they are rarely the whole solution. Therefore, it is essential to work with different teams to understand the real nature of the challenges to be addressed and how they can be solved. A recurrent challenge is that through smart city initiatives, governments are producing data that sometimes no one knows how to use.

Box 2.8. London's outcome-based methodology for data projects

The London Office of Technology and Information (LOTI) suggests that local governments should try to use the data they have and see if that helps to tackle real problems rather than spending time and resources designing systems and collecting data that add no value. A critical issue for London is not to be driven by data but to be enabled by data to make better decisions and design public policies not based on the available data but on outcomes. For this purpose, LOTI has created an outcome-based methodology that focuses on how data leads to action.

The methodology has six critical stages that are designed to pin down exactly what datasets are actually needed and why, making the information governance aspects of data sharing more achievable:

- **Outcomes – what are the desired outcomes?** – The process begins with thinking about the target population, the change that needs to be seen and the specific ways local authorities can help them improve their situation.
- **Actions – what is the intervention?** – This refers to who and what can do certain things differently if they had better information.
- **Insights – what is the data product?** – This considers what needs to be seen on a screen to enable the actions to achieve the desired outcomes.
- **Data – what data are required to create those insights?** – This refers to considering if existing data can be used, whether other public or privately owned data can be accessed and used, and whether new technology is needed to generate the data.
- **Ethics – is access and use of the data legal and ethical?** – This considers whether the project is worthy of citizens' trust, its potential limitations and unintended negative impacts of acting on this data, and whether action should be taken even if it is possible.
- **Enablers – what other enablers need to be present?** – This refers to other issues that need to be considered beyond data to achieve the desired outcome. Data alone are very rarely enough to be the solution by themselves.

Source: LOTI (n.d.[19]), *LOTI Outcomes-based Methodology for Data Projects*, https://loti.london/resources/data-methodology/; interview with Eddie Copeland, Director of LOTI, 4 May 2022.

The city of Columbus, United States, developed a smart city initiative that provides an example of the need to define the scope and purpose of data collection through smart city technologies (Box 2.9). Explaining what data will be collected and why is a critical element for creating support and buy-in for any smart city project and building trust. Transparency on what data are being collected and the reasons for that could be considered part of a change management or implementation strategy. It is important that smart cities provide this information from the outset and not wait until public groups request details on data collection and use.

The Smart Columbus initiative came to an end in June 2021 and the city government has continued the project as a "collaborative innovation lab". After almost five years, according to city authorities, the Smart Columbus programme was found to have successfully or partially achieved 22 of the 29 objectives identified and created 4 220 jobs (719 direct jobs from programme-related staffing expenditures) (City of Columbus, 2021[20]). A majority of the eight projects have continued in some form. Even for projects that were not continued, the knowledge and lessons learnt have helped increase awareness of emerging technologies and their benefits to all residents in Columbus. The case of Columbus shows that managing stakeholder expectations and understanding the importance of communications is key to a city's ability to mitigate risk and improve both awareness and technology adoption.

Box 2.9. Data governance components of the Columbus smart city initiative

In 2016, the U.S. Department of Transportation (DOT) awarded USD 40 million to the city of Columbus, Ohio as the winner of the Smart City Challenge. The funding was used to address the most pressing community transportation problems of the city through the use of digital technologies, applications and services to bridge social and technical gaps and meet the needs of residents of all ages and abilities.

With the resources, the city established the strategic Smart Columbus programme organised into three focus areas: enabling technologies, emerging technologies and enhanced human services. The programme included eight projects ranging from the development of a connected vehicle environment and smart mobility hubs to prenatal trip assistance and connected electric autonomous vehicles. The Smart Columbus Operating System was the core of the programme. It was designed and built to collect data from a variety of inputs, including public, non-profit, education-based and private sector contributors from different systems, devices and people. Data are made available for analytics, visualisation and artificial intelligence (AI) required by various smart city applications. The operating system is a platform designed for big data, analytics and complex data exchange. It captures the data and provides a means for multitenant access to aggregate, fuse and consume data. The operating system is scalable and can continue serving the city and private sector needs well beyond the life of the Smart City Challenge award period. At the end of 2021, when the programme ended, the operating system had collected more than 3 000 datasets in a wide number of areas, such as traffic, city infrastructure inventory, emergency response time, etc.

As part of the Smart City programme, the city government created a comprehensive project management plan that defined the principles and procedures for how the programme had to be managed to ensure delivery within the agreed scope, schedule and budget. Critically, it clarified the scope and purpose of the data collected by the operating system. The plan stated that the data in the operating system was defined by the data management plan (DMP) and the data privacy plan (DPP), which created the data governance components together.

The DMP documented how the data within the operating system were added, made accessible and/or stored. It also detailed how the data were created, captured, transmitted, maintained, accessed, shared, secured and archived. The DMP provided oversight for all eight Smart Columbus projects and guidance for managing the data within the programme as well as details on how and where data were shared, subject to applicable privacy, security and other safeguards, and how the data were made available to other actors to enable performance measurement and support independent evaluation.

The DPP provided high-level guidance, principles and policies to ensure the privacy of Smart Columbus demonstration data subjects and project participants. It also aimed to protect the operating system against breaches and the access of unauthorised users to personally identifiable information and other data. The DPP includes ten data stewardship principles that all DOT grant-funded Smart Columbus projects must follow. The privacy controls included: notice and consent, data minimisation,

transparency, de-identification and data curation. The DPP also included a privacy impact assessment to identify and mitigate privacy risks associated with each Smart Columbus project.

Source: City of Columbus (2020[21]), *Data Management Plan for the Smart Columbus Demonstration Program*, https://d2rfd3nxvhnf29.cloudfront.net/2020-08/SCC-E-DataManagementPlan-Update-v1.pdf; City of Columbus (2019[22]), *Project Management Plan for the Smart Columbus Demonstration Program*, https://d2rfd3nxvhnf29.cloudfront.net/2019-08/Smart%20Columbus%20Smart%20City%20Challenge%20Project%20Management%20Plan.pdf; City of Columbus (2020[23]), *Data Privacy Plan for the Smart Columbus Demonstration Program*, https://d2rfd3nxvhnf29.cloudfront.net/2020-09/SCC-D-DataPrivacyPlan-AnnualUpdate-V2_0.pdf; Johnson, J. et.al. (2022[2]), "Data governance frameworks for Smart Cities: Key considerations for data management and use", https://repository.law.umich.edu/jlm/vol2022/iss1/1.

A data strategy for smart cities should define the key elements of data governance

In the context of smart cities, a data strategy should set the governance arrangements that will govern how and under what conditions data can be accessed and exchanged, and the responsibilities of those in charge of managing and keeping data and platforms. An example is Colombia's National Data Infrastructure Plan (PNID), adopted in February 2022 (Box 2.10). It contains elements or features that are worth highlighting due to their contribution to the formation of smart cities in the country and the data governance dialogue. First, the PNID defines the basic elements of the governance of data at the tactical level: rules, attributions, responsibilities and processes that could also be followed in the organisation of smart city projects. Second, it defines the leadership for the strategy implementation. This leadership should not be just a single body or person but a more collaborative body that facilitates the exchange of views and experiences. However, if local governments wish to have a more collaborative model for data management, as Colombia's PNID suggests, there should be mechanisms or protocols for co-operation among the different local stakeholders. Third, probably the most critical part of the PNID, the technical level, is that it promotes the articulation of the data infrastructure with other data-related systems in the country, such as the national statistics system, the digital security and privacy of information, and the tools and technologies that facilitate interoperability. The message for local governments is that the smart city project must be connected to the regional or local statistics office, as is done in Bilbao, Spain. It is worth pointing out that Colombia's PNID is not explicitly linked to urban development as is India's DataSmart Cities strategy but provides the basic framework for the development of smart cities in the country.

Box 2.10. Colombia's National Data Infrastructure Plan

In 2022, Colombia's national government issued the National Data Infrastructure Plan (PNID) to promote the state's digital transformation. This plan is to support the government's efforts to enhance the economic recovery after the COVID-19 pandemic. For the Colombian government, the data infrastructure is a set of shared, dynamic and standardised resources arranged by different actors, which enables the permanent provision of key data for its use and the generation of social, economic and public value.

The data infrastructure is made up of six minimum components: i) the strategy and governance of the data infrastructure; ii) data (minimum, data, transactional and open data); iii) use of the data; iv) data infrastructure interoperability; v) data security and privacy; and vi) technical and technological tools. The data infrastructure governance guidelines include, among others, the following: rules (policies, standards, regulations, business rules); faculties and powers of decision; responsibilities and accountability; and processes related to data management during its life cycle.

The PNID will develop different mechanisms to promote data trust, data commons, data marketplace and data portal models. The national government led the structuring of the PNID through the Ministry of Information and Communication Technologies, the National Planning Department and the Administrative Department of the Presidency of the Republic. It also involved the participation of the private sector, academia and civil society.

The PNID sets the basic principles for data management such as: quality data; public trust and ethics in data management; standardisation and interoperability; accessibility, easy access and reutilisation; and privacy and data protection. It also sets the governance of data infrastructure that should define and integrate the different data sources into a single one, promotes the development of capacities of different actors for the adoption of a common approach in data management as well as the consolidation of standardised processes and measures for data protection.

For the development, implementation and sustainability of the data infrastructure and governance arrangements, the National Planning Department, the National Administrative Department of Statistics, the Administrative Department of the Presidency and the ICT Ministry will be in charge of co-ordination and overall oversight. The PNID is set to be co-ordinated with the interoperability model of digital citizen services. Critically, the data infrastructure must be articulated with the national statistics system and the Colombian spatial data infrastructure, particularly in relation to the classification of data, nomenclature, interoperability, concepts, quality of data and data management models.

Source: Government of Colombia (2022[24]), *Plan Nacional de Infraestructura de Datos*, https://www.mintic.gov.co/portal/715/articles-198952_resolucion_00460_2022.pdf.

Improving data privacy and security is at the core of data governance

Cities' desire to improve citizens' lives, the efficiency of city management and boost economic growth by using digital technologies raises security and privacy concerns. The reason is that smart city technologies capture personally identifiable information and household-level data about citizens, such as their location and movements, physical characteristics and daily activities. These data linked together generate a profile about individuals and communities to make decisions about them but not necessarily involving them. There are also concerns about how secure these digital technologies are, the data they generate from hacking and the costs they may imply for cities and citizens. The challenge for cities is to deploy digital technologies and gain the benefits expected from them while maintaining security and minimising the negative effects they may have on the city's infrastructure and residents. A large number of stakeholders and interests involved are vested in smart city projects and the diversity of technologies used makes it more difficult to meet this challenge.

Local governments generally have higher levels of trust from the population than national governments

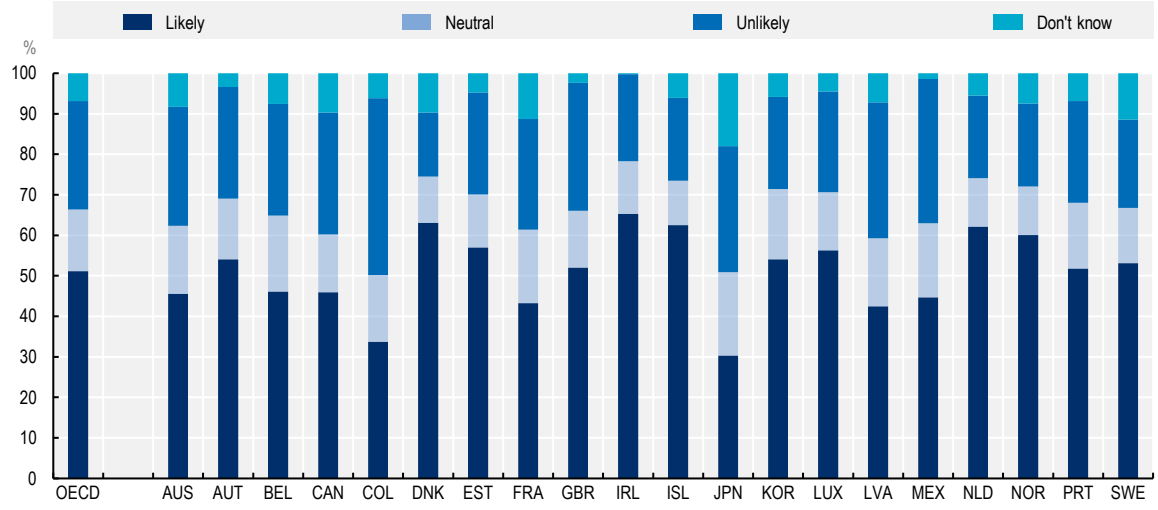
One of the tasks of data governance is offering a common basis to use data to attain shared policy goals and promote trust. The OECD considers trust as core to becoming a data-driven public sector (OECD, 2019[3]), which applies equally well to the city level. Trust may be defined as a positive perception of the actions of an individual or an organisation grounded in actual experience but determined by the subjective assessment of individuals (OECD, 2017[25]). Between 2007 and 2020, the greatest increases were in Germany and Iceland, while trust levels in Belgium and Chile fell most steeply. However, it must be pointed out that metrics of trust in government provide signals of people's relationship with their institutions and the state of public affairs in countries; though, as the OECD (2021[26]) points out, they remain highly aggregated and could be influenced by a wide array of factors and circumstances.

Research has shown that, at least in the European Union, local and regional institutions are more trusted than national governments (Arrighi et al., 2022[27]). This level of trust in local institutions seems to be closely related to the quality of public services and day-to-day policies, that means: the prospect of a well-functioning economy; decent schools and safe streets; security of property and data; properly maintained public transport and infrastructure; a healthy environment; and a thriving cultural landscape (Aguiar, Boutenko and Lacanna, 2021[28]). Trust is key to ensuring social stability; for that, all institutions, particularly national and subnational governments, must provide trustworthy information (Edelman, 2022[29]). That requires providing clear, consistent, fact-based information to break the cycle of distrust.

Citizens are more likely to provide the government – and its partners – with personal data providing that their data will be protected and not misused by the government or sold for marketing purposes for example, and that their data will be used to improve public service delivery. In other words, citizens need to perceive that, with the data they have provided to the government, public services will be more personalised and meet their specific needs. If the government and its partners fail to meet citizens' expectations by using data without permission or public service experiences do not improve, then trust is damaged and may take a long time to be repaired. In 2021, a survey conducted in Lisbon, Portugal, on data protection found that citizens generally have the perception that their data are not properly protected and there are risks of leaks or being hacked, they are worried someone else is using their personal data without their knowledge and permission, and there seems to be a general lack of knowledge on the data protection measures adopted by the city as part of its smart city programme (Cró and Castro Roegiers, 2021[30]). However, the results of the OECD Survey on Drivers of Trust in Public Institutions showed that a majority of people in most countries are satisfied with access to information about administrative procedures. More than half of respondents trust their government to use their personal data only for legitimate purposes (Figure 2.2) and trust in local governments is generally higher than in national government (Figure 2.3) (OECD, 2022[31]). Yet, governments need to strengthen their efforts aimed at reinforcing trust in the way they handle citizens' data.

Figure 2.2. Half of residents in OECD countries, on average, trust their government to use their personal data for legitimate purposes

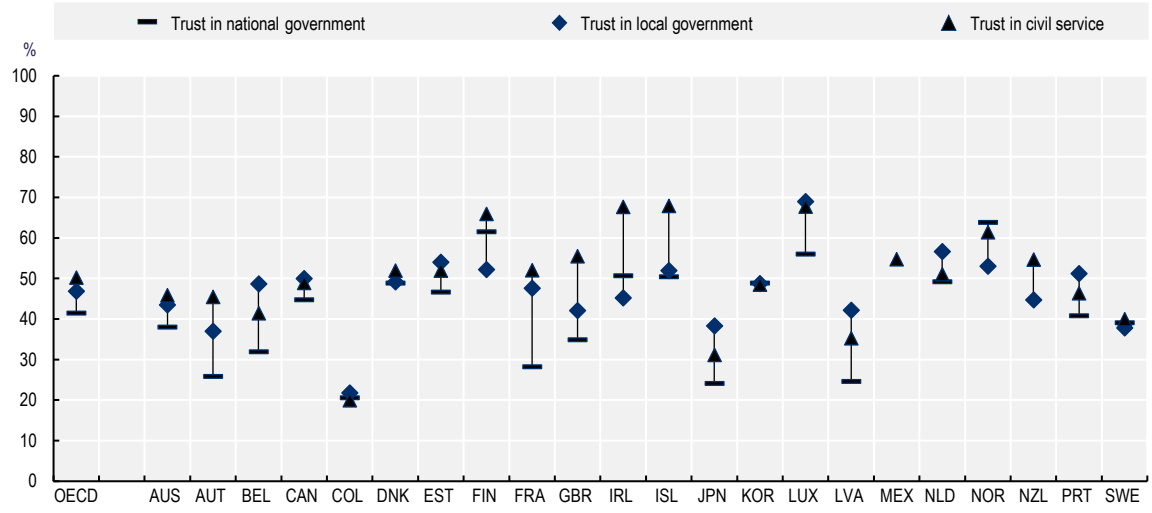
Share of respondents reporting different levels of perceived likelihood that their government would use personal data exclusively for "legitimate purposes" (on a 0-10 scale), 2021



Source: OECD (2022[31]), *Building Trust to Reinforce Democracy: Main Findings from the 2021 OECD Survey on Drivers of Trust in Public Institutions*, https://doi.org/10.1787/b407f99c-en.

Figure 2.3. People's trust in civil service and local governments is generally higher than in national government

Share of respondents indicating trust in various government institutions (responses 6-10 on a 10-point scale)



Source: OECD (2022[31]), *Building Trust to Reinforce Democracy: Main Findings from the 2021 OECD Survey on Drivers of Trust in Public Institutions*, https://doi.org/10.1787/b407f99c-en.

To that end, some governments have been adopting initiatives to build trust in government smart city projects and encourage citizens to share their data. Some have established practical mechanisms by which citizens and businesses can know which data government organisations hold about them. For example;

- In **Japan**, the Act on the Protection of Personal Information (APPI) has been amended to require more information to be provided to the individual about handling personal information in the offshore company to which they are relocating.
- In the **European Union**, the General Data Protection Regulation (GDPR), adopted in 2018, aims to protect citizens from privacy and data breaches. Companies can only use data that the data subject has agreed on, and consent has to be given in a clear and easily accessible form with the option to withdraw. The regulation itself is large, far-reaching and fairly light on specifics. It was designed to apply to all types of businesses, from multinationals down to micro enterprises. However, its complexity makes GDPR compliance a daunting prospect, particularly for small and medium-sized enterprises (SMEs). Thus, the European Commission created a specific website, gdpr.eu, to serve as a resource for SME owners and managers to address specific challenges they may face (EU, 2022[32]).

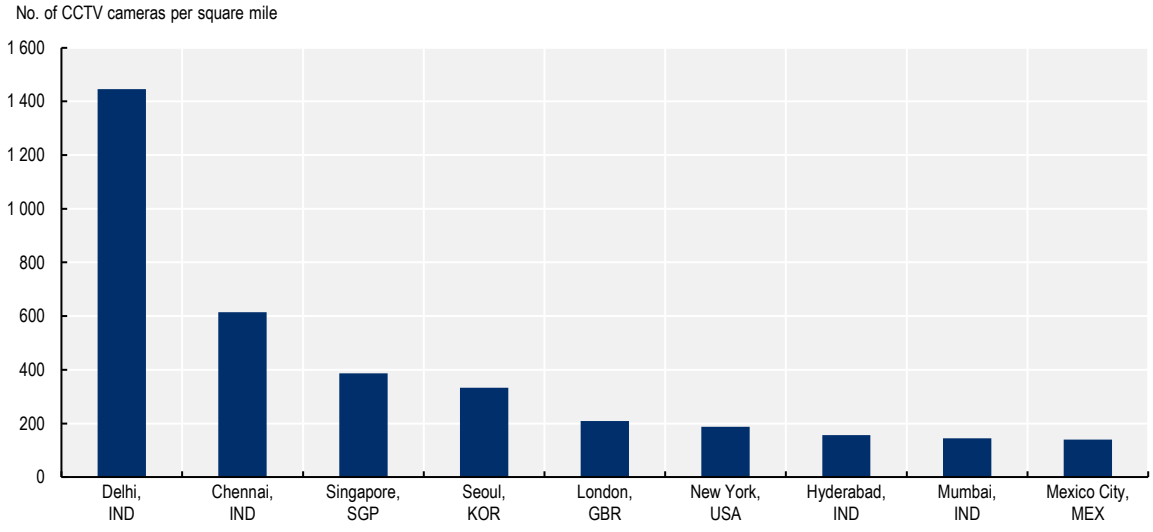
The phenomenon of datafication may potentially breach privacy rules

The use of digital technologies as part of smart city projects is giving place to a phenomenon called "datafication" by which concrete phenomena, situations or actions are transformed into data. Although these data can be used to improve services, it could breach privacy laws. Datafication creates concerns as the capture and circulation of data may involve a large number of individuals and the distribution of their data can occur across multiple devices, places and services as data flow easily across platforms.

Smart city technologies have transformed geolocation tracking, making monitoring people's location continuous. For example, smart cards used to pay for public transport, such as the Navigo card in Paris, France, the Isar Card in Munich, Germany, and the Suica card in Japan, collect information on people's

movements across a city. Cities such as London have installed sensor networks across street infrastructure to capture and track phone identifiers such as media access control (MAC) addresses – a unique number used to track a device in a network[6] – that could track the stores individuals visited, the duration of their stay and how often they visit a particular shop and use that information to show contextual adverts. Several cities across the world have installed digital closed-circuit television (CCTV) cameras that can zoom and track individual pedestrians (Figure 2.4). Local authorities are deploying CCTV cameras and facial recognition systems to bolster security in severely under-policed areas to prevent crime but in countries such as India, this is creating concerns about security and privacy as there are not strong enough laws to protect people (Chandran, 2023[33]). All data collected through digital technologies has the potential to assist in improving service delivery and making informed policy decisions. However, in many cases, private actors generally collect and store these data, creating concerns regarding the legitimate use of people's data.

Figure 2.4. Some of the most surveyed cities in the world



Note: This calculation does not include cities in China.
Source: Bischoff, P. (2022[34]), "Surveillance camera statistics: Which city has the most CCTV cameras?", https://www.comparitech.com/vpn-privacy/the-worlds-most-surveilled-cities/.

Addressing privacy concerns requires a comprehensive multi-domain approach

Protecting data privacy should be central to any smart city data governance arrangement. Kitchin (2016[35]) suggests that, to address privacy concerns, cities require a suite of solutions as there is no single solution to a complex political, technical and ethical challenge such as data privacy. Some solutions should be market-driven, others should be technical-oriented, should focus more on policy and regulations, or should be more oriented to governance and management. This mix of solutions would enable the rollout of smart city technologies in a way that protects people's privacy while minimising privacy risks.

Market-driven solutions require regulatory tools and oversight to ensure compliance with privacy regulations. Regulation needs to define security requirements and assurance processes that companies need to follow. It is essential for all stakeholders contributing to smart city services to acknowledge security risk management requirements. But regulation also requires companies to see data privacy protection as a competitive advantage. Across the world, 68% of consumers believe companies benefit more from using their data than they do; and 76% of consumers want to take more direct control over their data instead of companies and governments (Bella, 2021[36]). A critical problem in many countries is that citizens are not

keen on sharing the personal data that governments would need to better plan some services, for example commuting and geolocalisation data to improve traffic management planning. “Giving citizens the opportunity to actively decide on who can use their data and for what purposes, accompanied by trustworthy technology, processes and actors can also create incentives to share or generate such data” (Franke and Gailhofer, 2021, p. 8[5]). The experience of the city of Aizuwakamatsu in Japan shows how important it is to give residents the option to opt in to generate trust in how personal data are collected, handled, stored and protected. This allows residents to choose if they want to provide personal information in exchange for digital services and around 20% of the population have opted in to share their data.

Regarding technology solutions to address data privacy concerns, cities may use privacy-enhancing technologies (PETs), which are a broad range of technologies designed to extract data value without risking the privacy and security of the data, such as cryptographic algorithms, data masking techniques, anonymisation techniques and synthetic data generation, among others (Dilmegani, 2022[37]; Curzon, Almehmadi and El-Khatib, 2019[38]). Different technologies have been developed to assist cities in anonymising data through metadata aggregation, privacy masking, data purging and deep natural anonymisation technology (DNAT) that prevent the original subjects from being recognised by creating synthetic overlays and allowing cities to use videos and images safely without breaching privacy rules.[7] PETs aim to minimise data generation, preventing unnecessary processing of personal data while increasing individual control of personal identifiable information (PII) and facilitating legal data inspection rights. In Singapore, for example, the National Steps Challenge is an initiative by which a step-tracking device is linked to a mobile application; the aim is to encourage users to adopt a healthier lifestyle by offering incentives to participate in a national competition.[8] The risk regarding data privacy concerns the collection of personal quantitative information tied to an identified individual, which could expose personal and location information. According to research, PETs could protect the data privacy of participants in the National Steps Challenge initiative by, for example, applying a *k*-anonymity (i.e. ensuring all data entries share the values in their quasi-identifiers with $k-1$ other entries) to ensure that participant information is adequately protected (Curzon, Almehmadi and El-Khatib, 2019[38]). However, these technologies are not widespread yet and, until they are, cities should follow the Privacy by Design (PbD)[9] principles as they take a broad view of a data system and its data: proactive not reactive; privacy as a default setting; privacy embedded into design; full functionality; end-to-end security; visibility and transparency; and respect for user privacy.[10]

To administer market and technology solutions to protect data, some countries have conducted regulatory reforms to guarantee rights and freedoms on data and information and cities have implemented initiatives for data protection as part of smart cities projects to build trust. Efforts to protect data tend to focus on areas of: ethics – to guide behaviours across the public sector; privacy – to protect citizens’ privacy and to establish data rights; transparency and accountability – of algorithms used for decision making; and security – to manage risk to government data (van Ooijen, Ubaldi and Welby, 2019[39]; OECD, 2019[3]). At the local level, for example, when procuring digital products and IT services, the city of Vienna applies tender criteria that ensure digital sovereignty, paying particular attention to protecting the data of critical infrastructure and operators of essential services. The aim is to ensure that the operation of digital infrastructure and digital services is as independent as possible to guarantee a high degree of independence and flexibility, as well as a high degree of sovereignty, individualisation and service orientation for the economy, citizens and public employees. This could contribute to the resilience of the digital infrastructure and digital services required to maintain the city administration and essential public services.

Different legal frameworks are built around personal rights and regarding the generation, use and disclosure of personal data and the obligations of governments to protect that data. For example:

- In 2021, **Chile** established the Measures to Encourage the Protection of Consumer Rights (known as the Pro Consumer Law or *Ley Pro Consumidor*) to protect the consumer collective or individual interest to request compensation upon breaches into their personal data. It grants the Financial

Market Commission, the Chilean Transparency Council and the National Consumer Service supervisory powers regarding personal data processed within a consumer relation.[11]

- In **Korea**, the Personal Information Protection Commission, established to protect people's personal information, is required by the Personal Information Protection Act to establish a master plan every three years to ensure the protection of personal information (Government of Korea, 2022[40]). In the capital Seoul, all citizens are able to vote on line on budgeting decisions that fall within the city's participatory budgeting programme, launched in 2012 (Aguiar, Boutenko and Lacanna, 2021[28]).
- The **United Kingdom** aims to ensure that legislation is in step with innovation to protect personal data and citizens' privacy. This work involves experts from civil society and convenes a number of departmental groups to ensure that data work is adequately scrutinised and that data protection and privacy regimes are robustly upheld (OECD, 2019[3]). In London, the city government set up the London Datastore as a free and open data-sharing portal where anyone can access around 700 databases relating to the city's progress on issues such as job creation, public transport, housing, community safety, etc.[12] The premise is that transparency enables residents to assess the government's actions and build trust.
- In **Portugal**, the national government prioritised security as a guiding principle of its ICT strategy 2020. To enhance security, the government created the National Commission for Data Protection to supervise and monitor compliance with laws and regulations pertaining to personal data protection and to correct and sanction breaches of such laws and regulations (One Trust Data Guidance, 2022[41]).
- **Japan** has a very comprehensive regulatory framework for handling personal information (Box 2.11). This framework has solved the problem of about 2 000 local governments providing their own ordinance for personal information.
- In **Germany**, funding for smart cities is conditioned to abide by the European GDPR, by which data collected should be either non-personal or anonymised; cities should refrain from collecting data about individual citizens.
- In 2012, the **United States** set out a revised version of the Fair Information Practice Principles (FIPPs) – first published by the OECD in 1980 (OECD, 2013[42]) – in the Consumer Privacy Bill of Rights to improve consumers' privacy protections and ensure that the Internet remains an engine for innovation and economic growth. The bill contains principles such as individual control, transparency, respect for context, security, access and accuracy, focused collection and accountability.[13]

Box 2.11. Japan's comprehensive data governance regulatory instruments for data protection and management

Japan has three main laws regarding data protection. Data protection is constantly evolving as the scope of personal information disclosed by individuals in day-to-day transactions expands and use by businesses becomes more widespread. Three main laws that influence data management and governance can be mentioned:

- The Act on the Protection of Personal Information (Act No. 57 of 2003 as amended in 2020) (APPI) is Japan's basic law on the protection of the rights and interests of individuals, ensuring the proper handling of personal information. The APPI defines the responsibilities of the national and local governments and entities handling personal information in relation to the protection and proper handling of personal data and directs the adoption of a Basic Policy on the Protection of Personal Data. The Personal Information Protection Commission (PPC) is responsible for

monitoring and supervising compliance with the APPI and provides key guidelines and answers to frequently asked questions. The APPI delegates the power to request reports from the PPC to the ministers with jurisdiction over their respective business areas. For sectors such as healthcare, finance and credit, information and communications, the PPC has developed specific field guidelines taking into account the nature of the personal data handled and the particularities of the way they are used.

- The Act on the Use of Numbers to Identify a Specific Individual in the Administrative Procedure (Act No. 27 of 2013 as amended), also known as My Number Act, provides special provisions for the safe handling of personal information. In particular, the My Number Act issues rules to protect individual numbers as well as define the rules to manage and use this information efficiently in administrative organs and local governments.
- The Basic Act on the Advancement of Public and Private Sector Data Utilisation (Act No. 103 of 2016) determines the responsibilities of the state, local public entities and companies in the provision and appropriate and effective use of public and private sector data. The act is the government's response to the need to ensure the appropriate use of the information that circulates on the Internet and other information and communication networks in a way that contributes to tackling Japan's key challenges, such as an ageing population. The act requires the government to establish a Basic Plan for the Advancement of Public and Private Sector Data Utilisation.

Source: Government of Japan (2003[43]), *Act on the Protection of Personal Information*, https://www.japaneselawtranslation.go.jp/en/laws/view/4241/en; Government of Japan (2013[44]), *Act on the Use of Numbers to Identify a Specific Individual in the Administrative Procedure (Act No. 27 of 2013 as Amended)*, https://www.dataguidance.com/legal-research/act-use-numbers-identify-specific-individual; Government of Japan (2016[45]), *官民データ活用推進基本法 [Basic Act on the Advancement of Public and Private Sector Data Utilisation]*,, https://japan.kantei.go.jp/policy/it/data_basicact/data_basicact.html.

One of the biggest barriers to sharing data is the interpretation of legislation. In London, for example, each of the 33 boroughs has its legal team with its own interpretation of the legislation of data protection. This creates delays in decision making and implementation of projects. London's experience suggests that it is necessary to standardise the approach of information governance to align the thinking about the legality of data-sharing measures and tools.[14] Moreover, research has found that the different legal framing and policies for data protection across jurisdictions create a fractured regulatory landscape which could diminish its impact (Kitchin, 2016[35]). There are different obligations for smart city technologies deployed within countries and even cities depending on local laws and regulations.

Protecting data privacy also requires governance measures. Principle-led governance is a condition for creating a smart city that maximises data benefits and minimises risks to individuals. To reinforce the ethical management and use of data, some countries have established independent bodies and developed ethical frameworks. The central body focuses on government-held data and support government entities to build capacity for data management and see data as a valuable strategic asset. They also provide support for the implementation of data standards and may experiment with innovative methodologies for data management and sharing. For example:

- In **Australia**, the Australian Research Data Commons (ARDC) is the national research infrastructure provider that enables the research community and industry access to nationally significant, data-intensive digital research infrastructure, platforms, skills and collections of high-quality data. It also facilitates partnerships to develop a coherent research environment that enables researchers to find, access, contribute to and effectively use services to maximise research quality and impact (ARDC, 2022[46]).

- In **India**, the Data Security Council of India (DSCI) is a not-for-profit body that seeks to make cyberspace safe, secure and trusted by establishing best practices, standards and initiatives in cybersecurity and privacy (DSCI, 2023[47]).
- In **Ireland**, the Data Protection Commission (DPC) is the national independent authority responsible for upholding the fundamental right of individuals in the European Union to have their personal data protected. It is the supervisory authority for the GDPR, and also has functions and powers related to other important regulatory frameworks, including the Irish e-Privacy Regulations and the European Union directive known as the Law Enforcement Directive (DPC, 2022[48]).
- **Mexico** established the National Institute for Transparency, Access to Information and Personal Data Protection (INAI) as an autonomous constitutional body that guarantees compliance with two fundamental rights: access to public information and the proper use of personal data (INAI, 2022[49]).

At the city level, Smart City Advisory Boards provide a strategic vision of the composition and ambition of the smart city plan as the principles underpinning the smart city plans. The advisory board could be composed of representatives of local and regional governments, regulatory bodies, the private sector, academia and citizen representatives, among other relevant stakeholders. Among its tasks, the board can set an ethical framework for data protection as a result of smart city initiatives. For example, in London, since 2022, the Data for London Advisory Board – a leadership group of data and technology experts – has advised the mayor and the CDO on the development of the new Data for London platform and a data strategy to ensure data are managed effectively and responsibly (Mayor of London, 2023[50]).

According to research, it is also recommended to set up a smart city governance, ethics and security oversight committee with a more operational focus than the advisory board. Its aim should be to oversee and audit the work of the privacy teams, certify that the smart city activities are aligned with the regulatory requirements and ensure that citizens know how the smart city is being realised and how data are being generated, used, stored and shared (Kitchin, 2016[35]). In the United States, for example, the city of Seattle set up the Privacy and Cybersecurity Committee as part of the Community Technology Advisory Board, with the goal to ensure the protection of residents' data through information security policies and that they are free form unchecked surveillance (City of Seattle, 2023[51]).

Despite its added value to research and policy making, the use of data may be the origin of ethical considerations. For example, the use of geospatial data (location data) – critical for many smart city functions – may bring with it concerns such as: privacy, security and surveillance issues related to the capacity to directly or inadvertently observe private property, capture sensitive personal information and potentially put persons in harm's way; uncertain consent when using data from third-party owners; unintended or unknown surveillance; discrimination consciously or unconsciously built into algorithms; lack of representativeness or robustness of data; and data that may be stored on servers that can be easily accessed by unauthorised actors (Berman et al., 2018[52]). Since geospatial data often locate individuals, addresses or businesses and generally come from personal devices such as mobile phones, citizens may consider them a special or intimate type of data.

While the use of digital technologies for service delivery and decision making may bring benefits in terms of efficiency, convenience and safety, they also bring risks; that is why countries and cities are building trust through ethical frameworks or guidelines regarding data management. These guidelines provide users with information, resources and approaches to achieve ethical practices in data management. They do not intend to be prescriptive but work on ethical concerns. These ethical frameworks can be developed nationwide by countries or by cities (OECD, 2019[3]). An example of a national-level ethical framework is the United Kingdom's Data Ethics Framework, which guides public sector organisations on using data appropriately and responsibly in policy making and service provision. The UK government has codes of practice for the use of data-sharing provisions within the Digital Economy Act that contain checks and balances consistent with the Data Protection Act to ensure data are not used inadequately. The Data Ethics

Framework is used for data outside the scope of the legislation and guides policy makers and data analysts in the ethical implications of their work (Box 2.12). Germany promotes a value-based approach to data that sets values and principles, which defines how personal and non-personal data should be managed and may fill the gaps in areas that remain unregulated (BBSR, 2021[9]). Moreover, the experience of OECD countries (e.g. Germany, the Netherlands) suggests that the different stakeholders involved in data management and processes need to be aware of the risks and challenges posed by the use and sharing of personal and non-personal to ensure data responsibility.

Box 2.12. United Kingdom: Data Ethics Framework

In 2018, the United Kingdom established a Data Ethics Framework to guide public servants in the appropriate and responsible use of data in government and the wider public sector. It is aimed at anyone working directly or indirectly with data in the public sector, such as data practitioners, policy makers, operational staff and those helping to produce data-informed insight. The framework is divided into overarching principles and specific actions.

There are three overarching principles:

- **Transparency** means that actions, processes and data are made open to inspection by publishing information about the project in a complete, open, understandable, easily accessible and free format.
- **Accountability** means that the public or its representatives are able to exercise effective oversight and control over the decisions and actions taken by the government and its officials.
- **Fairness** means that officials should eliminate potential unintended discriminatory effects on individuals and social groups.

Five specific actions support the principles:

- Define public benefit and user needs.
- Involve diverse expertise.
- Comply with the law.
- Check the quality and limitations of the data.
- Evaluate and consider wider policy implications.

Source: UK Government (2020[53]) *Data Ethics Framework*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/923108/Data_Ethics_Framework_2020.pdf.

At the local level, the city of Bilbao in Spain provides an example of the efforts to ensure good data management and governance in the framework of its work to build a smart city and promote digitalisation. Bilbao's local council intends to use data only to create new services and improve the existing ones, to give citizens the guarantee that their data will not be marketed and that they will be used only for the benefit of the city and its residents. Bilbao City Council is working with a 2030 vision. The underpinning factor is to create a data-driven government based on data-driven decision-making processes that is able to provide all sectors and stakeholders with the necessary information to create value. The local government works with open and internal data. The latter requires specific governance processes as they may include personal and sensitive information. To reassure citizens about the use of the data, in 2022, the local council approved the Bilbao Data Manifesto to generate trust based on anonymised data (Box 2.13). The basic premise is that the data belong to the city and residents, not the administration. The Bilbao local council aggregates data to ensure the privacy of residents and the protection of their data.

Box 2.13. The Bilbao Data Manifesto to guide data management and governance

Bilbao City Council is determined to take advantage of this new opportunity to improve the quality of life of citizens by managing the data and guaranteeing its proper treatment within the framework of Bilbao's values. Thus, in February 2022, the city council established a set of principles to guide the management and use of data called the Bilbao Data Manifesto, based on the ethical values already included in the Bilbao Charter of Values. The basic premise of the manifesto is that all data provided to or acquired by the local government will be used to improve existing services and create new ones. All data in possession of the city administration or acquired through third parties through different agreements and conventions are subject to the principles set in the Bilbao Data Manifesto:

- **Justice, equity and solidarity** – Any system based on data will contribute to global justice and guarantee all people the same benefits and results. Data management should guarantee the rights of vulnerable groups, avoid discrimination and promote social cohesion with respect to disadvantaged social groups.
- **Sustainability** – Whenever applicable, any system based on the use of data will ensure the protection of the environment, and its care, including its ability to improve it.
- **Co-creation and co-operation** – To use resources in an optimal manner, projects that impact the largest number of sectors (public, private and citizens) will have priority.
- **Transparency** – In the event that personal data must be obtained and used, people's explicit consent must be reported.
- **Explainability** – The results of the work, analysis and/or systems based on data will be explained in detail for the understanding of all people. The decisions made, their justifications and the results obtained will be communicated in an understandable way, avoiding technical terms, so that anyone can understand it.
- **Reliability and human intervention** – Each of the automation processes deployed for the execution of routine tasks will be accompanied by methodologies for auditing, monitoring and verifying the executions.
- **Prudence** – Different alternatives will be considered for the design of the tasks, with the aim of having multiple perspectives. The conception of various approaches will allow carrying out contrasting actions, facilitating the optimal conceptualisation of the solution.
- **Responsibility** – Persons responsible for the work will be defined. All those involved in the chain of design, conceptualisation and construction will be taken into account and not only the developers of the technological solution as people closest to the code.
- **Privacy and data protection** – Bilbao City Council will ensure that the private sphere of individuals is left out of the analysis systems. It will implement policies regarding the right to technological disconnection and the right not to be profiled, measured and analysed.
- **Security** – Bilbao City Council will have a robust, safe and secure environment, minimising the risk of attacks and ensuring adequate access to information systems.

Source: Ayuntamiento de Bilbao (2022[54]), *Bilbao Data Manifesto*, https://kopuru.com/bilbao-data-manifesto-los-10-principios-eticos-que-regiran-el-uso-de-datos/ (accessed on 27 July 2022).

It is worth noting that "[t]he use of data-based applications in smart cities must not infringe on any fundamental rights or on the security, civil liberties or privacy of individuals. Algorithmic systems must not replace democratically elected bodies or the accountability of natural persons or legal entities" (BBSR, 2021, p. 17[9]). All levels of government need to work together to ensure proper data stewardship.

Collecting and sharing individuals' spatial data can lead to beneficial insights and services. However, it can also compromise citizens' privacy, making them vulnerable to governmental overreach, tracking, discrimination and unwanted advertisement. Therefore, countries and cities may also take into account the GeoEthics Principles proposed by a number of international organisations and statistics bureaus. Although these principles or guidelines are built for geospatial data, they can be applied to data management more generally. Table 2.3 presents a selection of available principles of guidelines to keep ethical considerations in the management of geospatial data. These guidelines or ethical frameworks provide a series of practical tools to ensure that location-enabled technologies and location data are used based on ethical considerations, and in turn, that could help enhance trust in the government's capacity to manage and protect data.

Table 2.3. Examples of geospatial ethical principles and guidelines developed by different international organisations

Guidelines or principles	Focus	Elaborated by
Ethical considerations when using geospatial technologies for evidence generation	The use of an ethical lens to assess geospatial technologies and resulting data prior to implementation of programmes, analyses or partnerships. It provides a checklist that may be used as a practical tool to support reflection on the ethical use of geospatial technologies.	UNICEF[15]
The Locus Charter	It proposes that a wider, shared understanding of risks and solutions relating to the uses of location data can improve standards of practice and help protect individuals and the public interest. It intends to manage risks to enhance the benefits of geospatial technologies.	Ethical Geo/ Benchmark[16]
A geoprivacy manifesto	It proposes 21 theses that, in general, argue that location information is different from other kinds of personal information and show why geoprivacy (and privacy in general) needs to be protected. It integrates technological, ethical, legal and educational aspects to shape the interaction with technology.	Keßler and McKenzie[17]
Ethical considerations in the use of geospatial data for research and statistics	It provides a checklist of ethical considerations when designing a statistical or geospatial analysis project. It enlists 16 practical steps to help researchers and statisticians navigate potential ethical issues for all types of projects.	UK Statistics Authority[18]
The Responsible Use of Spatial Data	Its purpose is to raise awareness of the ethical responsibilities of both providers and users of spatial data on the web. It searches to illustrate the issues specifically associated with the nature of spatial data and the benefits and risks of sharing this information implicitly and explicitly on the web.	W3C[19]
GIS Code of Ethics	It is intended to provide guidelines for GIS professionals to help them make appropriate and ethical choices when using GIS data. It provides a basis for evaluating their work from an ethical point of view and preserves and enhances public trust.	URISA[20]
Framework on the responsible use of location data	Its purpose is to inspire data users, initiators, executive teams, clients, directors and other stakeholders and provide an additional tool for the responsible collection, use and assessment of personal location data.	Geonovum[21]

Source: Table prepared based on the information provided in the OECD seminar on Geo-ethics Frameworks and Governance on 4 October 2022.

Ensuring data protection is a critical pillar of data governance for smart cities

Data protection is one of the key challenges of digital transformation in OECD countries and cities implementing smart city strategies. As smart cities become more interconnected and the level of digital

infrastructure becomes more complex and relevant, these services also become more vulnerable to cyberattacks. These can take different forms, close a system down or deny service use; extract data and information; or enter into a system to alter information (Dodge and Kitchin, 2017[55]). Because of privacy and security concerns, people tend not to share their data with government and private companies, which may limit the efficiency of smart city initiatives. Collecting incomplete and poor-quality data may undermine the usefulness of data and trust in government's capacity to manage data wisely and eventually the efficiency of the smart city projects. The basic tenet for OECD countries and cities is to ensure that data remain safe and available to users at all times. In Latin America and the Caribbean, there were 137 billion attempted cyberattacks between January and June 2022, a 50% increase compared to 2021; Mexico was the most attacked country (85 billion attacks), followed by Brazil (31.5 billion) and Colombia (6.3 billion) (Fortinet, 2022[56]). Thus, countries and cities invest in cyber security, which means protecting systems, networks and programmes against digital attacks, but it is still in its infancy in smart cities (Ma, 2021[57]).

Research has found five major vulnerabilities digital technologies have (Dodge and Kitchin, 2017[55]; Cerrudo, 2015[58]). Weak software security and data encryption, which means that smart city systems are built without minimal security. The use of insecure legacy systems and poor ongoing maintenance creates serious risks as smart city technologies are built on top of much older technology that has not been upgraded (Cerrudo, 2015[58]). The interdependency of smart city systems makes it difficult to detect which components are exposed to mitigate risks. These interdependencies create cascade effects as failures and disruptions in one part of the system may have knock-on effects on other critical services or infrastructures, and it is a key risk in city operating systems (Dodge and Kitchin, 2017[55]). Human errors and sabotage can also lead to exposing weaknesses in the system.

Data protection has increasingly become a major concern, especially for cities and private companies deploying cloud-based applications. Many cities across OECD countries rely on a wide network of sensors, technologies and interconnected data-gathering portals to operate smoothly. However, digital technologies can easily be hacked if they are not implemented with proper security. Smart cities are vulnerable to cyberattacks in many ways, as several different attacks could be working in unison to disrupt urban services, often using malware and 'zero-day' software vulnerabilities. These may result from data breaches and misuse or relate to the cyber security of the smart city technologies and systems themselves. The risks are important because systems may be diverted from their original use and cause moral (cyber-theft), economic and physical harm.

Threats to cyber security include attacks on critical infrastructure, bringing industrial control systems (ICS) to a halt; abusing low-power wide-area networks (LPWAN) and device communication hijacking; system lockdown threats caused by ransomware; manipulation of sensor data to cause widespread panic (e.g. disaster detection systems); and siphoning citizen, healthcare and consumer data and PII. Some of the most common attacks on the smart grid, for example, are the denial of service through channel congestion, computational flooding of equipment with low computer power, delaying a time-critical message that may cause a widespread shutdown, and forgery of data from various sensors across the urban area (Marahatta et al., 2021[59]; Ebrahimian et al., 2018[60]; Ma, 2021[57]). In addition, attackers can forge a customer identity to control building equipment remotely and cause various damages to customers (Parasol, 2018[61]).

Attacks on the smart transport system can occur via, for example, fake information when the attacker sends incorrect information such as certificates, alerts, security messages and identification (ID). The attacker alters, falsifies, or repeats data to mislead other drivers (Xie et al., 2020[62]). In other cases, the attacker may send large volumes of irrelevant messages clogging the communication channel and consuming the computing resources of other nodes with the purpose of disabling the case network of a vehicle, which can have vital consequences in the event of an emergency (Yan, Liu and Tseng, 2020[63]).

Smart cities are particularly vulnerable to data theft as hackers can infiltrate data banks and steal PII (Box 2.14). Device hijacking is another threat by which attackers take control of a device and use it to

disrupt processes such as road signals. Another threat is the Man-in-the-Middle attack (MitM), by which a hacker interrupts communication between two devices and sends false information to cause trouble.[22] For instance, a hacker may gain access to a mobility platform and report public transport delays, which could lead to more people using a car to reach their destinations, causing an increase in traffic and bringing a city to a standstill. In Japan, the selection of Tokyo as the host city of the 2020 Olympic games represented an opportunity to enhance the capacity and capability of the country in cybersecurity. In 2015, two years after the selection of Tokyo as Olympic host, the Japanese government adopted the Cybersecurity Strategy. The strategy highlights the need to create public-private cybersecurity partnerships, improve workforce development and develop cyber exercises. It also urges business leaders to incorporate cybersecurity in their business strategy and invest proactively in cybersecurity for innovation and vigorous growth (Matsubara and Mochinaga, 2021[64]).

Box 2.14. Examples of cities crippled by cyberattacks

- In 2018, the city of **Atlanta** was struck by a cyberattack that shuttered municipal courts and left residents unable to access services such as traffic tickets or water bill payment systems. Hackers placed malware on a computer that restricted access and then demanded a USD 51 000 Bitcoin payment to undo it.
- In 2019, the city of **Baltimore** suffered a ransomware attack that froze thousands of government computers and crippled dozens of services; the hackers demanded USD 80 000 worth of Bitcoin, which the government refused to pay.
- In 2008, in Poland, a teenager hacked the city of **Łodz** tram system with a homemade transmitter that tripped rail switches and redirected trains and derailed four trams.
- In 2022, a hospital in **Paris** was crippled by a cyberattack, drastically reducing the number of patients who could be admitted and forcing a return to pre-digital workflows.
- In 2023, the software of a trading firm in **London** called Ion Group caused chaos for City of London traders. Ion is a key player in the UK's financial system, with its software playing a vital role in the trading of debt, derivatives and shares around the world. Clients were forced to use pen and paper to process their trades.

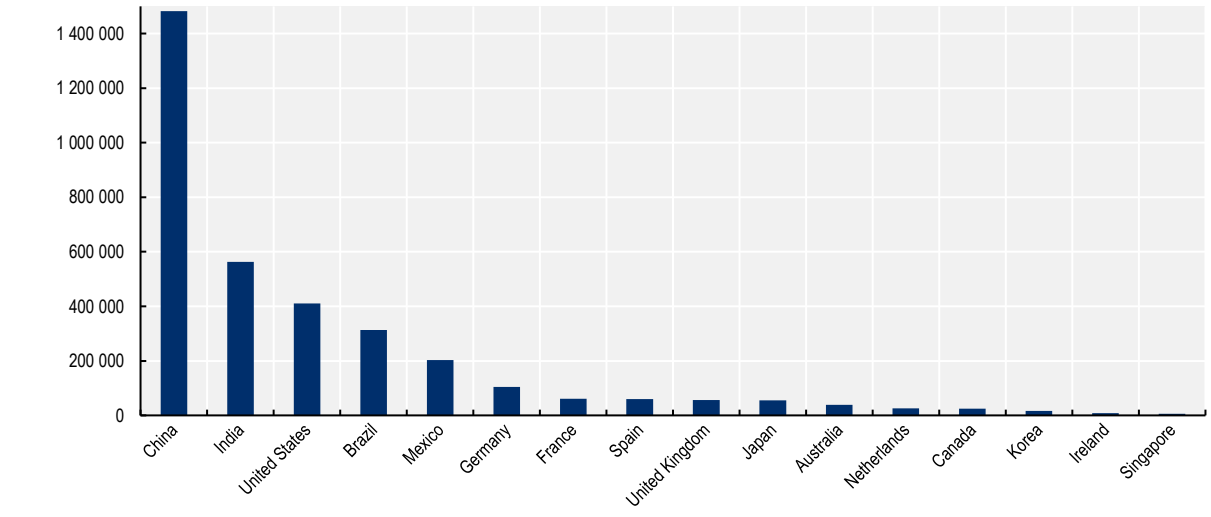
Source: Business Insider (2018[65]), "Atlanta has shut down courts and people there can't pay their bills online because of a crippling cyberattack the mayor has called 'a hostage situation', https://www.businessinsider.com/atlanta-cyberattack-cripples-city-operations-2018-3?r=US&IR=T; Business Insider (2020[66]), "8 cities that have been crippled by cyberattacks — and what they did to fight them", https://www.businessinsider.com/cyberattacks-on-american-cities-responses-2020-1?r=US&IR=T#st-lucie-florida-3; Wired (2008[67]), "Polish teen hacks his city's trams, chaos ensues", https://www.wired.com/2008/01/polish-teen-hac/; RFI (2022[68]), "Paralysed French hospital fights cyber attack as hackers lower ransom", https://www.rfi.fr/en/france/20220902-paralysed-french-hospital-fights-cyber-attack-as-hackers-lower-ransom-demand; Computer Weekly (2023[69]), "Suspected LockBit ransomware attack causes havoc in City of London", https://www.computerweekly.com/news/365530214/Suspected-LockBit-ransomware-attack-causes-havoc-in-City-of-London.

Several factors exacerbate the vulnerability of smart city technology. The lack of co-ordination among different stakeholders on who is responsible for maintaining security across the systems and the infrastructure; and the need for cities to show efficiency savings leading to a lack of digital security investments in many cities are jeopardising the infrastructure, intelligence, efficiency and sustainability of future smart city developments. Many cities also face critical staffing needs. Recruiting and maintaining highly skilled IT staff is a growing problem for local governments, and in particular, investing in cybersecurity personnel is hampered by the lack of funds. Cybersecurity plans are, in many cases, built under a siloed approach preventing a cross-function assessment and response to an attack (Dodge and Kitchin, 2017[55]; Cerrudo, 2015[58]). In addition, many smart city vendors may lack experience and

incentives in embedding security features into their products; and cities have been lax in demanding string security controls during the procurement process for the new systems (Dodge and Kitchin, 2017[55]). Designing flexible systems with high information protection capabilities is essential to prevent serious security incidents.

Cybersecurity workforce shortages also threaten smart city projects and hamper national and local cybersecurity strategies. The global cybersecurity workforce is estimated at 4.7 million workers but, to protect public and private organisations and enterprises from more complex threats, there is a need to fill a gap of 3.4 million cybersecurity workers worldwide (ISC2, 2022[70]). Brazil, China, India and the United States seem to have a wider workforce gap (Figure 2.5). Cybersecurity policies and strategies include measures to address training needs and raise awareness of cybersecurity but they may take a long time to mature. Due to high attrition rates in the public sector for cybersecurity jobs and low rates of availability of educational opportunities on cybersecurity, developing a digitally savvy workforce with adequate skills may take many years; thus, governments need to prioritise workforce development, ensuring adequate funding for such programmes (OAS, 2022[71]). According to research, the workforce shortage is particularly severe in areas such as government, transportation, aerospace and insurance, jeopardising the most basic functions of the profession, such as risk assessments, oversight and critical systems patching (ISC2, 2022[70]). The biggest challenges for cybersecurity professionals are the emerging technologies such as blockchain, AI, quantum computing and intelligent automation, and the continuous changes in the regulatory framework.

Figure 2.5. Cybersecurity workforce gap in selected countries, 2022



Source: ISC2 (2022[70]), "Cybersecurity workforce study. A critical need for cybersecurity professionals persists amidst a year of cultural and workplace evolution", https://www.isc2.org/ (accessed on 23 February 2023).

The implications of a data breach or data loss incidents can represent serious challenges for public and private organisations. Failure to protect data can cause financial losses, loss of reputation and citizens' trust, as well as legal liability, considering that most public and private organisations are subject to some data privacy standards or regulations. Therefore, countries have set formal requirements to protect citizens' data across data collection, storage, processing and sharing exercises. Authorities are issuing regulations and strategies for the handling and security of digital big data. As smart city projects involve large amounts of data, stakeholders need to consider new methods of managing their data risk exposure.

Off-the-shelf antivirus solutions are not enough as smart city projects and data strategies need a more comprehensive policy for the protection of government, companies and citizens' data.

Countries and cities collect different types of data that could be sensitive or non-restricted, depending on their nature. Various levels of data privacy risk should be considered when making decisions about their collection, storage, use and disclosure. For example, New York City, United States, has prepared a framework for classifying three tiers of data based on privacy risk level to support decisions about data collection, use, disclosure and storage (Table 2.4). The framework is informative only and does not represent a classification structure used by the city government. However, it is based on the city's privacy protection policies and its cybersecurity programme, policies and standards. Under normal circumstances, data in Tiers 1 and 3 will stay there, but data in Tier 2 may move to other tiers depending on several factors, such as how data collection is implemented.

Table 2.4. New York City's privacy risk levels of IoT data

	Tier 1	Tier 2	Tier 3
Definition of the tier based on privacy risk level	Data have no means of connecting to an individual's identity, location or behaviours. They are environmental or aggregate/statistical in nature There is little to no privacy risk expected in collecting these data with respect to individuals, except where aggregate metrics pertain to individuals in small groupings (e.g. <10), which, with other information, could lead to the identification of an individual. Typically, these data do not require the same scrutiny as the other tiers, although there may separately be policy, proprietary or other legal considerations in disclosing these data. Tier 1 data are likely to be classified as non-restricted information.	Data are highly dependent on the context, detail and the means by which the data are collected. Based on implementation, this type of data could either move up or down a tier to become restricted, sensitive or non-restricted.	These data will almost always be considered sensitive or restricted information and, if pertaining to individuals, are likely designated as confidential information by law. PII is sensitive or restricted by nature or through its ability to be used in connection with other data to identify or locate a person. Collecting, using, disclosing and storing these data should be limited, with appropriate prior legal review and safeguards in place to address any privacy or security concerns.
Examples	Examples of this type of data are: • Ambient temperature • Humidity • Air quality • Energy production (onsite) • Radiation • Water quality • Water levels (flooding) • Trash volume/servicing • Gas/chemical • Greenhouse gas emissions	Examples of this type of data include: • Traffic counts • Traffic flow (travel time) • Water flow • Energy usage • Sound levels • Pedestrian/cycling counts • Building access/usage • Infrastructure utilisation • Shared mobility utilisation	Examples of this type of data include: • Location data (vehicles, etc.) • License plate/car tag data • Biometrics • Health data

Source: NYC Government (2021[72]), *IoT Strategy - The New York City Internet of Things Strategy*, https://www1.nyc.gov/assets/cto/downloads/iot-strategy/nyc_iot_strategy.pdf.

Therefore, ensuring digital security must be a fundamental part of countries and cities' digital and data strategies. Research suggests that city governments need to adopt a security-by-design approach in the technical design and training of the workforce (Dodge and Kitchin, 2017[55]). Security-by-design implies the inclusion of security aspects from the outset of a smart city project. Conducting a security risk assessment and extensive testing of the security systems should be part of the design process. City administrations

should require digital technology vendors to monitor their products throughout their life cycle to identify potential risks.

Cities should also ensure to set up a core security team overseeing the security aspects of digital technologies related to smart city projects. The team should have specialist skills and responsibilities beyond day-to-day IT administration. The security team could be in charge of threat and risk modelling, testing the security of the digital technologies to be used in smart city projects, preparing a plan of action in case of cybersecurity incidents, conducting security assessments on a regular basis, and co-ordinating staff training on digital security (Cerrudo, 2015[58]; Dodge and Kitchin, 2017[55]). The Information Security Office (ISO) in the government of the city of Chicago exemplifies the role a security team performs to ensure security monitoring and response (Box 2.15). Installing such an office may be costly to some cities but the Chicago model operates in a "shared services" model, resulting in operational efficiencies and cost savings. In Spain, the city of Madrid is creating a Security Operations Centre (*Centro de Operaciones de Seguridad*, COS) to act as the backbone of the prevention, surveillance and response capabilities to cybersecurity incidents. Moreover, the city government set up the Municipal Information Security Committee, a collegiate body, to direct and oversee the implementation of the cybersecurity policy of the city and provide advice.[23] At the regional level, the *Comunidad de Madrid* is creating a Cybersecurity Agency to protect itself from future cyberattacks. The regional governments aim to create a climate of trust, provide a centralised vision of cybersecurity, improve the capacity to respond to cyberattacks, promote cybersecurity training and improve the IT security of the regional infrastructure.[24]

Box 2.15. The Chicago Information Security Office

In 2013, the city of Chicago set up the Information Security Office (ISO) in charge of evaluating and addressing risks and vulnerabilities regarding cybersecurity within the city. Some of ISO's objectives are:

- Develop and enforce an information security strategy, framework, policies and procedures that align with city of Chicago business needs, legislative and regulatory requirements and industry best practices.
- Assist the city's IT projects and functional areas with the development of efficient processes that are required to meet requirements as defined by the ISO and/or regulatory standards.
- Develop a risk management framework to be used in information security solutions and asset prioritisation.
- Develop a security awareness programme to ensure that city users understand their responsibility in protecting the city's assets and information.
- Ensure that information security controls assist privacy efforts.
- Monitor and measure information security vulnerabilities and incidents and provide timely responses to ensure confidentiality, integrity, availability and accountability of the city of Chicago and its third parties.
- Communicate the occurrence of significant security incidents, news, ISO decisions and actions with the city of Chicago.

Source: City of Chicago (n.d.[73]), Information Security Office, https://www.chicago.gov/city/en/depts/dgs/supp_info/information-security-office.html.

Governments are investing substantial budgets in developing state-of-the-art cybertechnologies based on AI and big data analytics, as well as strengthening capabilities to collect cyber intelligence, disturb Internet networks and disrupt major facilities. The United Kingdom, for instance, is investing GBP 2.6 billion in cyber and legacy IT between 2021-24, a considerable increase from the GBP 1.9 billion of the previous strategy. The European Commission invested EUR 249 million in digital technologies and cybersecurity in 2022.[25] In 2020, the United States invested USD 5.9 billion in cybersecurity (76% of all global cybersecurity funding), followed by Israel (USD 2.7 billion) and China (USD 1.8 billion).[26] It is unclear the extent these resources are reaching subnational governments in their quest to ensure data security as part of their smart city strategies.

To enhance cybersecurity, national governments such as in Korea and the United Kingdom are adopting digital security strategies (OECD, 2019[3]), which show that protecting cyberspace requires government leadership and a whole-of-society effort (Box 2.16). These efforts could inform the development of a detailed cybersecurity strategy at the city level, in line with their broader smart city projects or initiatives. Cities need to ensure that their cybersecurity strategy is in line with their interoperability systems. A key message from national governments' experiences is that ensuring cybersecurity in cities is not only the responsibility of local governments. National and local governments should build synergies in protecting data and infrastructure from attacks, for example forming digital security committees with representatives from national and subnational governments as well as the private sector to discuss challenges, possible solutions and build agreements to provide technical support and capacity building to local governments may be one way forward. The national government could take the lead but subnational governments' strategies should be aligned to ensure a coherent approach. These initiatives show that there should be a clear delimitation of responsibilities for data protection in the smart city ecosystem based on a strong governance model.

Box 2.16. Digital security strategies: Korea and the United Kingdom

Korea's National Cybersecurity Strategy aims to create a free and safe cyberspace to support national security, promote economic prosperity and contribute to international peace. For this purpose, the Strategy has six strategic tasks:

- **Increase the security and resilience of the national core infrastructure against cyberattacks to ensure continuous provision of critical services** by: strengthening the security of national information and communications networks; improving the cybersecurity environment for critical infrastructure; and developing next-generation cybersecurity infrastructure.
- **Enhancing the capacity to detect cyberattacks in advance and respond to security incidents promptly** by: ensuring cyberattack deterrence; strengthening readiness against massive cyberattacks; devising comprehensive and active countermeasures for cyberattacks; and enhancing cybercrime capabilities.
- **Establish a future-oriented cybersecurity governance framework based on trust and co-operation among individuals, businesses and government** by: facilitating public-private-military co-operation; building and facilitating a nationwide information sharing system on cyberthreats; and strengthening the legal basis for cybersecurity.
- **Create an innovative ecosystem for the cybersecurity industry to secure the competitiveness of technology, human resources and industries which are critical to national cybersecurity** by: expanding investment in cybersecurity; strengthening the competitiveness of the security workforce and technology; fostering a growth environment for

cybersecurity companies; and establishing a principle of fair competition in the cybersecurity market.

- **Foster a cybersecurity culture** by: raising cybersecurity awareness and strengthening cybersecurity practice; and balancing fundamental rights with cybersecurity.
- **Becoming a leading country in cybersecurity** by: strengthening international partnerships and guiding the formation of international rules.

The **United Kingdom**'s National Cyber Strategy aims to position the country as a leading responsible and democratic cyber power, able to protect and promote its interests in and through cyberspace in support of national goals. The strategy is based on five strategic goals:

- **Strengthening the UK cyber ecosystem** by investing in skills and deepening the partnership between government, academia and industry.
- **Building a resilient and prosperous digital United Kingdom** by reducing cyber risks so businesses can maximise the economic benefits of digital technology and citizens are secure on line and confident that their data are protected.
- **Taking the lead in the technologies vital to cyber power** by building the country's industrial capability and developing frameworks to secure future technologies.
- **Advancing the country's global leadership and influence for a more secure, prosperous and open international order** by working with government and industry partners and sharing the expertise that underpins UK cyber power.
- **Detecting, disrupting and deterring the country's adversaries from enhancing its security in and through cyberspace** by making more integrated, creative and routine use of the country's full spectrum of levers.

Source: National Security Office (2019[74]), *National Cybersecurity Strategy*, https://www.itu.int/en/ITU-D/Cybersecurity/Documents/National_Strategies_Repository/National%20Cybersecurity%20Strategy_South%20Korea.pdf; UK Government (2022[75]), *National Cyber Strategy 2022 - Pioneering a Cyber Future with the Whole of the UK*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1053023/national-cyber-strategy-amend.pdf.

Ensuring cybersecurity capability is a top priority of national governments. For example, research suggests that until 2021 at least, Japan faced workforce shortages since Japanese end-user companies outsource the majority of their IT and cybersecurity work (Matsubara and Mochinaga, 2021[64]). Therefore, their cybersecurity teams tend to be smaller than in other major countries. Research suggests that while only 28% of IT professionals work in house in Japan, the ratio is 65.4% in the United States, 61.4% in Germany and 54% in the United Kingdom (Matsubara and Mochinaga, 2021[64]).

Countries are implementing initiatives to improve trust in digital technologies and their capacity. In Singapore, the national government has, through the Infocomm Media Development Authority, requested Nanyang Technological University, Singapore to establish the national Digital Trust Centre to strengthen the country's capabilities in digital trust (Box 2.17). This is an example of how a city – in this case, a city-state – could formalise partnerships for cybersecurity to grow cyber capabilities as different stakeholders need to work together as a city government alone will not be able to develop the capacity and capability required to face cyberthreats. It also shows that smart cities need to develop skills and competencies across various disciplines and ecosystem layers.

Box 2.17. Singapore's Digital Trust Centre

Singapore is setting up a Digital Trust Centre (DTC) to drive the development of digital trust technologies, such as tools to ensure privacy in data exchange and assess the trustworthiness of digital systems, and support talent development. The DTC is an SDG 50 million investment from the Infocomm Media Development Authority and the National Research Foundation (NRF) under the Research, Innovation and Enterprise 2025 plan. It is hosted by the Nanyang Technological University, Singapore. It focuses on four areas of trust technologies:

- **Trust technology research** – to enable institutes of higher learning and research to pursue research in trust technologies and drive local and international collaborations.
- **Trust technology innovations** – to encourage academia and enterprises to form partnerships to develop and mature research ideas into market-ready solutions.
- **New sandbox environment** – to encourage and facilitate business to experiment with trust technologies to overcome challenges of data sharing.
- **Deeper local capabilities** – to support the development of talent in digital trust.

Source: Infocomm Media Development Authority (2022[76]), "Singapore grows trust in the digital environment", https://www.imda.gov.sg/Content-and-News/Press-Releases-and-Speeches/Press-Releases/2022/Singapore-grows-trust-in-the-digital-environment.

Governments are also investing in revamping their cybersecurity capabilities as part of their data and cybersecurity strategies to create a specialised workforce on cyberattacks. Cities could establish a network of cities, with the support of regional or even national governments, including academia and the private sector, to strengthen cyber defences. Some countries have even set up a special body in charge of cybersecurity and recruiting professionals. For example:

- In **Canada**, the national government recruits cybersecurity professionals to work across the government due to the increase in cyber threats and ransomware attacks following the COVID-19 pandemic. These professionals are in charge of protecting infrastructure, systems and processes citizens rely on from cyber and ransomware attacks.[27]
- In the **United Kingdom**, the National Cyber Security Centre is the national authority on the cybersecurity environment by sharing knowledge, addressing systemic vulnerabilities and providing leadership on key national cybersecurity issues. This has helped the UK government to simplify its operational structures, transform its ability to respond to national-level cyber incidents and initiate the rollout of innovative digital services that have helped to make organisations and individuals automatically safer on line (UK Government, 2022[75]).
- In **Japan**, the Personal Information Protection Commission (PPC), a regulatory body established to monitor and supervise compliance with the Act on the Protection of Personal Information (APPI), has issued a number of guidelines to provide detailed guidance on the scope and meaning of the provisions of the APPI and examples of their application (Government of Japan, 2003[43]). Non-compliance with the statements in the guidelines, which are expressed as obligations, may be considered a violation of the APPI. The guidelines cover a wide range of topics, including general rules, provision to third parties in foreign countries, pseudonymised and anonymised processed information, the obligation to confirm and record at the time of provision to a third party, administrative bodies and appropriate handling of specified personal information.

- In the **United States**, the Department of Homeland Security (DHS) operates enterprise-wide capabilities and offers tools and services to assist agencies in managing their cybersecurity risks. It has established baseline protective capabilities across federal enterprises through the deployment of perimeter security capabilities. The DHS works to deploy innovative cybersecurity capabilities and practices to protect information systems and adopt a more unified approach to securing our own information systems and, where appropriate, deploy standardised, cost-effective, and cutting-edge capabilities across high-value departmental information systems (US Government, 2018[77]).
- The **Organisation of American States (OAS)** has recommended its members invest in developing the workforce to provide people with education and skills development to bridge the cybersecurity workforce gaps. This could be done by, among other things: developing national strategies and action plans for cybersecurity workforce development; creating a governance model for the co-ordination and harmonisation of the different stakeholders involved in the process; developing public-private partnerships for launching new training programmes and updating existing curricula; updating the regulatory framework to promote cybersecurity development; and promoting the ongoing assessment of the labour market and cybersecurity workforce data (OAS, 2022[71]).

Proving to citizens why their data matters and reporting on progress

Public data alone are not enough to develop innovative services; data from different stakeholders are sometimes required. Encouraging citizens to grant third parties (i.e. government and private enterprises) access to their data and use them calls for being transparent and honest with citizens and proving the benefits of sharing data. When people perceive there is a direct benefit to sharing their personal data and that their data are managed in an ethical manner, they would be more willing to share their data for decision making or the design of public services. It is a process of give and take: if people give their data, they should expect something in return in the form of information, services and products.

Governments need to ensure that citizens understand how their data are used to help improve their lives, which can range from proactively managing traffic flows to safer street lighting and smarter energy use. Governments failing to consider privacy and/or consent can create tensions and challenges. Governments need to do more to be transparent about the data they collect and demonstrate the value of the resulting products. For example, the city of Adelaide, in Australia, is based in the driest state (South Australia). The city council is trialling the use of smart sensors to collect data to manage its water more effectively. The main benefit of the smart network project is the utility's increased ability to be more responsive to customer needs. Smart technology is being trialled in Adelaide because of the higher potential for customer impact from bursts and leaks (Cella, 2017[78]). The sensors, loggers and meters allow the water authority (SA Water) to detect water leaks before they become visible on the surface and help large businesses in the city track and manage their water use. Customers have reported an increased understanding of how they use their water. This detection and subsequent cost savings enable customers to pay back the investment on their smart metering equipment.

As governments seek to introduce more technology-enabled services, they will need more effective measures to reassure the public about their management of data and analytics. Neutrality and fairness are critical to avoid any bias and build trust. A data management platform must be operated jointly by public and private entities in adherence to the regulatory framework for data protection. This is because it may facilitate data sharing among public and private stakeholders, optimise costs and improve return on investment, improve data security, build on each other's capacity for data management and have better access to data from different sources for decision making. However, the government should assess regulation as an instrument to ensure neutrality and fairness.

One way of proving to citizens why their data matters and how it is being used is by reporting on progress on the implementation of the smart city strategy. Such a report should include the steps taken since the adoption of the initiative, the barriers encountered for their implementation and point to the efforts the city will undertake in the time to come. Moreover, the progress report should not just highlight what has been done and which activities are completed or are in progress, but what matters to citizens is the change achieved so far. For example, in New York City, the Office of the Chief Technology Officer has produced a progress report on the implementation of the New York City Internet of Things Strategy (NYC Government, 2021[79]). The report has been seminal in showing commitment to transparency and accountability in the planning, use and governance of connected technologies. It describes the work conducted since the adoption of the strategy and the upcoming activities.

Another way of showing why data matters is by using data to optimise public action. Cities are currently experiencing a convergence of open data, digital mapping, geolocation and the co-creation of services. Through the use of data, cities are in a prime position to be catalysts of new services and economic models that create value, jobs and well-being. For this purpose, it is important that cities ensure that all data produced by the city and residents through the use of public services are made available to all relevant stakeholders. For example, the city of Paris, France, releases financial, social, urban planning, environmental and transportation data every six months; and holds a quarterly consultation meeting with end users to know about their data priorities (Mairie de Paris, 2020[80]). Furthermore, the city government has created a programme called DataCity as a data science study accelerator programme that allows local and international start-ups to work on challenges selected by the city and its industrial partners, using high-quality data. The DataCity programme promotes the design of solutions tailored to the city, with a focus on sustainability, based on open data provided by the city and industrial partners (Box 2.18).

Box 2.18. DataCity Paris programme – Using big data and data analytics to tackle urban challenges

In 2016, the city of Paris and the start-up accelerator NUMA co-designed and co-developed the open innovation programme called DataCity Paris. Its aim is to identify urban challenges with major regional private partners to suggest possible start-up candidates and accelerate the development of solutions. The programme is based on challenges. The city authorities, citizens and industrial partners identify a series of challenges to make the city more intelligent and pleasant to live, to which start-ups can apply if their technology can help solve the challenge. The selected start-ups work on challenges put forward using data that is unprecedented in quality and quantity. A DataCity challenge is a problem that has not yet found its solution but for which collaborative work between start-ups, the city and NUMA experts will make it possible to develop a prototype viable solution.

Around ten challenges are identified each year in different fields, such as logistics, mobility, energy and many others. The start-ups receive a grant to develop and test their cutting-edge solutions and gain public exposure through the programme. The city and the industrial partners benefit from the solutions through new business opportunities, new services or quality improvement. The prototypes are tested for four months in situ in the Parisian urban space. During the first year (2015/16), the programme focused on improving energy performance in buildings and developing transportation in demand in one of Paris' boroughs, for example.

Source: Mairie de Paris (2020[80]), *Paris Smart and Sustainable. Looking Ahead to 2020 and Beyond,* https://cdn.paris.fr/paris/2020/02/26/f7dc822a66de6000cd910a145c7fca39.ai; Mairie de Paris (2019[81]), "DataCity 2019 : les startups qui font la ville de demain", https://www.paris.fr/pages/datacity-2019-decouvrez-les-startups-qui-font-la-ville-de-demain-6511#les-10-startups-selectionnees; ICC (n.d.[82]), *DataCity Paris*, https://www.intelligentcitieschallenge.eu/good-practices/datacity-paris

Data standards and open data for smart cities

Setting data standards improves quality and facilitates interoperability of smart city data

Data standards facilitate the integration of otherwise heterogeneous data collected from different sources and by different stakeholders (e.g. public and private organisations, academia etc). In general terms, "[d]ata standards are the predetermined merits that govern how data is managed, used, represented, formatted, defined, transmitted, structured, and tagged" (Satori, 2022[83]). They refer to technical specifications or recorded agreements that describe how data should be stored or exchanged across different systems so that they are understood and mean the same to all stakeholders. If data are going to be used, then they need to mean the same to every actor or user through common terminology and semantics.

Cities should work towards using a comprehensive, unified ontology (the representation and definition of concepts and their relationships) adopted across the board. Data should not be dependent on geographical location; they should be used in different places other than those where they originate from. Thus, a common terminology is essential to ensure data have the same meaning everywhere and rules to ensure their lawful use. Common data platforms are a key element to this goal but they require a non-disclosure agreement. Rules for data quality and standards are one of the components of Japan's Smart City Reference Architecture (SCRA) issued by the national government. Japan is promoting a base registry initiative to ensure that core data held by government agencies meet quality and management quality standards and can be used by society (see Chapter 1).

Setting standards may be a way forward to encourage citizens to share their data and, in a way, build trust in government. For example, the Abu Dhabi (United Arab Emirates) government has created standards for data management, which also serve as an assessment framework, to promote informed and responsible data ownership and usage, protect government datasets, engender and maintain stakeholder confidence in the capability of the government to deliver sufficiently secure and reliable services to residents, and maximise the return on investment in information assets and systems (Box 2.19).

Box 2.19. Abu Dhabi Government Data Management Standards

The Abu Dhabi government has developed a government-wide data management programme to be implemented by all government entities acknowledging that data are a key asset for the government. The Abu Dhabi Government Data Management Programme aims to improve both the data management functions and the data stored within the government. Owning and using high-quality data is acknowledged as a strategic enabler for the government to achieve its goal of becoming a world-class administration and for government entities to identify and deliver new or enhanced services to stakeholders.

For this reason, the government developed a core set of standards for data management based on six principles:

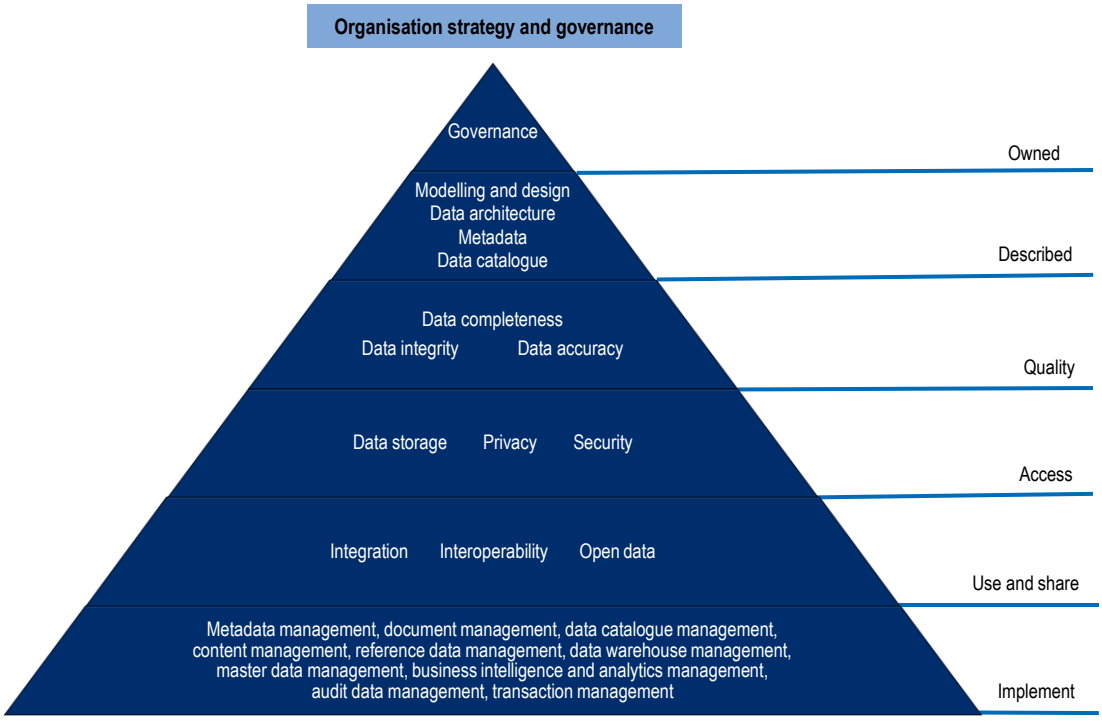
- Data shall be **owned**: all information used to enable the government's work must have a designated owner who is accountable for its proper custody.
- Data shall be **described**: all data must be appropriately described to allow their content and their purpose within the organisation to be properly understood.
- Data shall be of **good quality**: all data must be of the appropriate quality for their use within the organisation.

- Data shall be **accessible**: all data must be accessible to those who have a legitimate reason to use them and securely protected against loss, damage or misuse.
- Data shall be **used and shared**: all data must be available to share easily with any legitimate party, and their use must be appropriately managed.
- Data management shall be **implemented**: appropriate management of all data must be implemented through initiatives designed to introduce or strengthen particular data management capabilities.

Source: Abu Dhabi Government (n.d.[84]), *Data Management Standards*, https://addata.gov.ae/sites/default/files/AD-Gov-Data-Management-Standards-EN-v1.0.pdf.

Principles for data management that underpin data standards cover a wide range of data-related domains of both a management and a technical nature (Figure 2.6). Two messages from this experience are that it is not necessary to develop overly complex frameworks to build trust and manage data, and each government body or level of government should develop a programme that is suitable to meet the requirements for compliance with the standards while meeting their own requirements of data. The data management standards are intended to direct government entities and other stakeholders in areas requiring focus for the application of data management controls. Adherence to the control standards means data management controls are being consistently deployed across government entities. Authorities in Abu Dhabi developed control standards that represent the government's expectations for data management. Those are expressed in 13 domains of data management that are interrelated and mutually supportive. Entities and business partners handling government data are responsible for understanding the control standards and applying them in the context of all data assets they own.

Figure 2.6. Abu Dhabi Government Data Management Model



Source: Abu Dhabi Government (n.d.[84]), *Data Management Standards*, https://addata.gov.ae/sites/default/files/AD-Gov-Data-Management-Standards-EN-v1.0.pdf.

Critically, implementing data standards contributes to ensuring data quality, which is also another factor that builds trust in government capability for data management. Data standards improve data quality for better and more insightful decision making and allow for the reuse of data elements, thus reducing redundancy and enhancing reliability while also bringing down the cost of data management. Determining data quality is highly linked to data management standards. For example, Statistics Canada has developed guidelines for data quality defined around six quality dimensions: relevance, accuracy, timeliness, accessibility, interpretability and coherence (Box 2.20). These guidelines constitute practical measures that government organisations, all levels of government and private stakeholders can adopt to ensure data quality. There are several common points between Canadian and Japanese practices. For example, Japan's Public-Private Data Utilisation Act calls for the promotion of Open Data by Design in order to reflect user needs and ensure that the information published is kept up to date and published on a website in an easily searchable and usable form (Government of Japan, 2016[45]). A system of data quality assessment is critical to foster data accountability in the management of data.

Box 2.20. Statistics Canada: Guidelines for ensuring data quality

The Canadian statistical system defines data quality using six dimensions: relevance, accuracy, timeliness, accessibility, interpretability and coherence.

- **Relevance**: This refers to the degree to which data meet real user needs. To ensure relevance, organisations should create and maintain a list of current and potential users of all of the statistical organisation's statistical products, maintain bilateral and multilateral contact with the key users and determine data use and user satisfaction, among others.
- **Timeliness and punctuality**: Timeliness refers to the delay between the information reference point (or the end of the reference period) and the date on which the information becomes available. Punctuality refers to the difference between planned and actual availability. Actions include planning and developing a schedule for each production phase, ensuring they are carried out with regular follow-up mechanisms, and agreeing with data providers on an availability calendar for their databases.
- **Accuracy and reliability**: Accuracy is the degree to which the information correctly describes the phenomena it was designed to measure. Reliability reflects the degree to which statistical information, consistently over time, correctly describes the phenomena it was designed to measure. Actions include using appropriate quality control methods and quality assurance processes to detect and control potential errors in the various phases of the production process and using new technologies to automate procedures as much as possible to minimise errors from manipulation and data inconsistency.
- **Accessibility and clarity**: This refers to the ease with which users can learn that the information (including metadata) exists, find it, view it and import it into their own work environment. It also refers to the cost users need to incur to access data. Actions include establishing a system for documenting and archiving statistical data, providing multiple access and extraction methods, and making data files accessible for future analytic activities.
- **Interpretability**: This refers to the availability of supplementary information and metadata needed to interpret and use statistical information appropriately (e.g. underlying concepts, variables and classifications used and the methodology of data collection and processing). Actions include consulting the organisation's data interpretability policy, ensuring that the organisation's metadata base is up to date and ensuring the availability of quality indicators.

- **Coherence and comparability**: It refers to the degree to which data can be reliably combined and compared with other statistical information within a broad analytical framework over time but does not necessarily imply full numerical consistency. Actions include keeping concepts, definitions, classifications and methodologies up to date, keeping an up-to-date document of methodologies and frameworks for acquiring administrative data and collecting data from field operations and using a common frame for all surveys of the same type.

Source: Statistics Canada (2019[85]), *Guidelines for Ensuring Data Quality*, https://www150.statcan.gc.ca/n1/pub/12-539-x/2019001/ensuring-assurer-eng.htm.

Valuable experience can be learnt from the scientific data management field on standardisation. The FAIR Guiding Principles for scientific data constitute a concise and measurable set of principles to enhance the reusability of data (Box 2.21). The FAIR principles (Findability, Accessibility, Interoperability and Reusability) guide producers and publishers to maximise the added value gained by contemporary, formal scholarly digital publishing, ensuring that all components of the research process are available, fostering transparency, reproducibility and reusability (Wilkinson et al., 2016[86]). These principles have been adopted by research institutions worldwide. These principles suggest that, to make data findable, it should have sufficiently detailed descriptive metadata as well as a unique and persistent identifier such as a digital object identifier (DOI). To be accessible, data should be understandable to both humans and machines and stored in a trusted repository. For data to be interoperable, metadata should use a formal, accessible, shared and broadly applicable language for knowledge representation, such as agreed-upon controlled vocabularies. Finally, the principles suggest that for data to be reusable, they should have a clear usage license and provide accurate information on provenance. Although the FAIR principles are aimed at the academic community, they could provide valuable input for data management in smart city projects, enhancing data standardisation and interoperability. The city of Vienna uses the FAIR principles as part of the data spectrum of the Open Data Institute (ODI).

Box 2.21. The FAIR Guiding Principles for scientific data management

For data to be **Findable**:

- (Meta)data are assigned a globally unique and persistent identifier.
- Data are described with rich metadata.
- Metadata clearly and explicitly include the identifier of the data they describe.
- (Meta)data are registered or indexed in a searchable resource.

For data to be **Accessible**:

- (Meta)data are retrievable by their identifier using a standardised communications protocol.
- The protocol is open, free and universally implementable.
- The protocol allows for an authentication and authorisation procedure, where necessary.
- (Meta)data are accessible, even when the data are no longer available.

For data to be **Interoperable**:

- (Meta)data use formal, accessible, shared and broadly applicable language for knowledge representation.
- (Meta)data use vocabularies that follow FAIR principles.
- (Meta)data include qualified references to other (meta)data.

For data to be **Reusable:**

- Meta(data) are richly described with a plurality of accurate and relevant attributes.
- (Meta)data are released with a clear and accessible data usage license.
- (Meta)data are associated with detailed provenance.
- (Meta)data meet domain-relevant community standards.

Source: Wilkinson, M. et.al. (2016[86]), "The FAIR Guiding Principles for scientific data management and stewardship", https://doi.org/10.1038/sdata.2016.18.

Promoting open data should be part of a smart city data strategy

Promoting openness and transparency is a top priority for OECD countries. In particular, governments pursue opening up government data to empower citizens, foster innovation, create business opportunities and improve public services. Open government data are a core component of government-wide data strategies across OECD countries as they strengthen good governance due to the social and business value created by shared and public data (OECD, 2019[3]; 2020[87]). Open data enable the use of data as a platform for greater engagement and collaboration among stakeholders. Policies on open data focus on making data from public organisations available to everyone in open, free and accessible formats. The results of the OECD 2019 Open, Useful and Reusable Data (OURdata) Index revealed overall improvements in open government data policies and practices at the national level (OECD, 2020[87]) (Figure 2.7).

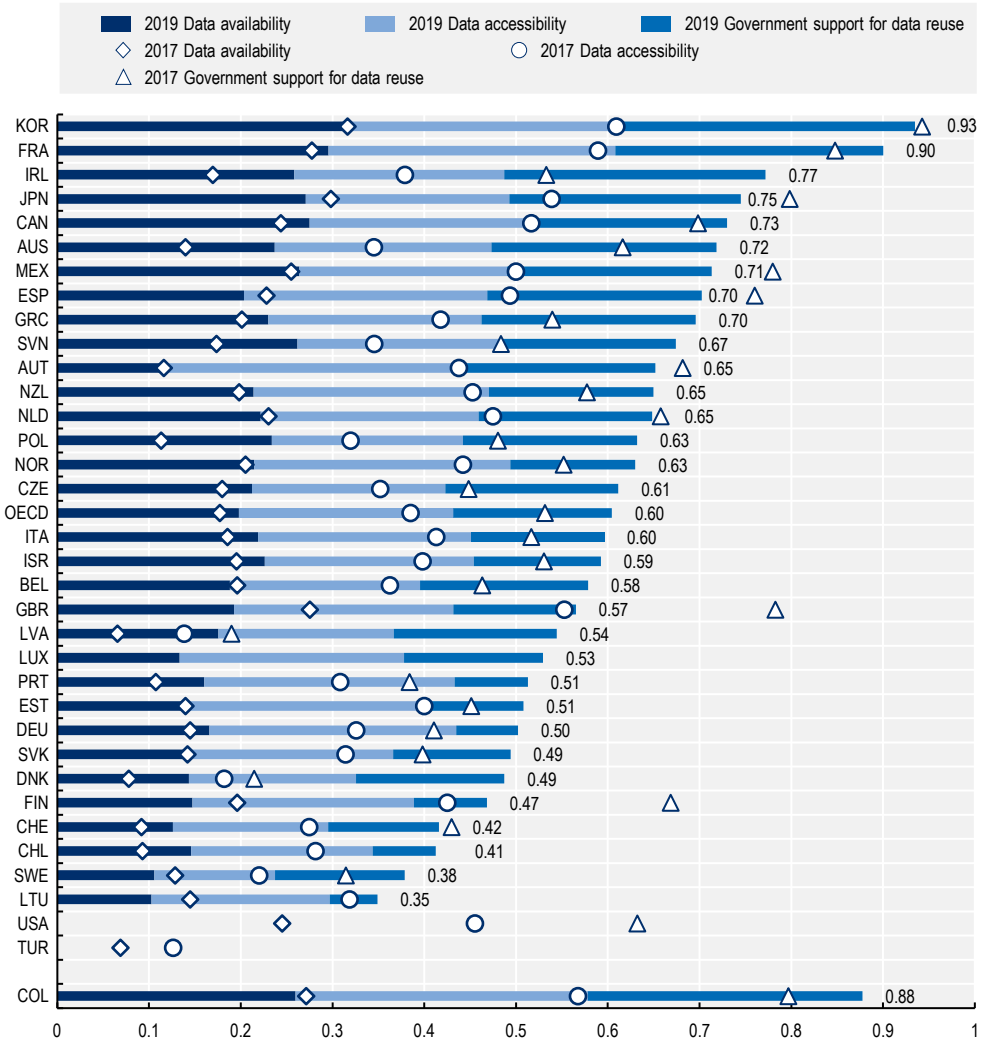
As Figure 2.7 shows, the results of the 2019 OURdata Index revealed an overall growing maturity in terms of open government data at the national level across OECD member countries. The improvements were driven by better data availability, increased data accessibility and stronger government support to open data policies. However, the OECD has found that while countries often include elements of data governance in their national digital government strategies, such as open data, data management and/or AI strategies, these elements are often fragmented (OECD, 2019[3]). This disconnection may be rooted in the governance arrangements, such as different organisations leading the open data policies, lack of clarity in the definition of responsibilities or even lack of leadership. These problems create a barrier to data sharing and integration, hindering smart cities' development.

Some countries have introduced specific arrangements to facilitate access, share and reuse of policy or sector-specific datasets. These arrangements benefit a number of organisations that share common goals and mandates. For example:

- In **Sweden**, the National Geodata Strategy of the National Land Survey authority was developed to cover all strategic issues related to handling geodata in the country. Its aim to build up a national infrastructure for geodata and encourage increased co-operation within the geodata sector. Lantmäteriet, the Swedish mapping, cadastre and land registry authority, is responsible for implementing the strategy in co-operation with the Geodata Advisory Board and other stakeholders (Lundquist, Rannestig and Sandgren, 2010[88]). The strategy led to the creation of the National Geodata Platform to provide access to nationally standardised basic data in various processes in society.[28]
- In **Japan,** the central government has implemented an evidence-based and data-driven approach to improve the impact of policies since 2017. Japanese authorities are promoting the open data initiative, in which the government widely discloses public data in machine-readable formats and allows secondary use of the public data for profit making or other purposes (Box 2.22). This initiative has the goals of improving people's lives and stimulating corporate activities and, in turn, contributing to the social and economic development of the country. The Public-Private Data

Utilisation Act instructs both central and local governments to make their data easily accessible to the public to use and reuse (Government of Japan, 2016[45]).

Figure 2.7. Open Useful Re-Usable data (OURdata) Index, national level, 2017-19



Source: OECD Open Government Data Survey, published in OECD (2019[89]), *Government at a Glance 2019*, https://doi.org/10.1787/8ccf5c38-en.

Box 2.22. Japan's policy framework on open data for the national level

Japan's policy framework on open data is composed of:

- The 2013 Open Data Charter Action Plan sets the measures for using public data in the country. It states that the central government cannot require local governments to release data; they will do so at their own discretion. However, the central government should provide information on best practices to encourage local governments to share their data. The central government commits to the publication of key data sets (e.g. national statistics, national elections and national budgets) and high-value datasets (e.g. crime and justice, education, energy and

environment, finance and contracts, geospatial, social mobility and welfare, and transport and infrastructure). Data are published on a national portal while promoting public engagement in open data activity.

- The 2017 Basic Principles on Open Data is the main policy document for open data in Japan and ensures the implementation of the Public-Private Data Utilisation Act. This document defines open data as public and private sector data held by the national government, local governments and companies, published in a form that is of easy access and use to all citizens via the Internet. It recommends that multiple organisations (i.e. local governments) jointly set up an open data portal site to facilitate access to standardised data across organisational boundaries.

Source: Government of Japan (2013[90]), *Japan Open Data Charter Action Plan*, https://japan.kantei.go.jp/policy/it/2013/1029_fulltext.pdf; Government of Japan (2017[91]), "Basic Principles on Open Data (provisional translation)", https://cio.go.jp/sites/default/files/uploads/documents/data_shishin_en.pdf; Government of Japan (2016[45]), *官民データ活用推進基本法 [Basic Act on the Advancement of Public and Private Sector Data Utilisation]*, https://japan.kantei.go.jp/policy/it/data_basicact/data_basicact.html; OECD (2019[92]), *OECD OURdata Index: 2019*, www.oecd.org/gov/digital-government/ourdata-index-japan.pdf.

Other countries have implemented measures to facilitate data sharing across levels of government. The aim is to ensure that the central government has access to data owned and produced by local authorities. While central authorities can define overarching data quality standards, in practice, local governments are responsible for ensuring data quality. For example:

- In **Mexico**, the national government has developed the Open Mexico Network (*Red México Abierto*). It is a network that seeks to encourage the exchange of mechanisms to establish open data policies at the local level, engage local governments in the central open data policy and facilitate the publication of open government data produced by local authorities on the central open data portal datos.gob.mx. More than 700 open databases have been published across 32 states and 25 municipalities (Government of Mexico, 2018[93]).
- In **Japan**, the central government has realised that most interaction with citizens takes place at the local government level. It has therefore made considerable efforts to try to encourage the adoption of the "open by default" principle among local governments. To this end, it has organised seminars where it presented the benefits of open data and involved local governments in central-level working groups for open data initiatives across the country. Moreover, the central government has created the portal data.go.jp, which contains over 24 000 datasets from 22 public central government organisations and 17 groups (e.g. land and climate, mining and manufacturing, housing, estate and construction and administration and public finance). The portal features a developer's page that provides a variety of information needed for developers of applications or new services using metadata from the portal.

At the local level, digital technologies have increased the amount of data produced by the city's residents through different sensors located in the urban space (e.g. cameras, meters, motion detectors, among others). Data are also generated through crowdsourcing, such as peer-to-peer platforms, voluntary citizens' feedback and data collected via smartphones and other connected devices. In France, for example, the city of Paris has made all structured data accessible by open license to promote their reuse and generate new applications since 2010. The city government also supports: i) big data analysis solutions, which are made more personalised and proactive through predictive and preventative approaches; and ii) open innovation with its partners through data exchanges that are kept secure and confidential, in line with the recommendations of the French data protection authority (Mairie de Paris, 2020[80]).

Data governance frameworks also make efforts to ensure access, sharing and collection of information and data across sectors. For instance, in the context of smart city projects, business-to-government reporting practices can benefit from the implementation of common data governance structures and tools across all layers of the governance model. For example, Seoul's integrated public sector data dashboard serves to strengthen public sector accountability through the centralisation of cross-sectoral data (Box 2.23).

Box 2.23. Seoul's integrated public sector data dashboard

In 2017, Seoul launched the Digital Mayor's Office, an integrated public sector data dashboard that aggregates multisectoral urban data to visualise the overall city status and produce indicators in real time. The dashboard supports accurate and streamlined decision making by the mayoral office on a daily basis through effective and up-to-date displays of city status, main policies and main project information, as well as functionalities such as video conferencing. The Big Data Division and the City Planning Division have led the establishment of a standard data integration framework and identification/co-ordination of necessary inputs from other departments respectively.

The inputs to the dashboard include 32 million data items from over 300 different information systems, such as TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) and more than 2 800 real-time CCTV feeds. The dashboard is mainly built upon an existing open data platform called Seoul Open Data run by Seoul, which covers all sorts of data published by the public sector classified into 16 categories, including education, transportation, healthcare, weather, etc. Furthermore, the dashboard has an additional scope of data, including public opinion trends, civic complaints and information on major projects.

The dashboard has been disclosed to the public since April 2020 through a large screen at three major subway transfer stations and made accessible on a website (http://scpm.seoul.go.kr/) via computers and mobile devices. It helps enhance the accountability of administrative decision making by enabling monitoring and feedback by citizens, the reporting and processing status of which is also integrated into the dashboard.

While a large portion of data comes from other open data platforms run by the public sector that already incorporate appropriate anonymisation steps in stages of collection or sharing to protect privacy, the dashboard ensures that all contents are presented without privacy-related information.

Note: TOPSIS is a multi-criteria decision analysis method.
Source: SCPM (n.d.[94]), *Whitepaper*, http://scpm.seoul.go.kr/resources/whitepaper_EN.pdf; Development Asia (2021[95]), *Digital Mayor's Office: An Integrated Smart City Data Platform*, https://development.asia/case-study/digital-mayors-office-integrated-smart-city-data-platform; Seoul Metropolitan Government (2020[96]), "Seoul's "Smart City Platform for Mayor" to lead global communication in the age of "untact", https://english.seoul.go.kr/seouls-smart-city-platform-for-mayor-to-lead-global-communication-in-the-age-of-untact/.

Enhancing co-ordination for smart city data sharing

The development of smart cities has been accompanied by the installation of data-sharing platforms as part of the data strategy and data governance arrangements. Countries and cities have thus been working to ensure the existence of a data architecture that reflects data quality standards, semantics and interoperability for data processing and sharing. Interoperability is an essential element to contribute to digital transformation and is vital to put smart city initiatives in place to ensure a modern, efficient and effective administration. Until a decade ago, smart cities depended on the use of information and communication technologies and the Internet, but now data and their management make smart cities

possible. The lack of adequate data governance arrangements can lead to duplication of data standards and technical solutions for data sharing, which would constitute a barrier for data interoperability across sectors, organisations, levels of government and across cities. Limited data flows hinder the development of new technologies and the development of better services to face challenges such as ageing and shrinking populations experienced in countries such as Italy, Japan, Korea, Poland and Spain, to name a few. This would be reflected in inefficiencies in service provision as citizens would be asked to provide the same information several times to the public administration.

Changing the mindset of city administrations is one of the critical challenges cities must face in improving data management and governance. The hierarchical and siloed organisation of cities is affecting their functionality and preventing them from benefitting from digitalisation. The experience of Helsinki, Finland, is that to make the most of the opportunities digitalisation provides, cities must offer digital services in a secure, personalised, user-friendly manner and provide them proactively and at the right time.[29]

A smart city data governance framework boosts the interoperability of heterogeneous data

The need for city administrations to interact with other public and private organisations and to exchange data or documents is increasing and becoming more important in the context of digitalisation and smart city building. These interactions, which are part of the digital transformation of countries and cities, are also becoming more complex as organisations are more interdependent. The ability of services to communicate and exchange information in an efficient, effective, quick and simple manner with other services across organisations and cities in order to achieve mutual development goals is not only demanded by political powers but expected by citizens.

Interoperability can be defined as "…the ability of different digital services to work together and communicate with one another. Digital platforms can develop application programming interfaces which enable these connections" (OECD, 2021, p. 13[97]). In 2021, the European Commission commissioned a proposal for an European Interoperability Framework for Smart Cities and Communities (EIF4SCC) where interoperability was defined as "[t]he ability of organisations and individuals to interact towards the delivery of services in cities and communities, through the exchange of data, information and knowledge, enabled by aligned processes and digital technologies, taking into account security and privacy issues" (EC, 2021[98]). Interoperability allows access and processing of data from multiple sources without losing meaning. It permits the integration of data for mapping, visualisation and other forms of representation and analysis. Interoperability enables people to find, explore and understand the structure and content of datasets to help create a contextual and holistic picture for analysis, better decision making and greater accountability.

National interoperability frameworks can guide interoperability at the local level

Some national governments guide the development or establishment of data governance arrangements through a national interoperability framework (NIF). A NIF generally aims to intensify and extend the collaboration and co-ordination among the concerned stakeholders by improving the practical aspects of the governance of interoperability. It provides a catalogue of interoperable services using the cartography of existing services. However, building national interoperability requires a behavioural change based on principles that constitute fundamental aspects of driving interoperability actions in every central and local government body:

- **Openness and transparency** regarding data, specifications and software used as well as procedures and services provided with the data.
- **Emphasis on solving residents' problems and generating benefits**. Data provided by residents should be returned in the form of benefits (i.e. products or services) that improve their lives.

- **Inclusion and accessibility**. Access to data should be a possibility for everyone and data should even be provided in several languages spoken in the city or country.
- **Building synergies through data linkage**. This refers to the reuse, reusability and sharing of data. When using data from other entities, it is necessary to see if the initiatives created produce synergistic effects as open innovation. Careful consideration should be given to the minimum data required to create value with the minimum amount of data linkage.
- **Fostering transparency in data management**. Most of the data that circulates in smart cities originates from residents' activities; thus, residents are the owners and should be able to exercise their rights regarding their use. It should be possible for individuals to verify how their data are being used based on appropriate consent and there should be appropriate opt-out procedures for that use if necessary.

The European Union is encouraging member states to focus on interoperability for digital services. The European Union's internal market guarantees freedom of free movement of goods, capital, services and people among states. Interconnected, interoperable networks and systems guarantee these freedoms. People and businesses must interact electronically with member state public administrations when looking for work abroad or reallocating their business. Member states are modernising their public administrations by introducing digital public services to make these interactions efficient, effective, timely and of high quality and to help cut red tape and reduce the cost and effort involved (EC, 2017[99]). However, there is a risk of creating isolated digital environments and, consequently, electronic barriers that may prevent national public administrations from connecting with each other and citizens and businesses from identifying and using available digital public services in countries other than their own. To avoid that, the European Commission developed the European Interoperability Framework (EIF) to give guidance to member states through a set of principles and practical recommendations as part of an interoperability model applicable to all digital public services of the union (Box 2.24). The EIF was originally prepared in 2010 and revised in 2017 to push a more ambitious vision for the interoperability framework and to factor in the latest technical evolutions.

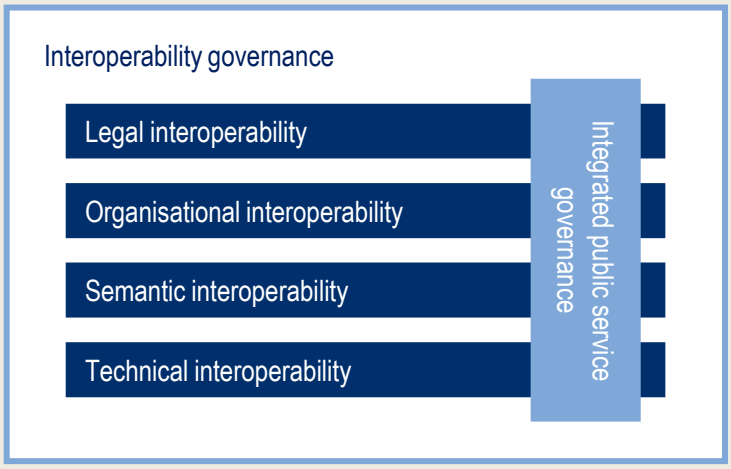
The experience of the EIF offers major lessons to consider. Interoperability governance is the key to a holistic approach to interoperability, as it brings together all the instruments needed to apply it. Co-ordination, communication and monitoring are elements of the utmost importance for successful interoperability governance. Moreover, setting standards and specifications is fundamental to operationalise interoperability and ensuring data are the same for all users. A critical lesson is that when preparing legal instruments, organisation business processes, information exchange, services and components that support public service interoperability should be at the core of works. Interoperability is a continuous task, as it is regularly disrupted by changes to the environment, such as legislation, the needs of businesses or citizens, political priorities, etc. Similarly, this experience suggests that an information management strategy should be drafted and co-ordinated at the highest possible level of the organisation to avoid fragmentation and set priorities.

Box 2.24. The European Interoperability Framework

In 2017, the European Commission adopted the European Interoperability Framework (EIF) as a commonly agreed approach to the delivery of European public services in an interoperable manner. The EIF defines basic interoperability guidelines in the form of common principles, models and recommendations. It includes 12 underlying principles: subsidiarity and proportionality, openness, transparency, reusability, technological neutrality and data portability, user-centricity, inclusion and accessibility, security and privacy, multilingualism, administrative simplification, preservation of information and assessment of effectiveness and efficiency. The EIF also includes an interoperability

model, which is applicable to all digital public services and may also be considered as an integral element of the interoperability by design paradigm. Figure 2.8 depicts the components of this model.

Figure 2.8. The European Interoperability model



- **Interoperability governance** is the background layer. It refers to decisions on interoperability frameworks, institutional arrangements, organisational structures, roles and responsibilities, policies, agreements and other aspects of ensuring and monitoring interoperability at the national and European Union (EU) levels.
- **Integrated public service governance** is a cross-cutting component of the four layers of interoperability. European public service provision often requires different public administrations to work together to meet end users' needs and provide public services in an integrated way. When multiple organisations are involved, there is a need for co-ordination and governance by the authorities with a mandate for planning, implementing and operating European public services.
- **Legal interoperability** is about ensuring that organisations operating under different legal frameworks, policies and strategies are able to work together. To ensure legal interoperability, member states have to perform "interoperability checks" by screening existing legislation to identify interoperability barriers: sectoral or geographical restrictions in the use and storage of data, different and vague data licence models, etc.
- **Organisational interoperability** refers to the way in which public administrations align their business processes, responsibilities and expectations to achieve commonly agreed and mutually beneficial goals. It also aims to meet the requirements of the user community by making services available, easily identifiable, accessible and user-focused.
- **Semantic interoperability** ensures that the precise format and meaning of exchanged data and information is preserved and understood throughout exchanges between parties. A starting point is to perceive data and information as a valuable public asset.
- **Technical interoperability** covers the applications and infrastructures linking systems and services. This includes interface specifications, interconnection services, data integration services, data presentation and exchange and secure communication protocols.

Acknowledging the importance of interoperability for the well-being of inhabitants, businesses, visitors and city/community administrators in the European Union, the European Commission commissioned a proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC). The aim is to provide EU local administration leaders with definitions, principles, recommendations, practical

use cases and a common model to facilitate service delivery to the public across domains, cities, regions and borders. It is based on five principles that define the direction of the interoperability in smart cities and communities: i) a human-centric approach; ii) a city needs-led approach at the EU level; iii) the city as a participatory-driven and open innovation ecosystem; iv) ethical and socially responsible access, use, sharing and management of data and technology; and v) technologies as key enablers, not as the objective.

Source: EC (2017[99]), *New European Interoperability Framework: Promoting Seamless Services and Data Flows for European Public Administrations*, https://ec.europa.eu/isa2/sites/default/files/eif_brochure_final.pdf; EC (2021[98]), *Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC)*, https://op.europa.eu/en/publication-detail/-/publication/f69284c4-eacb-11eb-93a8-01aa75ed71a1/language-en.

Based on the renewed EIF, Luxembourg has developed a data governance framework in the context of the NIF (Box 2.25). This framework takes a progressive approach to interoperability as it includes principles such as digital first, once-only and transparency. The NIF covers levels of interoperability such as: legislation, organisation, semantics and technique. The experience of Luxembourg's NIF is rather recent and it is not yet possible to analyse its impact or results. However, it suggests that adopting an NIF does not necessarily guarantee achieving its defined objectives and benefits per se, but rather marks the starting point for the long-term implementation of interoperability across government. The implementation of an NIF requires the participation of a wide number of stakeholders to produce tangible and concrete field measures. This requires setting an effective and efficient governance framework on all levels to implement the NIF and its principles.

In Argentina, national public sector organisations are mandated by law to exchange the public information they produce, obtain, work with or are responsible for with any other public body that requests it (Government of Argentina, 2016[100]). To this end, the Ministry of Modernisation is responsible for the creation of the exchange protocols, interoperability guidelines and complementary, explanatory, technical and operational standards necessary for data sharing. A key tool has been the creation of the interoperability module of the electronic management system called INTEROPER.AR. This module functions as an exchange node between the national public sector organisations' different information systems and database (Government of Argentina, 2018[101]). The national government has invited provincial and municipal governments to enter into co-operation agreements with the national government to form a decentralised node network by which information and data are shared across different levels of government. Each public body is constituted in an interoperable services module (MSI) node that together make up a decentralised network. The information between nodes is shared through services and only those authorised areas can access the data exchange through validations, electronic authentication forms and the use of digital certificates.[30] While in Argentina, there is a need for formalising a data governance structure at the strategic layer in the case of INTEROPER.AR illustrates the potential scalability of an interoperability tool. In this case, its application is being expanded to subnational levels of government.

Box 2.25. Luxembourg's National Interoperability Framework

In March 2019, the government of Luxembourg adopted the NIF, building on the new EIF while taking into account the context and specific national needs. The implementation of the NIF is expected to: boost efficiency and effectiveness gains; reduce costs (financial and human resources) in service development; produce time savings in service provision; improve the quality of services (notably via standardisation, reuse and mutualisation of services); enhanced services security via standardisation

and elimination of superfluous services; and lead to more transparency and openness for the end users and those in charge of service delivery.

The NIF aims to improve the practical governance of interoperability, intensify and extend the collaboration between the different concerned actors, complete and extend the mapping and the cartography of existing services and put interoperability at the centre of every project, action or decision (interoperability by design).

The NIF includes 48 recommendations at its core which provide a framework for the interoperability actions to be undertaken. The recommendations guide all concerned public sector stakeholders in integrating interoperability into any new service delivery project from the outset or how to adapt their existing services to be interoperable.

The government established the National Committee for Interoperability (CNI), composed of representatives of the various sectors concerned, to advance interoperability generally at the national and sectoral levels. The CNI oversees sectoral committees for interoperability. In every ministry, there is a Competence Centre for Interoperability responsible for the implementation of the NIF.

Source: Government of Luxembourg (2019[102]), *National Interoperability Framework*, http://digital.gouvernement.lu/en/dossiers/2019/NIF-2019.html.

Ensuring the interoperability of datasets is a critical step in building smart cities based on data. Interoperability frameworks ensure that subnational governments, in particular cities, have the necessary understanding of the standards to manage data, semantics and platforms to facilitate data sharing across cities. According to international experience, to achieve interoperability (i.e. how data are formatted allows diverse datasets to be exchanged and merged into meaningful ways), it is necessary to ensure data compatibility (i.e. data consistency across datasets). This would facilitate the use and exchange of data. For that purpose, a common understanding of the meaning of data needs to be agreed between the data provider and user. Continuous dialogue among different stakeholders (i.e. local governments, private companies, experts and individuals) is essential to maintain compatibility. Discussion on data meaning should be cross-sectoral so that data can be used and various services provided.

For example, in 2020, the Japanese central government adopted the Government Interoperability Framework (GIF) to use city data to create new value by structuring and ensuring high-quality data (Government of Japan, 2020[103]). This will enable services to be offered across cities, regions and even borders, not only in a single city. The GIF is a generic framework applicable to all entities of national and local governments. It lays out the basic conditions for achieving interoperability, acting as the common denominator for relevant initiatives across the country involving the public and private sectors and citizens. The GIF stresses the importance of receiving feedback from residents as users. The reason is that residents' participation would allow the creation of more and new services tailored to their needs. The GIF acknowledges that innovation in service delivery is possible not only through government and private sector actions but by the active participation of citizens.

National guidelines and recommendations can facilitate interoperability within and across (smart) cities

To enable interoperability, countries generally enact legislation to define a set of rules to control access to and sharing of data. Regulations help in the definition of common data standards and their enforcement to promote greater data interoperability and streamlined data-sharing practices. In general, these regulations focus on the central/national-level government organisations but subnational governments are also encouraged to emulate those practices. This is seminal in the formation of smart cities as it would ensure a common understanding and semantics across levels of government on data features facilitating data

flows across levels of government. Across OECD member and partner countries, examples of data-sharing regulatory instruments are vast (OECD, 2019[3]). In many cases, regulation is supported by softer legal and regulatory instruments such as guidelines, recommendations or codes of practice. For example:

- In **Argentina**, to help organisations to implement the Open Data Policy, the national government issued the Guide for the Identification and Use of Interoperable Entities. These are basic and fundamental data whose use is frequently repeated between datasets of different themes and sources. The guide provides public and private sector organisations with simple methods to generate, share and/or consume good-quality government-held data (OECD, 2019[3]). Interoperable entities are those that allow datasets to talk to each other but this cannot happen when two datasets name the same interoperable entity differently. In order for datasets to be interoperable, the guide establishes that all interoperable features present in a dataset must be identified and data about them followed by the same standard (Government of Argentina, n.d.[104]).
- In **France**, the national government issued the General Reference Framework for Interoperability (*Référentiel général d'interopérabilité*, RGI) in a quest to promote interoperability across information systems within the public sector. It is largely based on the EIF and sets standards for each level of interoperability (i.e. political, legal, organisational, semantic and technical). A critical element is that the RGI is open to adaptation to new technological developments, the evolution of standards and the need for interoperability. The RGI introduces the concept of interoperability profile (*profil d'interopérabilité*), which is a limited set of standards to use in a context and a determined use. The objective is to frame the use of the RGI and avoid the proliferation of standards and combinations of standards for a given use (Government of France, 2015[105]).
- In **Italy**, the Agency for Digital Italy published a *White Paper on Artificial Intelligence at the Service of Citizens* in 2018. It aims to improve the quality and usability of the data they provide to facilitate their use in refining AI systems (OECD, 2019[3]). The paper argues that the quality and interoperability of data are determining factors for the possibility of applying new technologies. It acknowledges that a challenge for digitalisation and interoperability is that data coming from a multitude of connected devices can be fragmented, heterogeneous and distributed irregularly in space and time. To face this situation, it recommends public administration aggregating data through the creation of an open platform for the collection, generation and management of certain types of data directly related to public administration (Agency for Digital Italy, 2018[106]).

For interoperability to enable a more efficient city administration, a citizen-oriented approach is required

National experiences in fostering interoperability suggest that enabling joined-up data is a way to improve decision-making processes and make service delivery more efficient and effective. Indeed, data-sharing frameworks should link desired policy outcomes (e.g. reduced congestion, building liveable cities, improved accessibility, etc.) to the regulatory and planning methods or use cases that may deliver those outcomes (e.g. congestion management, travel activity monitoring, data to support infrastructure interventions, etc.). Outcomes and methods should be linked to the specific data required to carry out those regulatory and planning actions. This includes rules relating to an appropriate level of aggregation, data handling, data retention period and auditability, as well as data destruction protocols (ITF, 2020[107]). For example:

- In **Spain**, all public administrations are connected to a central data exchange node called the "platform for data intermediation" (Box 2.26). One of its main achievements has been the reduction in the administrative burden of data sharing. Its message is that, as far as possible, under the legislation in force, cities/communities service users should be asked for once-only and relevant-only information, ensuring a fully transparent process on how data are used. The Spanish

experience shows that data-sharing mandates on the part of public authorities should build on data minimisation concerns by default.

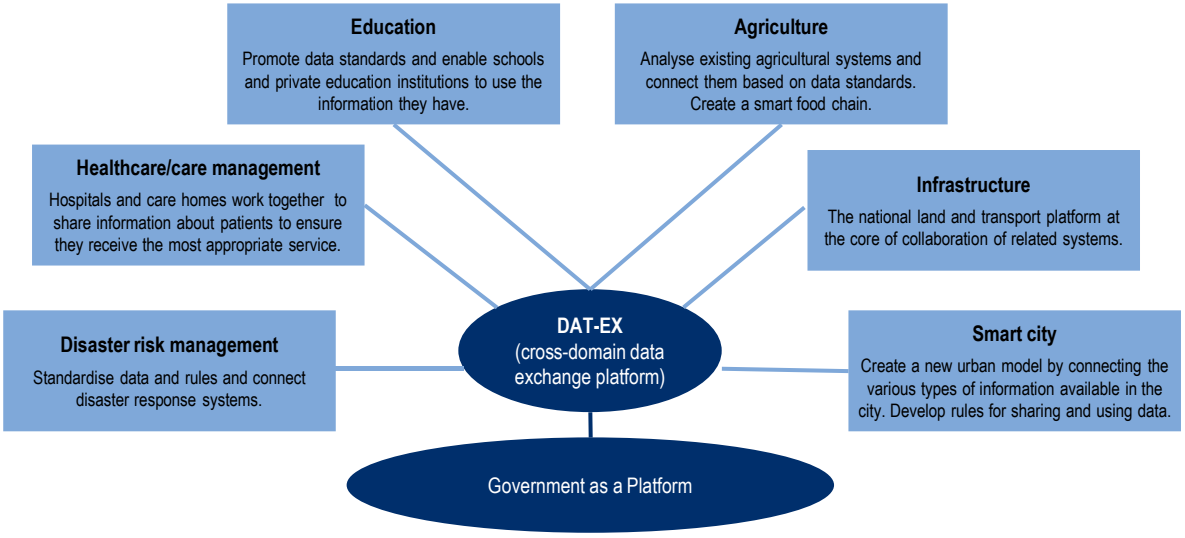
Box 2.26. Adopting a human-centric approach to interoperability – The case of Spain

The Spanish central government has set up a Technology Transfer Centre that publishes a general directory of applications and/or solutions whose objective is to favour the reuse of solutions by all public administrations. This portal informs about projects, services, semantic assets, regulations and solutions that are being developed in the field of electronic administration. As part of the digitalisation strategy, the government introduced the Data Intermediation Platform (*Plataforma de Intermediación de Datos*, PID), which connects all public administrations to a central data exchange node and reduces the administrative burden of data sharing. It is based on Law 39/2015 on Common Administrative Procedure, which states that citizens do not have to provide any data or document already held by the public administration. The exchange of data between public administrations is a fundamental task when it comes to providing advanced electronic administration services to citizens, improving the efficiency and effectiveness of organisations. Through the PID, all public administrations can consult any of the more than 130 certificates offered by more than 45 data providers, both from the General State Administration and autonomous communities, local entities, universities and other public entities. Among the data available are the identity and residence data of a citizen, data related to unemployment, official qualifications, cadastral data, etc. Citizens' authorisation to consult the data is requested. The PID has proven to be effective and has been well received by organisations, processing more than 531 million data queries from its start-up to 2020, generating estimated savings to date of more than EUR 2 700 million since 2007.

Source: Government of Spain (n.d.[108]), *La Plataforma de Intermediación de Datos*, https://administracionelectronica.gob.es/pae_Home/pae_Estrategias/Racionaliza_y_Comparte/elementos_comunes/Intermediacion.

- In **Japan**, the central government is the largest data holder, player and platformer in the country. Thus, the central government, with the support of the private sector, launched a cross-domain data exchange and use platform called DATA-EX in 2020 (Figure 2.9). The data platform consists of the glossaries, code sets and data models needed for data flows. The platform is to serve as a data search engine (data available in Japan and abroad), allow users to access the data they require (download data, API acquisition, contracts, transactions) and connect the required data (data collaboration, interoperability and data cleansing). DATA-EX aims to link different platforms already in operation: national government open data, local government open data, data platform of Tokyo Metropolitan Government, personal data store, information bank, data trading, public transportation, agriculture, geography and academia. DATA-EX intends to create a large data trading community in Japan, spanning across industry, academia and government and contribute to the promotion of a cross-industry and cross-border data exchange environment. The platform is expected to serve the multinational trading corporation's domestic and foreign network by enabling the sourcing, exchange, sharing and commercialisation of data products by leveraging the platform's advanced features and capabilities. The information systems of smart cities collect data across many networks, such as the fifth-generation technology standard for broadband cellular networks 5G. The data that come from the electrical component of a smart building, the transport network or the state of the road traffic must interact to bring value. At the end of the chain, algorithms and AI provide insights allowing communities to explore new areas of development. The interconnection of networks and the crossing and correlation of data flows largely determine the success, efficiency and value of an information system.

Figure 2.9. Examples of priority areas of Japan's DATA-EX platform



Source: Based on Government of Japan (2021[7]), *National Data Strategy*, https://www.digital.go.jp/assets/contents/node/basic_page/field_ref_resources/0f321c23-517f-439e-9076-5804f0a24b59/20210901_en_05.pdf.

Promoting interoperability requires the collaboration of a wide number of actors from different levels and policy domains

Open collaboration among cities as well as minimal digital interoperability based on open standards are crucial for the successful digital transformation of public administrations. Interoperability will only be possible if a governance framework facilitates collaboration and co-operation among different actors. The experiences of the Nantes Métropole in France and Takamatsu City in Japan show that collaboration among cities, regardless of their size, allows for better and more comprehensive data collection, economies of scale in terms of data collection and pulling resources towards a common platform.

Interoperability can be categorised as vertical and horizontal. The former refers to the ability of digital services to incorporate data of content from an upstream provider such as the central or regional government, while the latter refers to the possibility of digital services to communicate with other services, which could come from other cities, agencies, private sector and even citizens. For example, Japan's GIF covers three types of interactions:

- City to city, which refers to interactions between local governments.
- City to business, which refers to interactions between local administrations and businesses.
- City to citizens, which refers to interactions between the local government and citizens.

At the horizontal level, interoperability is ensured through agreements among local governments and among local governments and private sector actors. Cities may organise fora for the exchange of ideas, get partners for new smart city-related projects and draw lessons from other experiences. The experiences of the cities of Takamatsu and Toyama suggest that collaboration among local governments is not enough to ensure interoperability and ensure the optimal use and operation of data-sharing platforms. Partnering with the private sector and academia is essential for sharing lessons, getting to know best practices and finding potential business partners (Box 2.27). Moreover, Toyama's Sketch Lab and Takamatsu's Promotion Council constitute fora where discussions on real problems, data needs and how to get and manage them should take into account the needs of a wide number of actors.

Box 2.27. Local fora for collaboration, co-creation and partnering – The case of Takamatsu and Toyama

The city of **Toyama** has organised the Sketch Lab, which provides an opportunity for private and public actors to take on the challenge of solving regional issues and creates new business opportunities by providing a forum for dialogue. In 2022, there were 202 participants registered in the Sketch Lab from private companies, individuals, corporations and the government. Participants must pay YPN 2 000 a month to be a member and access all sessions organised in the lab. One of the objectives of the Sketch Lab is to promote innovation and co-creation by working together with industry, academia, citizens and government to develop a vision for the future and implement it. Discussion in the lab must ensure that innovations meet the needs of society.

In 2017, the city of **Takamatsu** installed the Smart City Takamatsu Promotion Council with the aim of discussing ideas to solve regional issues (e.g. economic vitalisation and safety and security) by collecting and analysing public-private data through a common IoT platform. The council is composed of ICT vendors, administrative agencies, education and research institutes, social infrastructure providers, financial institutions, communication network operators, local service providers, technology businesses and members from other sectors. It had 136 members in May 2022 and consists of working groups created for specific regional challenges. The council is carrying out awareness-raising activities with the goal of becoming a smart city with citizen participation, for example holding symposia and offering training courses for citizens in human resource development. The council serves as a forum for partnering; when an actor has a project proposal comes to the forum to present it and discuss it with possible partners to join forces.

Source: Toyama City (2022[109]), "Smart city promotion business", Presentation given to the OECD on 17 June 2022, Toyama; City of Takamatsu (2022[110]), "Takamatsu City's Smart City Vision", Presentation given to the OECD on 24 June 2022, Takamatsu.

In the United Kingdom, London provides another example of how to promote collaboration for data management and sharing. The London Office of Technology and Innovation (LOTI) helps the different boroughs work together by bringing the best digital technology and data to improve service delivery across the Greater London area.[31] As of 2022, 23 out of 33 London boroughs were members of LOTI. One of the aims of LOTI is to unlock the value of public sector information by bringing together member boroughs to analyse and act upon their data together. All local public services from the smart city perspective depend on the local mayors of the boroughs. LOTI facilitates collaboration and knowledge sharing to facilitate the digital transformation journey. In the Seoul Metropolitan Area, there is no official operation and consultative body for data management with cities around Seoul, such as Gyeonggi-do and Incheon, but co-operation takes place for data analysis that is needed jointly. An example is the analysis of commuting data in the metropolitan area, which is of interest to all cities around Seoul.

OECD (2019[3]) research suggests that interoperability requires a common data governance framework to ensure effective implementation of cross-sector data collection, sharing and/or accessing facilities. It is important to ensure seamless business-to-government communication due to the large role private sector companies play in the promotion of smart cities and data collection. Thus, implementing common data governance structures and tools across all layers of governance is essential to facilitate interoperability. This communication and data provision must be simple and avoid unnecessary procedures and red tape. The Netherlands offers a good example of how to reduce the burden imposed on businesses for the provision of information to local authorities and banks (OECD, 2019[3]). The Dutch government has introduced Standard Business Reporting (SBR) that defines a shared public-private data governance framework aimed at reducing the burden imposed on businesses for the provision of information to local

authorities and banks. This experience provides an example of smart city initiatives on how to reduce unnecessary requirements and procedures and make data management more efficient, enhancing interoperability.[32]

Cities are building big data platforms for data management and interoperability

With the adoption of IoT devices and systems for service delivery, many IoT protocols and standards have been developed. IoT devices are generally constrained by their limited functionalities (e.g. memory space and processing capacity) or are closed proprietary systems dedicated to one single task (Ahlgren, Hidell and Ngai, 2016[111]). Sometimes, even market forces work against interoperability, in particular in the IoT domain. This is the case, for example, when smart lighting systems only work with light bulbs from the same vendor with limited possibilities for third parties to be part of the smart system (Fältström, 2016[112]). Ahlgren, Hidell and Ngai (2016[111]) have found that standardised IoT protocols may not be enough to ensure interoperability; systems must be designed with openness considerations (i.e. open data and open platforms) from the outset.

Indeed, across countries, city authorities need to upgrade their capacity and capability for data management. This generally involves a single data platform to manage all data collected through a wide array of IoT devices. The platform is the cornerstone of a system of systems as it will be tasked with linking different fragmented systems. The reason is that not all services are delivered by the same providers that may have their own management platforms for data management. Enabling the use of city data and external data through the platform is key to providing a comprehensive view of the state of the city and designing more tailored services based on the cities and their residents' particular needs. The effectiveness of the city platform depends to a large extent on the trust the city can ensure in the reliability of the data quality, accuracy and security.

City platforms for data management enable a shift in the approach to data and policy making. Rather than focusing on a vertical siloed approach, data management platforms enable a more horizontal across-the-board approach that maximises the benefits of combining data from many different sources. It enables sharing data across administrative departments within the local administration, across different levels of government, among cities at different locations, not only neighbouring ones, and with private, voluntary and academic organisations. Using a platform to share open data is also a way of improving relations between local authorities and citizens, strengthening co-operation and co-ordination among local governments and across governments at different levels, enhancing efficiency in public administration and boosting innovation in public service delivery. For example, the use and governance of data in Barcelona in Spain, London in the United Kingdom, Nantes Métropole in France and Seoul Metropolitan Government in Korea provide important lessons on how the notion of a smart city can be reconceptualised to be responsible, citizen-centric and privacy-preserving.

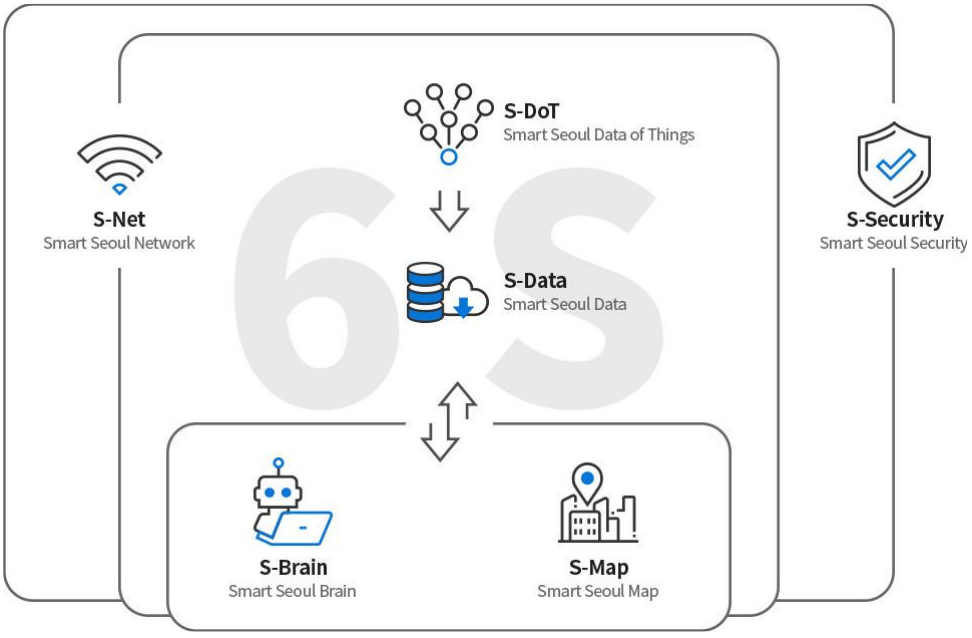
- In **France**, three local authorities – the Loire-Atlantique department, Nantes Métropole and the Pays de la Loire region – have created a common platform for opening up public data. These authorities allow all reusers (citizens, associations, companies, local authorities, etc.) to access a wide range of open data from the same portal. Whether users connect to data.nantesmetropole.fr, data.loire-atlantique.fr or data.paysdelaloire.fr, they benefit from all of the data and features of this shared platform. To ensure an orderly approach to data sharing and consistency of the open data portals in form and substance, the three local authorities issue a charter of uses of the shared approach (*Charte des usages de la plateforme Open Data mutualisée*) (Nantes Métropole, 2022[113]). These rules of use as well as their evolutions are subject to validation by the co-ordinators of the pooled approach in the steering committee composed by the three local authorities. In addition, Nantes Métropole participates in the national transport.data.gouv experiment led by the Inter-ministerial Directorate for Digital and State Information and Communication System (*Direction interministérielle du numérique et du système d'information et*

de communication de l'État, DINSIC), the Ministry of Transport and Etalab. The transport.data.gouv platform constitutes the French National Access Point (*Point d'Accès National*, PAN) and aims to reference all transport data. It contributes to the improvement of the links between data producers and reusers and provides all of the tools and information necessary for their quality, interoperability and reuse.

- In **Germany**, the city of Hamburg adopted a comprehensive Digital Strategy for Hamburg that establishes the adoption of digital technologies to improve residents' quality of life. Data are regarded as a key element in the building of digital cities. Thus, the strategy includes the Urban Data Platform Hamburg (UDP_HH) as the technological "data hub" of the city. Its goal is not to be a uniform central data resource but the standardised technical linking of the city's many decentralised systems and databases (system of systems). Moreover, the Urban Data Hub (UD-HUB) aims to co-ordinate the handling of urban data. The technical organisational unit is responsible for the strategic management of the common municipal data infrastructure. One of its main tasks is the operation and further development of the UDP_HH as well as the organisation and standardisation of the technical data and process interfaces (e.g. Xbau and Xplanung) and the facilitation of the integration of data from procedures of the urban actors to the UDP_HH (City of Hamburg, 2020[114]).
- In the **United Kingdom**, London authorities have concluded that cities need a simple well-known and trusted technical means to share data among departments and stakeholders. For that reason, they created the London Datastore, which is an open data-sharing portal where anyone can access data relating to the city. Citizens, business owners, researchers and developers can have access to data provided through more than 700 datasets. The datastore includes a High Streets Data Partnership, a Night Time Observatory, the Planning London Datahub and data on economic fairness. In June 2022, London announced an investment of GBP 500 000 to create a new platform to boost data innovation and establish a data governance body. The new Data for London platform will act as a "central library" for the vast amount of data held across the capital, enabling residents to access both public and private data more easily and in a more sophisticated manner.[33]
- In **Spain**, in 2011, the city of Barcelona set the Open Data BCN portal as part of the Barcelona Ciutat digital strategy to ensure and facilitate the access, storage and sharing of public information with the objective of maximising available public resources, exposing the information generated or guarded by public bodies, allowing data access and use for the common good and for the benefit of anyone and any entity interested.[34] Public information can be of any type or subject: pictographic documents, statistical data, results of studies or analysis, information on public services, etc. A wide range of users (e.g. private companies, researchers, public institutions or citizens) may make use of information resources for any purpose, maximising the economic and social possibilities offered by this project: promotion of transparency in management, improvement of services to citizens, generation of business activities and social impact, in search of efficiency in governance. The Open Data BCN service is transversal to several of the pillars of the city's digital strategy[35] and is based on the principle that all public information managed by municipal public entities must be publicly exposed by default, allowing their reuse. The Open Data BCN service provides information in an automatically processable manner, enabling processing efficiency through the latest and most advanced technologies.
- In **Korea**, the Seoul Metropolitan Government (SMG) has created a system for data management to respond to future challenges pre-emptively and leverage advanced technology to build confidence in smart services. The system is known as the 6S model for a smart city-based infrastructure (Figure 2.10). It is a simple but comprehensive system for converging and linking high technology and data. Its first component is the Smart Seoul Network (S-Net), a smart city communication infrastructure that can provide smart city services throughout Seoul's public living area. It is the foundation of the future smart city Seoul that guarantees citizens the right to communicate and solves numerous urban problems. Data are collected from the different IoT

devices (Smart Seoul Data of Things, S-DoT). IoT sensors are installed throughout the city of Seoul to collect, distribute and analyse various urban phenomenon data such as fine dust, living population, noise and illumination at once, and use it to formulate data-based urban policies and discover services for citizen feeling, and to implement a safe city by collecting and utilising smart CCTV city safety data. Then, the S-Data integrates all data from Seoul Metropolitan Area to use in real time. It collects, shares and utilises all data from the city of Seoul to promote the data economy and play the role of smart city infrastructure to implement Data Sharing Seoul. The S-Brain analyses a wide range of data across municipalities, including administration, transportation and environment, to support AI-based decision making that creates new services. Data are also used in the S-Map, which is an advanced system that implements Seoul equally in three-dimensional (3D) virtual space and predicts changes related to urban planning, environment and safety, enabling evidence-based policy responses. In response to the increasing security threats of new smart city technologies, the S-Security provides safe public administration services through accident prevention and implements measures to ensure the safety of personal information.[36] A key message from Seoul's experience is that even if a city has the technology for building data management platforms, it is essential to have the necessary policies in place to make the process work.

Figure 2.10. Seoul's smart city-based infrastructure – The 6S model



Source: Seoul Metropolitan Government (n.d.[115]), Seoul Smart City Platform, https://news.seoul.go.kr/gov/archives/529453.

Ensuring interoperability can start within the local public administration itself. According to the experience of Estonia and Korea, a key challenge for interoperability is to capture and share data across ministries. A digital administration must unify and centralise its citizens' information. This would make a more cost-efficient and effective administration, as in many cases, citizens have multiple IDs issued by different government agencies. Each ministry or department's dataset has its own characteristics and information. This profusion of data in different administrative bodies causes duplication, slows down government action and is detrimental to citizens' well-being. To address this issue, in 2021, the Seoul Metropolitan Government (SMG) established the first stage of the Big Data Service Platform to store public data in one place (Box 2.28). The goal is to unify all public data collection and management, usually dispersed among

different SMG institutions and departments, with the aim of producing, utilising and opening high-quality public data. The platform is composed of a unified, integrated management system for storing and utilising public data and a physical infrastructure (data lake) that stores huge amounts of source data in one place. To operate the platform, the SMG established an integrated data governance system to unify data access and collection authority management. By producing and distributing high-quality public data through metadata management, data standardisation and quality management, the SMG set the basis for public-private data analysis and utilisation convergence. The SMG operates other data platforms for more specific purposes: Open Data Plaza, Big Data Campus and Seoul Smart City Platform. A basic feature is that each of these platforms has a different target population and, thus, access rules, although, in principle, they are all accessible to citizens. The SMG's experience in data governance and management suggests that to build more effective data management practices, it is necessary to: i) regard data as a public resource that can be used by public and private actors to create value and not as a by-product of social and economic activities; ii) strengthen the data ecosystem for a more dynamic flow of data production, distribution and utilisation; iii) specify the roles of each institution to co-ordinate data collection and management across policy fields avoiding data duplication; and iv) adopt a comprehensive national data strategy that guides the creation of value by collecting and analysing data nationally.

Box 2.28. Smart Seoul infrastructure – Big data platforms for data collection and analysis

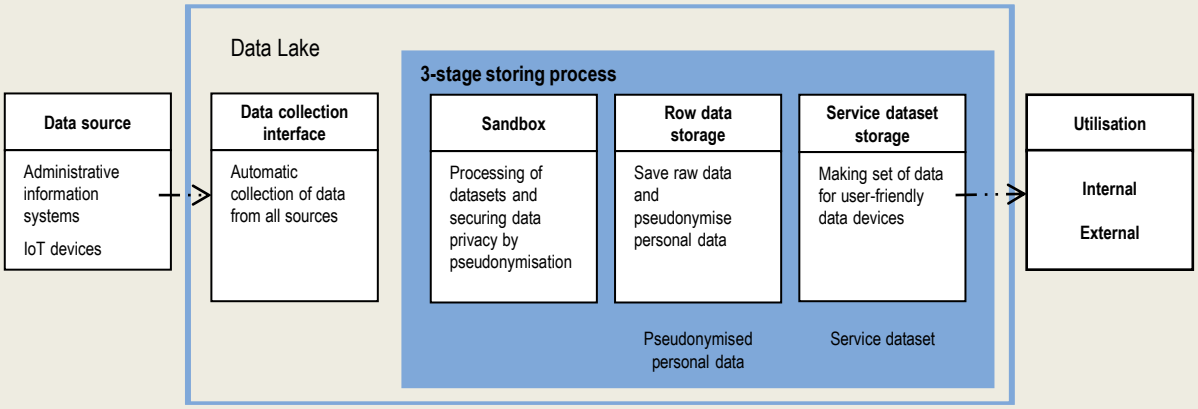
The SMG operates big data platforms for data collection, analysis and storage.

The **Big Data Service Platform** (also known as the Big Data Lake) is a project to unify public data integrated management system and establish a large data infrastructure to collect, store and utilise data generated by various administrative information systems. This will include data on public transport, environment, safety and others, conveniently stored all in one place, including city data generated by IoT sensors throughout the city. In a later stage, the project will support administrative innovation through the combination and analysis of private and administrative data. It will establish an AI predictive administration system by applying AI technology to the administration of Seoul. The platform is accessible to all public officials, researchers and citizens in Seoul but access rights vary by data and service characteristics. The Big Data Lake consists of a "total collection interface" that performs the function of securing, retaining and processing city-related and administrative data, and a "three-stage storing process" to collect data (Figure 2.11). The data storage space pays particular attention to security as sensitive and personal information may be stored. A "sandbox" processes sensitive information to non-identifiable (aggregate and anonymous) data that do not get stored. The non-identifiable data are then stored at the source.

The **Open Data Plaza** is a citizen-accessible platform that enhances public interest and transparency through the opening of public data and allows citizens to create new services directly by using public data to create economic and social values. Currently, it has datasets covering 12 fields, such as public health, general administration, cultural tourism, industrial economy, welfare, public transport and safety. Data are provided in six different formats: Open API, LOD, sheet, chart, file and link.

The **Big Data Campus** provides cloud-based big data analysis infrastructure using open source and data held by the public and private sectors. The SMG wants to share big data resources through the Big Data Campus and to solve various social problems by converging and analysing big data with citizens by sharing, converging and analysing big data resources through the Big Data Campus. The Big Data Campus provides 42 types of big data collected by the city since 2013, which includes information on credit card usage and public transportation usage that are difficult for individuals to access. The platform collects various civic proposals and opinions from civic groups and supports the sharing of innovative ideas through the organisation of different contests.

Figure 2.11. Big Data Lake composition and function



Source: Information provided by the Seoul Metropolitan Government to the OECD for the project on Smart City Data Governance of Japan.

The **Seoul Smart City Platform** (Digital Mayor's Office) provides visual information on major policies and projects of the SMG in real time. It does this by integrating 32 million data managed by 300 systems from each department along with 2 800 CCTVs. Prior to its launch, administrative data were distributed by department and provided individually, making it difficult for citizens and the mayor to analyse all data comprehensively.

Source: Information provided by the Seoul Metropolitan Government to the OECD for the project on Smart City Data Governance of Japan.

Data governance is the underpinning of successful data analytics initiatives in smart cities

Interoperability should be pursued by governments at all levels

Although national governments are taking the lead to facilitate interoperability for data sharing across national-level organisations, subnational governments are also adapting interoperability frameworks to support their smart city initiatives. Some interoperability frameworks focus on specific sectors or policies. This helps organisations share common goals and mandate to access, reuse and share common datasets. As mentioned above, Sweden's Geodata Strategy of the National Land Survey authority was key to bringing coherence and fostering the value of geodata for efficiency, innovation and competitiveness (Lundquist, Rannestig and Sandgren, 2010[88]). In the Netherlands, the Dutch Metropolitan Innovations (DMI) ecosystem aims to facilitate data sharing, not only among cities and across levels of government but also among public and private stakeholders. The DMI ecosystem also seeks to ensure better connections between various domains (e.g. mobility, urban planning and housing) and stakeholders to optimise the use of data (Box 2.29).

Box 2.29. Dutch Metropolitan Innovations – Leveraging data for mobility and urban planning

In February 2023, the Dutch national government approved the creation of the Dutch Metropolitan Innovations (DMI) ecosystem to leverage the use of data in different urban policy domains such as housing, mobility and urban planning. This initiative received financial support from the National Growth Fund – a governmental fund promoting sustainable economic development – for EUR 85 million. Public

and private stakeholders have directed an additional combined fund of EUR 201 million towards the ecosystem.

Through the DMI, cities and their partners can leverage data and digital technologies for smart city development. Its current focus is the application of digital solutions in the physical domain: houses, offices, streets, parking, traffic, transport, air quality and public space. The DMI is designed to ensure better linkages with other (physical) domains such as energy, water and climate adaptation.

The DMI ecosystem is comprised of three layers: technical, knowledge and impact.

- In the **technical** layer, an innovative federated data-sharing infrastructure is built and maintained for ecosystem partners. By keeping data at the source, through the implementation of digital policies (e.g. smart automated contracts) and trust in data sharing (e.g. through mitigating risks in cybersecurity, privacy and commercial risk), the DMI allows for the development of a governed automated data marketplace. The technical layer also includes data and product catalogues, data quality management, data governance, transaction registering and automated payments.
- The **knowledge** layer includes building blocks that enable designing and running the technical infrastructure, as well as domain-specific knowledge on the impact layer (e.g. technical standardisation, functional requirements for applying digital access management to cities, smart traffic management, digital twin interoperability, etc.). The building blocks are created and disseminated through communities of practice, training, reports and implementation in educational programmes.
- In the **impact** layer, applications are built and maintained to solve specific problems: ingestion of sensor data at scale, data integration and blending, data visualisation (digital twins), smart access applications, mobility hub design and management, shared mobility management in areas with low parking facilities, yield management in public transport, optimised digital city service management, integrated planning, as well as optimised management of construction projects including ingoing and outgoing traffic of people, vehicles and materials, city logistics applications and others.

The DMI ecosystem is designed to comply with future EU legislation on data spaces, data sharing (commercial and non-commercial) and data privacy and governance. It enables integrated problem solving by liberating data from its silos to benefit policy makers and private stakeholders, facilitating and stimulating the collaboration between public and private parties across domains and organisational boundaries. Through the ecosystem, solutions can be rolled out at scale to achieve impact on a national level.

Source: Government of the Netherlands (2023[116]), *DMI-ecosysteem voor mobiliteitsvernieuwing en slimme, duurzame verstedelijking*, https://dutchmobilityinnovations.com/spaces/1216/dmi-ecosysteem/0ver-ecosysteem.

At the subnational level, interoperability also takes place within sectors and across cities. Cities take measures to ensure data sharing among organisations in the same sector, such as transport or the judiciary. Interoperability is also used to ensure data can be shared across cities to build and provide common public services.

The city of Buenos Aires, Argentina, and Los Angeles County in the United States exemplify the case of interoperability within a policy sector as both cities have used IT platforms for data sharing and make public services more efficient and effective.

- The case of judicial power in the **city of Buenos Aires**, Argentina, provides a clear example of the efforts cities are conducting to ensure interoperability within the same sector to enhance efficiency

and effectiveness in service delivery. In 2014, the Judicial Council (*Consejo de la Magistratura*) decided to initiate a process of digital transformation of the judiciary of the city of Buenos Aires. At that time, the Judicial Council had a variety of systems to manage files in the criminal, misdemeanour jurisdictions, administrative and tax, chamber of appeals, etc. These systems were designed in different databases making administration complex. To make the judicial system of the city more modern and efficient, the city analysed the experiences of the province of San Luis and the city of Salta, which had already made a digital transition in their judicial systems. Based on these experiences, the city decided to use the IURIX application as it had been key in the design of a multi-organisation, multi-instance architecture based on a single database with embedded digital signature and processor. The city of Buenos Aires implemented a Judicial IT system platform (*Servicios Informáticos Judiciales*, SIJ) to be able to exchange information with internal and external bodies to the judiciary of the city of Buenos Aires, in such a way that when a system connects to the SIJ, it automatically establishes a connection with the rest of the systems that are part of the platform. The SIJ is a service-oriented architecture that enables interoperability among all systems of the judicial power of the city, maintains the independence of the different systems, and facilitates scalability; indeed, if one service is improved, improvements can be made in all other services (Ferrero, 2021[117]).

- In **Los Angeles County**, United States, the local government partnered with the Los Angeles Network for Enhanced Services (LANES) – a non-profit organisation responsible for operating a community-based health information exchange (HIE) for hospitals, health systems, clinics in Los Angeles County – to connect all healthcare databases in the county. Los Angeles County has nearly 10 million residents, accounting for approximately 27% of California's population. In Southern California, healthcare is delivered locally as most patients typically seek care within their metropolitan area. Patients visit health facilities where data omissions could extend to duplicate, incomplete or inconsistent records missing recent medical encounters and demographic data such as laboratory or other diagnostic tests, medications, allergies and family medical histories. The lack of quality, relevant and reliable patient data and the inability to share them is a challenge for providers as patients switch across healthcare services. The county's healthcare system is rather fragmented and requires connecting beyond electronic health records. Thus, the local government and LANES have partnered to aggregate medical records and put them to use for Los Angeles health service providers. The aim is to connect local providers across the care continuum to the most up-to-date patient data when needed and from various sources. In 2018, L.A. Care Health Plan teamed up with LANES to help to provide co-ordinated healthcare. More recently, Health Net of California, UCLA Health, Emanate Health and Beverly Hospital and LANES joined forces to make robust clinical data available to HIE provider participants (Modaressi, 2020[118]).

Interoperability facilitates transnational data flows but requires specific governance arrangements

Data flows across borders in the context of globalisation and digitalisation is also increasing and is needed to ensure economic growth on a global scale. In this context, interoperability is becoming more relevant and cross-border data flows demand greater government action to ensure the protection and ethical use of data, particularly citizen data, when those are collected, processed and used by organisations from all sectors (OECD, 2019[3]). Stronger international data governance arrangements are needed to monitor the access, use and sharing of data produced in different countries.

Japan has been an international leader in the promotion of trust in data management for economic growth and social well-being. Since 2019, the Japanese government has been promoting an international order for Data Free Flow with Trust (DFFT) (Box 2.30). DFFT is a basic concept for the data-driven society the Japanese government is promoting. Since digital data are driving the economy forward, DFFT entails that countries and citizens must be able to put data embodying intellectual property, national security

intelligence and so on under careful protection while enabling the free flow of medical, industrial, traffic and other most useful, non-personal, anonymous data across borders.

Box 2.30. Data Free Flow with Trust and the Osaka Track

In January 2019, the Japanese Prime Minister invited leaders at the World Economic Forum (WEF) to build an international order for DFFT, a call to draft international rules for the digital age that carefully protect sensitive data whilst allowing productive data to flow across borders. This is a vision where openness and trust exist in symbiosis.

In June 2019, trade and digital economy ministers at the Group of 20 (G20) Ministerial Meeting under Japan's presidency stressed the importance of cross-border data flows for productivity, innovation and sustainable development. The meeting was an opportunity to discuss the barriers to data flow, such as security, data protection and intellectual property, that damage public trust in digital technologies. At the G20 Osaka Summit, leaders issued the Osaka Leaders' Declaration, stating that legal domestic and international frameworks should be respected and, at the same time, the interoperability between each framework must be enhanced to allow data to flow more freely. The Osaka Track constitutes an invitation to discuss how stakeholders should co-operate across all regions and disciplines to achieve the vision of open and trusted data flows.

Source: Japanese Cabinet Office (2019[119]), "Toward a New Era of "Hope-Driven Economy": The Prime Minister's keynote speech at the World Economic Forum Annual Meeting", https://japan.kantei.go.jp/98_abe/statement/201901/_00003.html on 2 August 2022; WEF (2020[120]), *Data Free Flow with Trust (DFFT): Paths towards Free and Trusted Data Flows*, https://www.weforum.org/whitepapers/data-free-flow-with-trust-dfft-paths-towards-free-and-trusted-data-flows/.

To achieve the goals of the DFFT vision, it is essential to promote rules (i.e. privacy, security and intellectual property issues), technologies (i.e. security technologies) and data quality (i.e. accuracy, updated and comprehensive datasets) to build trust in government and its stakeholders.

To further advance the Osaka Track – a collective term for the global governance processes needed to unleash the benefits of more open and trusted data flows – the WEF has issued a series of recommendations to implement the DFFT vision, such as:

- Governments should issue good privacy and security protections that empower users to control rights to their personal information in accordance with international guidelines and standards.
- Businesses should provide information on data treatment and enhance transparency.
- Governments and large industry actors should forge public-private partnerships to advise micro enterprises and SMEs on using digital technologies to drive growth and competitiveness.
- Governments should negotiate trade agreements that include obligations with respect to data while ensuring sufficient discretion to regulate in the public interest (WEF, 2020[120]).

A clear example of how to govern cross-border data flows is the agreement among Estonia, Finland and Iceland to reinforce data sharing to improve cross-border public service delivery. In 2013, Estonia and Finland signed a memorandum of understanding to initiate formal co-operation for the development and management of a software environment that enables secure connectivity, searches and data transfers among various public and private databases. This supported the implementation of cross-border digital services in areas such as tax, health and education, and enabled the deployment of Estonia's X-Road data-sharing platform in Finland. The interconnection of Estonia's and Finland's X-Road platforms in 2018 facilitated greater, automated and secure cross-border data sharing and is considered seminal in the development of additional cross-border services in the region (OECD, 2019[3]). To deepen co-operation in

a more formal yet flexible manner, the governments of Estonia and Finland decided to create a separate jointly managed special purpose organisation to administer the X-Road development called the Nordic Institute for Interoperability Solutions (NIIS) (Box 2.31). The success of the cross-border deployment of the X-Road between Estonia, Finland and their partners is due to technical reasons but, more importantly, to the shared data governance policy structures at the strategic level.

Box 2.31. The Nordic Institute for Interoperability Solutions and X-Road

In 2017, the governments of Estonia and Finland signed a memorandum of association to create the Nordic Institute for Interoperability Solutions (NIIS). In 2018, the NIIS took over the X-Road core development from Finland's Population Register Centre and Estonia's Information System Authority. Iceland and the Faroe Islands became partners of the NIIS in 2018 and 2019 respectively. X-Road is an open-source software and ecosystem solution that provides unified and secure data exchange between organisations. It is a standardised, cohesive, collaborative, interoperable and secure data exchange layer.

The NIIS aims to be a strong influencer in digital governance and a growing platform for cross-border co-operation and innovation. It contributes to digital developments and initiatives in the Nordic countries, Europe and globally, and welcomes new members.

Source: NIIS (2022[121]), *Homepage*, https://www.niis.org/ (accessed on 29 September 2022), X-Road (2022[122]), *X-Road® Data Exchange Layer*, https://x-road.global/ (accessed on 29 September 2022).

Data linkage platforms are essential to enable city-level data sharing

Cities and communities are confronted with complex challenges, ranging from an ageing population to energy efficiency and urban mobility. Thus, a large number of cities started making use of digital solutions to tackle those growing challenges; but the result, in many cases, has been a fragmented system for service delivery as every city has developed its own digital response. The lack of interoperability is a major obstacle to progress in digitalisation and innovation in cities. It prevents having a coherent national interoperable environment that facilitates the delivery of services that work together, within and across organisations or public and private domains, resulting in suboptimal public services and is a barrier to the integration of services provided at the local level and for effective communication among different data platforms and technologies. To use data more effectively in the framework of smart city initiatives, cities are building data linkage platforms that enable mutual linkage and sharing of data with relative ease.

Cities are also using IT platforms to share data across administrative departments and enhance data sharing with neighbouring cities in the framework of smart city initiatives. City governments generally implement a platform to collect, store and share data from multiple sources such as mobile phones, computers, cameras, sensors and others. The purpose is to collect data that can be used to provide better services, contributing to well-being and reducing costs for the city government. For example, since 2017, the city of Takamatsu in Japan has been building an IoT common platform using FIWARE as a cross-disciplinary linkage platform (Box 2.32). The platform can be used in any combination to suit the requirements of the users. Figure 2.12 shows that the platform includes a test environment where universities and private companies can run tests with the data collected. In 2020, the neighbouring municipalities of the town of Ayagawa and city of Kan'onji decided to use the common IoT platform of the city of Takamatsu by signing a collaboration agreement to form a wide-area disaster resilience initiative (FIWARE, 2020[123]). The basic idea was that utilising IoT data generated from a wider area provides more

reliable and better insights. At the same time, such a wide-area collaboration also benefits residents who commute across municipality boundaries on a regular basis.

Box 2.32. The city of Takamatsu's IoT Common Smart City Platform for data utilisation

The city of Takamatsu in the Kagawa prefecture is highly prone to natural disasters such as typhoons and flooding that have caused material damage and loss of life. Climate change is making such disasters even more severe, common and unpredictable. The city needs to innovate in its responses due to the growing number of elderly people needing assistance. Saving lives is a top priority for the local government, thus placing disaster management high on the list in its smart city initiative.

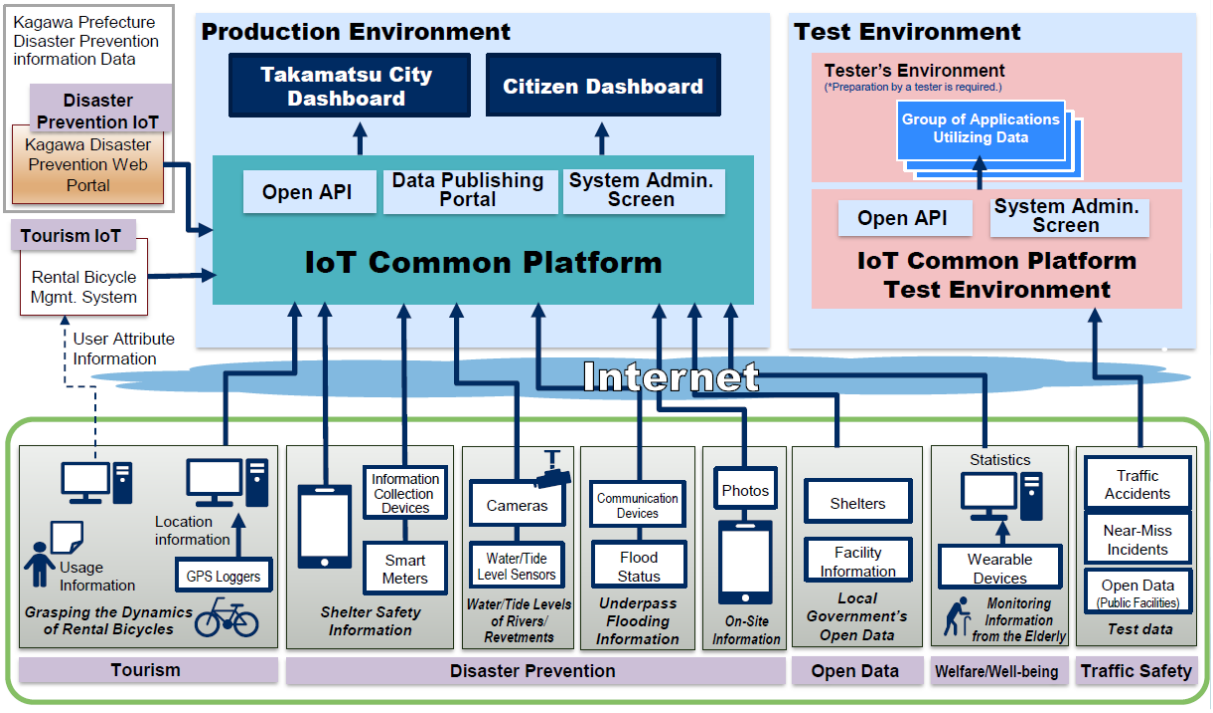
The city of Takamatsu is the first city in Japan to adopt the FIWARE platform as a cross-disciplinary data linkage platform. FIWARE is a collection of software modules that support the development and diffusion of the next generation of Internet technologies. It makes it possible for ordinary citizens, businesses, central government and municipal organisations to access and use public data freely. The accumulated data are stored on cloud servers where they can be shared, analysed and processed. The platform has 25 modules (e.g. data management, device management, big data analysis, authentication, event detection and open data linkage) organised in 5 chapters. Open source and license-free, each module can be used in any combination. Takamatsu has built a system that leverages the power of advanced IoT technology to collect, store, visualise and analyse data in the three particular fields considered a high priority for the local government, namely disaster management, tourism and welfare.

- **Disaster prevention and management**. Takamatsu is a city at risk of flooding of local rivers caused by localised torrential rain and typhoons, as well as by tsunamis and high tides along the coast, which have increased in recent years. The local governments need to assess the need for shelter quickly, should a large-scale disaster occur. For this, the city, with the support of digital technology corporation NEC, installed water and tide level sensors at the observation points designated in the city's flood prevention plan. The sensors provide data on water and tide levels that, together with data regarding water, tide and rainfall levels provided on the prefecture of Kagawa's disaster management website, allow the city to have a complete visualisation of the level of threat on the Takamatsu Wide Area Disaster Management Dashboard. The information also helps the city to determine whether or not more shelters need to be opened and the status of open shelters.
- **Tourism**. The government of Takamatsu wants to enhance its position as a tourist destination by making the most of its location and natural assets. To this aim, the local government built a system that tracks the usage of bicycles rented out to tourists (including foreign tourists). Its flat topography makes it easy for tourists to visit the different sights by bicycle, so rental bicycles are commonly used. The government installed a Global Positioning System (GPS) tracking unit on the rental bicycles. When a rented bicycle with a GPS is returned to a rental bicycle station, the GPS log data are automatically collected via Wi-Fi. By comparing these data with user information, such as nationality, gender, age, usage purpose, etc., collected beforehand (with user consent), this system is able to analyse the user's movements. The results are stored in a common platform and visualised on the city's dashboard, particularised as a point of departure, destination, duration of stay and travel routes.
- **Welfare and well-being**. To collect information on the health of senior citizens who live alone and provide timely responses to individual emergency cases, the city of Takamatsu implemented a programme that involved asking citizens to wear a wearable vital sensor and cardiac rate monitor. The sensors also provide information on whether individuals wearing the

device are able to move and exercise as well as their location. The information is collected on the common platform and this avoids the need to have people on site at all times.

Source: Ishii, K. and A. Yamanaka (2018[124]), "Building a common Smart City platform utilising FIWARE (Case study of Takamatsu City)", https://www.nec.com/en/global/techrep/journal/g18/n01/180106.html; City of Takamatsu (2022[110]), "Takamatsu City's Smart City Vision", Presentation given to the OECD on 24 June 2022, Takamatsu.

Figure 2.12. Overview of Takamatsu City IoT Common Platform (FIWARE)



Source: City of Takamatsu (2022[110]), "Takamatsu City's Smart City Vision", Presentation given to the OECD on 24 June 2022, Takamatsu.

Data interoperability enables the functioning of smart city services – The case of smart mobility

As a key component of smart city policies, smart mobility depends on managing and sharing vast amounts of heterogeneous data to ensure mobility benefits. By linking digital technologies and infrastructure, smart mobility projects seek to improve traffic management. It expands on the concept of intelligent transport systems to leverage communicative assets such as vehicles and infrastructure, mobility data platforms and shared mobility services. When all these components work in co-ordination, they have the potential to improve mobility in cities while reducing the negative aspects of public transport (ITF, 2020[107]).

Smart mobility requires taking advantage of (digital) technologies and data to deliver benefits. France, for example, has created a smart mobility platform to provide and operate a digital infrastructure to enable cities to regain power in mobility management.[37] However, smart mobility requires an adapted regulatory framework that enables innovation without compromising other objectives such as efficiency, inclusiveness and safety. The International Transport Forum (ITF) and the OECD noted that governments do not need to regulate all aspects of smart mobility, although they need to ensure the overall regulatory framework is linked to other global public policies (ITF, 2020[107]). Voluntary agreements and contractual and concessionary agreements also have the potential to guide private sector action in smart mobility.

Removing existing regulation that is no longer adapted to current needs is another task to be conducted while designing a smart mobility initiative. This could reduce excessive regulation that could prevent efficient service delivery.

Transport systems – and smart mobility projects in particular – generate an increasing amount of data. These data may be used to improve the performance of the transport system but also achieve other policy objectives such as housing and environmental protection. Certainly, data generated by transport systems cause tensions regarding which data are collected, by whom, for what purpose and how to balance individual and commercial value and public and social value (ITF, 2020[107]). The data governance arrangements need to enhance the capacity of stakeholders to follow data-sharing rules and address concerns about data collection and sharing. Smart mobility also calls for clear guidance or rules for data sharing, portability and reporting. These rules need to ensure the integrity of data to enable ticketing, payments and access rights and identification. Data should be shared with public authorities to monitor compliance with safety rules and use of public space, but also for planning purposes to improve efficiency and sustainability. The governance of data sharing should address these overlapping needs and enhance the capacity of stakeholders to abide by the data-sharing rules. Data sharing should be based on data minimisation by default.

Moreover, making the IT systems compatible is essential for interoperability. The case of the Suica card issued by the East Japan Railway Company (JR East) in Japan exemplifies this case (see Annex 2.B). To ensure service expansion, all actors must follow the same protocols, semantics and technical parameters. This is even more relevant in cases where, like the Suica card, this transport card is used for other purposes such as paying for consumer goods and increasing the need for more co-ordination with a wider number of stakeholders.

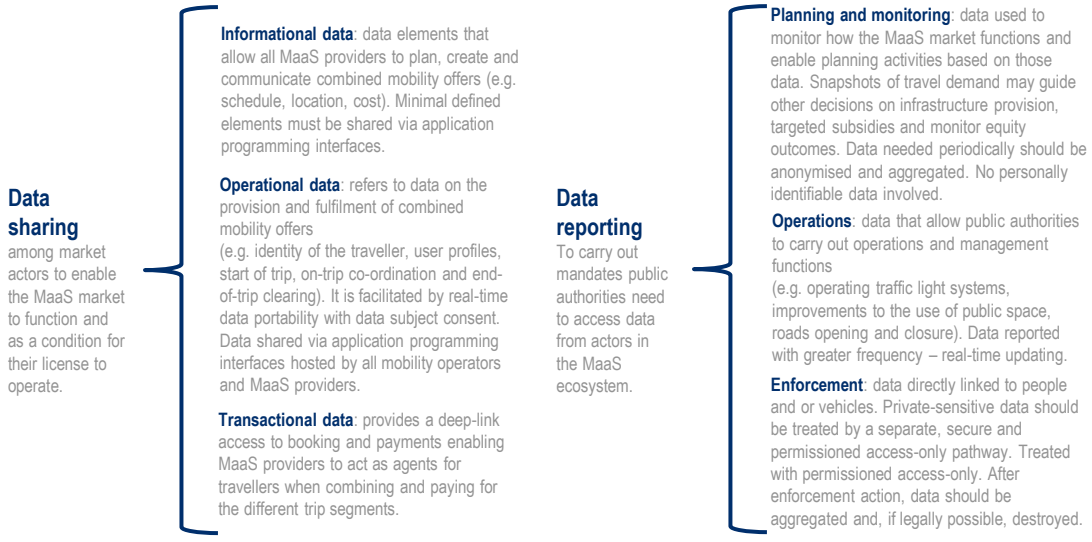
Mobility as a Service (MaaS) is a particular smart mobility initiative that exemplifies the use of data and the need for a clear data governance structure. MaaS builds on the idea of accessing via a single medium – for example, a smartphone – a large variety of mobility services, including public transport and shared mobility services (Crozet, 2020[125]). A large number of mobility service providers interact in a co-ordinated manner to give users the opportunity to access a wide range of mobility services. For MaaS to function, it needs to ensure data sharing and portability requirements among stakeholders and data reporting to public authorities to facilitate monitoring and planning while ensuring personal data protection (ITF, 2021[126]).

MaaS aims to facilitate travellers' mobility through a customer-facing user interface supported by a back-office exchange of usually sensitive information among different stakeholders (ITF, 2021[127]). Therefore, it requires a comprehensive and agile data governance framework that guides the management of data sharing and reporting. These governance arrangements need to achieve three goals: an efficient service for travellers, a remunerative business for MaaS providers and meet broader urban and social development objectives.

Several cities have introduced MaaS projects, such as: Helsinki, Finland, via the Whim system that offers multimodal packages;[38] Hanover in Germany uses the Mobilitatsshop application to offer single public transport tickets;[39] and Vienna, Austria, uses the WienMobil application through which users can buy a diverse range of public transport tickets and subscriptions.[40] These experiences show that there are different organisational and governance models for setting up a MaaS system. Helsinki uses a commercial integrator model in which the MaaS operator signs bilateral agreements with the transport operators to finance and operate the system with minimum investment from the local government. Vienna uses a back-end platform model by which the local authority sets up a platform to integrate data on different mobility services (e.g. timetables, booking, ticketing, routes). This platform is then used by MaaS operators to build their MaaS solution (Cerema, 2019[128]). Hanover uses transport as the integrator model, where the public transport network operator develops the service to attract other mobility service operators to take part in the MaaS solution (Cerema, 2019[128]).

Different factors allow the MaaS systems to operate, for example, having a diversified and efficient public transport network, good mobile phone network coverage and physical connections of the mobility services. However, one critical element is the open data and data exchange infrastructure. Cities require APIs for route calculation, booking, ticketing and price systems (ITF, 2021[126]). To enable MaaS, cities need to put into practice a data-sharing system by which all mobility operators and MaaS providers share certain data that allow them to keep their license to operate and the market to function. These data can be: informational, to allow MaaS providers to plan, create and communicate mobility services; operational (e.g. identity of the traveller, access to vehicles and services, the start of trips etc.) that can be shared with the consent of the user; and transactional to provide access to booking and payment to facilitate combining and paying for trip segments. Audit mechanisms are needed to monitor adherence to purpose specifications in processing and retaining data. It is also important that data reporting mechanisms are put in place to allow public authorities to access data from the MaaS ecosystem to plan, monitor and control market functions (Figure 2.13). Transport and city authorities need to ensure that technical mechanisms for data reporting are in place and aligned with those of data sharing, adopting security and data access protocols to guarantee the security of the sensitive data involved.

Figure 2.13. A suggested data architecture for a MaaS ecosystem



Source: Based on ITF (2021[127]), "Developing innovative mobility solutions in the Brussels-Capital Region", https://doi.org/10.1787/37cc3a85-en.

To offer their services, operators normally use an application-enabled platform that may be operated by the operators themselves, the city or transport authority, or a dedicated third party. Although this also raises the question of the rules to access the platform, which serve as gatekeepers and how to prevent anti-competitive behaviour. When the platform is developed and operated by the operators themselves, it may provide great value for consumers, as services are highly co-ordinated; it, however, is unclear how they contribute to broader public policy goals such as well-being, sustainability and inclusiveness. When the public authorities operate the platform, integration with other policy goals is generally ensured but it may be harder for new MaaS operators to enter into the market or may create concerns about favouritism by public authorities. When a third party operates the platform, the risks encountered with publicly operated platforms may be avoided but the platforms require transparent operating rules, auditability and accountability towards public authorities (ITF, 2020[107]). Adopting platform access standards may reduce the transaction costs associated with delivering platform-mediated MaaS services. The platforms enable easy and open integration of mobility services within the MaaS ecosystem.

Annex 2.A. Inter-governmental collaboration, common standards and taxonomies for greater interoperability – The case of the city of Aizuwakamatsu

In Japan, in the Fukushima prefecture, the city of Aizuwakamatsu had a population of 116 171 inhabitants in 2021. Like the rest of the country, Aizuwakamatsu is experiencing a population decline of 6.3% between 2011 and 2021 (i.e. more than 1 000 per year); the birth rate has declined by 23% in the last decade. In particular, the working-age population (aged between 18 and 64 years) shrank 13.7% in the same period. However, the proportion of elderly residents (31% of the population) exceeds the national average (28.8%) and the amount of people requiring long-term care is close to 40% of the local population (Muroi, 2021[129]). The city is home to an important agglomeration of ICT-related industries represented by Smart City AiCT at the University of Aizu, the largest university in the country dedicated to advanced ICT software and hardware training and research, and to a semiconductor factory. After the 2011 earthquake, which affected large areas of the country, and the Fukushima nuclear plant disaster, the local government has been promoting a number of smart city initiatives to underpin recovery and tackle the main sociodemographic issues that affect the city.

To manage the situation, the city government has been promoting a number of smart city initiatives through the Smart City Aizuwakamatsu strategy and vision. The objective of the smart city strategy is to use ICT in fields such as healthcare, welfare, education, disaster prevention, energy, transport, agriculture, government, infrastructure and environmental protection. To design and implement the different smart city initiatives, the local government promotes the active participation of citizens to understand their needs better. It collaborates with private enterprises such as Accenture in the creation of different ICT-related projects for service delivery. The local government facilitates piloting private companies' smart projects in the city, which will be upscaled to the rest of the country. There is a strong collaboration with the University of Aizu, which provides advice and technical co-operation, and takes the lead in the training and upskilling of the private and public workforce on ICT. In the local government, the city also is deploying staff with ICT skills to implement different smart city initiatives across the administrative departments.

Therefore, data collection and management are essential elements of the smart city strategy. Data are essential to design personalised services based on data provided by residents. The city introduced a management operating system with an information platform, Aizuwakamatsu Plus, with the support of Accenture. The platform provides tailored information on more than ten digital services such as transportation, medical care, childcare and tourism. Opt-in is the fundamental approach to the city smart city initiatives, allowing residents to choose if they want to provide personal information in exchange for digital services. Around 20% of the population have opted in to the platform.

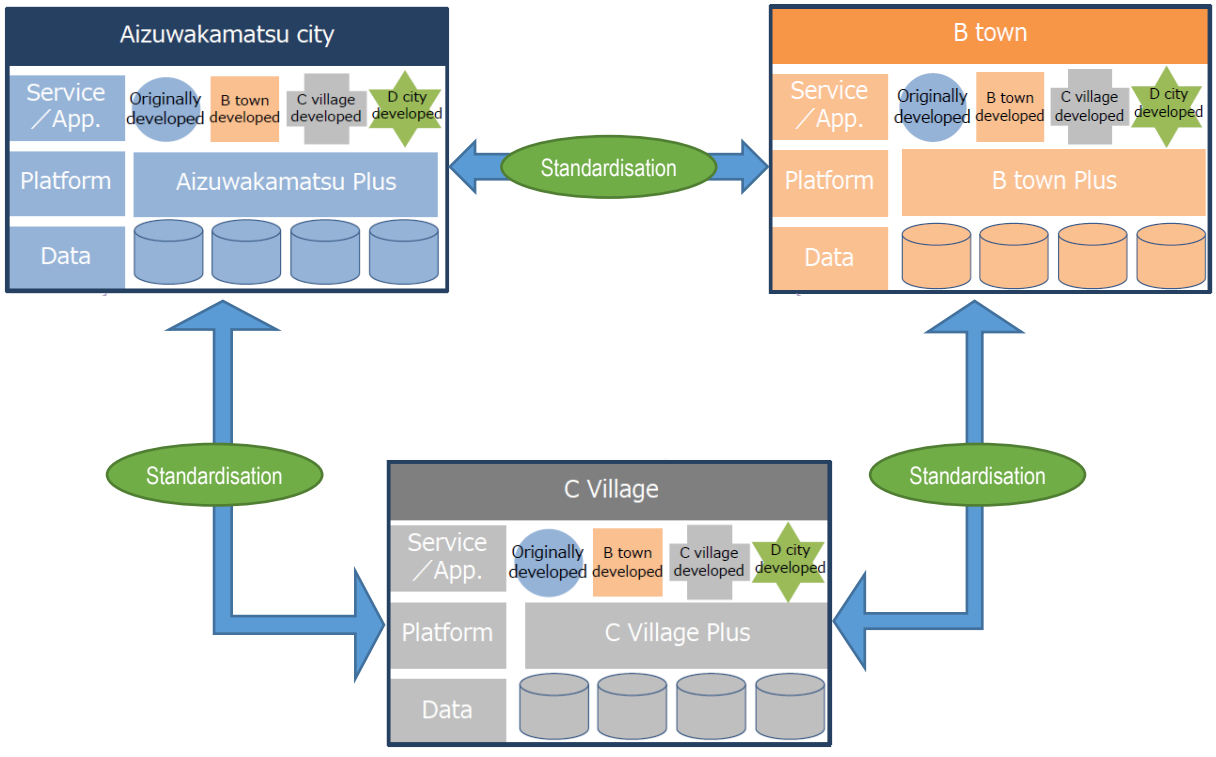
The digital platform Aizuwakamatsu Plus is the city operating system (OS). It functions as an open data platform and links datasets to the city. It is fed by IoT sensor data, open data, data provided by citizens who have opted in and data held by private companies. The role of Aizuwakamatsu Plus as the city OS is fourfold:

- **Functions as a one-stop service to citizens**. Citizens can use their regional ID to access and manage digital services in a wide variety of fields. The portal consolidates city services in a single, streamlined interface for citizens to use.

- **Connects services and functions**. It supports service providers in the development of efficient services and creates a more user-friendly experience by providing the authentication, ID management function and the “opt-in” management function that all services use in common.
- **Co-ordinates data and asset management**. By developing a standardised API based on the Smart City Reference Architecture established by the Cabinet Office, data and asset management functions can be provided to allow for flexible and diverse data co-ordination.
- **Facilitates co-operation with other cities (and their OS)**. Citizen data can be linked with other cities’ OS on an “opt-in” basis, allowing for the horizontal development of various new services intended for city OS systems (Annex Figure 2.A.1). This method allows interoperability and more efficient service delivery across different cities and regions.

Collaboration must be based on common data standards, taxonomies and platforms for data sharing that are able to communicate with each other. Annex Figure 2.A.1 shows that with an open and standardised architecture, different cities, towns and villages can share data and develop new services without depending on a specific vendor. Moreover, services developed in other settings (i.e. cities or villages) can be used quickly and at a lower cost. The experience of the city of Aizuwakamatsu shows that deploying the city OS horizontally contributes to a stronger regional community and that the more local governments work together on sharing a common platform for data management, the more sustainable it will be.

Annex Figure 2.A.1. Inter-municipal co-operation for interoperability – The case of the city of Aizuwakamatsu



Source: Based on Muroi, S. (2021[129]), “Initiatives and vision for Smart City Aizuwakamatsu”, Information provided to the OECD by the government of Aizuwakamatsu City, Aizuwakamatsu.

Different services have been linked to Aizuwakamatsu Plus. For example, in the tourism industry, the city operates Visit Aizu, an inbound tourism website that reflects preferences according to the nationality of the visitors and displays tourism content that varies depending on the selected language and the time of the visit, rather than simply making a multilingual tourist site. In addition, if the users select their nationality/city, planned date of visit and individual interests, the site presents a recommended plan according to these data. Another example is the Line Chat application, a service that uses the smartphone application LINE to answer citizens' questions 24 hours a day, every day of the year. The services have been upgraded to include services such as finding doctors open on holidays, garbage disposal, snowplough location information and inquiries related to COVID-19, among others. In healthcare, through the Aizu Healthcare Demonstration Service, residents can access a number of services such as visualisation of medical check-up results, lifestyle disease risk analysis and visualisation of conducted physical activity according to wearable devices. These healthcare services have led to an improvement of 95% in health awareness and 89% of improvement in the adoption of healthy habits (Aizuwakamatsu City, n.d.[130]).

Annex 2.B. Interoperability for greater digital inclusion – The case of JR East Suica card

In Japan, railways have become integral to people's daily lives (mass commuter transportation, real daily contact points). The East Japan Railway Company (JR East) is one of the six main railway companies that provides passenger rail services in the country. It focuses on the eastern part of the country, which includes the Tokyo Metropolitan Area. The company was created in 1987 through the privatisation of Japan National Railways. JR East has three business domains. The first is transportation services that include a 7 401 km passenger line network and1 676 stations that provide services to 12 million passengers daily. In fiscal year (FY) 2021, the company reported revenues of JPY 954.3 billion (approximately USD 7 billion) (JR East, 2021[131]). The second domain is what the company calls "lifestyle services" as it operates 193 shopping centres and 9 190 hotel guest rooms. Finally, the IT and Suica Services refers to a digital network centred on the Suica card. Through these domains, JR East aims to provide seamless services for information, purchases and payments in people's mobility and daily lives through business development centred on railways.

Since customer satisfaction with having different train cards for different train operators was low, in 2001, JR East issued a prepaid e-money card for travelling and shopping, the Super Urban Intelligent Card (Suica). Though not an e-money card when launched, JR East was the first company in Japan to introduce the service.

The Suica card uses the pay-as-you-go method: travellers need to recharge the card, which gets debited every time it is used. There are four types of Suica cards: physical, digital (on mobile phones), employee and student ID, and credit, which is another functionality of Suica. The card can be used on JR East lines in the Tokyo Metropolitan Area as well as for subways, buses and the Tokyo Monorail that connects Haneda Airport with Tokyo. In addition to the Tokyo area, the Suica card can be used for certain transportation systems in the Hokkaido, Kyushu, Sendai and Niigata, Tokai and West Japan areas. Other uses include a key function for shared bicycles and cars.

JR East has other business activities besides rail passenger transport, such as hotel accommodation, retail and restaurants where the card can be used. The Suica card can also be used for paying in businesses affiliated with the card, as it has been linked to merchandise sales at stations, restaurants and hotels. Thus, the card can be used for purchases on board trains as well as from vending machines, to rent coin lockers and for spending at convenience stores and restaurants. JR East has agreements with Apple Pay and Google Pay to enable the card to be used for the services they provide.

The company wants to expand the Suica card nationwide. The aim is to make the card a replacement for train tickets. There are associations with other train companies throughout the country so that the card can be used in different areas. Suica is normally used for short-distance trains but, since 2018, the card can be used on high-speed train services. Nowadays, ten different transportation companies across the company accept the Suica card, facilitated by the use of JR East technology for their own cards. The ten transportation integrated circuit (IC) cards (including Suica) are not linked in terms of data but rather in terms of standardisation (so that they can be used mutually) and the data are owned by each rail company. In 2021, JR East was reported to have issued 86.63 million Suica cards, with 250 million monthly transactions for public transportation electronic money. The card is accepted in 1.15 million stores.[41]

JR East uses the big data collected both through the Suica card and the payment platform e-Money to generate a station chart or report providing information station by station and even sells the data to third parties. Before the introduction of the Suica card, there was no possibility of getting detailed information about who boarded from which station and alighted at which station: JR East only had information on the trains. The use of the Suica card has allowed the company to produce big data that can be utilised and traded. The data collected through the card help to improve passenger convenience as it allows them to be cashless and ticketless at the stations. It also helps the company reduce costs as the equipment and hardware are cheaper and security is improved. JR East's main businesses are train passenger transport and retail businesses (i.e. hotels, restaurants) and the introduction of the Suica card has opened up a new business activity through the marketing of data.

Indeed, JR East collects two types of data. Data related to railway operations include operation information data, train congestion data (i.e. stress-weighted data), ticket gate open data, image data (i.e. inside stations and trains) and maintenance data (e.g. electricity, rails, station buildings, escalators, elevators, air conditioning, etc.). These data are used to provide timely information to passengers (e.g. train delays and cancellations), for operation management (e.g. to improve operation schedules and air conditioning) and for improving the design of facilities in stations and trains. The use of the Suica card allows JR East to collect information such as the profile of passengers (i.e. age bracket, gender, origin and destination, and the length of their visit to a station). These data are for JR East use but can also be considered marketing data from the perspective of understanding people's movement. JR East receives requests from real estate companies and businesses located in the neighbourhood of the station for this kind of data. In fact, JR East started to provide data services in May 2022. Local governments have also begun to approach JR East, inquiring about statistics regarding the origin and destination of travellers, in view of using that data in their sales and marketing activities such as tourism.

Private data are protected as information such as names and addresses are not used for analysis. However, some of the cards are for students and office workers and that characteristic provides JR East with a clearer profile of the customers. The other type of data refers to customer usage, which includes Suica settlement data,VIEW credit card data (i.e. customer data, settlement data), ticket sales data and point of sales data. This type of data is used to guide users and improve services, as well as management data for a variety of measures.

Nowadays, other train operators accept Suica cards. Every train operator has its own card. The cars are not linked by data but by standards, making interoperability possible while protecting data privacy and ownership. When data are aggregated, the rail companies carry out the aggregation use the same specifications for each company's data. The JR East card system is very different from that used in other regions, even if the Suica card can be used there. To allow this aggregation, instead of asking other companies to use the JR East system, the company provides the specification so that the card can be used in other systems. It is a combination of two or three different systems. JR East and other train companies focus more on unifying data standards rather than linking their datasets. Therefore, it is possible to see the use of different cards in different systems. A similar situation can be observed in cities, as interoperability is ensured by having the same standards as linked data.

The card system of the JR East Suica card has also been used in some smart city initiatives. JR East and the city of Maebashi in the Gunma prefecture have linked My Number Card (the social security card in Japan) to Suica. This entails that some information stored in the My Number Card is identified by Suica's IC chip and retained. This facilitates the provision of some services, such as applying discounts on buses to residents of the city of Maebashi. This experience suggests that, in the future, it will be possible to mix administrative information with transport data for better service provision and even use Suica cards to access health services.

In 2014, JR East launched an application to provide information about routes and trains, and eventually expanded it to provide other services. The application has a real-time route function that gives the best route from Stations A to B by combining direct train information. The application includes information on train delays. JR East has been working with different transport providers, such as other train, bus and subway companies, to provide more real-time information regarding all transport providers. The application includes train congestion information and, thanks to the installation of cameras in each train coach, passenger numbers and crowding statistics. This information is provided to application users as there was a demand for this kind of information during the COVID-19 pandemic.

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3 Smart city data governance – The way forward

Data governance in smart cities should foster the quality of data to enhance evidence-based decision-making processes at all levels of government. It should prevent undesired impacts of managing sensitive (personal or business) data. Based on international experience, this chapter provides a series of practical recommendations to improve data governance practices to enhance trust in and improve the functioning of smart city projects. It concludes with a proposal for future areas of research to advance the development of smart cities.

Strengthening smart city data governance – Avenues for action

Cities worldwide are undergoing major transformations in response to megatrends such as digitalisation, demographic ageing, climate change, the aftermath of the COVID-19 pandemic and the global energy crisis triggered by Russia's war of aggression against Ukraine. In this context, cities are seeking ways to advance more productive, inclusive and sustainable development and upgrade residents' well-being. Digital technologies and opportunities to leverage data are providing countries and cities with new ways to provide public services and improve everyday life. Countries and cities are investing in their capacity to collect, analyse and use massive and growing amounts of data to automate processes, improve service delivery and make smarter decisions. However, rules and regulations regarding the collection of, access to and control over data need to be clearly defined to ensure the effective use of data in policy making and preserve trust in government.

The preceding chapters of this report have provided an overview of international experiences on how data could contribute to the development of effective smart cities. Countries and cities have deployed various smart city and data governance frameworks, which indicate growing awareness of the importance of data. At the same time, the variety of frameworks also points to the need for a coherent set of guidelines or principles to guide data management and use and to help overcome obstacles to effective smart city initiatives. Such obstacles include:

- Difficulties in scaling up smart city initiatives, which often remain at a pilot stage without generating substantial spillover effects.
- Lack of reliable and long-term financing for smart city projects.
- A complex and sometimes fragmented regulatory framework.
- Unclear definition and co-ordination of roles among different stakeholders (i.e. government, academia, private sector, civil society) for the design, implementation and monitoring of smart city projects and data management.
- Insufficient capacity at the local level to use and manage data for implementing smart city projects.
- Fragmentation and incompleteness of data due to the lack of incentives and co-operation mechanisms for interoperability, and inconsistent formatting of datasets in public and private sectors, incurring a cost of data collection and maintenance.
- Security risks related to data and lack of trust in governments' capacity to preserve people's privacy and ensure data security.
- Lack of international standards for the consistent use and management of data stemming from the use of digital technologies.

To overcome those challenges, there have been several attempts to provide countries and cities with a series of principles, ethical codes and data governance guidelines. For example, the Basque Declaration that promotes productive, sustainable and resilient cities in Europe has formulated a series of normative guiding ideas to that end (Basque Country/ICLEI/Ayuntamiento de Bilbao, 2016[1]). Other proposals include: the six principles of data governance for sustainable smart cities (Franke and Gailhofer, 2021[2]); the overarching design principles for data governance frameworks (Johnson et al., 2022[3]); the principles of the Amsterdam Data Manifesto (Tada, n.d.[4]); the Bilbao Data Manifesto (Ayuntamiento de Bilbao, 2022[5]); the manifesto in favour of technological sovereignty digital rights for cities (Bria and Bain, n.d.[6]); the principles to follow designing the city's data strategy (UN-Habitat, n.d.[7]); and the principles in the declaration of the Cities Coalition for Digital Rights (n.d.[8]). All these principles tend to be normative and seek to enhance citizens' digital rights while promoting the role of cities as testbeds for innovative policies and projects on digitalisation. They all aim to enhance the value of the data that cities generate and to guarantee data privacy as well as the responsible use of data. Such normative principles can help identify, structure and operationalise different and sometimes competing goals. Their objective is to support and

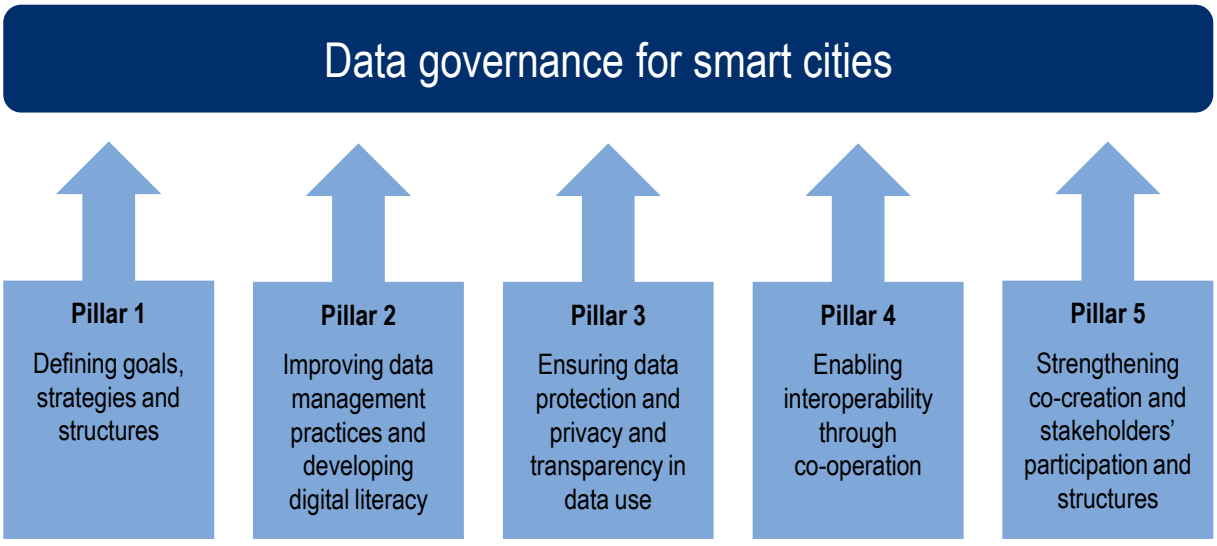
guide decision makers in the design and implementation of a data governance strategy for smart cities (Franke and Gailhofer, 2021[2]). Normative principles provide a public and open data infrastructure that facilitates the development of innovative data-driven applications to improve access to public services and quality of life while guaranteeing citizens' data ownership. However, their implementation depends on the specific context of cities and countries.

Building on existing guidelines and a comparative analysis of international experiences, this report proposes a set of practical recommendations to enhance smart city strategies and govern the management and use of data that smart cities generate. The experience of OECD member and partner countries presented in previous chapters underpins the following set of policy directions, which intend to offer practical guidance in the organisation of smart city data governance arrangements. The policy directions are organised around five pillars: i) defining goals, strategies and structures; ii) improving data management practices and developing digital literacy; iii) ensuring data protection and privacy and transparency in data use; iv) enabling interoperability through co-operation; and v) strengthening co-creation and stakeholders' participation (Figure 3.1). Their purpose is to:

- Support local governments in the design and implementation of smart city and data strategies.
- Remove barriers to data flows within and across cities.
- Foster co-operation among local governments and across levels of government for data management and use.
- Promote partnerships with different stakeholders in data management.
- Provide recommendations on how to organise governments to implement smart city and data strategies.

The five pillars are grounded in the acknowledgement that digitalisation, the adoption of smart city strategies and the use of data are not an end per se. They should rather be part of an overarching urban policy aimed at transforming cities into productive, sustainable, inclusive and resilient places. Therefore, governments should first consider the extent to which their digitalisation and data policies are embedded in their national urban policies and local urban development strategies and plans. The five pillars proposed here should then be considered as a complement to these urban policies.

Figure 3.1. Proposed pillars of smart city data governance



Pillar 1. Defining goals, strategies and structures

Strengthening smart city data governance requires a clear vision of what cities will look like in the future and the role data will play. Strategic thinking and preparatory work must be conducted before designing a data platform and acquiring and deploying (digital) technologies. Countries and cities should define strategic priorities from the outset and establish how data use can help to address challenges in achieving such priorities (e.g. sustainable mobility, efficient public administration, environmental protection.).

What national governments could do:

- Develop a national holistic vision and policy framework to guide the development of smart cities at the local level to avoid fragmented approaches and how data may be governed as a shared resource among different stakeholders for the common good, while balancing individual privacy interests and democratic claims to open data and the public domain.
- Foster alignment at the local level with the work on data at the national level (e.g. alignment with a national data strategy or sector-specific strategies).
- Ensure compliance at the local level with national regulations or requirements related to data, as applicable, including privacy protection.
- Link the national smart city framework to the national urban policy framework to support the development of sustainable cities by assessing the impact of digitalisation on cities and mainstreaming digitalisation into the national urban policy.
- Ensure that the national smart city framework clarifies the roles and responsibilities of different actors in data collection, storage and sharing of data.
- Designate a central body or set up a co-ordination mechanism that organises the implementation of the national smart city framework and fosters stakeholder engagement.
- Encourage a national dialogue on the role in data governance of the national statistics office and what it has to offer national and subnational governments, the private sector and citizens on data management and protection.

What local governments could do:

- Develop a smart city strategy tailored to the specific needs of the city and its residents in line with the national smart city framework and identify strategic goals (e.g. improve mobility, reduce emissions, increase administrative efficiency, etc.) as well as the data that would be required to achieve those goals. Consider investing in a broader citywide digital ecosystem rather than a standalone intervention, as it provides little opportunity for synergies among stakeholders.
- Develop a data strategy tailored to the needs of the city that ensures a purposeful use of data for integrated and sustainable urban development.
- Link the smart city strategy to the urban development strategy of the city (or metropolitan area) by mainstreaming how digital technologies and data contribute to urban development.
- Advance smart city pilot projects that focus on reducing inequalities and help bridge the digital divide within cities.
- Assess upfront the scalability of smart city projects to ensure that the entire city or region can benefit from digital solutions and data use in the future.
- Include measures to enable small and medium-sized enterprises (SMEs) access to data and enhance capacity for data management as part of smart city initiatives.
- Clarify the distribution of responsibilities for smart city and data management within the local administration and establish inter-disciplinary working groups or consider appointing a city chief data officer or steward to guide the implementation of the strategy.

Pillar 2. Improving data management practices and developing the digital literacy of local public servants and citizens

A smart city framework requires a clear governance structure to manage data across the public, private and third sectors (e.g. voluntary organisations, community groups, residents' associations, social enterprises, etc). The governance structure and data strategy should leverage existing strengths to improve the use of data and define priorities and potential threats. Cities should adopt data management practices that ensure data are fit for purpose, have been collected in standardised formats and are managed in secure systems. Data management practices should strive to improve the quality of data so that they can be used more effectively and drive better insights and outcomes from their use. This also implies that cities need to develop the right data skills through education and training programmes and ensure that residents can continue to develop the data skills they need throughout their lives.

What national governments could do:

- Assess existing strengths, weaknesses and areas of opportunity to boost better use and sharing of data across levels of government, as part of their work on developing the smart city framework.
- Promote open data at the local level as part of a smart city data policy framework and connect these efforts with open data initiatives at the national level.
- Promote the use of national data standards to improve the quality of data and facilitate interoperability in line with international practices.
- Provide support to local governments to reinforce their digital skills and capacity for data management, including the ability to manage networks and large volumes of data as well as information technology (IT) security.
- Promote the adoption by local government of data governance tools developed at the central level to promote scalability and data integration.
- Support local governments in the implementation of data protection regulations.

What local governments could do:

- Develop a data strategy to ensure the city has access to the necessary data for decision making, define the key elements of the data governance infrastructure that will govern who, how and under what conditions data can be accessed and exchanged, and assess on a regular basis the role of the city as data producer, supplier and user.
- Develop a methodology for data collection under an outcome-driven approach by defining the scope and purpose of the data needed and the role data have in achieving the city's development goals.
- Provide evidence to citizens on why their data matters and regularly report on the progress of the implementation of smart city projects and the impact data have had through publicly available reports.
- Conduct a systematic review of smart city and data projects with the participation of other stakeholders, particularly on pilot smart city projects.
- Ensure that recruitment of data-savvy staff is part of the city's recruitment and training strategies and that developing sound data literacy is linked to urban development.
- Develop agreements with academic institutions, the private sector and upper levels of government to ensure sufficient legal, financial and human resources for systematic knowledge building, organised exchange of experiences and training within city administrations for the upskilling of the local public workforce, in particular their digital and communication skills, and the ability to manage networks and large volumes of data as well as IT security.

Pillar 3. Prioritising data protection and privacy and placing transparency in data use, storage and sharing at the top of the agenda

Setting codes of conduct on how public officials and other stakeholders should use data is of paramount importance to protect against threats to data safety, avoid risks of mismanagement and preserve accountability and trust. Clear rules and responsibilities for ensuring data protection are therefore a core element of data governance.

What national governments could do:

- Emphasise the importance of data protection in the national smart city framework.
- Promote consistent data privacy policies across subnational governments as well as cybersecurity workforce development to harmonise practices across levels of government.
- Define and communicate any data-sharing obligations of subnational governments (e.g. for open data).
- Develop a cybersecurity strategy and action plan accompanied by measures to address the cybersecurity workforce shortages in co-ordination with the private sector and education institutions.

What local governments could do:

- When designing smart city and data management strategies, consider the ethical implications to guide behaviours across the local public sector, mitigate risks and retain public trust in the use of data both in geospatial contexts and more generally.
- Ensure the adoption of an ethical code of conduct or principles for data management to promote a value-based approach to data and the use of privacy-by-design solutions.
- Check the integrity and adequacy of data they use for decision-making to promote data accountability and build trust.
- Request consent for data collection, storage and use and provide opt-out mechanisms.
- Adopt a multi-domain approach to address data privacy and security concerns, ensuring that the problem is tackled from multiple policy angles with the support of different stakeholders.
- Adopt a security-by-design approach when designing smart city projects and conduct an analysis of cybersecurity capabilities to detect skills shortages. This should include the removal of personal information through measures such as: de-identification; defining in-transit data protection requirements (e.g. encryption standards); and using a certificate management service that includes revocation processes to invalidate certificates when security is compromised.
- Openly communicate to citizens what kind of data is being collected and for what purpose.
- Ensure the installation of a core team overseeing the security aspects of smart city technologies with specialist skills and responsibilities beyond the day-to-day IT administration.
- Ensure that any collection, processing and publication of data by public and private agents follow data protection rules, minimising the processing and use of personal information, adopting audit mechanisms to monitor adherence to purpose specification in processing and retaining data to avoid data misuse.

Pillar 4. Enabling interoperability through co-operation, data standards and the creation of infrastructures

A critical element of smart city data governance is to ensure that data can be used and shared across cities and other stakeholders in different sectors to ensure consistency and facilitate the repetition of processes or reach a shared understanding. Governments should strive to integrate and join up data from

multiple sources and across systems to use data to the fullest extent possible in enhancing well-being. Data can be shared more easily if tools and processes are developed in line with a standard for data exchange and a standard for semantics and/or a working method. Interoperability is not just about data exchange but also data management and is a characteristic of good data quality as it facilitates value and knowledge creation, as well as collaboration. Open data, which is essential for smart city projects, requires data to be interoperable from a technical, legal and institutional perspective. Although interoperability is a feature of good quality data, it may be a challenge for governments as it involves a technological layer, data and format layers, a human layer and institutional and organisational layers. Legacy frameworks could hamper digital transition as governments may end up using outdated tools and data frameworks not fit for purpose. National governments should therefore take the lead in developing standards for data management that facilitate interoperability and data flows.

What national governments could do:

- Develop policies, guidelines and standards for smart cities that are conducive to interoperability and data sharing as part of any existing national interoperability framework. They should be conducive to help in the development of projects and plans to better understand interoperability needs at the technological (i.e. standardised interfaces), data and format (i.e. data structure based on models and codified according to standards classifications and semantics), human (i.e. a common understanding of data regarding meaning among producers and users of data) and organisational (i.e. allocation of responsibility for data collection, processing, analysis and sharing within and across organisations) layers.
- Support and promote the development or use of open interfaces and standards to enable inter- and intra-municipal co-operation and data standardisation.
- Support small and medium-sized cities in building shared capacity for data management.

What local governments could do:

- Ensure that all new IT infrastructure investments in the city are based on the needs of residents and visitors, drawing on a wide variety of data to provide value to different stakeholders.
- Issue clear rules for interfaces and responsibilities to facilitate interconnectedness of infrastructures, data and services.
- Conduct agreements with different stakeholders to ensure that data generated from and collected about the city and held in common remain open data and can be used by every vetted actor.
- Introduce a system of data quality assessment that guarantees data accountability for data management by ensuring data accuracy, completeness, uniqueness, consistency, timeliness and validity.
- Develop data-sharing rules of informational data, operational data and transactions among stakeholders to enable smart city services (e.g. healthcare, transport) to function.
- Develop data reporting rules from smart city service providers to local authorities to monitor and control market functions. This involves data for planning purposes, data on operations and enforcement actions.
- Ensure the adoption of shared, open cross-government standards, formats and protocols across cities to make service delivery more effective and efficient.
- Enable the use of common data access methods, semantics and syntaxes to reduce regulatory compliance burden when reporting data to public authorities.
- Promote the co-ownership of data management platforms by public and private stakeholders to increase capacity and reduce investment costs.

- Ensure, with the participation of the private sector, that the new technologies and applications used are reversible and backward compatible (i.e. an operating system or technology that allows interoperability with an older legacy technology or system) and equipped with open interfaces and standards to ensure long-term functionality of networked infrastructures.

Pillar 5. Strengthening co-creation and the participation of a wide number of stakeholders

The governance of smart city data is more than just focusing on how data are collected, used, stored and shared. For example, it should also address how the rules that govern data are made, who takes part and under which processes. The success of data management largely depends on the participation of a wide number of stakeholders. One actor alone cannot guarantee the success of a smart city project as it will need inputs from different sectors and access to a wide variety of data. Building partnerships is the most effective way to develop a governance structure that favours co-creation and collaboration in an orderly fashion.

What national governments could do:

- Promote partnerships between cities and the private sector to co-ordinate activities and investments for smart city projects by building local support for smart city projects, highlighting their social benefits and the private and non-private sectors' social responsibility and developing a business case that shows the value of the project to stakeholders in the private sector.
- Develop support programmes and incentives for SMEs to be part of the public-private partnerships for smart cities, such as providing national financing support for the smart city projects and highlighting the public recognition and improved perception SMEs may get through their participation in the partnership.
- Promote fora for the exchange of experiences among local governments to build competency and improve ways to transfer knowledge from one setting to another.
- Ensure smart city data governance includes meaningful participatory decision-making processes, involving the groups the data pertain to or those affected by datafication efforts. This requires engaging urban communities in data governance to reflect on issues of what data get collected and through which standards, and how conflicting rights and interests might be negotiated and resolved.

What local governments could do:

- Adopt a citizen-oriented approach in the development of a smart city and data management strategy by placing citizens' needs at the centre of the initiative and engaging local policy makers and citizens in evidence-based, decision-making processes aimed at improving well-being, increasing citizens' satisfaction and reducing costs in service delivery.
- Develop partnerships with the private sector (i.e. large enterprises and local SMEs) and other relevant stakeholders (e.g. non-governmental organisations, academia and civil society) for smart city development and data management, conducting data science studies on relevant topics (e.g. energy efficiency, social policies, public administration) to optimise local government's public policies and help the city administration gain a new understanding of data science techniques and methods.
- Look for innovative ways to increase civic participation in smart cities and data management but avoid forcing the use of digital technologies and also offer analogue ways of communication to avoid excluding groups of the population who might not be digitally savvy.
- Seek dialogue with business and academic sectors to look for options to ensure the knowledge and added value created in the city benefit all residents.

- Make available all data produced by the administration and the residents using urban services to all stakeholders, especially innovators and researchers, following the rules set in the legislation on data protection, analysing the possible consequences of sharing certain datasets and examining the steps to take in case of a data breach.
- Implement regular consultation meetings (in person or on line) with end users so they can share their priorities about their data needs.

The way forward on smart city research

To contribute to the improvement of smart city data governance and based on the findings of the previous chapters, future areas of research to advance the development of smart cities could include, for example:

- **Smart cities and the net zero future**. Digitalisation has opened up a range of possibilities to optimise urban planning and improve services while creating new revenue streams, jobs and business ventures. Urban agglomerations are incubators for cutting-edge technologies and their density and size offer economies of scale that can cut the cost of infrastructure and innovation. For example, digital technologies are a key instrument towards a more efficient use of roads and vehicle capacity by monitoring traffic conditions; if traffic flows are smoothed and infrastructure capacity is improved, then the environmental burden linked to congestion and kilometres travelled could be reduced (ITF, 2020[9]). Moreover, the use of digital technologies as part of urban and mobility planning could help reduce environmental impacts by limiting displacements. Smart mobility-induced shifts to lower emission technologies like electric vehicles and well-planned and -used public transport could further reduce emissions. By 2024, the International Energy Agency expects that 83 billion connected devices and sensors will create large, diverse datasets on a wide range of topics, such as energy consumption, air quality and traffic patterns. Next-generation energy systems can leverage the data from these connected buildings, appliances and transportation systems to reduce energy consumption, improve grid stability and better manage city services (IEA, 2021[10]). This mix of factors puts cities at the leading edge to come up with creative solutions to climate and energy challenges, and enhances cities' role in accelerating progress towards clean, low-carbon, resilient and inclusive energy systems. Several cities around the world have already introduced digital technologies over the last decade to make city management more efficient, effective and sustainable, but there is little evidence of the results achieved and the lessons learnt. Therefore, further research could help: i) assess to what extent digital technologies have actually contributed to change behaviours that lead to a reduction in emissions in cities; and ii) assess what policy or strategy changes are needed to ensure smart city strategies are conducive to emissions reduction.
- **Smart cities in the face of heatwaves**. Climate change, global warming, the greenhouse effect and the loss of natural reserves constitute threats to cities' sustainability. Climate change is affecting people's well-being (OECD, 2021[11]) as it produces more regular and longer heatwaves impacting people's health and requiring households to use more resources to cool down their houses. Although emissions have declined in 175 out of 432 large regions across OECD countries between 1990 and 2018, and metropolitan regions register lower emissions per capita than remote regions (OECD, 2022[12]), cities are getting warmer. Persistent heatwaves affected Western Europe during the summer of 2022. Cities in Portugal and Spain reached temperatures of up to 47°C[1] and the United Kingdom exceeded 40°C for the first time in history.[2] In Asia, Japan registered an unprecedented heatwave with temperatures over 40°C for several consecutive days during the summer of 2022, leading more than 5 000 people, mostly senior citizens, to seek hospital treatment due to heat stroke.[3] In the Americas, Canada and the United States have also recorded extreme temperatures over the summer season.[4] By the mid-21st century, nearly two-thirds of the American population is forecasted to experience perilous heatwaves and the southern regions are expected

to experience more than 70 consecutive days of more than 40˚C.[5] City infrastructure, such as roads and buildings, absorbs heat and then releases it back into the city, meaning that urban areas register higher temperatures than rural ones. Therefore, the central research question would be how the use of digital technologies through smart city programmes can prepare cities to deal with the effects and impacts of more frequent and longer heatwaves. Some cities are increasing green spaces and expanding cool roof programmes but the range of strategies to deal with heatwaves is vast. Further research could provide targeted policy guidance, based on a collection of international experience, on how to leverage innovative technologies to address heatwaves and improve both safety and quality of life in cities.

- **Leveraging digital technologies and data at the city level to improve public safety and security**. One of the main goals of national and local governments is to deliver safe, secure and sustainable cities. Building a "safe city" requires not only an infrastructure with sensors connected by a shared network but multi-agency collaboration to share intelligence, operational procedures and planning. Digital technologies are a key element to this end as they can produce real-time information, with traffic data, sensor positions, resource locations, weather and other intelligence to allow behavioural analysis. The use of Internet of Things (IoT) devices and connectivity services, and safe city solutions enable governments and police departments to protect their citizens from many threats ranging from terrorist attacks to natural disasters. Digital technologies support the work of other city services such as public health, fire and rescue, border control and social services. In the event of a suspicious event, alerts are sent to the appropriate personnel and sophisticated facial recognition technology helps alert teams, when a known shoplifter has entered a store or area for example. However, the use of this technology may give room for mistrust as people may feel under constant surveillance. Digital technologies could also create threats to people's safety due to cyberattacks (Dodge and Kitchin, 2017[13]; OAS, 2022[14]). Hence, further research in this area could help analyse how smart city strategies are contributing to making cities safer and more secure and how local authorities are building trust in the use of digital technologies for safety and security reasons among residents without violating citizens' liberties through surveillance.
- **Enhancing the digital and data management skills of cities**. Having access to a highly skilled workforce is a key component in the development of an efficient and effective government. The design and implementation of smart city projects and their success are largely conditioned on the skills available in the local public workforce. In particular, small and medium-sized cities face barriers to attracting and retaining specialised staff in areas such as data analytics, smart city management, data technology development, etc. The development of smart cities and their digital transformation tends to focus on developing technical solutions rather than the corresponding human resources. In some cases, cities have reached agreements with research centres and universities to train and retrain their workforce in the latest digital developments, but this is not the only long-term solution. Research in this area would focus on strategies to close the gap between current and future skills demands of the local public workforce in the smart city sector. Further research could focus on the development of digital and transferable competencies of smart cities' professionals and how to help them increase their creativity and efficiency. It would also look into the job profiles necessary for the operation and development of smart cities, in particular smart city managers, IT managers and IT officers.
- **The role of SMEs in the development of smart cities**. While large companies often drive the development of smart cities, there is less research about how SMEs are contributing to the development of smart cities. SMEs could benefit from accessing the data produced in smart cities but it is less clear to what extent they could contribute further to the production of those data. SMEs need support to harness the vast availability of advanced technologies to their advantage and this is of the utmost importance in the context of the COVID-19 pandemic that reinforced the need to transition to a digital world. Further research in this area would therefore focus on how SMEs can invest in leveraging digital technologies and being more competitive. This research would explore

how governments can help SMEs reskill their workforce, particularly on data management in smart cities, and improve access to financing in order to partner smart city projects.

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Notes

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Smart City Data Governance

CHALLENGES AND THE WAY FORWARD

Smart cities leverage technologies, in particular digital, to generate a vast amount of real-time data to inform policy- and decision-making for an efficient and effective public service delivery. Their success largely depends on the availability and effective use of data. However, the amount of data generated is growing more rapidly than governments' capacity to store and process them, and the growing number of stakeholders involved in data production, analysis and storage pushes cities data management capacity to the limit. Despite the wide range of local and national initiatives to enhance smart city data governance, urban data is still a challenge for national and city governments due to: insufficient financial resources; lack of business models for financing and refinancing of data collection; limited access to skilled experts; the lack of full compliance with the national legislation on data sharing and protection; and data and security risks. Facing these challenges is essential to managing and sharing data sensibly if cities are to boost citizens' well-being and promote sustainable environments.

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