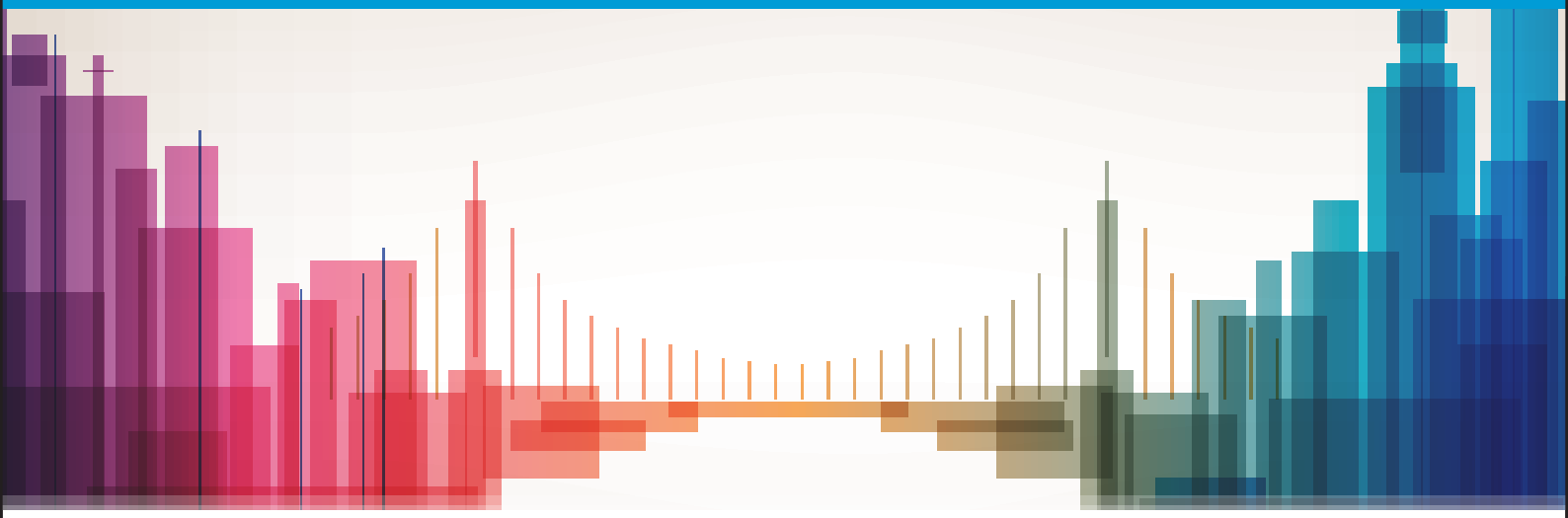
United 4 Smart Sustainable Cities

Simple ways to be smart



Convention on Biological Diversity

United Nations ECLAC

Food and Agriculture Organization of the United Nations

ITU

UNDP Empowered lives. Resilient nations.

United Nations Economic Commission for Africa

UNECE

UNESCO United Nations Educational, Scientific and Cultural Organization

UN environment programme

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United Nations Framework Convention on Climate Change

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United 4 Smart Sustainable Cities

Simple ways to be smart

Foreword

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Disclaimer

The opinions expressed in this publication are those of the authors and do not necessarily represent the views of their respective organizations or U4SSC members. In line with the U4SSC principles, this report does not promote the adoption and use of Smart City technology. It advocates for policies encouraging responsible use of ICTs that contribute to the economic, environmental and social sustainability as well as the advancement of the 2030 Agenda for Sustainable Development.

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Executive summary

The term "smart city" conjures up images of futuristic, high-tech large cities that are clean, efficient, and a delight to live in. This image is at odds with the experience of most city dwellers and for many cities, appears to be out of reach, or indeed a demanding proposition. A common perception is that smart cities are all larger cities that function smoothly, are well resourced and with deep skill bases, that can be drawn on to develop sophisticated, high-tech interventions. This perception excludes the majority of cities and human settlements which are not large or well-resourced and have operational challenges.

However, smart technologies and ideas have relevance for all cities and settlements as they enable better city management and operation and can improve quality of life. This report on "Simple ways to be smart" was conceived to identify smart interventions that do not require excessive material or capacity inputs, and yet can help cities and settlements to become more inclusive, safe, resilient, and sustainable.

Smart cities have also been criticised for serving the needs of the elite at the expense of the majority of city residents, thus increasing inequality in cities. However, if smart cities are developed based on needs, they can provide public services that are more efficient, effective and personalised. To ensure that cities are developed for the benefit of all, they need to put residents and local concerns at the centre and to reaffirm the role of local authorities as trusted agents and guardians of equality and social cohesion. This report collects examples of smart interventions that support the aforementioned goals, and produces a guide for cities that wish to embark on the journey to be "smarter".

ITU describes a smart and sustainable city (SSC) as an "innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects", a definition embraced by U4SSC, and this is the definition adopted for the purpose of this report. In adopting this definition, it is important to recognise that smart interventions need not be technology-based but should be premised on evidence. These interventions should also pay careful attention to the target population whose needs are being addressed.

This report defines criteria for what makes an intervention smart and simple. Being mindful of the need for sustainability interventions that would support one or more of the sustainable development goals, were sought. In particular, interventions that would not contribute to increasing inequality were pursued for the purpose of this report. Based on these criteria a call was issued for case studies and over 30 were identified. From these, 10 illustrative cases were selected to be elaborated on further. Key features of other cases are described in the text.

The smart and sustainable interventions selected are characterized by ease of implementation, low cost, and proven benefits. They are not intended to be a prescriptive checklist of smart interventions that cities ought to undertake. Rather they are intended to inspire cities with some possibilities of what can be achieved using smart technologies and ideas. The hope is that the selected interventions help a wide range of cities and settlements to be part of a strategic and holistic process of development towards the 2030 Sustainable Development Goals.

The cases identified fall into five categories that illustrate the range of benefits that can result from smart interventions. There are cases that (1) improve city administration, (2) have environmental benefits, (3) change the role of people in the city, (4) improve the experience of living in the city and (5) improve the resilience of the city. These five areas of city improvement are discussed in Chapter 3, however, they are not intended to be the only areas in which cities can get smarter. These areas highlighted aim to illustrate simple ways to be smart and to inspire cities into thinking about how their specific problems can be addressed in a smart manner.

The report includes a simple framework that encourages cities to evaluate city problems in terms of information and communication components, and the potential for improvement that comes from being smarter in these two areas. It also briefly delves into the key factors relevant for the implementation of smart initiatives. The target audience for this report is local government officers responsible for city planning and management. Other key smart city stakeholders are also expected to benefit from the core themes addressed in this report.

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List of abbreviations

API	Application programming interface
CO2	Carbon dioxide
CoJ	City of Johannesburg
EDRMS	Electronic document and record management system
EV	Electric vehicle
FAO	Food and Agriculture Organisation of the United Nations
GPS	Global positioning system
GSM	Global system for mobile communications
GTFS	General Transit Feed Specification
ICT	Information and Communication Technology
IoT	Internet of Things
ISO	International Organization for Standardization
ITU	International Telecommunication Union
LCS	Low-cost sensor
LEDs	Light-emitting diodes
NGO	Non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
PDF	Portable document format
QR	Quick response (code)
RAS	Recirculating aquaculture systems
RFP	Request for Proposal
RMTC	Rede Metropolitana de Transportes Coletivos (Goiania, Brazil)
SaaS	Software as a Service
SDGs	Sustainable Development Goals
SIDS	Small-island developing state
SIM	Subscriber identification module
SSC	Smart sustainable city
SWOT	Strengths, weaknesses, opportunities, threats
U4SSC	United for Smart Sustainable Cities
UN	United Nations
UNDRR	United Nations Office for Disaster Risk Reduction
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNU-EGOV	United Nations University Operating Unit on Policy-Driven Electronic Governance
WEF	World Economic Forum
WHO	World Health Organization

1 The focus on simple smart interventions

1.1 Smart cities

Over the past three decades, the idea of a "smart city" has been suggested as a means of dealing with the challenges of urban living and governance. As urban areas grow in number, population and complexity, old urban challenges such as providing services, maintaining order, supporting a thriving economy and ensuring a pleasant way of life become more complex and difficult to address. There are also new urban challenges such as environmental sustainability, shifting patterns of civic engagement, new health challenges and the need to ensure greater social and economic inclusivity. To meet these old and new challenges, cities need to transform more rapidly as incremental development is unlikely to be sufficient.

Smart cities have always advocated the use of technology, initially with a focus on incorporating new ICTs into city infrastructures, and more recently on the collection and analysis of city data.[1,2,3,4,5] A future is imagined in which widespread technology and software deployment will become key to managing cities. Technologies that collect and analyse data, as well as communicate between city actors and infrastructure, can automatically and rapidly respond to situations in the city. This vision of technological intelligence is central to projects such as the 'City Brain' deployed in Hangzhou and other Chinese cities that combine data from multiple sources to manage traffic flow and emergency responses in real-time.[6]

However, over the decades, the smart city discourse has also been concerned with economic growth and development, entrepreneurship, creativity and innovation, service delivery, improved quality of life, environmental sustainability, the city as an eco-system or "system of systems", and shifting approaches to city governance from top-down to consultative.[7,8,9,10] These themes feature in many of the definitions and programs that have been proposed for smart cities. They are reflected in the definition that has been adopted by the United Nations initiative known as United for Smart Sustainable Cities (U4SSC), which describes a smart sustainable city as "*an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operations and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects*".[11]

In the last decade, the role of people[12], as intelligent agents in the city, has come to the fore. The smart city conversation has shifted to emphasize that both the intelligence of smart technologies and the intelligence of people are needed to successfully address the challenges of twenty-first century cities. People in the city, in the form of city employees, entrepreneurs, innovators, service providers, workers, civic activists, residents and visitors configure the smart city through their actions and use of the city. They are both an important source of ideas, creativity, feedback, energy, skills and capabilities to bring the smart city into being and also the reason for the smart city to exist. So, the Smart City increasingly refers to the ability of smart people to devise interventions to solve urban problems and the mechanisms to facilitate that.[13]

1.2 Can every city be smart?

Many of the Smart Cities that are in the public eye are large cities that are economic hubs, or capital cities. Smart City rankings consider the “world’s leading cities” (Global Power City Index), the "top major global Smart cities" (Global Smart City Index) or the “capital metro regions” (IESE Cities in Motion Index).[14] “Smart city” is thus positioned as an aspirational title that can only be conferred on a few exceptional cities, and this idea is reinforced by programs like the competitive 100 Smart Cities Challenge in India or the Gerakan 100 Smart City program in Indonesia. In reality, all cities face challenges that need to be addressed using innovative approaches, new technologies and the power of creative collaborations between multiple stakeholders. The challenges may be on a different scale in smaller cities or be affected by local geographic, political or economic conditions, but all cities need to become smarter to survive and thrive in a rapidly transforming world.

Technology-focused conceptions of the smart city as well as concerns to attract knowledge workers or the “creative class”[15] to cities, in the pursuit of economic growth, have been criticised for positioning Smart cities as exclusive, creating rarified enclaves for the elite and valuing some people over others in the city.[16, 18]

Questions have been raised as to whether smart city interventions do deliver their promised social and environmental benefits.[19]

As a result, many cities, especially medium-sized and smaller cities and those in developing countries that are far from being well-functioning, find that their smart city ambitions, if they exist at all, are questioned. For such cities, becoming smart is often discouraged, particularly when resources are constrained, and the high-level technical skills required to implement many smart city solutions are lacking. Cities face criticisms for tackling smart city projects when there are more pressing needs for housing, water or employment, and yet it is precisely these urgent and important needs that should be addressed with innovative interventions that make the most of smart technology and the creativity and insights of smart local people. Addressing such problems may or may not make use of sophisticated technology, but they will require innovation to think of new ways to tackle these most urgent problems.

This guide presents the idea that all cities can, and should, be smarter with low-cost interventions that do not require extensive infrastructure or very high skill levels to implement. It assumes that smart cities need to be fully inclusive, using the skills and serving the needs of all city stakeholders through interventions that are people-centered and focus on addressing pressing local needs. In much the same way as the circular economy is an opportunity to rethink production and consumption to address environmental goals, so the transition to a smart city provides a unique opportunity to rethink how a city functions and serves the people who live, work and play in it, with the goal of reducing social and economic inequalities.[20]

1.3 Smart interventions

Smart interventions in a city can take many forms. They may entail installing new infrastructure, like smart lighting along city streets, or a new software system, such as an automated voice system to respond to queries coming to the city's helpdesk. New software might be implemented entirely within the local government offices, like a fleet management system, or it might be something that promotes interaction between city residents and local government, like an app that residents use to report maintenance issues around the city.

This report uses the term *smart interventions*, rather than smart solutions, to indicate an interest in all the steps that go into creating a smarter city, and not just the implementation of technology solutions. Smart interventions may not involve technology directly; rather they may set up the conditions for other, smarter interventions. Implementing an open data policy setting out what city data will be made public and how, a consultative process to investigate how residents or local businesses understand a smart city, a public library offering computer training, or a business incubator for start-ups are all examples of smart interventions.

Although the role of technology remains central to the idea of a Smart City, our definition also allows for the use of "other means" to enhance life in the city and so interventions to improve the mental and physical health of residents by improving city parks or exercise programs can also be considered smart interventions, since they improve quality of life of present and future generations.

Smart interventions can be originated by different city stakeholders. This report is targeted at local government and hence focuses on the smart interventions that are within the mandate and capacity of local government to initiate and implement, but they could equally be initiated by businesses (large and small) or by non-profit or social organisations. Increasingly, smart initiatives are being seen as collaborations between local government and other city stakeholders, each contributing different insights, capacities and resources. Such collaborations are particularly important because of the systemic nature of cities.

1.4 Simple smart interventions

For cities that are starting to become smarter it makes sense to begin with simple interventions and to use the experience to develop capacities, processes and institutional knowledge that can be leveraged for more complex interventions over time. Cities that do not have resources to spend on experimenting, should focus first on interventions where there is a high chance of success.

Simple means easy to understand and easy to use, hence it should be easy to comprehend the concept, the path from the intervention to the intended outcomes, and the technology. The use of the smart intervention encompasses the implementation process and the changes in behaviour that are expected from city stakeholders, be they city employees, residents, or businesses. Simple interventions should be easy for people to adapt to and should improve their experience, particularly where the goal is widespread use.

In selecting the cases to be examined in this publication, the authors considered what would make a smart intervention simple. The following criteria served as the guide.

Table 1: What makes a smart intervention simple? (Criteria developed by the working group)

Cost	A smart intervention is simple if it is low cost, or creates a new revenue stream to offset costs. If the intervention is demanding large proportions of the city budget, or a special financing arrangement, it is not simple.
Duration	A smart intervention is simple if it can be expected to show returns within a year. (This might be done with a pilot project.) Interventions should be able to show real results, quickly. If it will take 2 or 3 years for results, it is not simple.
Scale	A smart intervention is simple if it is small-scale or can be piloted on a small scale and then scaled up. If the intervention has to be implemented across the entire city, or multiple city departments at once, it is not simple.
Technology	A smart intervention is simple if it makes use of proven technologies. Proven technologies have been in use for several years and there are documented cases of success. Unproven technologies are not simple.
Skills	A smart intervention is simple if it makes use of the skills that a city already has, or skills that exist in the city's businesses or communities. Interventions that require rare or sophisticated technical skills or obscure knowledge are not simple.
Complexity	There are a number of aspects that could contribute to the complexity of smart interventions. Complexity is increased when the intervention requires: (1) ambitious behaviour or process change from any city stakeholders, (2) co-operation or interoperability across agencies, or (3) legal or regulatory changes (although this may depend on context). Interventions that include these requirements are not simple.
Sustainability	In addition to being smart and simple, interventions need to be sustainable. A smart intervention is sustainable if (1) there is a plan for its continued operation, particularly with respect to maintenance, skills, and financial sustainability beyond any initial investment. The authors also consider an intervention sustainable if it (2) makes a contribution towards one or more of the SDGs and does not work against any of the SDGs. Specifically, smart interventions that increase inequality (SDG5 and SDG10) or risk making life worse, particularly for people who are already vulnerable, should not be considered.

These criteria can be used by cities to screen potential smart interventions, starting with simple interventions, while they build their awareness of where complexities may arise and capacity for more complex interventions.

One way to ensure that smart interventions are simple is to focus only on well-defined technology solutions that have been implemented, reviewed and are already in the market with established deployment and support models. However, such "out the box" solutions, no matter how customizable, will only be simple to implement in contexts for which they were designed and where they have already been proven. Where such smart solutions have been successful in neighbouring cities, they are likely to be simple and smart. Otherwise, they need to be evaluated for contextual differences such as support, cultural norms, local practices and skill levels.

Consequently, it is not recommended that cities simply seek to replicate solutions implemented elsewhere. Smart Cities are cities that take full advantage of the creativity of their residents and local businesses. Relying on replication of smart interventions misses the opportunity for cities to innovate locally. For cities in developing country contexts it is particularly important that in-depth knowledge of local city conditions, culture, resources and practices be harnessed to find novel and workable solutions to local problems. Examples of such simple, smart interventions are included in Chapter 3.

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2 Why smart matters

While population growth is slowing, it has not yet peaked and it is expected that cities will have to accommodate many more people. At the same time, we need to preserve or use wisely what is left of the planet's resources, to reduce the effects of climate change, and learn to live harmoniously, while adapting to challenges like the recent global threat to health. It is important to find ways to turn cities into more sustainable, intelligent, but also inclusive spaces, where people are at the centre of city development.

The challenge, when it comes to addressing city problems, is that cities are complex systems with many subsystems. They are "complex systems whose infrastructural, economic and social components are strongly interrelated and therefore difficult to understand in isolation".[21] Cities are particularly complex because they include "intelligent agents", in the form of people, who choose how to live in the city and they each respond to situations in their own way. This makes it difficult to predict the outcomes of city interventions. It also means that what works in one city may not work in the next. As a result, there are no "best practices" that can be recommended.

For cities to tackle the new and old challenges they face requires experimentation with new approaches and technologies. It also requires cities to share their ideas, attempts, successes and failures. To effectively change complex adaptive systems, including cities, requires many small interventions with constant feedback loops to detect the impacts. Smaller changes, carefully observed, make sense because they are easy to adjust; to scale back or ramp up as the impacts are observed.[22]

Harnessing simple, smart solutions, taking advantage of technological development such as artificial intelligence, machine learning, mobile computing, cloud computing and Internet of Things, can help cities to better understand their problems, to design and test smart interventions, to track in real-time the impact of those interventions, to scale up the things that work and to quickly put an end to those that don't. Finally, developments in communication make it possible for cities to share what they learn, as they learn it, with other cities and with the people in them.

2.1 What is "smart" depends on the context

While cities face some common challenges, they face different challenges too, and they have different resources at their disposal. Many cities face a backlog of issues to address, including growing inequality, climate change impacts, corruption, crime and similar intractable problems. Solutions to these challenges need to be highly contextual. This does not mean that cities can't learn from each other, but that all smart interventions need to be adapted and trialed for effectiveness in new contexts. Some examples of contextual differences are:

2.1.1 Small-Island Developing States (SIDS)

SIDS represent some 20 percent of UN membership and more than half the Commonwealth. Most have populations smaller than 1.5 million people and grapple with vulnerabilities linked to their size, history and location. They lack economies of scale and depend on a few key exports and narrow resource bases. Transportation costs are high due to geographical remoteness and the need to import strategic commodities like food and fuel. As a result, they are sensitive to external shocks and extremely susceptible to natural disasters, magnified by climate change.[23] SIDS need to redefine and augment human and organisational capabilities that have been negatively affected by a history of slavery, colonialism, and unequal access to global economic and other resources.

Many SIDS have siloed and bureaucratic governance models left over from their colonial past. Decision-making is highly centralised and slow, which limits the kind of innovation, creativity, and out-of-the-box thinking that enables modern tech solutions to deliver value. Smart solutions are inhibited by organisational structures and cultures at odds with principles of collaboration, agility, accessibility, dynamism, transparency, openness, simplicity, and people empowerment. Applying even simple smart interventions in unsupportive cultural contexts could increase inherent vulnerabilities and dependence on imports, rather than unlock local solutions to local problems.

2.1.2 Sub-Saharan African cities

In sub-Saharan Africa many people still lack access to basic necessities such as food, shelter and safety. Many are in economically precarious situations and in most countries fewer than 10% of people have Internet access at home[24] Addressing these challenges is difficult because of geographic factors and poor infrastructure, such as access to reliable electricity. At the same time African cities are growing rapidly, with estimates that they will house 1.34 billion people by 2050 and this puts pressure on already limited infrastructure.

Key to improving conditions in sub-Saharan Africa will be better city government and e-government to provide efficient, high-volume services. Sub-Saharan Africa contributes relatively little to the climate crisis with low levels of energy consumption. Ideally, living conditions need to be improved without the negative impacts that have resulted from development in other parts of the world. There is evidence that smart, climate-adaptive urban development can be effective to address the backlog of urban service-delivery, and provide employment in African cities.[25] However, solutions need to be cost-effective and simple to implement and maintain. Interventions also need to be suited to the context and local input is needed to align them with local practices.

2.1.3 Latin-American cities

Latin America has reached urbanization rates of around 80%. Despite the fact that this urbanization process has not produced an equal improvement in development, it has undoubtedly produced better living conditions, reflected in many indicators, such as employment, education,

healthcare, and access to ICTs. This rapid urbanization was not planned. As a result, there has been informal agglomeration around cities, creating slums which amplifies inequality and segregation so that not everyone has benefitted from urbanization. On the other hand, the cities sprawl far from the city centres. This impacts the overall productivity of cities, affecting commute times and increasing emissions.

A political turning point is approaching, where cities and territories, as a consequence of rapid urbanization, are gaining power and are beginning to introduce an agenda that aligns with the SDG's as a development framework. These political changes are expected to generate instability in the region. Infrastructure is under pressure as a result of unplanned urbanization, but the investments needed to improve it require stability. A political agenda for development is needed that empowers local and also federal government with more economic independence, but with more specific guidelines and a better planning process. The ICT agenda needs to be central in these development plans.

2.1.4 Small and medium-sized cities

Factors such as population, population density, number of settlements, economic performance and infrastructure are used to classify cities. According to the "functional definition", a city is not measured only in terms of size and population.[26] As cities act as administrative, commercial, religious, and cultural centers for their surroundings, their role in a political, economic, and cultural context determines their position. Therefore, cities might be considered small or smaller in terms of resources such as human, financial and natural resources.

For smaller cities, smart interventions that enable better services with fewer resources would be helpful. Such cities do not have excess resources with which to experiment, so that proven solutions, and solutions that can be adapted to local resources would be beneficial. For smaller cities, shared services (like cloud storage) and solutions can offer access to advanced technologies without the need for dedicated infrastructure. Working in collaboration with other neighbouring cities might enable cities to share the cost of developing smart solutions.

2.1.5 Shrinking cities

In many parts of the world, cities are shrinking, with significantly declining populations. De-industrialisation and out-migration are some of the reasons that cities shrink, often related to changing economic conditions and structural shifts.[27] In the United States, this problem is most commonly associated with the Rust Belt, while parts of Eastern Europe and Japan also experience similar problems. Shrinking cities do not necessarily reflect a shrinking national population, in some countries people choose to move to bigger cities where there are better facilities and opportunities.

Shrinking cities face challenges because the infrastructure was built to support a larger population, and its maintenance can become a serious concern. They also struggle to continue to deliver high levels of service to all areas of the city and may have to try to consolidate the population

to create sufficient density for efficient service delivery.[28] Shrinking cities may benefit from smart interventions that can provide services remotely. They have also benefitted from opportunities for greater involvement from residents in deciding strategies to cope with the decline, as well as new ways to communicate with residents.[29]

2.1.6 Rapidly-growing cities in developing contexts

On the other hand, many cities are experiencing rapid growth as people move into them in search of better opportunities and living conditions. The fastest growing cities in the world are in low income or developing countries.[30] Faced with rapid population growth such cities experience multiple social, economic and environmental challenges. They often have growing slum areas with poor housing and sanitation. Such areas are unplanned and can be very difficult to provide with normal city services. Additionally, cities in low-income or developing countries often face an infrastructure deficit which limits economic growth. With many city residents engaged in the informal economy, cities may find that they have only a small tax base and they often find it difficult to collect taxes effectively.[31]

All of these challenges might lead such growing cities to conclude that being smart is beyond their reach. However, such cities need creative ways to provide services and technology offers ways to interact with residents and provide services at scale. Where government services are not functioning optimally, the private sector has often stepped in to meet needs.[32] This tradition can be usefully built on to develop innovative smart solutions that are suited to these often chaotic, expanding cities.

2.2 Local innovation

Cities have been described as "hotspots of human culture and ingenuity".[33] As well as brimming with life and culture, they are also sites of innovation. The proposition of Smart Cities is that innovations in technology, policy and processes[34] can help to address some of the challenges that cities face, which seem insurmountable, using existing tools and approaches. Because cities face very different conditions, and smart interventions are difficult to transfer across contexts, innovation is required to address contextual differences. Catalogues of smart interventions, including this one, should not be viewed as cases to be replicated so much as examples to inspire.

A city does not become a smart city merely from the use of ICTs in its processes. A smart city is one which seeks to capitalise on available technologies to find solutions for pressing issues society is facing.[35] To be smart, every city needs to innovate and to create the conditions for ongoing innovation. A smart city might be thought of as an urban innovation ecosystem that effectively manages its own development by innovating constantly in aspects of city management and operations as well as in the ways that the city is occupied and used by residents and visitors. This innovation is likely to take advantage of technologies that extend our human capacities to learn, remember and act.

Internet access, web-based development tools and platforms, cloud-based solutions, as well as online access to innovation and making communities make it far easier for innovation to take place, even in smaller locations. Local innovation is facilitated by technologies that put information, ideas and the tools to put ideas into action in the hands of many, at relatively low cost. Creative and collaborative platforms can be used to develop interventions and solutions appropriate to a particular time, place and cultural context. Such tools make it possible for multiple partners to work together, pooling resources and experimenting, making it more likely that effective solutions will be found.

The world in 2020 is at a crossroads. Disruption caused by the COVID-19 global pandemic and mass movements for equality and social justice provide a real opportunity to shift the smart city conversation towards greater equality, community empowerment, and local innovation to create new areas for and approaches to economic and social development. New technologies and approaches can provide residents with the means to actively participate in the city, "motivated to collaborate with each other to create new use cases and applications that solve specific local problems".[36]

3 Ways to become smarter

To understand how cities are using smart approaches case studies were collected and analysed. These case studies are presented in this section. The criteria for the choice of cases were discussed during March 2020, and in April 2020 a call for cases was drafted and distributed. More than 30 case studies were proposed and discussed. Cases were submitted and refined between April and May 2020.

Analysis of the cases shows that they could be grouped into:

1 Local government administration and service-provision,

2 Environmental concerns,

3 People and the city's relationship with them,

4 Experiences of the city, and

5 City resilience.

These categories were not neat, nor entirely mutually exclusive, but they do correspond to five of the commonly accepted six smart city dimensions.[37] They also seemed appropriate for the cities we are targeting as well as current concerns and agendas. As a result, these categories have been used to structure this Chapter.

In what follows, some of the smart initiatives in each category are presented and key issues and concerns for cities pursuing them are discussed. Some cases are presented in full under each section, while some are discussed more briefly in the text.

This selection of case studies is not intended to be a prescriptive list of smart city initiatives, but rather as a source of inspiration for cities. Cities should consider the potential benefits and issues discussed in each section and consider which initiatives might best align with their own needs and resources.

3.1 Administration and service provision

A good starting point for cities that aspire to being smarter, is to focus on their administration and internal capacity, to harness technology to improve what they do, and in the process to develop internal capacity and understanding of the potential of smart technologies and data. The benefit to cities of starting with their administration is that the city has a large degree of control over these functions and has access to budgets for their operation.

By exploring ways to improve administrative functions, city employees can learn more about the capabilities of smart technologies and can use their own experience and deep knowledge of administration to good effect. At the same time employees will be developing their capacities to implement smart initiatives. This will put city employees in a better position to design smart interventions more broadly and will give the city a greater chance of success in becoming smart.

3.1.1 Record-keeping and data governance

A large part of the city's administrative function involves record-keeping, whether it is recording expenditure, city assets and ownership, or purchasing decisions. Most fundamentally, technology offers the benefits of keeping electronic records which include greater security, lower storage costs, and greater ease of access and sharing. While there are many information systems available to aid cities with their administrative tasks, the challenge for smaller cities is that systems require infrastructure and expertise to implement and operate. New technologies make it easier for cities to implement such systems through shared infrastructure and with minimal expertise.

Cloud services can provide the infrastructure to store data and run software. They will typically ensure that systems and data are always available, backed up and secure, providing both the hardware and the technical services to keep the systems functioning. Cloud services are useful for cities because infrastructure can be added and removed flexibly, simplifying procurement and reducing costs. Larger cities are able to implement their own shared cloud for internal use, however, this is generally beyond the reach of smaller or resource-constrained cities. It may be possible for such cities to share the services provided by a larger neighbouring city or to use a national service, where that exists.

Public cloud services are provided by private organisations and cities will need to assess how acceptable it is to use them to store city data, depending on local regulations. For example, national data protection laws may prohibit the transfer of data outside national borders, while cloud services may physically locate infrastructure in other countries. Public cloud services can generally be used to provide access for residents to city services, open data and information. Cities will need to create a roadmap for how different cloud platforms will be used and how security, privacy and data sharing will be managed.

3.1.2 Process enhancements

By digitising and automating city administration, cities can also improve on their internal processes. Paper-based systems are slow and resource-intensive. They are also prone to error. Digital processes can be more efficient, for example allowing residents to submit requests online and moving requests through the city offices following a defined workflow. Electronic workflows are more consistent, can be monitored for efficiency, and documentation cannot be lost along the way.

Creating digital processes from manual ones is not simple, but many of the administrative processes in cities are similar and well established. It should be possible for cities, working with suppliers that are familiar with the context, to redefine simple processes in a couple of months. Fully implementing new processes and the systems that go with them can take longer. There is some adaptation on the part of staff to new electronic routines, and training will be required to ensure smooth operations. However, the skills that staff gain in the process will benefit them and the organisation in the long term, as they grow to understand the potential and limitations of digital work as well as the changes that it necessitates.

The chief benefit of digital processes is that they generate data along the way. Not only will the city have records in electronic form, but data about how many applications are received, how fast they are processed, and the results can be used to monitor the effectiveness of city processes and to improve them over time.

3.1.3 Cases to consider

The two cases highlighted in this section look at common systems that cities use. The first discusses how small cities in Spain have implemented electronic document and records management systems. The second discusses how fleet management systems can help cities to better manage their vehicle assets. Other ideas for cities to consider are discussed here.

One simple way for cities to start providing electronic services is through a city website. City websites can provide information for local businesses and residents about services and the performance and plans of the city. More sophisticated websites can offer online requests for services, monitor progress, give feedback to the city and engage in consultative processes. There are companies specialising in developing and hosting websites for small cities and many information systems that are designed for cities have built in web interfaces that can be used by employees, local businesses and residents. Such web interfaces may remove the need for smaller cities to develop a fully-fledged website. However, in contexts where many residents and small businesses use mobile technology rather than websites, cities might want to consider making these services available in a mobile-friendly format or as mobile apps. There is more discussion of how cities interact with their residents in section 3 of this chapter.

In Nairobi County in Kenya a mobile web-based solution has been used to improve revenue collection and to reduce corruption.[38] In the past, printed revenue collection receipts were issued in exchange for payments. This system was exploited by dishonest employees who printed counterfeit collection receipts and colluded with defaulters in return for bribes. In collaboration with a private company and the National Bank of Kenya, the new system allows registered users to make payments directly using MPESA mobile money. This has reduced contact between city employees and Fiat currency, reducing pilferage. It also provides flexibility for city residents and businesses. While this system was implemented on a county level and was not a simple undertaking, it illustrates the potential of smart interventions to address intractable problems.

Where cities can, they should take advantage of existing, off-the-shelf systems, particularly where such systems have been successful in similar cities. However, even resource-constrained cities can make use of low-code development platforms to create their own customised systems.[39] Such platforms make it easy for organisations to create efficient digital solutions without the overheads of more traditional systems development. Using agile and visual development, it is possible to prototype an idea in minutes and evaluate its feasibility. Applications can be developed for processes in any organisation using drag and drop to develop interfaces and process flows. Staff of non-technical disciplines such as Human Resources and Accounting have developed web and mobile applications with little assistance. Effectively these platforms reduce the skill level needed for software development, overcoming skill shortages creating employment opportunities, and increasing flexibility and innovation.

Case 1: Electronic document and record management

The problem

Many small cities continue to provide services using traditional processes. Typically, this means that a resident must go to an office and make a request using paper forms. A file is created for each request and these files are passed from one functionary to the next as the request is processed. Such processes are time-consuming and resource-heavy, requiring a large staff contingent to interact with residents and costly filing and storage resources. They are also prone to errors and physical files can easily get lost.

The small city of Ronda in Spain, with around 35 600 inhabitants,[40] is a good example. In 2015 this city switched to an Electronic Document and Record Management System (EDRMS) to improve services to residents and to gain efficiencies in the municipality. Such systems can be costly and are often seen as beyond the resources of small cities, but a system that is provided as a service means that the city does not need to buy or maintain computers and does not need specialist skills to configure or run the service.

The solution

Gestiona is a cloud-based Electronic Document and Record Management System (EDRMS) that is provided in Software as a Service (SaaS) mode to the city of Ronda.[41] The system allows local administration processes to be automated in an easy and user-friendly way. Its main features are:

- Digitization of documents and creation of electronic documents and folders, compliant with European and Spanish national standards.
- Documents are stored in a hybrid cloud that can be accessed from any location with an Internet connection.
- Electronic sharing of documents between city departments.
- Electronic signature of documents using digital certificates.

- A complete city website with online procedures, including separate sections for employees and the public.
- The option to program tasks and messages for individuals and organizational units, reducing user errors and making it possible to monitor workflows.
- Tools for auditing processes, documents and users.

The system allows residents to make requests and get information about the status of their requests online, reducing the need for them to go to the municipal offices.

Importantly for a small city like Ronda, the system does not require infrastructure to be implemented. The system is provided as a service which makes the implementation fast. Employees are able to work from any location with an Internet connection. The interface is web-based, intuitive and user-friendly with menus and options adapted to the administrative work.

In small municipalities, the Gestiona system can satisfy most needs. In medium-size cities the system can be integrated, using an Application Programming Interface (API), with other departmental applications, like census or accounting, to fully automatize the internal processes. This system is not suited to larger cities that require advanced data analysis modules for process optimization and more sophisticated participation channels.

Results

During 2019 the city of Ronda had 4390 electronic procedures initiated by residents using the website. Internally, 10 511 electronic folders were created, and 178 739 documents were signed electronically.

The city has benefitted because:

- The number of face-to-face interactions at offices has been reduced by almost half.
- The traffic near the Town Hall has been significantly reduced.
- 80% reduction in the use of paper and printers by the city.
- 60% reduction in processing times.
- The ability to work remotely made it possible for the municipality to operate during the COVID-19 lockdown.

The same system has been implemented in more than 6000 small and medium-size cities in Spain since 2015, most with fewer than 20 000 inhabitants.

Keys to success

To implement the system, the city had to face some challenges:

- The local regulatory framework had to be modified to allow residents to use online procedures, electronic documents and digital signatures.
- The city's internal processes had to change, replacing paper documents and traditional stamps with electronic documents and digital certificates.
- Decision-making bodies have had to adapt to issuing all regulations, decrees and agreements electronically.

The key to success has been organisational change management. In addition to changing the processes, city employees who were used to paper-based methods, had to learn new processes and to change their work habits. This required full support from the local authorities and strong training and support phase to encourage staff to adapt. For Ronda, the transition to the new system was supported by two months of consultancy after which a specialist local officer took over. This local officer now provides local support with the supplier offering remote support.

Case 2: Smart fleet management

The problem

Most municipalities have large vehicle fleets to support different city functions including waste collection, ambulances and emergencies, security patrols and public transportation. The costs of running and maintaining this fleet can be considerable, including the cost of fuel and maintenance, insurance and provision for replacement when needed. In addition, municipalities need to manage and reduce emissions, to schedule the use of vehicles and the related personnel effectively and to ensure that appropriate policies are in place and adhered to.

The Municipality of Ezeiza, near Buenos Aires, with 160 000 inhabitants was interested in using technology to make better use of vehicles, to save costs, but also to diminish fuel consumption and emissions of contaminants. Technology innovations also allow other improvements such as increased security, tailoring the frequencies of public transport, reduced emergency response times, and many other benefits.

The solution

Fleet management systems are relatively easy to implement and readily available.[42] Typically, they include features such as:

- Defined policies and procedures for fleet management.
- A database of vehicles, their use and current status, as well as details like when they were purchased.

- Maintenance records for each vehicle that can be used to assess the best preventative maintenance procedures.
- Tracking of vehicle expenses and budget controls.
- Automatic notification of planned maintenance and replacement, according to policy.
- The allocation of vehicles to departments and drivers.
- Route planning and optimisation.
- Sensors and geo-location for real-time tracking of vehicles, recording parameters such as fuel consumption, speed, acceleration and deceleration, location and routes, and time in use.
- Event or incident management for responses that involve multiple vehicles.
- Monitoring of vehicle location to identify theft or misuse.
- Data analysis to evaluate vehicle and supplier reliability over time, as well as service effectiveness and efficiency.
- Dashboard to monitor progress against fleet management goals.

Such systems can be implemented in stages, starting with basic record-keeping for the vehicles and gradually extending to real-time monitoring and the analysis of the data collected. The data can be used to improve services. For example, maintenance records can show which vehicle makes are less likely to suffer breakdowns and purchasing policies can be updated accordingly. Data on vehicle routes can be used to improve public transport by offering more or less frequent services.

Technologies required to implement fleet management systems are readily available and inexpensive. This project could be implemented with cheaper devices initially and then, based on the information collected and results, upgraded to more sophisticated technologies. A gradual implementation can allow the city to examine the costs/benefits/viability of each stage.

Results

Fleet management solutions have been implemented in many cities, including the Municipality of Ezeiza[43] and the Municipality of Cipolletti, where a GPS control system has allowed the city greater control of vehicles and has resulted in service improvements.[44]

The benefits that result from improvements in basic record-keeping include:

- More effective record-keeping and control of the fleet.
- More effective preventative maintenance, reducing the time that vehicles are out of service and ensuring lower vehicle turnover.
- Compliance with policies on maintenance and replacement.

With real-time tracking of the vehicles the following benefits can be realised:

- Efficient use of vehicles, reducing costs of fuel, maintenance, staff.
- Fewer accidents.
- Increased security of vehicles.
- Reductions in emissions.
- Data that can be used to analyse and improve services.

Additionally, there are other, less tangible benefits. Such a system is a good place to introduce and enforce a culture of control and efficiency, as well as to expose city employees to smart solutions and develop their understanding of how data can be used to improve city functioning.

Keys to success

This project touches many different areas of a municipality, each of which has different objectives, interests and expertise. To be successful, this initiative has to be designed and driven from a strategic level to take these differences into account. It also needs to be implemented with careful political judgement.

For real-time monitoring of vehicles, good quality, high-speed connectivity is important.

3.2 Environment

With most people living in cities, there is a high and growing demand for natural resources. This is most obvious in large and growing cities, but the same challenges face smaller cities. Cities can contribute to lowering the demand for energy, water, and other resources. They also have to manage the supply in responsible ways. Smart interventions give cities tools that they can use to better understand environmental challenges and to monitor the effectiveness of responses.

Cities in developing parts of the world on the whole consume less energy and other resources than those in the developed world. However, these cities have to address environmental challenges with fewer resources, rapidly growing populations, and aspirations to achieve the kind of living standards that the developed world already enjoys. For these cities, finding ways to improve living conditions without adopting the levels of resource consumption of the more developed world is a priority.

Smart interventions have tackled many environmental problems, from managing energy and water supply and demand, to waste collection and air quality monitoring. The common denominator in these interventions is that smart technologies allow the collection and analysis of data that improves understanding of the problems and the effectiveness of the solutions. This data makes environmental problems more visible, and raises awareness.

Some smart city initiatives have contributed to environmental problems. For example, the rapid deployment of shared bicycles in China led to massive dumping.[45] In addition, electronic waste is a growing problem and so the use of technology needs to be more thoughtfully approached. Not all smart initiatives benefit the environment, and the impact of additional technology needs to be taken into account in the design of any smart intervention.

3.2.1 Increasing visibility

Smart Internet of Things (IoT) devices can be used as environmental sensors to monitor dust, air pollution, odours, noise, humidity, weather and radiation levels. Environmental monitoring solutions also enable the observation, control, and sustainable management of infrastructure for power supply, air quality, recycling, waste management, water and sewerage.

Perhaps the most important smart intervention is to use the data that can be generated to increase awareness of environmental problems and to lobby for changes that are needed to address them. Environmental concerns are readily embraced by city residents, but solutions are more difficult to design and implement. Climate data is that digitalised, analysed and made available through public portals can be used to:

- Assess and predict climate variability.
- Design adaptation and mitigation measures.
- Disseminate real-time information, such as weather and air quality, to the public.
- Build public awareness through climate change education and training.
- Build capacity in the analysis and interpretation of climate data.
- Seek financial and technological support for interventions to address climate change.
- Prioritise environmental issues as areas for corporate social responsibility.
- Lobby for legislation and policy support for effective monitoring and control around environmental issues.

3.2.2 Air quality

According to the World Health Organization (WHO), more than 80% of people living in urban areas that monitor air pollution are exposed to air quality levels that exceed WHO guideline limits.[46] In cities, the major outdoor pollution sources include vehicles, power generation, building heating systems, waste incineration and industry. Cities need to be concerned with cleaner transport, energy efficient buildings, clean power generation, the energy sources used in homes, industrial waste and better municipal waste management, all of which will contribute to better air quality.

One of the challenges with air quality is that it can be difficult to detect and is often invisible. Smart air quality monitoring can raise awareness of the problem and can be used to mobilise different stakeholders to address it. It is possible to collect air quality information across large, distributed areas and to correlate the data with population density, industrial and commercial activity. This can help cities to understand what drives pollution and to identify appropriate courses of action. While such systems can be costly, small scale systems are available that allow a city to monitor local air quality levels.

Data on air quality can be used by city decision-makers to monitor how well policies are working. Data that is shared with residents empowers them with real-time information about their surroundings. Individuals can decide to stay at home, or change their running route when pollution levels are high. This monitoring is possible in near real-time.

Cities that are monitoring air quality include London and Surat, in India.[47] Resource-constrained cities may be able to make use of cheaper sensor and citizen science or educational projects, with the support of researchers to do something similar (see Case 3).

3.2.3 Energy and water

Energy and water provision are key services of cities. Both draw on natural resources and need to be carefully managed. Cities need to pay attention to both the supply and demand for these services. Smart technologies can help cities to understand and manage the demand and can be used to manage the supply more sustainably.

In many cities, the municipality owns and manages many buildings. Consequently, one smart intervention that is attractive to cities is to retro-fit buildings to reduce their energy use through better insulation and automated management of lighting and heating. At the same time, buildings can be fitted with solar panels or other mechanisms to make use of freely available energy sources. Such interventions make use of proven technologies and can be implemented incrementally. They also usually result in cost savings which makes them easy for a city to incorporate into their plans.

Cities can also use smart devices to monitor the demand for energy and water from businesses and residents. Understanding patterns of use enables the city to anticipate demand and, when necessary, to introduce measures to manage demand. During the 2017 water crisis, Cape Town made use of data about water consumption to map which households were complying with water restrictions and call out those that were not.[48] The city succeeded in reducing water consumption by more than 50% during the crisis. Such monitoring and reporting devices are widely used. Implementing them can be complex, however, as residents and businesses may resist their introduction.

3.2.4 Waste

Cities rapidly generate waste that can be difficult to dispose of given the concentration of many people in urban areas. Waste removal and treatment has long been a core function of municipalities.

Traditionally cities collect waste from households and consolidate it for disposal. Households may be required to take household waste to collection points. Many smart solutions have been developed for improving waste collection in cities. These include systems that improve the efficiency of truck routes and smart bins that notify the city when they need to be emptied. While many of these systems are quite sophisticated there are also simpler versions. For example, a city in Canada has added QR codes to bins that residents can scan to inform the city when the bin is full. Such a solution avoids the potential of sensor or network failure and so might be more reliable, if residents participate.

The traditional process of collection and removal of waste fails in cities where the waste generation outstrips the resources of the city to effect collection. This is the case in many cities in the developing world. Waste that is not collected pollutes living areas, or results in informal dumping with associated health and environmental impacts.

The separation of waste into different recycling categories for treatment is an important element of managing city waste. In cities where waste collection is ineffective, the informal sector contributes to this process with informal "rubbish pickers" (as they are called in South Africa) collecting and selling recyclable waste. For many cities, it has become necessary to harness the energy and inventiveness of the informal sector to address recycling. Instead of being seen as a problem, informal waste collection is now being seen as part of the solution. Case 4 tells how a small city in Colombia has worked to formalise this work.

While such initiatives need not involve technology there have also been attempts to apply technology to the problem. In India, Kabadiwallah Connect have developed apps to support informal sector recycling.[49] Their apps inform homeowners of waste separation and drop-off points, and they tell the informal waste collectors, known as Kabadiwallahs, where they can collect and sell their waste.

Case 3: Air quality monitoring

The problem

The combined effects of ambient (outdoor) and household air pollution cause about 7 million premature deaths every year, largely due to stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections. Furthermore, urban pollution can extend beyond cities, affecting agricultural areas that are vital for food security and income. The challenge with air pollution is that it is mostly invisible, making it difficult to understand and make people aware of the extent of the problem.[50]

Air quality has traditionally been measured using sophisticated monitoring stations, each costing hundreds of thousands of Euros. These are very accurate, but they are not numerous and, in many places, they do not exist. This means that many places are unaware of the types of air quality problems they face, or the extent. Larger cities have been able to establish good monitoring programs with sophisticated websites that present the data, and programs to improve the quality of air, but this has been beyond the reach of most cities.

The solution

Low-cost sensors (LCSs) for air monitoring, combined with the IoT could be a cost-effective solution to assess the air quality in a city, in both outdoor and indoor environments.[51] There are hundreds of commercially available LCSs with costs ranging from hundreds to several thousand Euros. Prices depend on the quality and the extent to which collected data are post-corrected (processed to improve data quality using machine learning or algorithms).

The sensor modules can be powered by solar panels since they have a very low power consumption and the data is collected in .csv files that take up very little storage space. Planning is involved to decide where the sensors must be placed, how they will be looked after, if data will be collected in real-time (over a network) or whether memory cards will need to be read, and how frequently the data will be collected. The sensors, and possibly other infrastructure, will need to be purchased and installed. Depending on the city processes, this could take 6 months to a year to implement.

The results need to be communicated, usually through a website or mobile app. There are clear standards on air quality for the different pollutants that the sensors measure. So, it would be simple to compare the data recorded with the standards, making it easy for everyone to understand the meaning of the results.

The use of low-cost sensors for air quality monitoring has generally been approached through citizen science and educational activities, engaging residents and students in the measurement and analysis. A growing global network of home enthusiasts is using kits to build their own sensors and collect data which is shared on websites.[52]

The number of sensors used can be scaled to suit the budget. Where there is currently no monitoring, even one sensor would give useful data. However, sensors installed where air quality is expected to be poor (near highways, industrial or construction areas, fire areas) and where one would like air quality to be good (schools, libraries, hospitals, parks) will be the most useful for the city.

Results

With some support, it is possible for a city to collect data about air quality from multiple locations, relatively cheaply. Such data can be used to visualize air quality and to connect it with the consequences for health, the economy, and quality of life. Such data would supplement official country data, increasing the spatial coverage, and would fill the data vacuum where no monitoring is currently undertaken.

Low-cost monitoring networks could help to identify emission sources and the most affected segments of the population, in places where air quality control was never in place and enable cities to experiment with interventions to improve the air quality. Air pollution impacts on human health could be estimated by using tools recommended by the WHO.[53] The interdisciplinary use of these data may generate valuable information for lobbying, serving to demonstrate the necessity for policies aimed at sustainable development of their cities. The data can also be used to raise awareness among local businesses and residents.

Keys to success

Most cities are unlikely to have the expertise to design and implement an air quality monitoring program. The choice of sensors, where to locate them, and how to interpret the data collected, all require expert knowledge. Companies that produce low-cost sensors are not, at present, regulated. Cities need the advice of technical experts to ensure that they buy products that work as they claim.

Consequently, this kind of intervention has to take place in collaboration with local scientists and researchers. Cities that have strong existing relationships with such experts will find the project simpler to initiate. This provides an excellent opportunity for cities to work with local universities and schools. Engaging more people increases the data collected and raises interest in air quality.

Studies show that low-cost sensors are unstable and often affected by atmospheric conditions. For this reason, the scientific community must be strongly linked to these projects so that they can guide the city on the meaning of the data. At this point, low-cost sensors are a good tool to detect hot spots and the temporal and spatial trend of pollutants in a city. They are inadequate for replacing more comprehensive and formal monitoring.

Once in place, the sensors will return data immediately, however, reporting on the data and deciding what it means and what can be done with it may take some time. Cities should plan for a one-year project to see useful results communicated through a website.

Case 4: The role of informal waste collectors

The problem

Popayán is a small city located in the southwest of Colombia, with a population of approximately 277 000 inhabitants, according to the 2018 census. From the end of the 1980s, the city began to recover, on a small scale, usable, recyclable material coming from domestic and commercial activities. At the end of the 1990s, three organizations dedicated to the recovery of this material had been consolidated. However, at that time, the city did not have enough collection routes to cover its entire extent. In addition, many individual recyclers worked independently and disjointedly, which generated conflicts with these organizations. By not consolidating the recovered materials, quantities of recovered materials were reduced, preventing the growth of the sector, hampering business development and under-valuing the work.

The solution

In 2016, the national government, declared recyclers the subject of special constitutional protection and instigated actions to formalise their jobs through the associations that were already recycling waste collected by the public cleaning service. To accomplish this, recyclers have a period of 5 years, during which they must progressively comply with administrative, financial, technical, and commercial obligations imposed by the decree.

The associations register with the Superintendency of Public and Domiciliary Services (SPDS), which provides support to address technical, organizational, administrative, and business issues. The SPDS monitors whether the associations are fulfilling their obligations through a web-based platform, the Unified System of Information of Domiciliary Public Services (USI).

Results

The implementation of this decree has encouraged entrepreneurship through the creation of more associations, as well as improving social inclusion. Recyclers have joined the formal sector through the associations for the recovery of usable material. Their work has been dignified, working conditions have improved, as well as their quality of life.

In 2016, the recycling organizations were made up of approximately 100 workers. By 2019, 162 were reported,[54] an increase of more than 60%. This has led to better organized collection and recovery activities and consequently to an increase in the amount of material recovered. Between 2011 and 2016, 2173 tons was recovered, while between 2017 and 2019, this rose to 7430 tons,[55] a 70% increase in just three years.

Keys to success

This initiative has succeeded through strong government support and because informal recyclers were recognised as part of the solution.

The budget for the formalization and operation of the associations comes from different sources. Rates have been established by the government for the commercial purchase of the recovered material, according to weight. Non-governmental organisations (NGOs) and the municipality support the initiative, through the recycling fund. Revenues also cover environmental awareness and education activities for residents to improve separation at the source.

To improve performance in collection tasks, some of these associations are in search of software tools that facilitate scheduling of routes, monitoring of collection points and weight by type of material collected in real-time. So far, no tool has been implemented by any association.

3.3 People in the city

Smart cities rely on intelligence and intelligence can be interpreted in three different ways. First, intelligence can mean information. Smart technologies provide opportunities to collect detailed information about the city, the people in it, and how it is functioning. Second, intelligence can mean the ability of technologies that use machine learning and sophisticated analysis techniques to detect patterns and build understandings of how a city is functioning. But perhaps the most important meaning of intelligence is the third one, and that is the judgement and interpretation that people bring to the conditions of cities. This section focuses on the role of people in the smart city.

Cities are made up of the people who live in them as well as the people who pass through them. People run the smart city, and occupy the city as residents and visitors. People contribute to the economic life of cities, both through running businesses and as customers for those businesses. They live in the city and take part in the many activities that make up the functioning of the city.

People need cities as places to live, but they also come to cities in search of economic and social opportunities, as well as improved quality-of-life. From cities, people expect services such as housing and access to power, water, healthcare and transportation. They also look for cities that offer them opportunities, such as education, employment, and recreational facilities. People want to feel a sense of belonging in a city and feeling safe is a high priority. Smart cities pay attention to these expectations and how best to meet them in the interests of all their stakeholders.

On the other hand, cities need people; without people, cities die. While for growing cities, a rapidly increasing population is a problem, many cities struggle with declining populations and face the challenge of attracting people to live in them. The smart city literature has been concerned with how cities attract a specific class of people, knowledge workers, or people with particular skills that can support plans and initiatives for competitiveness and economic growth. But for many cities, there is little choice in who their residents are, and cities have to find ways to thrive with the residents they have.

People provide ideas, as well as the energy to carry them out. Smart cities take advantage of the capabilities of residents, building their capacities, as well as establishing networks and partnerships to harness the energy and inventiveness of residents, including businesses. Engaged and active city residents are key to the success of Smart cities and for this, people need to be empowered to engage with the city. Prerequisites for people to take part in the smart city have been identified.[56] They include:

- Technology infrastructure (reliable electricity, affordable Internet access).
- Access to technology (access to affordable, effective devices).
- Skills and capacities (digital literacy, learning opportunities, empowerment).
- Rights (access to information, privacy and anonymity, freedom of speech).
- Trust (in technology, in technology suppliers, in data custodians, in government).

3.3.1 Interactions between cities and people

The Organisation for Economic Co-operation and Development (OECD) developed a model to describe the types of interaction between a government and the people.[57] This model can be adapted to smart cities. The model describes three levels of interaction: Information only, where information is provided from the government to residents, consultation, where government consults residents to ask their opinions, and participation where government and residents work together to co-create smart interventions.

Some of the ways that cities can interact with people are given in Table 2.

Table 2: Modes of interaction between cities and residents

Information only	Consultation	Participation
• Public document repositories and informational websites • Newsletters in physical or electronic forms • Blogs, webcasts, podcasts • Customer service centres or kiosks (physical or virtual) • Inbound call centres • Interactive voice response (IVR) systems	• Town meetings (physical or virtual) with opportunities to discuss issues • Interactive websites • Polls on specific issues, outbound call centres • Active discussion forums • Responsive social network accounts • Apps that collect data from residents	• Open data portals that allow people to use city data to draw conclusions about city functioning • Workshops, brainstorms, hackathons and co-creation events around specific issues • Community interest groups and networks • Apps that allow residents to contribute to city initiatives • Resident-driven initiatives

The World Economic Forum encourages what they call a 'inhabitant-centric' approach within cities.[58] Often, consultants, politicians and businesses are included in decision-making in cities, while other inhabitants are overlooked. This can lead to initiatives being implemented which fail due to resident's dissatisfaction. Consultation or better still, active participation, can ensure more sustainable results with residents who are generators of ideas, services and solutions, rather than subservient and passive recipients of them.

Smart technologies enable cities to effectively connect their inhabitants to each other, connecting both their human intelligence and their smart devices into an underlying, invisible 'computer' of modern urban life. Such technologies can collect data from residents about what city services they use and how, and this data can be used to inform city planning. However, to ensure trust these activities need to be transparent, and cities need to seek permission from residents to collect and use their data.

One danger in databases collected from services, surveys or social media is the risk of social representation bias. Cities can use effective policies to mitigate this risk by, for example, ensuring that city databases are based on representative and balanced samples of people belonging to different

social strata, including diverse backgrounds, cultures and disciplines, vulnerable persons, persons with disabilities, ethnic minorities, women, children, geriatrics, refugees and other categories facing potential exclusion, discrimination, abuse, human rights violations and marginalization.

3.3.2 Making people smarter

The challenge for cities is to ensure that residents can fully participate in the smart city. For some cities, this begins with ensuring that basic needs are met and that residents are healthy. People who are sick or who are struggling to meet their basic needs are less likely to have the interest or energy to devote to engaging as residents.

The Smart Healthy Citizen (SHC) program[59] focuses on knowledge and practice of nutrition and exercise as fundamental to people's health. It also supports emotional development, digital skills and encourages a good media diet. The program provides a website and interactive platform, supported by a blog and social media. Smart Healthy Citizen has been able to transform a city's way of working and empower people to be smart. The first pilot program in Córdoba, Spain brought together different spheres of the city, to work inter-sectorally, in a challenge: to reduce by 10% the number of overweight children in the population. Through education and technology solutions the program achieved a 14.5% reduction in BMI in 9 months. As a result, an ambitious study on intelligent education and being overweight was carried out.[60]

The Smart Healthy Citizen program puts people at the centre, offering organizational and educational alternatives that empower self-care and are particularly relevant in the COVID 19 crisis. It is a model that is now being adopted in Andalusia, Spain and should be easy to adapt for other cities. The success of the program is not the technology, but the multidisciplinary work, where doctors, teachers, mayors, merchants and associations, work together for a common cause: health and childhood.

Where levels of digital literacy are low, cities need to work together with educational organisations to ensure that residents learn not only how to use technology, but also to use it thoughtfully. Digital literacy is more than just computer skills, it encompasses an understanding of online security, ethics and conventions. In some circumstances, developing digital literacy begins with ensuring that people have access to services as simple as electricity, and the opportunity to use technology. Case 5 discusses how the city of Johannesburg in South Africa has been increasing access as part of its smart city plans.

The outbreak of COVID-19 in 2020 led to people globally having to engage using virtual meetings, e-learning and remote working. Schools had to operate online, many people worked from home, and municipal offices are delivered services digitally. This experience has highlighted efficiencies and environmental benefits, which make it likely that such practices will continue in the future. The challenge with digital work is ensuring that inclusion is fostered and that the digital tools can be used collaboratively rather than only for one-directional communication. Great strides were made

towards more effective use of technologies during 2020. Cities have the opportunity to build on this experience, and the knowledge that has been gained.

3.3.3 Equality

One of the concerns related to smart cities is that research shows that some smart initiatives have increased inequality in cities by focusing on the needs of an elite, by implementing systems with inherent biases, or by not engaging widely enough with the city stakeholders who are impacted by the initiatives.[61] The New Urban Agenda and the 2030 Agenda for Sustainable Development both highlight the importance of creating smart and accessible cities that benefit all of their residents. Cities working towards being smart need to be aware of this and to actively seek out smart interventions that support inclusion, diversity and equality.

Cooperation and collaboration between the various stakeholders in a city are key for the success of smart interventions.[62] It is important to take a holistic approach towards smart city agendas, considering the concerns of inhabitants, institutions, systemic structures and operations. Such 'comprehensive decision-making' requires cooperation and careful communication.[63]

Technology can enable inclusion. For example, technology can facilitate communication between residents and the city, making it possible to come up with appropriate solutions to local problems. Smart technologies can be used to address some of the needs of differently-abled people. However, smart interventions need to be culturally appropriate, so that they can be integrated into local urban identity and culture.[64] Cities need to seek out solutions that are flexible and can be adapted to their circumstances.

The World Development Report 2016 on Digital Dividends[65] notes that acceptance of technologies is paramount for cities in the initial stages of integrating smart technologies. Understanding and acceptance of technologies should be monitored within the city to ensure that city and the city's occupants are on the same page and satisfied with developments. For this reason, cities need to invest in their social infrastructure to ensure that smart initiatives succeed.

Case 5: Digital literacy and access

The problem

For the residents of Johannesburg, in South Africa, to participate in the smart city, they needed to have access to the Internet and the skills to be able to use online resources. Learning to use online resources is easy once one is able to get connected and search for information. The problem in Johannesburg is that Internet penetration is low (estimated at 53.7% for South Africa in 2018). Few houses have Internet access and mobile data is expensive. One gigabyte of data costs seven times more in South Africa than in Egypt and nearly three times more than in Ghana, Kenya and Nigeria.[66]

This means that many people in Johannesburg are excluded from the online world and thus also excluded from opportunities to communicate and socialise, gain access to information, learn, and pursue employment opportunities. The City of Johannesburg has embarked on a comprehensive smart city strategy; however, their efforts are hampered by this lack of access. Where people cannot engage electronically with the city, much of the service provision has to be face-to-face, and so the efficiencies that technology promises cannot be realised.

The solution

To expand access to the Internet, the City of Johannesburg has been providing free public Wi-Fi at city libraries, community centres and bus stops since 2015. The motivation for the project was to facilitate better communication with residents, to increase the information available to residents and to improve economic opportunities for residents,[67] where the provincial unemployment rate is 28.9%.[68]

At the libraries, some computers are provided, but many people bring their laptops to work on. Many also connect to the public Wi-Fi using mobile devices. By using the city libraries and bus stops the city takes advantage of infrastructure which they control, and so it is easier to deploy and manage the technology. Each user is provided with 300 megabytes of data per day or 9 gigabytes per month, if used daily. There is also unlimited access to a set of services provided on the City's Maru a Jozi portal.[69]

To assist residents to use the service the city set up a partnership with the University of Johannesburg. Students were employed as 'Digital Ambassadors' to spend time at libraries explaining to residents and library staff how they could connect and showing them how to search for information on the Internet. This service was provided for a limited time, establishing a base of residents with skills, and training librarians. Now many users of the library service are able to ask other users for assistance.

Results

By the end of 2016, the City had provided more than 1000 hotspots and they had been used by more than 400 000 residents.[70]

Residents have identified benefits from the program,[71] including:

- Easier communication and more avenues for communicating.
- Savings on their data costs.
- Access to learning materials and opportunities.
- Access to job opportunities.
- Identifying business opportunities and earning through online initiatives.
- The wi-fi hotspots have become social sites where residents have met people and made friends.

Keys to success

Some key elements of this program that contributed to its success were:

- The partnership with the local university, that provided initial training and boosted the skills of residents.
- By making use of city infrastructure (libraries and bus stops) the city was able to secure the technology and to maintain it.
- A comprehensive publicity campaign that made people aware of the facility, including posters at the libraries and in buses explaining the service to residents.
- Allowing uncontrolled use of the Internet, the city has engendered a sense of empowerment and allowed residents to be inventive about how they use the facility and what interests they pursue.

While Johannesburg is a large and fairly well-resourced city, this initiative can be adapted for smaller cities or those with resource constraints. Cities can roll out wireless hotspots incrementally as funds become available. Partnerships with network providers can be forged to cover some of the costs.

Case 6: Resident feedback system

The problem

Swachh Bharat Mission (Clean India Mission) was introduced by Prime Minister Narendra Modi in 2014, with the intention to enable India to become clean and free of open defecation.[72] Over 60 000 000 individual latrines have been constructed, and their locations are recorded on Google maps. However, the real task is their maintenance and upkeep. Depending upon location, a public toilet might be used by many individuals and needs to be kept clean. Cities across India are evaluated by the Swacch Survekshan annual cleanliness survey conducted by Quality Council of India.[73]

Government works best when people are directly engaged in public service delivery and the Swacch Survekshan allocates marks for resident feedback which includes feedback on the cleanliness of the public toilets. The use of an ICT-based feedback system holds 10 marks under Swacch Survekshan 2020. However, any solution for feedback needs to be simple, cheap and easy to operate and maintain.

The solution

A simple but smart technology intervention aims to address the issue by installing a simple feedback mechanism at each public toilet. The device has three buttons, green, yellow and red, that can be pressed to signify that the experience of using the toilet is good, neutral or troubling. A wall-mounted unit needs only a power supply connection and a place to be installed, and most public toilets already have a power connection. The device is very affordable, averaging INR 5000 for each unit, and the operational cost would include electricity charges. It can be retrofitted in any public toilet. It is enabled with GSM/IoT and there is a backend system in place for relevant reports and a dashboard.

When the button is pressed, a sensor is triggered, and a notification is sent to the server. Notifications are typically sent using a GSM SIM card in the device, and this has proved reliable as network availability has improved. The device location and the feedback are captured. At some locations, instead of the device, a mobile app is used to give the feedback after scanning a QR code. Feedback using a free SMS service is also available and can be used without a smartphone.

The results of the feedback are reflected on a dashboard.[74] An alternative is that reports can be sent to the city officials on a daily or weekly basis. In some cases, consistent negative feedback can trigger an automatic text message to the caretaker, advising them to improve their facility. If the device is not working, the site supervisor informs the supplier.

Results

This system has been implemented since 2015 in many Indian cities that are part of the Swacch Survekshan, such as Indore, Navi Mumbai and Ahmedabad. Benefits of the system have included:

- Cleaner public toilets, better sanitation for residents.
- Better experiences of people using public toilets, leading to less open defecation.
- Data collected helps the city to see which toilets are used most frequently or experience the most problems.
- The city is able to monitor the performance of contractors and intervene to address problems.
- Residents have the opportunity to give feedback and feel that they are heard.

There were also some challenges:

- At some site, the site-supervisor kept on giving only positive feedback.
- Sometimes there are problems with the device like connectivity & network issues.
- In cities where power failures are frequent, the device does not work during the outages.
- Some of the devices are not water-resistant and this has caused them to fail.

Keys to success

Support from the urban local bodies and contractors, recognising the importance of sanitation, was a major factor in making it a success. Site supervisors are important in ensuring that the system is working and to improve the rate of use, as well as to respond to negative feedback. City officials need to check the dashboard, analyse the data, investigate and respond to recurring problems.

The need to be ranked as a city with a good Swacch Survekshan score, helps maintain the momentum to collect resident's feedback. The first Swacch Survekshan survey was undertaken in 2016 and covered 73, mostly larger, cities. By 2019 the survey had grown to cover 4237 cities. It is said to be the largest cleanliness survey in the world.

Different funding models exist with some cities contracting to have the devices included in a service contract, rather than paying for the devices outright. This allows cities to adopt approaches that work for them. Costs can also be adjusted based on the functionality of the system.

3.4 Experiences of the city

Thus far, the report has considered the provision of city administration services, environmental concerns, and the relationship the city has with the people in it. A key aspect of smart cities is the experience that people have on a day-to-day basis of living in the city. Many smart interventions have a direct impact on this day-to-day experience. The experience of the city includes where people live as well as the spaces in which they work, socialise, seek out services, and spend their leisure time. A key aspect of the experience of the city is how people move about in the city, including their experiences of walking and using transport. This section delves into simple, smart interventions that can improve these experiences.

The city influences housing provision through planning and building regulations. These are mostly long-term initiatives and so are not considered in this publication as they don't meet our criteria for being simple. Likewise, the spaces that people occupy for business, social activities, and leisure activities are planned for in the longer term. There are simple interventions that cities can make to improve existing infrastructure. For example, cities are increasing the use of their parks and green spaces through maintenance, improved lighting and the provision of exercise and play equipment. When it comes to transport, major changes such as the provision of different transport modes, also require long-term planning. However, there are also simple interventions that can be used to make incremental improvements.

3.4.1 Experiencing the city on foot

When more people in cities walk, they are healthier and cities are less polluted, noisy and dangerous. Walking in cities can be encouraged by improving the walkability of streets. Researchers have developed a simple tool to assess the walkability of city streets. This tool, in the form of a spreadsheet, is easy to apply and to adapt to local conditions. Making use of an assessment tool like this can help the city to identify ways in which walkability can be improved, and also to prioritise where such improvements should be made.[75] In general, work that improves city surfaces and removes obstacles is simple and smart because it also benefits people pushing prams, using wheelchairs, or wheeling their groceries home in a cart.

One important aspect of walkability is the need for streets, parks and parking lots to be well lit. Streets that are well-lit are safer and more pleasant to walk in after dark. Smart lighting not only provides light, and manages the cost and energy consumption involved, it can also turn street-lights into an intelligent resource providing services such as Internet access, environmental sensors, crime detection and traffic monitors. Adding Internet access to street-lights changes the experience of the street for pedestrians who are able to access information and entertainment as they move through these spaces. In Case 7 we examine smart street lighting solutions as a simple and scalable smart intervention for cities.

Active transport includes transport modes like scooters and cycles that are human-powered. These modes of transport give people the ability to travel a bit further than when walking, and so can provide good connections between where people live and public transport; the 'last mile'. It may be possible for cities to better accommodate such modes of transport with minimal change to infrastructure, by, for example, reallocating street space to bicycles, or identifying and paving areas that connect spaces. Many cities are making use of private or public bike-sharing systems. Such systems have been very successful in some cities, but have created problems of congestion, waste and safety in other cities. Cities that are interested in exploring such solutions need to carefully assess their suitability for the local context.

3.4.2 Public and private transport

The experience of cities is greatly enhanced by an effective public transport system that enables people to move around the city using a range of transport options. While major long-term changes to public transport are seldom simple, there are smart interventions that can be implemented easily. One of these is the creation of a public transport information system, using the freely available Google Transit platform. Using standards, open protocols, interoperable components and already existing solutions can all contribute to keeping smart interventions simple. If city residents or visitors have to interact with a solution, adopting a well-known application has even more benefits, as it reduces the challenge of learning to use it. The public transport information system described in Case 8 is a good example. It uses a very popular solution, already known and used by more than 1 billion people.

Public transport can also be enhanced by providing Wi-Fi at stations or in the vehicles, by integrated ticketing solutions that simplify payment, and by integrating assistive technologies for hearing and visually impaired people, such as voice instructions at a ticket vending machine.

The use of private cars in cities creates congestion and pollution. It also makes for a poor city experience. In the United States, some 73 percent of the metropolitan workforce spent more than 90 minutes commuting to work, while an estimated 30 percent of traffic in urban areas is caused by cars looking for parking.[76] While many cities, particularly in Europe, are actively planning to reduce the use of private cars, the reality is that private cars will continue to play a role in cities in the near future, because of their convenience. Smart interventions can, however, help cities to manage the impact.

The European Union's Empower initiative looks to change the ways in which people move around cities by helping cities to make changes that encourage the use of active transport, shared transport (such as taxis) and public transport.[77] They have developed tools to help cities to design business models to reduce private car usage and incentive plans that motivate behaviour changes. They have also developed a range of apps that cities can use to support these plans.

One of the challenges with private car ownership is that most cars stand idle for much of the time.[78] In some cities it has been estimated that up to a third of city real estate is devoted to parking. While drivers struggle to find parking, lot owners report underutilization, excess capacity, and lost revenue. Smart solutions can assist in optimising the use of existing parking space by directing drivers to vacant spaces using apps that show pricing, distance, popularity, and number of remaining spaces. For cities and private companies that operate parking lots, smart solutions can be used to improve revenue collection through the use of license plate recognition, e-ticketing, and the automated recording of parking time. Smart parking solutions are widely deployed, with their complexity and ease of deployment depending on the features that are used. Such smart interventions can be useful for cities wanting to decrease the use of cars as they can help cities to pass on the full cost of car ownership to drivers, ensuring that cities are not subsidising private car ownership. Parking revenues can also be used to support initiatives that encourage behaviour change.

3.4.3 The future of city mobility

During 2020 city dwellers got to experience their cities without traffic and experienced a return of birds, a lack of noise and clean air. This has led to renewed interest in reducing congestion in cities and reclaiming space. As people return to the streets, the need for people to maintain a healthy distance from others has led to greater interest in more space for pedestrian walkways and for cafes and restaurants to spill out onto the street. Cities have been closing streets and widening walkways. While some of these changes will be temporary, the general desire to lessen social density will be lasting. At the same time, fear of using public transport has increased the use of private cars. To avoid losing the benefits of public transport, cities are going to have to allay such fears.

It is unlikely that cities will be able to do without vehicles entirely. Deliveries need to be made and people need to transport bulky items to their houses. However, in some cities, there is already a trend away from driving with young people ignoring the need for driver's licenses and fewer people owning cars. These people then also raise awareness of the need for public transport and streets designed around people rather than cars. The increased use of shared vehicles results in fewer cars and less parking space being needed. The prospect of driverless cars introduces the possibility in the future of easy to summon, individual transport that is safe and convenient. These changes suggest that in the future roads will be more multi-purpose and the design of cities will change to accommodate changing needs. For now, cities can begin to engage with residents about what such a future city might look like.

Case 7: Smart street lighting

The problem

Lighting provides access, convenience and safety, greatly enhancing the experience of the city, but is one of the biggest expenses for most municipalities, constituting up to 40% of the total budget. Public lighting contributes to around 19% of the electricity production and is responsible for about 6% of greenhouse gas emissions.[79]

At the same time, cities are challenged to bring more services into cites such as video monitoring, environmental monitoring, public wi-fi, public address systems, electric vehicle charging and small cell networks like 5G.

The solution

A combination of LED's and IoT sensors can bring significant saving for municipalities. LED-based lighting by itself brings considerable energy savings, but autonomous operation of the lights, based on the environment (ambient light) and human presence (motion sensors) can bring further reductions in energy usage, as well as reducing light pollution. For example, lights can be switched on at sunset, to a low intensity and become brighter when they sense people nearby. If the lights are connected to a network, they can be monitored and controlled remotely. This enables efficient maintenance and, with analysis of the usage patterns, constant improvements in the service.

At the same time, lighting poles are being re-invented as smart poles to provide additional services on the street.[80] They can be used to mount a range of sensors, to support digital displays and public address systems, as points for EV charging and to provide Wi-Fi connectivity. Not all cities will need all of these services, but the infrastructure provides flexibility to tailor a system to local needs.

With proper maintenance, the lifetime of a system of smart street lighting can be around 20 years. The system starts delivering value immediately, through energy savings. The cost of such a system will depend on the services that are included. Where existing infrastructure is retrofitted the costs can be significantly reduced. Smart street lighting can be implemented incrementally, starting with one area or with a limited range of services, and expanding as funds become available. A resource-constrained city should start with some basic features as a pilot project and expand as cost-savings are realised.

Results

Smart street lighting has been implemented in many cities with well-documented results:

- In Jaipur, India, savings of 72% in energy and a significant reduction in CO2 and light pollution were achieved with a connected smart lighting solution.[81]
- In Texel, a small Netherlands island, a 60% energy saving was achieved with reduced light pollution and increased safety using a centrally controlled lighting system.[82]

- Groningen, Netherlands, reduced energy usage and maintenance costs by 50% and increased public safety using an intuitive lighting solution that automatically dims based on movemen.t[83]
- Cardiff, Wales, used a retro-fitted solution to replace 14000 street-lights with light-emitting diodes (LEDs), with wireless central monitoring to achieve 60% savings in energy with better control and operational insights.
- Los Angeles, USA, replaced 180 000 street-lights with LEDs resulting in a 65% energy saving and reducing CO_2 emissions by 65000 metric tons annually.

Apart from cost and environmental benefits, these projects have resulted in a better sense of safety for residents, as well as employment opportunities.

Smart poles are an excellent candidate for local innovation, as they can be designed and constructed to meet local requirements and challenges. Considerations such as the style and design can be adapted to use local parts and materials, and adapted to integrate with existing lighting poles. Energy sources can be adapted based on local conditions, such as providing solar power in areas with inconsistent electricity provision. Such local innovation can provide opportunities for local businesses.

Keys to success

- Cities that have succeeded with these projects had a set of goals and benefits to achieve.
- An important first step is the unbiased research of the problem, possible solutions and the long-term holistic benefit of implementing such an initiative.
- Implementation depends on a clear scope and scale. Cities are advised to start small, with a simple set of services and then scale. A larger project should be phased with clear deliverables.
- The implementation of the project will involve the solution proposal, evaluation, pilot implementation and evaluation, full implementation and evaluation.
- Close collaboration is needed between local government, implementation partners, technology advisors, vendors and the public.
- To derive the benefits throughout the product life cycle, sound planning is needed, careful evaluation of the vendors' abilities and ensuring access to parts for up to 20 years.
- A staffing plan is needed to ensure that the system can be serviced across the entire lifetime; this might entail using vendor staff initially, but needs to include development plans for city staff with escalation to vendor support where necessary.
- Cities need to secure funding.

Case 8: Public transport information system

The problem

Cities generally provide multiple forms of public transport such as buses, taxis, trams, subways, ferries and trains. Traditionally information about these options has been published by the different companies that provide the services on their individual websites. For residents and visitors, it can be very time-consuming to work out what options are available, where and how to use them and what the optimal options are for moving around the city.

The solution

A Public Transport Information System greatly improves the mobility experience in cities. It integrates data from available public transit modes and informs the passenger:

- Alternative routes connecting an origin to a destination.
- Schedules.
- Location of stations.
- Integration information – where and when the different modes connect.
- Trip duration.
- Trip cost.
- Up-to-date departure and arrival time.
- Real-time service alerts.

Google Transit is a free platform that cities can use to create a Public Transport Information System easily and cheaply.[84] Passengers can plan trips using the popular Google Maps application which is available for most smartphones and Internet browsers. Google Transit accepts information about publicly accessible services operated on fixed routes and schedules. Bikeshare programs, car rentals, campus shuttles and taxis are not accepted. Using this solution, almost any city can provide useful public transport information for passengers.

The city[85] provides static data (stations and routes), and real-time data (vehicle positions), using a public documented protocol, the General Transit Feed Specification (GTFS). Real time data is optional but allows the system to provide live transit information, up-to-date arrival and departure times and other service alerts. The tools used to set up the system are very simple, mostly related to converting and formatting data. Even the geo-referencing of stations and routes can be done using free and well documented products, such as Google Earth.

It is a short-term project. Benefits can be expected in a few months. The time for a city to implement the solution depends on many factors: transit modes, number of stations, routes, trips, whether the transit data is already geo-referenced and the experience of the technical team. As a reference,

a city with a population of 2 million, 200 routes operated by 1000 buses with 5000 bus stops, using a two-member team and with information about the schedule, routes and location of stations being available, will take no more than a few months to learn how to use the platform and prepare, test and publish the static data. Once the data is published by Google Transit, the benefits are immediate: city residents, visitors, frequent and occasional passengers can use Google Maps to plan their trips.

This system is low cost. The city does not pay to publish the transit data. The main cost for the city is to prepare and keep the GTFS files updated. The passengers can use the service for free, only covering the cost of the Internet connection. The city does not pay for the ICT infrastructure and servers to provide the service to the passengers, nor is it responsible for producing, distributing and maintaining the app (Google Maps) used by passengers. Google Maps is free, well known and used by more than a billion people every month.[86]

Results

Public Transport Information Systems based on Google Transit are already used in more than 70 countries in Africa, Asia, Australasia, Europe, North and South Americas.[87] London, Paris, Madrid, Lisbon, Tokyo and New York are some of the cities that use the service.

The metropolitan area of Goiania in Brazil is an example. Five companies operate a bus transport network covering 6576 km^2 and 18 cities, with a population of more than 2.2 million. The system has more than 1200 buses, 290 routes and 6400 bus stops. The public and private agents responsible for the service are integrated in an organization named RMTC.[88] In 2009, RMTC developed a Public Transport Information System with many components, including information systems, a call centre, terminal and station signage and a service to help passengers plan their trips.[89] Google Transit was used for the latter.

A Public Transport Information System benefits the city by:

- Saving time for passengers by easily providing information.
- Giving passengers information to choose the best route depending on their needs, for example: fastest, least transfers, most scenic, least walking, wheelchair accessible, etc.
- Contributing to the effort of moving people from private cars to public transport.

Keys to success

It is important to keep the data up-to-date and publish all changes in the public transport network. Google Transit files should be automatically generated by the public transport systems. All changes will be published to the passengers with minimum effort. The same parameters used to operate the network will also be used to inform the passengers, reducing errors.

It is very important to have the participation of all operators that serve the same region. If the tram operator does not provide its data, for instance, this mode will not be used to calculate the best route for the passenger and the quality of the service will be reduced.

Although large and complex public transport networks may benefit more, the ease of use and the low cost of the solution suggest that it may be viable even for small cities with a few routes. This is especially true if the city receives tourists and other visitors or is part of a larger metropolitan area.

3.5 City resilience

Resilience can be defined as "a measure of the persistence of systems and of their abilities to absorb change and disturbance and still maintain the same relationships between populations or state variables".[90] Urban resilience has been explained as the "ability of human settlements and organisations to recover quickly from and continue to prosper in the context of increasing impacts of natural and man-made changes or disasters".[91] A resilient city is one which can "tolerate disruptions before reorganising around a new set of structures and can anticipate, prepare for, respond to and recover from a disturbance".[92] Urban resilience is increasingly important as the number of city-dwellers grows and natural disasters and social tensions threaten the regular life of cities.

Most pertinently, the importance of resilience has been highlighted since the Covid-19 pandemic. States, businesses and individuals have called attention to the need for greater resilience of cities in the face of the pandemic and the subsequent food shortages and economic challenges.

Smart technologies give cities new tools for taking preventive measures, responding to emergencies, and planning for longer-term sustainability and growth. Kupers & Ching[93] developed a resilience framework for smart cities, with three main categories of:

- Structural resilience which refers to the 'systemic and infrastructure aspects of resilience'.
- Integrative resilience which highlights the 'complex interconnections of the system'.
- Transformative resilience which examines broader capacity issues and longer time horizons in terms of distributed governance, foresight capacity and innovation and experimentation.

Cities have recorded success in improving the quality of life of their residents by improving their structural, integrative and transformative resilience. Singapore, a very water-scarce area, improved its water system by using new techniques and technologies, from desalination to setting specific water catchment areas. Bogotà worked on the social issues mushrooming from heavy traffic problems, expanded its sidewalks and saw a decline in crime rates in some neighbourhoods as a result. The Netherlands enhanced its flood management system by designing new infrastructure and technologies. In all these cases, uncalled-for social and infrastructural problems were countered through the use of smart designs and technologies.

3.5.1 Characteristics of resilient cities

Resilient cities reveal several qualities that allow them to withstand, respond to, and adapt quickly to shocks and stresses.[94] Cities can work to develop these characteristics. Some simple actions that cities can take are noted in the table below.

Table 3: Characteristics of resilient cities and how to develop them

Characteristic	Description	How to develop this
Adaptive	Manages uncertainty by evolving – modifying standards, norms or past behaviour; uses evidence and knowledge gained from experience when making decisions about the future	Become persistent about measuring and monitoring to understand what works and what does not; change anything that is not working, observe the results and iterate until it works
Robust	Able to absorb shocks and emerge without significant loss of functionality; robustness depends on a system that is well-designed, built and managed to absorb the impact of a shock and continue to operate	Evaluate points of weakness in key city systems and strengthen them; make plans for longer-term improvements of critical weak points
Redundant	Intentionally develops or creates access to more than one source of action, service or service provider so that spare capacity is available when faced with unexpected demand, a disruptive event or extreme pressure	Work with a wide range of suppliers, organisations and other city stakeholders; identify key points of failure and plan for redundant infrastructure, systems and skills
Flexible	Individuals, households, businesses, communities and government adjust their behaviour or actions to respond rapidly to change	Encourage flexible behaviour in the municipal structures by encouraging changes that are supported by evidence and monitored for effectiveness
Resourceful	Uses available resources in innovative ways and sources additional resources when required to effectively and quickly restore essential services and systems in a crisis or under highly constrained conditions	Encourage problem-solving using available, local resources, rather than seeing costly, inaccessible "best" solutions as the only option
Inclusive	Diverse actors and communities are fully consulted, engaged and empowered in the policy process, including in the policy design stage, when possible	Use simple technologies to engage all city stakeholders in designing policies, making decisions, innovating, implementing interventions, and evaluating the results
Integrated	Uses a co-operative and, ideally, collaborative, or participatory approach to policy and programming that transcends sectoral and administrative boundaries to better ensure coherent decisions and effective investment	Work to cross boundaries between city functions and systems, and to encourage participation from a wide range of city stakeholders

3.5.2 Developing resilience – knowledge

The first step towards developing resilience is to better understand the potential for crises in each specific context. Smart tools that improve what cities know about their current state as well as real-time information that helps cities to observe the impact of interventions as they happen, better equip cities for absorbing shocks and to find effective adaptation and recovery solutions faster. A central database and dashboards with data visualisation tools can help planners to use geospatial mapping to understand conditions in the city and to make better-informed decisions.

Using technology to collect data reduces the cost of gathering data and provides cities and their occupants with real-time information. This information can be used to improve existing systems in ways that enhance the sustainability and resilience of cities.[95] Information can be used to influence behaviour by, for example, redirecting people to different transit routes, or to use less energy and water, or to adopt preventive health-care measures that reduce the strains on healthcare systems. Data collected from sensors integrated into city infrastructure can be used to manage service provision crises, as was the case in the Cape Town water crisis of 2017, which used sensors integrated into its water system and electrical meters.[96] Data from social media sites can be used to provide cities with real-time information about what their residents are doing and feeling. Crowdsourced information can be crucial in times of crises, helping cities to, for example, map out evacuation routes, or ascertain the occupation rate of shelters.

3.5.3 Developing resilience – planning

One simple step that cities can take towards resilience is to plan ahead. Cities can start to develop a resilience strategy framework. Such a framework would include:

- Policies and measures to detect, prevent, prepare for and respond to climate change and natural disasters, based on the guidelines of the United Nations Office for Disaster Risk Reduction (UNDRR) Sendai Framework and the United Nations Framework Convention on Climate Change (UNFCCC).
- An assessment of the most relevant climate change and natural disaster risks and impacts for the city, such as changes in air quality, sea level, food security, biodiversity, etc.
- An assessment of the most relevant human-induced risks and impacts for the city including civil unrest, war, migration, etc.
- Plans to monitor the most important risks and impacts, to assess the cost, and to reduce vulnerability.
- Design of resilient infrastructures and systems for the prevention, mitigation, adaptation to and recovery from anticipated and potential risks and impacts.

- A financial plan to meet the requirements of operational risk management, based on Public Goods Valuation.
- Awareness building and institutional capacity building initiatives on risks, mitigation measures, impact reduction, crisis management, adaptation, etc.

While cities may not have the capacity to create a full and detailed framework, plans to address even one or two of the most pressing concerns will benefit the city.

3.6 Securing city e-governance

As cities increase their use of digital tools for providing services and for engaging with city stakeholders, the potential increases for crises that arise from disruption of the digital infrastructure. Cities might be smarter, but without considering their cyber-resilience, these tools might not be available to manage physical crises. Disruption to online services may, in turn, become crises. For this reason, smart cities need to take some simple steps to manage their e-governance systems. These include:

- Security: Making use of automated vulnerability detection tools in their e-governance systems and assets.
- Reliability: Preventive maintenance of e-governance system assets and automated tools to identify points of failure (database, servers, power supply, networks, software, etc.), with fault-tolerance or fail-over mechanisms.
- Database security: A documented and tested backup and restore plan to recover databases with adequate support of version control, data integrity & data encryption mechanisms for transmission over secure networks.
- Data-centre security: The city's data centre should have 24/7 security monitoring with proper alarm systems for security violations.
- Application server security: Incorporation of security protocols and certificates, antivirus solutions, along with proper role-based multi-user access controls.
- User training: Periodic training to ensure that all system users are properly aware of good practices as well as the business processes, system functionality, system risks, user roles and access rights needed to perform their jobs effectively and safely.

Using a shared service data-centre which hosts the city's applications and data is often more secure for a city than trying to run their own, because the service provider is able to provide optimal physical and technical security.

Case 9: Aquaponics for food security

The problem

Communities living in regions of the world where land is expensive, water is scarce, and soil is poor, particularly those in arid or semi-arid areas and small island developing states, depend to a great extent on the import of food and many products to satisfy their nutritional requirements. In some of the Caribbean SIDS, nearly 80 percent of the food consumed is imported. This high dependency on food imports leaves many SIDS extremely vulnerable to things like commodity shortages, transportation disruptions, and exchange rate fluctuations, among others.

Moreover, in parts of the world with very high urbanization rates, many natural resources, including soil and freshwater, are already overexploited. Countries are faced with resources limitations including a decrease in arable land, constrained freshwater supplies, soil degradation and soil nutrient depletion. These conditions present similar threats to food security. Even where countries have sufficient food, there are concerns about the quality of the food with many consuming diets that are energy-dense, but lacking in micronutrients, leading to obesity and diet-related chronic diseases.

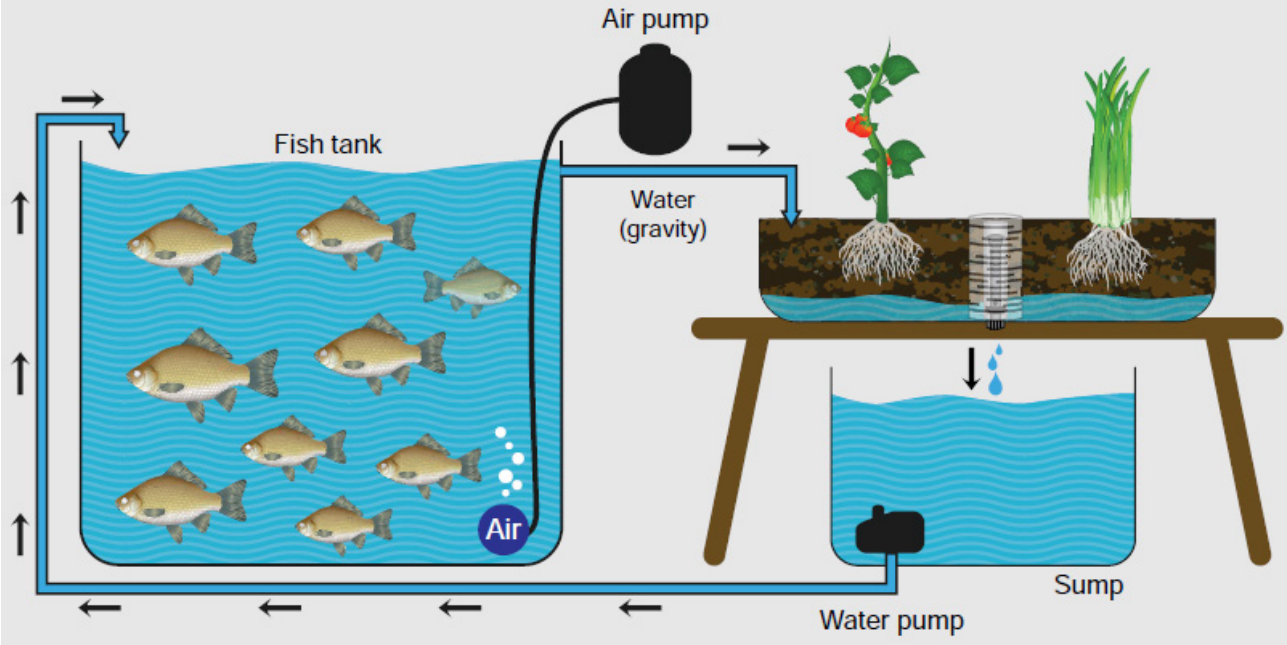
In cities, hunger exacerbates many other social problems and this has been particularly highlighted during the COVID19 crisis that has impacted food availability in many cities. Cities are thus taking an increasing interest in food security and are formulating strategies to ensure adequate supplies of nutritious food.[97]

The solution

Aquaponics, a method of growing agricultural crops without the use of soil, provides a sustainable alternative to conventional farming and food production.[98] It is a practice based on natural ecosystems that does not deplete non-renewable resources and appears to be a promising sustainable food production method.[99]

Aquaponics combines two well-established practices: recirculating aquaculture systems (RAS) and hydroponics. Recirculating aquaculture systems use biofiltration to clean the water in fish farming where fresh water is limited. They reduce the need for fresh, clean water while still maintaining a healthy environment for fish. Hydroponics is a method of growing plants without soil, using a liquid nutrient solution. Hydroponics is used for growing plant crops, particularly vegetables, using a fraction of the water that would normally be used. Aquaponics combines these two practices to both farm fish and grow vegetables, with the plants filtering the water and the fish fertilizing the plants.

Figure 1: Aquaponics system [100]



The benefits of aquaponics include:

- It is a closed-looped system where very little waste is generated and inputs are minimized.
- Extremely water-efficient and hence an option for areas with limited fresh water.
- Appropriate for areas with poor quality soil because it requires no soil; avoids soil degradation, including soil compaction, salinization, depletion, pollution and disease.
- No fertilizers or chemical pesticides are required, producing healthier food without environmental damage.
- Can be used in urban and peri-urban environments where no or very little land is available, providing a means to grow dense crops on small balconies, patios, indoors or on rooftops.
- Aquaponics is adaptable and can be developed with local materials and domestic knowledge to suit local cultural and environmental conditions.
- There is a wide and growing information base about aquaponic farming, including readily available online resources.
- The technology and techniques are relatively simple and easy to adopt, with initial support for farmers.
- The daily tasks of planting, tending to the system, and harvesting are less physically strenuous than traditional agriculture and can be done by people with less physical strength and stamina.
- Better control of production leads to fewer losses.

Results

Currently, aquaponics serves many worldwide communities with limited freshwater resources, limited suitable land for other agriculture production systems and high market prices for fresh vegetables and fish. Reports on progress include:

- In **Antigua** and **Barbuda**, entities including, Indies Greens, Lincoln Farms, Barbuda Research Centre and individuals have adopted aquaponics. There have been activities to build awareness of this form of food production through school tours and a fish fry. Information and resources are limited, but Indies Greens are providing training in aquaponics.[101]
- There has been research into the economic viability of aquaponics farming in **South Africa**, and an organisation in Grahamstown is offering support, equipment and online training in aquaponics.[102]
- A study conducted in **Mauritius** found that there was considerable interest in the technology but little knowledge of the techniques. Strong market demand for vegetables would support such farming, although a local preference for marine fish would limit the market for the freshwater fish used in aquaponics.[103]
- Projects in **Gaza** have provided households with aquaponics kits and training that have enabled them to supplement household food with vegetables and herbs.[104]

From these and other projects, it has been established that hydroponics can provide households with nutritious supplements to their food supply. It also gives small-scale farmers the potential to earn a supplementary income and, for commercial farmers, it is a viable business with economic, health and environmental benefits. In addition, aquaponics opens up possibilities for technology innovation with the commercial development of equipment such as plug-and-play-type modular aquaponic kits, solar-wind powered chilling and dehydrator units and smart water grid management systems.

Keys to success

While aquaponic farming is relatively easy, it does require investment in equipment and training to start with, and a base of locally-appropriate technology and techniques. For example, in areas with unstable power, equipment that can use alternative power sources may be necessary.

Cities can support improving food security through aquaponics by partnering with researchers, agricultural organisations and business incubators to support farmers with training, access to finance, equipment and stock, and expert consultation. Networks of smaller producers should be encouraged to facilitate buying equipment, fish stock, feed, and seeds in bulk, at a cheaper price and can thereby lead to opportunities for scale up and commercialization.

Large-scale systems require careful planning and financial viability assessment including the availability and affordability of inputs (fish feed, buildings and plumbing supplies), the cost and reliability of electricity, access to markets and the prices those markets will support.

Case 10: Conscious crisis management

The problem

It is difficult to prepare for crisis management because crises don't happen often enough for cities to develop the necessary skills. As a result, when crises do hit, cities do not always manage them in the most effective manner. Having a conscious approach to crisis management can help cities to learn from the crises they do encounter and to develop the skills to manage crises more effectively.

For many cities effective crisis management is hampered because of the ways that cities are structured and usually operate. For example

1. Decision-making processes are slow and deliberate, with layers of approval and checks.
2. Organisations are structured to divide city operations into manageable units.
3. City structures are hierarchical, with approval processes that follow the hierarchy.
4. Municipalities are part of greater state or provincial and national structures.
5. Political considerations need to be taken into account when decisions are made.

The solution

By using a structured review of crisis management, cities can start to identify what is hampering effective crisis management and to develop the processes, structures and skills to be able to respond more effectively to crises. Researchers have identified a structured process that municipalities go through during the crisis.[105] In Table 4 the steps in this process are identified, using the case of the Joué-les-Tours drinking water crisis as an example. Phases 3, 4 and 5 might be repeated as different options become available.

Table 4: Phases of crisis decision-making

Phase	Focus	Example
1	Identify the inflection point between normal and crisis situation	Two facts became obvious: (1) the city's entire water supply is from the Loire and (2) the water in the Loire may be contaminated
2	What makes the risk become acute?	A reaction is needed and cannot be delayed further without endangering people's health
3	Possible decisions are considered and the effects that will be triggered are identified	If, for example, the city's water supply is stopped then alternatives will be needed to get water to people
4	Resources are assessed	The means to get water to people are assessed and the available resources measured
5	The decision is evaluated	With the collected information, it is now possible to evaluate the impact of the decision and possibly suggest different options
6	Action is taken and the collective system retracts against the crisis	The water supply is stopped and alternative water supply measures are initiated; the scenario plays out

A "simple and smart" structured review method might include the follow steps:

1 All information about the crisis, the responses and the consequences is recorded and stored in the municipal archives.

2 Identify a facilitator with good interpersonal skills and an auditor to record the sessions.

3 Establish a list of the main actors in the crisis and other parties that are interested in the review.

4 Invite teachers to the review so that they can take account of lessons learnt and develop new best practices.

5 Identify the stages of the unfolding of the crisis and what happened at each stage in a factual manner.

6 Identify the main points that impeded progress during the crisis and understand why.

7 Make use of traditional consulting tools such as a SWOT analysis to better understand the effectiveness of city responses.

8 Use a participatory tool to get the opinions of the local population of the city's handling of the crisis, immediately and up to 2 years after the event.

9 Identify changes in structures, processes or practices that will be able to ease the response to similar crises in the future and draft recommendations to the appropriate structures.

10 Set up steps to monitor the implementation of recommendations, built into city annual plans.

Results

The following are examples of cities that have used these structured approaches to better understand their crisis management processes.

- IPSN Fontenay-aux Roses analysed relevant social and behavioural aspects of communication and identified behavioural insights to improve communication campaigns.
- Joué-les-Tours, the largest suburb of the city of Tours with 37 500 inhabitants (in 2016), examined what the actors employed by towns and involved in the emergency management thought about the emergency response to the crisis caused by the pollution of the city's drinking water in 1997.
- Toulouse, the capital of the French region of Occitanie with 479 553 inhabitants (in 2017), used this approach to conduct a sociological survey on the impact of the explosion at the AZF fertilizer factory in 2001 and observe in situ emergency services at the public hospital.

The benefits reported by cities include the imagining of new infrastructures to replace damaged ones. In Toulouse, the damaged site has been replaced by a medical centre. Social networks have densified as NGOs were created in the area most affected to help the vulnerable. These NGOs became permanent and were still active in 2014. In municipalities, new services of crisis prevention were created providing both better ways to deal with a crisis when it occurs, as well as implementing prevention mechanisms. For example, at Joué-les-Tours, the sites that water is sourced from have been diversified. A database of disaster responses has been compiled for further research and analysis. An unexpected consequence was to infuse a spirit of prevention among the residents about potential accidents and the need to prevent them.

Keys to success

The following have made these analyses of crisis situations effective:

- Involve both local and national offices to share information and lessons learned (in France a disconnect between state and mayor's offices has hampered crisis management).
- Support from the municipalities and a genuine desire to change an organizational dysfunction.
- Identifying micro-mistakes that accumulate to make the situation impossible to manage.
- This process worked in middle-sized cities but may be less effective in larger cities where city functions have a high degree of independence and it may be more difficult to make a holistic evaluation.

his tour

4 Understanding simple ways to be smart

Frameworks have been proposed to help cities to understand smart city interventions. These frameworks enumerate technical architectures, the dimensions of the city, and give criteria for structures and processes that cities will need to be smart.[106] Such frameworks are readily available to cities online.

Here, the report aims to create a simpler framework that highlights just two key aspects of smart interventions: information and communication. This framework requires no special infrastructure of cities, nor any particular structures and procedures. Rather it serves to raise awareness among cities of the key features that make interventions smart and to help cities to evaluate potential interventions

4.1 Case analysis

In the discipline of Information Systems, it has long been recognized that information and communications technologies essentially facilitate two things. Firstly, they facilitate the collection, storage and analysis of data, especially in volumes and at levels of detail that were not possible in the past. Secondly, they facilitate the communication of information rapidly, conveniently and across distance. These two characteristics of information and communications technologies can be seen in the case studies described in this report.

The table below provides a brief analysis of the ten case studies indicating how each of them:

- Collects, stores and analyses data, (either existing or new), and
- Communicates information between stakeholders.

Table 5: Analysis of cases in terms of information and communication

Case	Information	Communication	Outcomes
1 Electronic document and record management	Digitalization of documents Cloud storage Electronic signatures City website for employees and the public	Electronic sharing of documents The option for programmed workflows Residents use a website to make and view requests	Reduced face to face interactions Faster services Reduction in paper and printing Facilitates remote work
2 Smart fleet management	Data base of vehicles, their status and history Explicit policies Maintenance records to optimize procedures Tracking of expenses	Automated notification for maintenance and replacement Sensors and geo-location for real-time data about vehicle use Dashboard to monitor fleet performance	Improved compliance, maintenance, record-keeping Increased security Reduced emissions Culture of control and efficiency
3 Air quality monitoring	More data, collected from more sites Improved knowledge of specific, localized air quality concerns	Low-cost sensors collect data from more positions Website or mobile app to communicate results Partnering with researchers to understand technicalities of sensors and how to interpret the data	Improved awareness of air quality concerns Cities can take action to address key areas for air quality
4 The role of informal waste collectors	Imposed administrative, financial and commercial obligations that result in information about who is collecting, what and where	Communication via existing associations with their members Web-based system to communicate progress	Encouraged entrepreneurship Development of the recycling industry Improved working conditions
5 Digital literacy and access	Digital ambassadors with ICT skills	Marketing campaign to publicize the service Face-to-face interactions with digital ambassadors	Increased the number of people in Johannesburg with access to the Internet, thus facilitating other smart city services
6 Resident feedback system	Annual cleanliness survey Opinions of users are collected at the point of service Accumulated feedback is available	Collected data is transmitted using GSM or QR codes and a mobile app or SMS Text messages to care-takers to address problems Dashboard or reports to inform city officials	Management is better informed about public experience Improved sanitation and health Residents feel heard

Case	Information	Communication	Outcomes
7 Smart street lighting	Lights use environmental conditions (e.g., ambient light and human presence) to turn on and off Usage patterns are recorded and give operational insights	Information is transmitted from the lights to the city for analysis using a network Sensors are used to detect environmental conditions	Energy savings Lower costs, including for maintenance Reduced emissions Greater sense of safety for residents
8 Public transport information system	Schedules, location of stations, routes and modes of transport are collected in one place Trip duration and cost information Real-time departure and arrival times, service alerts	Google maps (a well-known and widely-used platform) is used to communicate with users. City shares transportation information with Google Transit by uploading files	Passengers save time and cost by comparing their options Encourages use of public transport, contributes to lower emissions
9 Aquaponics for food security	Information about farming methods, technical set-up Information about markets, access to finance and other business matters	Online sharing of information needed to succeed Partnering with researchers, agricultural organisations and business incubators to support farmers	Good source of food for contexts with limited freshwater or land for agriculture and high market prices for vegetables and fish
10 Conscious crisis management	Information about the crises, responses and consequences is collected and stored in city archives Analysis of the data using defined tools Input from the local population	Face-to-face facilitated review process Participatory tools to collect views of the public Share steps to implement recommendations in city annual plans	Proactive analysis of crises responses and actions to improve in future. Infuses a spirit of prevention among the residents

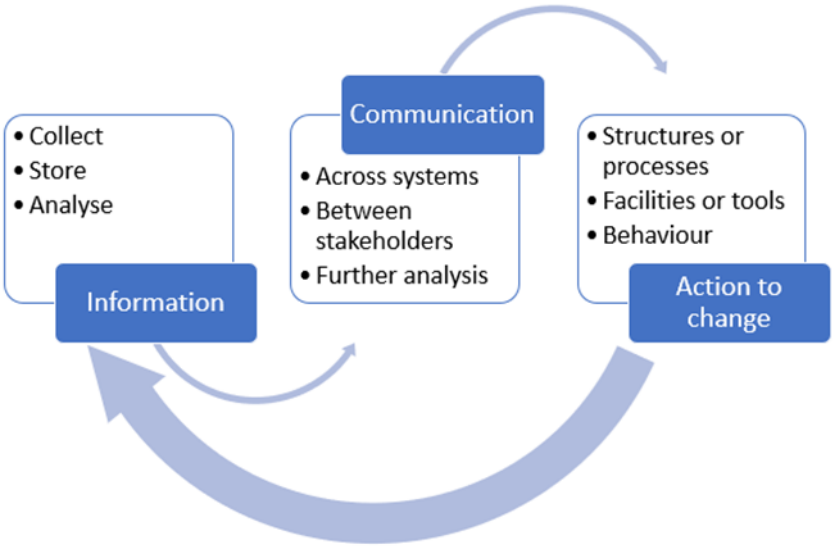
In these examples, it is observed that smart interventions always involve the collection of data and its analysis as well as the communication of information between stakeholders. These two steps are often improved by the use of technologies, but this is not always necessary. In circumstances where knowledge is embedded in individuals, such as in Case 5 (student ambassadors) and Case 9 (researchers) the digital encoding of data may be inappropriate. Likewise, there are circumstances (such as in Cases 4, 5 and 10) in which face-to-face human communication is more effective than that mediated by technology.

Nevertheless, the analysis of interventions in terms of information and communication provides an opportunity for cities to evaluate how each of these two aspects might be addressed more smartly, including through the use of new technologies.

4.2 Smart framework for change

The above analysis leads us to propose the following smart framework for change. This framework indicates that, for any city challenge, the collection and analysis of relevant information, together with carefully thought-out communication, can be used by cities to influence change.

Figure 2: Smart framework for change



In understanding information about a particular city challenge, cities can ask questions like:

1 What data do we have about the situation?

2 What data do we not have?

3 Where could we get additional information about the situation?

4 Are there more effective ways to collect this information?

5 How and where will we store this information?

6 How can we analyse this information to best understand the situation?

To answer these questions cities should consider the new information capabilities that technology enables such as the automated collection of data, cloud storage, and machine learning analysis techniques. At the same time cities should not be dazzled by new technology and should choose approaches that are appropriate to their context, resources and capabilities.

In understanding the possibilities for communication about a particular city challenging, cities can ask questions like:

1 Where is there information about this situation (in a system or people)?

2 What system or stakeholders do we need to get the information to?

3 How do we currently communicate with these systems or stakeholders?

4 Are there more efficient or effective ways to communicate?

5 What needs to be communicated, and how often?

6 Does communication need to be in one direction or in many directions?

To answer these questions cities should consider the new communication capabilities that technology enables such as communication over distances, real-time communication, the provision of information that can be consulted asynchronously, such as on a website, and the use of devices such as sensors and mobile devices. At the time cities should not forget tried and tested communication approaches such as advertising campaigns and face-to-face consultation with stakeholders. Cities should choose approaches that are appropriate to their context, resources and capabilities.

The information that is collected, analysed and shared will enable stakeholders, including city officials, their partners and city residents, to act differently. This could include changing structures and processes within the city, new facilities or infrastructure, or changing behaviour. Any such changes will, in turn, generate new data which can be collected and analysed to develop very accurate understandings of each situation.

This framework provides cities with a simple, information-systems approach to the capabilities of smart solutions, and can be used to analyse where smart interventions can be used to bring about change in response to city challenges.

5 Implementing simple smart

There are guides for cities wanting to be smart that recommend creating smart city roadmaps, planning processes and advisory committees as well as support infrastructure such as a project office, and procedures for monitoring and evaluation.[107] However, special structures, processes and offices are not necessary to begin the journey. For cities without the skills and resources for such comprehensive approaches, becoming smart can be integrated into city planning and existing city procedures and structures. Doing so can strengthen such city functions and an integrated approach is more likely to result in better integrated smart initiatives which directly address the city's priorities.

ITU has produced a guide for cities that are working towards becoming smart and sustainable.[108] This guide makes two important points about becoming smart: first, that each city starts from a different baseline, and second, that there is no final destination to the Smart City journey. The guide presents a process for SSC transformation that includes setting a vision, identifying targets, building consensus among stakeholders, implementing projects, measuring progress and ensuring accountability. This process can be used as a simple guide for city leaders.

This section highlights three key considerations that need to be taken into account and steps that cities might want to take to improve their chances of success.

5.1 Building smart capabilities

As cities work towards being smarter, perhaps the most important consideration is to develop the skills and capacities needed to understand the potential of smart solutions and to be able to plan and manage their integration into the city's operations.

In smart interventions, there is often a focus on technical skills needed to implement technology solutions and cities may feel that their skills base is inadequate for this. However, most smart interventions also require a sound understanding of city administration, the inter-relationships between different areas and levels of government, and of public service budgeting and financial controls. It also helps to have a good understanding of political agendas and the interests of the various city stakeholders. This kind of expertise is likely to already exist in the city, while technical expertise can be contracted in. Cities should not underestimate the importance of their embedded knowledge in designing and implementing smart interventions.

There are two specific areas in which cities need to develop skills to support smart interventions:

1 Improving information capabilities and understanding of the potential of ICTs.

2 Improving their ability to partner and manage partnerships.

Developing information capabilities can start with involving all staff in the use of information systems so that they develop a better understanding of how such systems work. This can be as simple as the use of email and messaging systems in the office as any exposure to information and communications technology helps to build understanding.

More specifically, cities need to develop capabilities in managing and interpreting data. Many smart city interventions are based on the collection and use of data, and cities need to understand the challenges. Cities need to identify staff who can be trained in various information capabilities and to use a mix of formal and on-site development to develop their skills. Some of these skills are technical and involve for example, the collection cleaning, and storage of data. Others are to do with the management of data, with institutional policies, and with concerns such as data privacy. Cities will need staff to be familiar with local legislation and regulations surrounding the collection and use of data and will need to implement procedures to ensure compliance.

Since smart interventions often entail cities working collaboratively with technology suppliers and depend on buy-in and support from other city stakeholders, it is important to develop skills in partnering effectively. Many smart initiatives entail contracting a technology partner, usually through a tender process, and unclear specifications or poorly structured tenders can contribute to project failures.[109]

So, city officials need to develop the skills to undertake procurement processes like

- Preparing a Request for Proposal (RFP), describing a problem and the benefits expected of a solution.
- Preparing tender documentation with all the required terms & conditions.
- Evaluating submitted proposals and selecting the vendor that bests meets all the required criteria.
- Contracting with suppliers in such a manner as to protect the city's interests and ensure success.

Many smart interventions span departments and involve a range of internal and external stakeholders. Open communication is necessary between functional units, particularly where interventions integrate systems and processes across departments. Cities can also benefit from good communication with nearby or similar cities or municipalities. Knowledge sharing between peers can be an effective way to develop knowledge, to identify useful smart interventions, as well as to prevent known pitfalls.

Additionally, cities need to develop skills in communicating with and engaging with city stakeholders, both in the planning stage, to understand city problems and in the implementation phase, to ensure buy-in and adoption of smart solutions. New technologies offer opportunities to interact more frequently and in more depth with city stakeholders, and cities should develop skills in their use, as well as the use of more traditional consultative mechanisms. City government is becoming more collaborative and cities that engage residents, organisations, and local businesses will be able to draw on these partners to contribute to and strengthen their smart city efforts.

5.2 Planning to be smart

Smart city planning needs to be integrated into existing city planning processes and budgets, so as to be problem-driven and not driven by technology-solutions or vendors. Most cities have some level of planning already in place. City plans typically anticipate the key challenges in the city and map out city responses to those. They also include plans for the major functions of the city such as the provision of energy, waste management, mobility, sanitation, buildings and infrastructure as well as emergency management. Smart city planning can be incorporated into these city plans.

Smart city planning begins with the diagnosis of city problems. A good way for cities to become smarter is to start by using the data that they already have, and analyses of this data to better understand and frame city problems as part of their planning process. Once problems have been identified, cities need to ask: "How can smart technologies assist us with these?" What is important is that the problem and the intended benefit need to drive the solution, rather than a specific technology or vendor.

Cities have been encouraged to make use of models such as the Smart City Wheel to identify areas in which smart solutions can be applied, but they should be aware that such tools are often designed to create demand for smart solutions, rather than to address city challenges. Prioritization of interventions too, should be based on the priorities for cities. So, for example, a city might face the challenge that many residents struggle to feed themselves. Such a problem is addressed only indirectly by most smart city models, through initiatives to strengthen the economy, while a city many need more direct and immediate interventions.

It is not necessary to have or to allocate a separate budget to smart city projects; rather the resources for those projects can form part of the city's regular budgeting process. Many smart solutions, such as the smart lighting case discussed, can actually save money for cities and so can be used to free up resources.

There is one aspect of planning for smart cities that is different from traditional city planning, and that is the need for coordination across different city functions. One of the advantages of smart solutions is the ease of sharing of information across departments. This makes it possible to craft solutions that address multiple needs at once, such as resident feedback systems to more than one service area. For this reason, there needs to be good communication between different parts of the city, sharing of plans and the active search for solutions that can address different challenges through the same mechanisms. As a city becomes smarter, smart infrastructure will proliferate, often installed by different agencies, departments or private companies. It is useful if the technologies employed are compatible so that they can communicate with each other and share information.

The best way to ensure that different agencies and departments can work together and that technologies used are future-proof would be to adopt common standards for Smart City infrastructure and information technologies. Such standards are useful to ensure interoperability of technology. They also facilitate technology transfer and ensure comparability by defining common measures for progress. The ITU's Telecommunication Standardization Sector has developed standards to support Smart City transformations through the ITU-T Study Group 20 on IoT and Smart Cities and Communities.[110]

Standards relevant to smart cities include:

- ISO/TC 268 Sustainable cities and communities.[111]
- IEC SyC Smart Cities.[112]
- ITU-T Y.4000 series: Internet of things and smart cities and communities.[113]

Smart solutions can be developed within the city, with the assistance of appropriate partners. There are opportunities to discover and drive local innovation through government-supported tech accelerators that help the private sector and residents to develop solutions to improve public services. During the COVID-19 crisis, a local innovator in Barbados built a public health emergency management application in just three weeks using web-based development tools. CivTech in Scotland has pioneered such efforts, with companies developing minimum viable products in just a few months, which can be used to attract investment and partnerships to develop the products and move them to global markets.

5.3 Smart project success

The success of any smart initiative depends on how carefully the project is defined, clear objectives, sound planning, including financial planning, the management of risks and challenges and having clear and agreed indicators to measure outcomes.

Some of the factors that improve the chances of success in smart interventions include[114]:

Problem framing: How problems are framed can affect effectiveness of solutions. For example, traffic congestion can be framed as "We need wider roads and more parking", or as "We need to get more people onto public transport", or as "We need people living near where they work". Each of these will point to different solutions. Problem framing needs to be discussed and negotiated with all city stakeholders

Political awareness: Many smart interventions span city functions and involve both internal and external stakeholders, each of which may have different objectives, interests and expertise. To succeed, smart interventions need to be sensitively designed and implemented with political judgement.

Funding: The budget required, long-term financial sustainability, funding mechanisms, processes to monitor costs and contingency plans need to be put in place for any smart intervention. Sustainability of the project will depend on sustained funding until and after the project becomes fully operational.

Leadership: Smart interventions are more likely to succeed with the support of local leadership, such as city mayors.

Evidence: Cities that use data as evidence to support their decisions, and monitor progress using data will make better decisions and will develop information skills. Making good decisions is particularly important in resource-constrained situations.

Shared resources: Cities find it easier to implement smart initiatives if they identify and draw on the resources and capabilities of all the city stakeholders, including residents, cultural organisations, businesses and the public sector.

Communication: Proactive communication between internal and external stakeholders and knowledge sharing across different cities and structures ensures that people remain positive about the intervention and increases the chances of success.

Monitoring: Monitoring the effect of a smart intervention could be as simple as a public poll to measure user satisfaction, or data from an app or website about user adoption rates, a usage indicator such as electricity consumption, a financial indicator for payments or savings, or an environmental indicator such as the level of greenhouse gases. Indicators can be adapted from international standards such as the U4SSC Key Performance Indicators.[115] Indicators need to be decided at the inception of the smart intervention, as well as how and how frequently they will be measured. The data collected can then be used to improve and align the initiative with the objectives.

Training: When making changes to city procedures and work practices, a strong training and support phase (Case 1) and training of key staff members during and after the project (Case 7) can be essential for success.

6 Conclusion

Smart cities are often depicted as futuristic, high-tech spaces that are efficient, clean, beautiful and good to live in. The problem with this vision is that many cities then conclude that being smart is beyond their capabilities; it is something that other, bigger, more developed, or better-resourced cities do, or it is something to aspire to once the city is functioning effectively. The reality is that all cities are messy and complex with parts that work and parts that don't. New technologies and new ways of working create opportunities to improve cities and these opportunities should be used by all cities, regardless of their size, capabilities, resources, or stage of development. Indeed, cities that are inefficient and struggling stand to gain the most by becoming smarter.

Becoming smart has also been presented as a massive, costly process that involves special budgets and dedicated structures, big infrastructure projects and the contracting of large consulting companies; something accessible to only the most advanced and wealthiest of cities. While cities do successfully implement special smart project offices and design and implement city-wide infrastructure projects, this is not the only way to be smart. The smallest cities or communities can become incrementally smarter by learning about the power of data and information and taking steps to address their challenges smartly. The most dysfunctional of cities can use smart principles to improve the ways in which they operate.

This report examined simple ways to be smart that are relatively easy to implement. Informed by input from over 100 experts, seven features of simple, smart interventions were identified. Such interventions are (1) relatively low-cost, (2) can achieve results within a year, (3) can be piloted or started small and scaled up, (4) make use of proven technology, (5) use available skills, (6) have no complicating factors and (7) are sustainable. Using these criteria cases were identified of simple, smart interventions that are within the capabilities of most cities.

The cases identified fall into five categories that illustrate the range of benefits that can result from smart interventions. There are cases that (1) improve city administration, (2) have environmental benefits, (3) change the role of people in the city, (4) improve the experience of living in the city and (5) improve the resilience of the city. These five areas of city improvement are discussed in Chapter 3, but they are not intended to be the only areas in which cities can get smarter. They are intended rather to illustrate simple ways to be smart and to provoke cities into thinking about how their specific problems can be addressed in a smart manner.

The smart interventions discussed here include web-based applications and services, traditional information systems, infrastructure projects and programs for services. They make use of sensors, public technology platforms, cloud storage and simple feedback devices, but also low-tech procedures and policies to change the city and how people live in it.

These examples are intended to inspire cities to examine smart interventions and to craft new kinds of applications, services and content that create local value. From application development software to mobile app development, from e-learning platforms to cloud-based content creation tools, from content management systems to the creation of editable PDF forms that make the delivery of Government services easier and more efficient, cities can leverage a wide range of existing tools to improve their operations and positively impact people's lives.

Cities are also encouraged to partner with organisations and individuals in the city, and to share knowledge with peer cities, to find out what works, how to implement smart interventions and to innovate locally relevant solutions.

This report proposes that cities examine their challenges in terms of information and communication, the two elements that change when cities become smarter. In approaching any city challenge, a good starting point is to consider the information that is known and could be collected and analysed, and to look for smart ways to learn more about each challenge. The second step is to consider how the situation might change with different ways of communication and communication tools. Thinking through these two aspects of a city challenge will lead to ideas for smart approaches to address the problem and will provide feedback so that any change can be monitored and adjusted.

In Chapter 5, the report gives suggestions as to the kind of skills that cities will need to become smarter as well as how to develop them and how to partner to access the skills they lack. Cities are encouraged to incorporate smart planning into their existing planning processes and to use their existing structures and budgets to become smarter. This approach ensures that smart initiatives are problem-driven and address the most pressing needs of cities.

Cities around the world, big and small, old and new, functioning and dysfunctional are under pressure to address problems and improve the quality of life for their inhabitants. Think big, start small and learn fast is the approach recommended for cities wanting to become incrementally smarter, implementing simple smart interventions to build healthier cities for happier people.

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