Training Materials

For Implementing Smart Cities in Asia and the Pacific for Inclusive, Resilient, and Sustainable Societies

Smart Cities

United Nations Centre for Regional Development (UNCRD)

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Training Materials

For Implementing Smart Cities In Asia and The Pacific

For Inclusive, Resilient, And Sustainable Societies

Prepared by Justin Hyatt

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Abbreviations

ADB – Asian Development Bank
AI – Artificial Intelligence
ASEAN – Association of Southeast Asian Nations

ATC – Area Traffic Control
BRT – Bus Rapid Transit
CAP – Climate Adaptation Plan

CCTV – Closed Circuit Television
DRT – Demand Responsive Transport
EST Forum – Environmentally Sustainable Transport Forum
EU – European Union

EV – Electric Vehicle
GDP – Gross Domestic Product
GHG – Greenhouse Gas Emissions

GIS – Geographic Information System

HD – High Definition

HOV – High Occupancy Vehicle
ICCC – Integrated Command and Control Center
ICT – Information and Communication Technologies
IDC – International Data Corp
IoT – Internet of Things
IP – Internet Protocol
ITS – Intelligent Transportation System
ITU – International Telecommunication Union
LED – Light Emitting Diodes
LRT – Light Rail Transit
LVT – Land Value Tax
LTE – Long Term Evolution (Telecommunication)
NAP – National Adaptation Plan
NITRD – Networking and Information Technology Research and Development (USA)
NMT – Non– Motorized Transport
NOAH – National Operational Assessment of Hazards (Philippines)
MAAS – Mobility As A Service
MoD – Mobility on Demand
MOHUA – Ministry of Housing and Urban Affairs (India)
MRT – Mass Rapid Transit
MSME – Micro Small Medium Enterprise
OECD – Organisation for Economic Co-operation and Development
PPP – Public Private Partnership
QoL – Quality of Life
SAR – Special Administrative Region (Hong Kong)
SCADA – Supervisory Control and Data Acquisition
SDG – Sustainable Development Goal
UN – United Nations
UNCRD – United Nations Centre for Regional Development
UNESCAP – United Nations Economic and Social Commission for Asia and the Pacific
UNESCO – United Nations Educational, Scientific and Cultural Organization
WSN – Wireless Sensor Network

Preface

The training materials in this resource are designed to support practitioners and experts in delivering Smart City knowledge throughout Asia and the Pacific.

These materials are intended to guide the trainer through all the essential concepts and knowledge that the smart city framework contains. It aims to provide a convenient way to instill new insights and working methods for the learner.

An important caveat must be made at this point. The Smart City model is a robust and evidence-based framework for coupling smart technologies and digitalization with urban systems and urban governance, potentially bringing huge benefits, fiscal savings, and increased efficiency to urban management.

However, this model is not an end to itself. The Smart City model, in its ideal application, is a way to deliver the goods for such high-level objectives as social and environmental cohesiveness, quality of life, sustainable economic development, resilience, and inclusiveness.

Attempting to achieve a smart city should never be a goal on its own. Instead of simply aiming for a "smart city" a more useful ambition would be to work towards achieving a "smart and sustainable city" or a "smart and resilient city." Numerous combinations are possible; it is ultimately up to each project or region to stake out its overarching vision and embed shared and connected principles in one overarching vision. Seen this way, "smart" is an important and integral part of the overall building blocks to achieving better cities – yet it should always integrate closely with mutually supportive concepts.

Within that context, practitioners and trainers, while using this resource, are encouraged to maintain a close interrelatedness between the Smart City framework and the higher-level objectives, along each step of the way. Therefore, throughout the modules, reference will be made to "smart and sustainable" or "smart and resilient" in addition to other combinations.

Similarly, simply *calling* something "smart" will never in itself produce a result or benefit that is truly smart, delivers efficiency or better service, or brings benefits to the target population. It will be required to implement smart city solutions wisely and methodically. Achieving real objectives is never achieved by inserting buzzwords.

Fast computer networks alone will not save the day. Human ingenuity, creativity, resourcefulness – in a word, the human brain – will always be needed to direct and manage the most appropriate and sane solutions for the organization of society and economy, including, but not limited to, the Smart City framework. According to the Asian Development Bank, smartness is manifest when data can be utilized to improve decision-making. Remember that technology should be there to serve humans, and not the other way around!

With that in mind, the reader is invited to embark on this journey through the world of Smart Cities and will hopefully find this to be a useful guide with many practical insights.

Introduction

"Humanity is facing an existential contradiction: we are building an urban future for ourselves, yet urbanization in its current form is threatening the very future of humanity ad the natural world."[1]

- Herbert Girardet

Background

As is well known, cities are the main driver of economic growth, innovation, and technological disruption. Cities are grand centers of culture and human accomplishment and have been nurturing and sheltering humanity for millennia. Yet, for the first time in human history, urban populations have recently surpassed rural populations, and more than half of the world's population now lives in cities. The United Nations predicted that an estimated 2.5 billion more people are expected to be living in cities or urban areas by 2050[2]. It doesn't require a lot of imagination to realize that a lot of dwellings, neighborhoods, and cities are going to be built in the upcoming decades.

This is all accounted for by the growth paradigm. With the expansion of markets and rise in economic activity, industrialization and economic growth around the world has led to rising income and standards of living, but also lurking threats. For without concerted efforts to shift the business-as-usual growth trajectory, a time bomb of environmental degradation, urban blight, overpopulation, food shortages, and extreme disparities between rich and poor is waiting for the coming generation.

In tandem with unfettered economic growth, rapid population growth, and the resource extraction required to sustain this growth, we have seen a massive increase in global trade in a globally interconnected economic system, and increasingly dire consequences are making themselves felt. The youth climate activist Greta Thunberg has aptly commented "our house is on fire."

Among the many effects of the growth paradigm, some of the most salient features are: rapid population growth, urbanization, and motorization along with heat-trapping effects of vast swaths of land that have been paved over by concrete; add to this an increasing number of disaster events due to climate change impact. The proliferation of disease and global pandemics, as well as conflict over contested territory and resources. All of these facts and phenomena threaten the fabric of city life, in the sense that for many urban dweller's life can be uncomfortable and difficult at best, and could deteriorate even further without timely interventions.

Beyond that, cities in Asia and around the world face numerous challenges, ranging from safety and security to inadequate infrastructures and basic services; insufficient natural resources: water, food, and energy scarcity; sewage and waste management issues, traffic congestion, air

[1] Herbert Girardet, A New Age - Creating regenerative urban systems is a key to solving the many interconnected crises of our times, Resurgence & Ecologist Nov/Dec 2021

[2] The UN World Urbanization Prospects, 2018, https://population.un.org/wup/

and noise pollution, road crashes and fatalities; GHG emissions and climate change, sea-level rise, and many more. Meanwhile, cities are also suffering from other socio-economic issues such as inequality, social disparity, migration, and social segregation. All of these urban issues and challenges have severe negative impacts on the experienced Quality of Life (QoL).

As early as the 1970s, the effects of damage to the environment became well known, and research spearheaded by Donella H. Meadows and Dennis L. Meadows led to the household term "The Limits to Growth."[3] The conclusions reached were that unless the given trends of industrialization, resource depletion, consumption, and production are altered, limits to growth on the planet will be reached within 100 years, leading to a severe disruption of life and society on earth. Although the concept of "limits to growth" may have not yet made it into every mainstream economics textbook, its concepts are well understood, and important further work has led to our understanding of concepts like "carrying capacity" and "ecological footprint." While there has been a growing awareness of the issue, with mobilization happening in certain contexts, no serious alteration to the growth trajectory has taken place since then; if anything, growth, and consumption around the world has only increased exponentially. This has led and continues to lead to urban blight and highly unsustainable urban settlements.

Today we know that the ecological footprint of humanity is a matter to be taken seriously. In 2017 it was estimated that the global environmental footprint was 1.73 planet earths, meaning that anything beyond 1.0 is an overshoot: the level of resource consumption that goes beyond the sustainable use of resources. The United States of America is thought to have the highest overshoot, with an ecological footprint of 5.0 earths, while Australia is not much behind, at 4.1, with South Korea landing at 3.5 (2018, Source: Global Footprint Network).[4]

It should be clear to the reader that the future sustainability of the planet is closely connected to the models and practice of urban development, and it is of paramount importance that urban development models adopt more sustainable approaches, in order to support the achievement of the UN's Sustainable Development Goals (SDGs). Not only that, but sustainable models of urban development will also bring countless benefits to urban dwellers. In the search for better solutions to urban problems and better models of development, the "Smart and Sustainable City" model can serve as a robust and complex solution set (or operating systems) for cities.

The concept of the smart city has been under continuous evolution and has gained ground in the global discourse concerned with improving the city's performance and the quality of life for its inhabitants. As smart city initiatives emerge, they carry with them the potential to provide better opportunities for accessing jobs and markets, to facilitate the competitiveness of cities (by attracting people, businesses, and capital), and to offer better urban services. Smart cities make use of technology and innovation to solve urban problems, adopting a variety of policies and strategies to improve social integration, economic competitiveness, and environmental sustainability.

However, all the smart solutions listed in this resource (See Module 5 – Smart Technologies and Solutions) will only be useful if greenhouse gases are reigned in, fossil fuels are phased out,

[3] Meadows, Donella, et.al. (1972) The Limits To Growth

[4] https://www.footprintnetwork.org/our-work/ecological-footprint/

energy use transitions to renewables and as a consequence the earth may begin a regeneration and healing process.

In this context, the United Nations Centre for Regional Development (UNCRD) is organizing capacity-building programs and training workshops to assist member countries from developing regions in Asia and the Pacific. In order to support smart city initiatives, this training manual has been prepared, with the aim to assist policymakers, planners, government officials, and experts in building smart cities and communities in Asia and the Pacific, and beyond.

Module 1: Smart Cities – a global movement

"Smart city is an innovative city that uses 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".

- International Telecommunication Union of the United Nations

Figure 1- photo by Xavier L. Singapore transport network and cityscape

1.1 Purpose of the Module

The main aim of this module is to provide an overview of the smart city vision, concept, components, and overall objectives. The perspective of the city as a complex whole is needed to understand how smart city components take their place and shape the city's many structures and interconnectedness.

1.2 Key learnings Points

1. There is no absolute consensus on a definition of the Smart City concept. This is not necessarily a bad thing, as the smart city core concept is easily modified and adapted by cities for various needs.
2. The smart city objective is to improve the quality of life of urban residents by addressing numerous urban issues and challenges with the help of state-of-the-art technology, better management tools, and innovative solutions.
3. A part of the Smart City mission is to improve the safety, security, and efficiency of urban operations and services by optimizing resources through smart technologies.

4. Technology and Smart City approaches should never amount to a standalone solution. The best results can be achieved when smart city principles are combined with other social, environmental, and economic principles.
5. The smart city is a complex ecosystem of people, processes, policies, organizations, businesses, technology, and legislation integrated to create the desired outcomes and other enablers working together to deliver a set of better results.

1.3 The Smart City concept – in search of a universal definition

As the comprehensive definition of a smart city is still evolving, a smart city is defined by different authors and organizations differently. There is no universally accepted definition of a smart city.

Box 1: Smart city definitions

Some of the different definitions for a Smart City:

The British Standards Institute - "the smart city is an effective integration of physical, digital, and human systems in the built environment to deliver a sustainable, prosperous, and inclusive future for its citizens".

The Government of India, "Smart cities provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a lighthouse to other aspiring cities".

European Union - "A smart city is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business".

There is no single smart city framework or size fits all strategy, but instead cities and countries have tailored the smart city concept to their respective contexts, based on local factors, such as: development stage, digital development maturity and each individual government's capacity. A good example of this is seen within Asia and the Pacific, where the factors and policy priorities vary greatly, and hence smart city programs have taken up very different approaches, from building basic information and communication technology (ICT) infrastructure to sophisticated big data and Artificial Intelligence (AI) enhanced applications and platforms.

Smart cities use smart technologies and smart solutions including Internet of Things (IoT), Information and Communication Technologies (ICT), big data to increase operational efficiency, to monitor, control, and integrate various urban systems. A major feature of smart city initiatives is to use digital solutions and innovations in technology to improve, upgrade and make urban public service delivery more efficient. However, data alone will not lead to higher levels of efficiency and productivity. Data must be correctly applied, based on a sound scientific approach, and linked to appropriate applications.

A "smart and sustainable city" approach should intrinsically promote human and social capital, as well as environmental protection, augmented by natural and economic resources that can be supported by technology-based solutions and innovation. When this is the case, the pursuit of sustainable development goals enjoys its standing as a high-level objective within the Smart City

framework.

1.4 Smart City Strategies – as seen in practice

Smart city strategies have also been shaped by various policies, as in Europe, where the priority has been towards addressing energy efficiency and sustainability, and multiple initiatives have been supported through focused funding and dedicated programs from the European Union's Directorate General of Energy. In the United States, smart city narratives have focused, inter alia, on sustainable mobility, due to support in the form of funds from the United States Department of Transportation. In P.R. China the focus has often been to develop holistic systems for all sectors of the urban environment, including transport, water, energy, and health care.

Another example is Singapore's smart city initiative, a collaboration between Singapore's Punggol Digital District and the Singapore Institute of Technology, a business park, to foster development in cybersecurity and IoT technologies. A data-sharing collaborative, the Data Innovation Program Office, is also envisioned to encourage transparent business interactions.

As seen in this brief scan, the smart city concept comprises a highly flexible model for development. In terms of the "leap-frogging" potential involved, cities from the global south have a lot to gain by its inclusion in urban planning departments.

1.5 Smart City Vision and Objectives – focus on SDGs

The smart city components belong within the wider comprehensive framework and vision for building cities and communities safer, more efficient, resilient, livable, and sustainable. If closely following the sustainability and resilience path, a smart city approach can rightfully claim to belong to and support the broad vision and high level objectives seen in SDG 11: *Make cities inclusive, safe, resilient, and sustainable.*

The smart city's contribution to the high-level objectives includes improving the quality of life in cities by applying advanced state-of-the-art technology, better management, and innovative solutions. According to the Asian Development Bank, high level objectives seen throughout the Asia-Pacific region include quality of life, economic growth, sustainability, resilience, and inclusiveness.

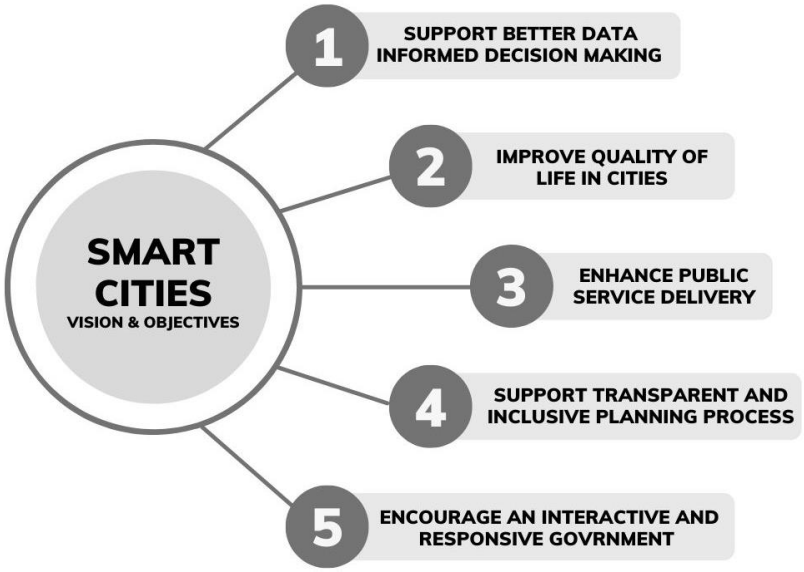
It is essential that an integrated smart city approach be closely linked to human-centered governance and involvement. This foresees the participation and interaction of citizens, the sharing of knowledge and tools (such as physical infrastructures with digital technology in the built environment), and the accessibility by the public to government institutions and important processes.

When sticking to a human-centered smart city approach, technology, services, and planning need to directly serve people, since people should be the first to profit from a smooth functioning smart, and sustainable city. And beyond "smart" it should also be remembered that cities are more than just hubs for innovation and conglomeration of businesses, they are also homes, spaces, and places where children grow, play, learn and make memories.

Smart city planning should be closely integrated with climate mitigation and adaptation. With the onset of global warming and increased climate-related hazards, the United Nations developed frameworks such as National Adaptation plans (NAP) and Climate Adaptation plans (CAP) to help cities incorporate a climate resilience approach to planning, where urban

environments and businesses take stock of the risks associated from climate impacts and develop relevant adaptation strategies. To this end, smart cities and the smart and sustainable city framework provides a strong base for cities to implement supportive strategies. The ability to harness data, monitor and respond to environmental fluctuations and instability, and curb the human impact on the natural world, will all be a part of this framework.

Smart Cities, Vision & Objectives



Source: Author, 2022

1.6 A Digital Support System – serving the Smart City vision

In order to serve the above vision, logical steps and technical capacity is required. The following should be included in any smart city basic support system

- **Efficient service delivery:** To use digital solutions and innovations in technology to improve, upgrade and make urban public service delivery more efficient, in turn addressing the overall competitiveness and resilience of a city or community.
- **Better decision-making capability:** To use data and digital technology to make better decisions and improve the quality of life in cities. Real-time data enables public and private stakeholders to monitor events as they unfold, understand fluctuations, and come up with an immediate response and cost-effective solutions.
- **Monitor resource use:** Better monitoring resource use will reduce greenhouse emissions, save money, improve efficiency, and more. Examples include smarter urban transport networks, upgraded water supply, waste disposal facilities, and more efficient ways to light and heat buildings. Implementing this can amount to huge wins for the environment.
- **Network management:** Smart cities focus on improving network management, including a digital interface for citizens and government, and encourage overall cooperation and communication between different layers of urban governance.
- **Responsive governance:** Smart Cities emphasize a more interactive and responsive city administration through more transparent and responsive governance, thanks in part to feedback loops, monitoring and early warning systems.

1.7 Smart City and Data – Basic Principles

It is well established that at the core of smart cities is the use of data; but there is still ambiguity about how and when to use data, and also about who uses the data, which includes being clear about data ownership and privacy as well as data accessibility. These are important factors to ensure equitable and transparent use of public data.

A report by McKinsey highlights this key aspect, that "*Smartness*" *is not just about installing digital interfaces in traditional infrastructure or streamlining city operations. It is also about using technology and data purposefully to make better decisions and deliver a better quality of life."*[5]

This forms the lead for framing the smart city principles surrounding data and technology:

- To use big data to **increase the operational efficiency** of all urban services
- **Increase data accessibility and transparency**, to enable the easier exchange of data within governance systems and outside of government systems, with private organizations.
- To use data to develop **research-oriented planning** – wherein governments work in close collaboration with research communities, institutions (educational and private,) and dedicated research organizations to study data-informed solutions.
- **Develop and implement smart technologies and smart solutions** including Internet of Things (IoT), and Information and Communication Technologies (ICT), to monitor, control, and improve the quality of government services.
- To improve the **integration of urban systems**, such as waste, water, electricity, lighting, heating, transport, and mobility, thereby improving the conscious and sustainable use of resources, monitoring consumption, and reducing waste.
- To **promote effective collaboration** among different stakeholders including the private and public sectors to foster business and innovation for a sustainable future. This is a programmatic approach to engage its stakeholders across the ecosystem, and can be beneficial for numerous areas, including access to information and open data sets.
- Developing a **dedicated ecosystem comprised of multiple capability layers** such as value layer, innovation layer, community engagement layer, governance, management and operation layer, policy, processes, and public-private partnerships, and financing layer, information, and data layer, connectivity, accessibility and security layer, and smart city technology and infrastructure layer.

1.8 Smart City Ecosystem – Smart and Inclusive Governance

The smart city is a complex ecosystem of people, processes, policies, organizations, businesses, technology, and legislation integrated to create better solutions for a city teeming with people. Despite all its complexities, the city and its requisite solutions can still be managed in an orderly and effective way. A successful and sustainable smart city takes a programmatic approach to engage its stakeholders across the ecosystem. It is of fundamental importance to build a broader

[5] https://www.mckinsey.com/business-functions/operations/our-insights/unlocking-the-future-the-keys-to-making-cities-great

smart city ecosystem that will lead to a smart, sustainable, fair, and green city.

A smart city ecosystem comprises multiple capability layers such as value layer, innovation layer, community engagement layer, governance, management and operation layer, policy, processes, and public-private partnerships, and finance layer, information, and data layer, connectivity, accessibility, and security layer, and finally technology and infrastructure layer.

1.9 Limitations of a Smart City

There are several limitations to note concerning Smart City planning. First of all, it must be stated that for cities in developing countries, where basic infrastructure and service needs are not yet met, smart solutions may have to wait. It is essential to have the basic needs taken care of before more advanced solutions can be offered. Clean water, sanitation, access to basic amenities are all a part of the basic infrastructure that urban residents should be able to count on. Of course, where it is possible to leap-frog with the help of smart solutions, that can be done, yet IoT connectivity should not be prioritized if there is insufficient access to clean drinking water or if hunger and malnutrition are recurring problems.

While there are many best practices in Smart City approach around the world, it should also be noted that globally validated solutions still need to be respectful of local traditions. There is no reason that local values and flavors cannot be supported by global best practices and smart solutions, however the end goal should not be to replicate another city's success, but to integrate these competently into the local environment. The urbanist and writer Charles Landry has noted that a creative city is spurred by the local traditions and knowledge.[6]

Finally, there needs to be value added to smart city connectivity. Many systems receive new functionality by being connected to data or monitoring, but this always requires a burden of proof. Citizens and users may not want to have everything connected all the time, everywhere. The level of connectivity and applied smart solutions is something that should be locally determined, not based strictly on international best practice or national mandates, but in harmony with local needs and wishes.

By the same token, when digital interfaces are built into service delivery, there always need to be solutions provided to people who are not hyper-connected. For instance, it should be remembered that not everyone owns a smart phone, and not everyone has access to mobile data. These facts alone often go missing when introducing new or upgraded smart systems. Keeping in mind the lowest common denominator should be planned into any smart city program.

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[6] Charles Landry, The Creative City, A Toolkit for Urban Innovatorss, 2000

Questions for Trainers

1. What are the most salient features of a Smart City?
2. Which definition of a Smart City resonates the most? With what other areas (social, environment, etc.) does it resonate the most?
3. Why is it important for every Smart City development to have high level objectives?
4. How can Smart City programs best contribute to SDG 11: "Make cities inclusive, safe, resilient, and sustainable"?
5. How do the needs of government, business, academia, and citizens differ in a Smart City project, and connected to the connected vision and objectives?
6. What are some limitations to Smart City planning that might need to be handled through another set of solutions?

Module 2: Smart City Prerequisites

"*We are reversing the smart city paradigm. Instead of starting from technology and extracting all the data we can before thinking about how to use it, we started aligning the tech agenda with the agenda of the city*"

- Francesca Bria, former chief technology officer of Barcelona

Figure 2: Photo by Louie Martinez, Tokyo tower and Tokyo, seen from Mori building

2.1 Purpose of the Module

This module highlights the prerequisites for Smart City planning and projects. The majority of these concepts relate to visionary thinking and leadership, integrated planning, data use and analysis expertise, tools and technologies, human resources, institutional framework, and an appropriate investment and financing environment.

2.2 Key learnings Points

1. Visionary leadership: Above all, a Smart City program will be greatly facilitated by the presence of visionary leadership. The world could greatly use more leaders who are able to rise beyond their own ego and tenure and realize the potential they have of impacting their city for good, for years to come.

2. Integrated planning: Starting with the strategic integrated planning, the present willingness and dedication of decision-makers as well as relevant departments must be present, backed up by appropriate budgetary conditions. Planning must start at the earliest possible date, and all involved departments need to have a robust inter-departmental communication system.

3. Infrastructure and technology checklist: The requirements include high-quality internet and wireless networks, data collection systems, dependable renewable energy supply, advanced technologies and digital tools, skilled workforce including tech-savvy specialists, highly versatile staff, capable of collaboration in a diversified and international context.

4. Big data provides cities, research institutes, and economic players the opportunity to obtain valuable information and insights from a large pool of data. Yet this requires wise stewardship, robust privacy laws, and legally enshrined transparency.

5. Appropriate institutional development, human capacity and expertise, appropriate financial investment mechanism, and transparent and good governance are all fundamental for smart city development. Tools, training, and upskilling are the keys to success.

2.3 Smart City Prerequisites – Before Getting Started

There is an essential process to undertake before launching a Smart City program. This involves a careful scan of all the required prerequisites, in other words, the conditions or attributes that need to be in place, in order to make a Smart City project successful. Some of the main categories include visionary thinking, leadership, data handling capacity, expertise, tools, and technologies. Those are all elaborated in this module. There are many other general requirements also covered here (such as broadband internet), and finally there are strategic planning prerequisites and a logic framework model.

As was mentioned in the previous module, having in place the basic infrastructure and services is essential before providing advanced tools. A review of the current state of affairs and performance report would provide a level of clarity, and hopefully confidence in being able to move forward.

Very early on, the strategic planning capacity and leadership needs to be listed. It is essential for the present willingness and continuous dedication of the decision makers and relevant departments to be present, backed up by appropriate budgetary conditions. If these are not present, any smart city project is doomed to failure.

Part of laying the strategic planning foundations for a smart city program involves developing a comprehensive strategy. Relevant action fields and municipal resources must be lined up, with all participating departments engaged and linked by communication protocols. Specifically, a prepared strategy should include financing plans, detailed demarcations of stakeholder roles and tasks, implementation plans and road maps for selected or pre-selected projects, as well as an assessment of the wider criteria and infrastructure, network, and capacity conditions.

General prerequisites for launching smart city programs and projects include in particular an infrastructure and technology inventory:

- High-quality internet and wireless networks
- Data collection systems
- Dependable renewable energy supply
- Advanced technologies and digital tools
- Skilled workforce including tech-savvy specialists

- Highly versatile staff
- Capacity to collaborate in diverse and international contexts.

Public utilities and service providers make up further items in the checklist. A smart city needs access to resources such as a continuous supply of energy; water supply and sewerage; sanitation and solid waste management system, an efficient, integrated, and high-quality public transport network and mobility services, good governance (including e-governance), and associated government services, public and infrastructure safety, availability of reliable emergency services; state of the art early warning system for disaster events.

Another model, developed by Econsult Solutions, inc., Thoughtlab, lays out the ideal conditions and the necessary logic framework for advancing from the initial assessment to ensuring the longevity of a smart city effort. The steps in this model are as follows:

Phase 1: Assessing current city needs
Phase 2: Addressing enablers, such as governance, infrastructure, technological innovation
Phase 3: Cooperation with existing digital ecosystems for strategy development and implementation
Phase 4: Securing needed investments for the longevity of the program

Several of the general prerequisites and enablers are described in the following sections.

2.4 Visionary Thinking and Leadership – Starts With Asking the Right Questions

Above all, a smart city development program will be greatly facilitated by visionary leadership. The role of visionary thinking and keen perception of future possibilities cannot be understated. In particular, leaders who are able to rise beyond their own ego and tenure and realize the potential they have of impacting their city for good, for years to come – such leaders are rare but when elected, have the ability to achieve historical feats.

At the outset of a "visioning" process, city authorities and leaders should ask and review fundamental questions with the help of the other stakeholders and include consultations and participation of local residents. The questions include:

- What kind of city do people want in the future?
- What is needed for a citizen to be able to live and work and lead a meaningful life?
- What kind of city will provide better opportunities for all citizens?
- Where will smart tech solutions help, and where are other solutions better suited?
- Are the future scenarios currently on the table resilient and sustainable?
- Is the proposed smart city features inclusive and do they provide equal opportunity for all sectors of society?
- Are the city's ecological parameters fully mapped out, with current needs identified, and are there ways of making the city more sustainable, green, and resilient? Can the percentage of parks, forests and green corridors be increased?
- What kind of institutional arrangements and financing are required to develop the desired future scenario?

  All these questions, including the process that goes with it, demand visionary thinking, leadership quality, and better planning approaches. Visionary leadership should include long-term planning, at minimum the next forty or fifty years, or well beyond that. Future,

visions should not only fulfill, the basic requirements of city residents but also imagine the possibilities and opportunities of future generations.

Visionary leadership for developing a smart and inclusive city should be closely connected to seeking the involvement of citizens. *Thus, participation – the participatory city - will be a great boon for cities with visionary leaders who truly want the best for their citizens and have come to appreciate the benefits of co-creation and participation.*

An additional aspect of visionary leadership is the quest to seek out the opinions and entice the involvement at the broadest level of all citizens. Wise leadership means that a broad range of stakeholders, including citizens and all residents, will have the opportunity to voice their concerns, wishes and dreams. Taking this into consideration and putting mechanisms in place to consult with and incorporate wide-level inputs into policy formulation will greatly benefit every urban project and increase the satisfaction levels of residents, as well as the popularity of leadership.

2.5 Expertise and Knowledge – Smart Humans

A vital enabler of smart city feasibility is expertise and know-how. Without the human capacity to run programs, operate technology, intelligently apply appropriate solutions, deploy the ability for troubleshooting, maintain a link to the higher-level objectives – without the training and skills for all of this, smart city solutions will not work. Machines can't run themselves in an open system without human control, and even provided future developments in AI, that would not be desirable, except for in limited cases.

Thus, city leaders should understand that without adequate knowledge and suitable smart city experts and professionals, it is impossible to plan for smart city. Therefore, planning, implementation, monitoring, and operation of the smart city should include a wide variety of qualified experts with diverse knowledge and skill sets. Policy makers, planners, city leaders and the municipal staff and administrative officers, who are mainly responsible to implement the smart city projects, may need to upgrade their skills and competencies for the successful implementation of the smart cities program. It is equally important to engage financial institutions and financial providers for the necessary investment.

Beyond that, a whole host of stakeholders and partners will be useful in order to successfully carry out a complex smart city project. This list makes a good starting point: Energy suppliers, educational, healthcare, transportation and logistics providers, businesses leaders and industries, construction and real estate companies, IT professionals, environmental experts, civil, electric, and electronic engineers; social experts, scientists, media representative and the wider public all should be included in the smart planning process for successfully achieve the goals of smart city.

Digital skills training is one important component of fulfilling the human and expertise prerequisites for smart city programs. This can be undertaken by way of managerial training programs and exchange of best practices and experiences with more advanced cities or skills providers (such as in cases of city twinning).

The upskilling of staff, which may be organized via twinning arrangements with advanced cities, and partnerships with academic institutions and technology providers should all be prioritized for those cities and programs that are just starting out on the path to a smart city.

This is further of significance in those cases where a digital divide exists between or within local governments and between first tier and second or third-tier cities. This is also a case where the national government should step in and provide funds, programs, and bootstrapping opportunities. This is also important for the sake of equity. Not only between regions, but also within society, the digital divide can be large in places, and technology-driven solutions and access to networks should provide and made available for everyone, regardless of income level, minority background, or socioeconomic status.

Finally, the urban-rural divide also needs to be considered, with services and solutions valid just as much for smaller urban centers as for the big cities. It should be kept in mind that if rural amenities drastically improve, this will have a positive effect on stemming the migration to cities – which will in turn benefit current cities in lessening the additional burden of population growth.

2.6 The Use of Data – is it The New Gold?

Data is often seen as the new gold in highly digitalized societies. This claim does need to be qualified. But first off the advantages are listed: Big data provides cities, research institutes and economic players the opportunity to obtain valuable information and insights from a large amount of data collected through various means and sources. With the help of big data sets, city authorities can make better decisions in a host of areas. High on the list are means to reduce costs and resource consumption in numerous areas of activity. Data also helps the relevant departments to better understand what is happening in the population centers and where specific needs arise. For research institutes, data helps to analyze and understand social science dynamics and provide policy inputs to the government. For economic players, data helps businesses to understand the needs of the market and respond accordingly in product development.

Therefore, the effective analysis of big data and its applications are key to smart city development, particularly for analyzing, managing, operating, and developing integrated solutions. Data Volume, Velocity, and Verity (3V) and the reliability of these three big data components are important factors for their application and output. The use of big data technologies for the smart city enables efficient data storage and processing to produce information that can enhance numerous smart city services and solutions. This is particularly the case for the real-time exchange of data across the city. Real-time data exchange has fast been growing into a top smart city data application and a glaring omission where this has not yet been realized.

Big data have the potential to provide insights into urban planning, public safety improvement, transport operation, and urban management. With the help of big data, policymakers, planners, and city officials can make data-driven decisions that help to improve the quality, effectiveness, and cost of services. Moreover, by leveraging different data sets, the smart city approach can tackle various urban challenges such as road safety, traffic congestion, crime, resilience, and sustainability. Similarly, open data platforms in a smart city can increase citizen engagement and encourage new forms of creativity and innovation among developers and other service providers.

But before fully embracing the rush to accommodate big data, caution is advised. There is still ambiguity about how and when to use data, and also about who gets to use the data, which includes being clear about data ownership and privacy as well as data accessibility, to ensure an equitable and transparent sharing of public data. Privacy rights and regulations will need to be clearly encoded in existing laws, and where these don't exist, they will need to be updated. It is also important to realize that, as with any emerging technology, it is wise to better understand systems and their consequences, before making hasty decisions and policies. See also Module 5, specifically section 5.7 Big Data Analytics and Cloud Computing.

A report by McKinsey highlights this key aspect, claiming that "*Smartness" is not just about installing digital interfaces in traditional infrastructure or streamlining city operations. It is also about using technology and data purposefully to make better decisions and deliver a better quality of life.*[7]*"*

2.7 Tools and Technology – the Basic Currency of a Smart City

One of the prerequisites for smart city development is the availability of high-quality affordable internet and wireless (Wi-Fi) services for everyone. Connecting high-speed broadband options for people, infrastructures, and services significantly helps improving urban efficiency, convenience, and quality of life. In ICT frameworks, internet and wireless infrastructure connect objects and machines by transmitting data using wireless and cloud computing technology. With the use of Wi-Fi networks, urban residents can engage with the smart city ecosystems in various ways using smartphones, computers, and mobile apps. Connecting people with physical infrastructures and urban services with the help of smart devices and wireless technologies can reduce the urban cost and improve the connectivity of utilities, public services, and sustainability.

Digital urban connectivity, rapid, secure, reliable methods of data transmission, improved penetration of telecommunication and mobile phones, comprehensive energy grid, fast broadband internet, and Wi-Fi connectivity are essential components of the smart city framework to enhance efficiency and connectivity.

2.8 Collaboration and Partnership – Breaking Down Silos

Strong collaboration and partnership are important to achieve effective smart city development. Collaboration among diverse stakeholders sets the stage to utilize the collective knowledge and experience needed to innovate, create, cooperate, and solve urban problems.

An inclusive and smart city will be built along the lines of a strong collaboration model among different stakeholders:

- National, state, and local governments
- Private, business, and industry
- Universities and research institutions
- Financial institutions, and banks
- Non-government organizations
- Think tanks
- Communities of practice

[7] https://www.mckinsey.com/~/media/mckinsey/business%20functions/operations/our%20insights/smart%20cities%20digital%20solutions%20for%20a%20more%20livable%20future/mgi-smart-cities-full-report.pdf

- Bilateral and multilateral organizations

In general, smart city projects demand multi-sectoral engagement and collaboration to enhance problem-solving capacity and achieve efficiency and effectiveness in the implementation of a smart city project. Learning to share information, build open communication channels, and collaborate widely, is all built on trust. This can take time, which is why it is important to start early in fostering relationships and nurturing them.

Questions for Trainers

1. What are three excellent qualities of a visionary leader?
2. How would you set up a *visioning* process at the beginning of a Smart Cities collaboration?
3. What are a few concrete ways that a citizen can participate in the planning stage of a Smart City program?
4. What types of planning or strategy documents will best prepare the ground for launching a Smart City project? What are further institutional arrangements, financial mechanisms or technologies that should be in place?
5. If planning a combined smart and sustainable city project, what are additional elements that should be added?

Module 3: Smart City Core Principles

The smart city must keep the public trust by providing excellent safety measures and a secure environment for all individuals, organizations, and businesses.

Figure 3 - Photo by Zean Wu. Shenzhen, PR China, site of a future ecocity

3.1 Purpose of the Module

The main aim of this module is to establish Smart City core principles. The core aspects of the smart city principles include safety and security, equity and inclusiveness, resourcefulness and resilience, integration and inclusiveness, green growth, and liveable environments. Further principles include innovation and transformation, resource conservation, public and private sector participation, people-first principles, and several more.

3.2 Key learnings Points

1. Safety and security are essential elements of any Smart City development. The smart and safe city must keep the public trust by providing excellent safety measures and a secure environment for all individuals, organizations, and businesses.

2. The essential element of a Smart City should be an equitable and inclusive society. The smart city approach should focus on true social inclusion in order that no one is left behind. The smart city supports reducing the wealth gap, gender gap, diversity gap, and ethnicity gap, by specifically targeting social equity and inclusiveness.

3. A smart city should be based on high-quality infrastructure and better services, with built-in flexibility and resilience, so that troubleshooting becomes simple. The smart city should be able to restore and function under severely constrained and difficult conditions. The Smart City framework includes the ability to absorb, be adaptive, robust, flexible,

resourceful, integrated, and bear transformational capacity.

4. A truly smart city should create people-friendly urban infrastructure and urban system design with a clean, pristine, and liveable environment for its residents. Then it can be called a smart and sustainable city or a smart and humane city.

5. Resource optimization and sustainability are at the core of the Smart City philosophy. A smart city should reduce pollution, waste, carbon footprint, and greenhouse gas emissions for a cleaner, healthier environment by use of clean and green technologies and solutions. Once these factors have been included, a city can become a smart and green city.

3.3 Safety and Security

As smart cities function with the help of the Internet of Things (IoT) based on digitization and cyberspace, safety and security are core components of a smart city development. Urban systems such as energy and water supply, urban mobility and transport systems, smart banking, and other urban systems are largely dependent on the IoT, big data, cloud computing. The smart city must keep the public trust by providing excellent safety measures and a secure environment for all individuals, organizations, and businesses, as a base for cooperation and achieving common ground on policy, or engaging in daily transactions.

Safe urban housing, robust and user-friendly infrastructures, fireproof public safety services, strong cybersecurity, safeguarding data, privacy, and physical assets leveraged by the best digital technologies are essential parts of the smart city.

Connectivity can directly support seamless operations and security protocols. High Definition (HD) and Internet Protocol (IP) video surveillance and security cameras effectively help to improve urban safety by monitoring social spaces and responding in helpful ways to the public. There are related benefits to providing connectivity and digital oversight to items such as street lamps, traffic lights, dedicated pedestrian facilities and bicycle lanes, efficient and accessible public transport (metro, light rail, and urban bus networks), smart waste bins, and other city services. Providing a level of access and management to the relevant city department will enable seamless operations and quick responses as incidents arise.

3.4 Equity and Inclusiveness

An essential element of the smart city should be an equitable and inclusive society. The smart city should focus on true social inclusion in order that no one is left behind. The vast majority of cities around the world are composed of a wide range of diversity – including race, ethnicity, income, industries, and institutions. This is what makes cities special, interesting, and competitive, but it also requires equity to be prioritized. In a smart and fair city, equality and fairness should be guiding principles – top-level objectives. A smart and fair city will cater to the needs of often marginalized populations: the urban poor, women, children, the elderly, and the physically disabled. These populations should not only be better catered to but also fully included in the planning process, following the guidelines on participation. A smart and humane city should provide an inclusive, equitable economic system that offers well-paying jobs and socio-economic opportunities for all. An end result is providing the opportunity to live with dignity and high quality of life.

An additional aspect of inclusiveness was already mentioned earlier: watching out for the lowest common (digital) denominator, meaning that technologically illiterate or otherwise those persons without easy access to computing and smart phones also need to be cared for. There should always be a backup solution for someone with a lower technological barrier. An additional aspect of this is creating user-friendly websites and digital interfaces for the visual or hearing impaired.

3.5 Resourcefulness and Resilience

A smart city should be resourceful and resilient. Resourcefulness indicates a city's ability to restore and function under severely constrained and difficult conditions by providing appropriate solutions to different urban problems. This involves resilience. Resiliency is the ability to bounce back and restore ideal conditions following any unforeseen events or problems. The smart and resilient city should have the ability to be adaptive, robust, flexible, resourceful, and other relevant measures and approaches.

3.6 Efficiency and Productivity

The smart city should be efficient and productive. It is important to develop efficient and productive urban infrastructures and services that can improve the productivity of urban residents. This connects in particular to mobility systems as well as delivery and freight operations; well-integrated and coordinated urban services, a high-skilled workforce, better urban institutions, and good transparent governance. It is equally important to build and design a resource-efficient smart city framework, with a greatly reduced need for natural resource consumption and low or zero carbon functional systems. Environmental protection and low energy patterns can be effectively built into the business environment and local economy since the transition away from a high-energy society also brings with it green jobs and a greening economy.

Prior to unleashing new urban infrastructure, it is highly advised to do test runs. This involves launching a pilot project or test site, where users and the general public are able to try out and experience new infrastructure, services, and situations in real life situations. As these are programmed to run for a limited period (several months up to one year) this provides an excellent opportunity to observe and collect feedback, which will be invaluable before introducing the long-term project. All along the way, user input will be highly valuable in understanding shortcomings in the design.

3.7 Green Growth and Liveable Environment

Smart and sustainable cities should provide a healthy and liveable environment. This includes a steady supply of fresh air, clean water, and accessible green spaces and parks. Everyone should have the opportunity and encouragement to engage in active and healthy lifestyles. Smart Cities should follow a high standard of amenities provision within a vibrant public realm.

Smart Cities can play a vital role in urban transformational projects. Smart City components should support the transition to sustainable and livable cities, and thus also a low-carbon economy. Features includes well-designed streetscapes, open green spaces in the city centers, communal art, public space enhancements, local public markets, as well as upgraded and vibrant neighborhood conditions. All of this helps to promote a well-balanced urban ecology, economy and thriving communities.

3.8 Innovative and Transformative

Smart cities should look beyond technology led solutions and maintain and promote research and innovation. This will demonstrate that truly smart cities recognize their greatest asset in their population. Smart cities need to approach technology as a tool, and not an end to itself. In tandem with technology, further crucial components and concepts include nature-based solutions, pro-social and community values, the leveraging of local and indigenous knowledge, and fostering innovation and research, with a focus on promoting young talent. In particular, indigenous knowledge, customs, and wisdom, as passed down through many generations, should be upheld and celebrated.

There is a lot of knowledge that falls outside of the realm of the Smart City framework, and this should not be lost in a smart in sustainable city. Furthermore, potential participants in a smart city development may be less reluctant to join, if they know that their treasured traditions will be upheld.

3.9 A Smart and Humane City with People at the Core

A truly smart city recognizes its citizens as its greatest asset by placing citizens and people at the core. From the initial stage to the final stage of the smart city planning cycle, citizens and communities must be given a central role. Putting people first, a smart and humane city is based on people-friendly planning and overall design. This principle should be clearly featured and enabled in every aspect of smart city planning. See the recommendation at 8.4 Neighborhood Planning Centers.

3.10 Private Sector Participation

To utilize people, particularly, the private sector's knowledge, expertise, and resources for smart city development, it is important to seek private sector involvement in the city development process. Public-private partnerships (PPPs) could be a vital mechanism that helps to enable higher levels of efficiency in setting up or executing smart city projects. This connects to the broader topic of partnerships and cooperation, touched on in modules 5 and 6.

3.11 Resource Conservation, Optimization, and Sustainability

The smart and sustainable city model promotes the conservation and regeneration of the resources, and thus the circular economy. The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible. A smart city should cater to waste reduction through better waste management or incentives to achieve zero waste in landfills. In this way, the life cycle of products may be extended, while following the mantra of reducing, reusing, and recycling. However, in order to effectively extend the life cycle of many products (including technology products) it will be necessary to bolster laws that require manufacturers to build products with a longer life span. Once the product reaches the end of its life, its materials are kept within the economy wherever possible and used for the next product, thereby creating further economic value[8].

[8] https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

Resource optimization and sustainability are thus at the core of smart and sustainable city development. Solutions are needed to address urban challenges brought on by motorization and urbanization. A smart and sustainable city can help to create a blueprint for decarbonization and the elimination of greenhouse gases, with the aim to achieve a cleaner and healthier environment, brought in part by the use of clean and green technologies.

There is a broad diversity in the application and embeddedness of the principles listed here. For instance, India's Smart Cities Mission focuses on the following six fundamental principles.

Figure 4 - Smart Cities Mission Principles:

Source - https://smartcities.gov.in

Questions for Trainers

1. Why is it important to have principles and not just goals? Create your own list of principles, starting with the most important ones, and explain your preferences.
2. What issues and challenges is your city facing that could be addressed by looking more closely at the underlying principles?
3. List three pilot projects that could serve to better understand their long-term implications.
4. What are practical examples of terms like inclusive, resilient, or livable?
5. What are ways that local and indigenous knowledge can harmonize with Smart City programs, maintaining a respect for ancient knowledge, and without diminishing their relevance for modern society?

Module 4: Pillars of the smart city

Comprehensive planning and decision making that is supported by the participatory governance, citizen engagement, while maintaining transparency, data privacy and technical know-how are basic element for smart city development.

Figure 5- Photo by Bill Mead. A man supplies a roof with a photovoltaic panel

4.1 Purpose of this module

This section addresses the main pillars of the smart city, that is the main sectors where smart city initiatives can bring about the meaningful impact and positive change. These are the areas where smart city interventions may be logically applied, and where fertile ground for Smart City developments can be found.

4.2 Key Learning Points

1. It is important to understand the potential of technology to improve service delivery in all the different urban sectors and for the various operational suppliers.

2. Smart city technologies can take on various roles, streamlining processes within the different urban sectors, such as: optimizing operations, enhancing monitoring and evaluation, providing feedback loops, improving quality control, building cooperation and communication between systems and networks, improving energy efficiency, and setting up automation and improving the reliability of technology dependent systems.

3. Smart systems allow urban managers to make informed and systematic decisions based on validated data and limit the influence of human error in the decision-making protocol.

4. Better planning and decision making is supported by an improvement in democratic processes and the upgrading of participatory governance, citizen engagement, while maintaining transparency and data privacy. Digital technologies can facilitate enhanced communication and cooperation by a broad range of stakeholders.

5. Smart city initiatives are well suited to harmonize with and improve different models of cooperation (Government to Citizen Model (G2C), G2B or Government to Business Model, Government to Government (G2G), Government to Employee (G2E).

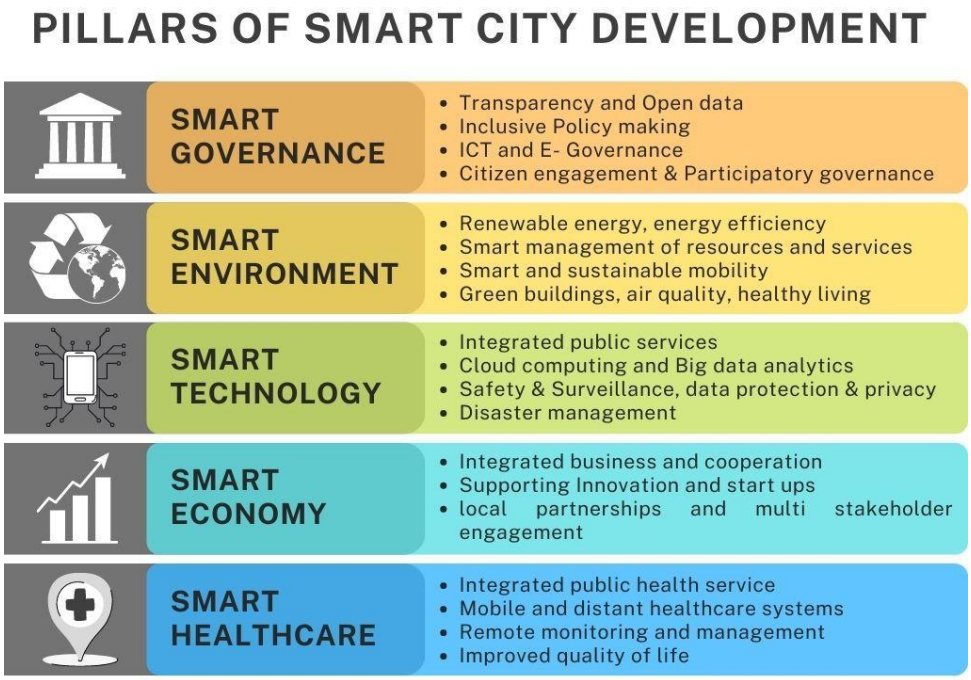
6. Smart Cities initiatives require a nurturing environment, with the right policy frameworks and regulations, to harness benefits and avoid risks.

4.3 Background

Urban environments are dependent on the performance and quality operations and outputs in several important sectors – governance, infrastructure services, technology integration and digitization, efficient mobility, healthy people, a better environment, and a vibrant economy.

The Smart City framework is prevalent for several sectors, where its various components will have maximum positive response. The most widely recognized pillars of the smart city model are - *Smart governance, Smart environment, Smart city system, Smart mobility, Smart economy and Smart living*

Additional sectors where smart interventions are needed are healthcare management and funding and investments.



Source: Author, 2022

4.4 Smart Governance – Policy, Planning, Transparency, and Digitization

In the rapidly urbanizing world of the 21st century, urban governance is confronted with change at breath-taking speed. This has consequences that are manifold, such as the mismanagement of service delivery, ignoring the needs of marginalized groups, and unsustainable consumption of resources, time, and money. Urban governance must adopt tools and technology that not only help with management but also invigorate the democratic process of planning. The smart governance pillar emphasizes this, by advocating for the use of technology to facilitate and support better planning and decision making, improve democratic processes and transform the ways in which public services are delivered. It focuses on how open and transparent, accountable, collaborative, and participatory principles are incorporated in the governance process. This can be found in E-governance platforms.

E-governance supports transparency and equal opportunity for participation and contribution by regularly publishing and updating progress online. Smart tools and technologies such as ICT, social networking, and online media play vital roles in the improved implementation of smart city goals. The smart governance pillar also addresses alternate models of intergovernmental cooperation such as the Government to Citizen Model (G2C), G2B or Government to Business Model, Government to Government (G2G), and Government to Employee (G2E).

One of the most advanced E-governance systems is to be found in Estonia, the first government to create a completely paper-free parliament. According to Smart Cities analyst Herman van den Bosch: *"e-Estonia is currently the most ambitious project in technology-assisted politics in the world: It includes anybody involved with government and it has changed the daily lives of citizens. Almost all public services are involved: Legislation, voting, education, justice, health care, banking, taxes, and police. These are digitally linked to each other via one platform.*"[9]

In Indonesia, smart city governments have mainstreamed the use of mobile apps and platforms for everyday government transactions and appointments. City-wide command centers for monitoring and operations are also being built by local governments. Looking to the future, incorporating AI assets for smart surveillance and big data analytics is one expectation.

4.5 Smart Environment – tools for managing the built and natural environment

"Smart Environment" describes how a city government manages and develops its urban and peri-urban environment, including the built and the natural environment, to improve livability for all citizens. Tool and applications include managing the reduction of waste, monitoring, and managing water pollution, improving efficiency in water management, improving energy efficiency in public spaces, and accelerating local energy transition by supporting the take-up of renewable energy options (ranging from large scale solar farms to micro scale applications). Further options include the monitoring and management of buildings (water meters, automation in buildings services).

The smart urban environment pillar also addresses the overall safety, security, and quality of life in cities. This encompasses surveillance and the use of digital technology to improve and monitor safety in both public spaces and within buildings and homes.

Smart tools and applications to manage the natural environment focus on larger environmental impacts, such as reducing urban heat island and affects, monitoring and improving air quality, reducing vehicular emissions, restoring the health of natural environments such as public parks, urban forests, peri-urban agriculture and gardens, and improving the management of storm water

[9] Herman van den Bosch, Smart and Humane, https://amsterdamsmartcity.com/updates/news/the-humane-city

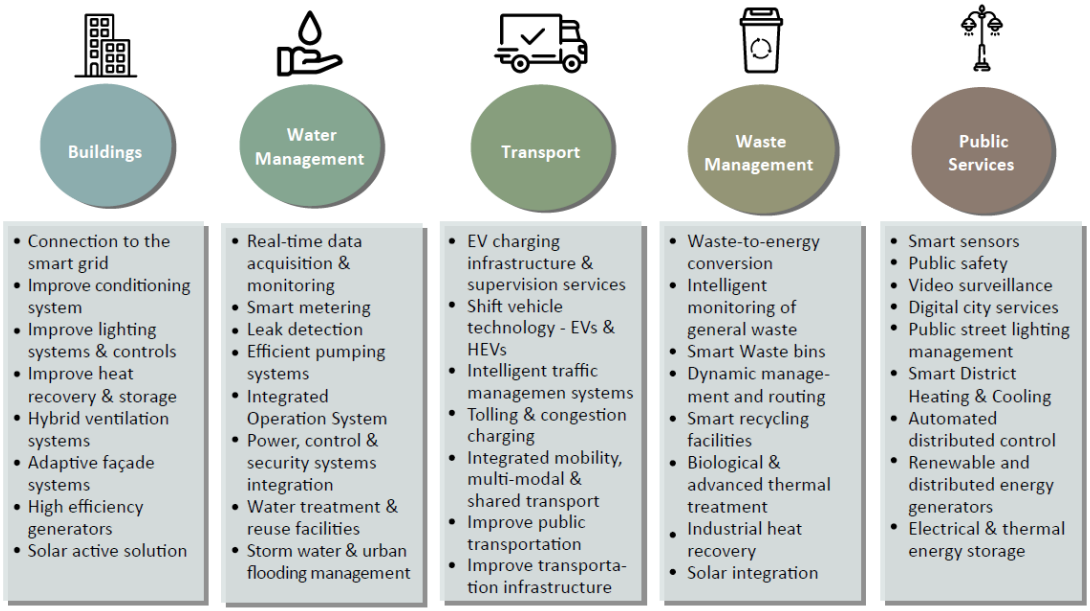
collection, runoff, and flooding. It also explores new urban planning standards and policies to improve efficiency and minimize environmental impacts, and tools to help create resilient communities. This area has a strong overlap with "regenerative urbanism".

- **Energy –** *"Smart energy management is a component of smart city development aiming at a site-specific continuous transition towards sustainability, self-sufficiency, and resilience of energy systems, while ensuring accessibility, affordability, and adequacy of energy services, through optimized integration of energy conservation, energy efficiency, and local renewable energy sources." (Mosannenzadeh et al., 2017, p.57)*

  The implementation of smart energy management needs to be understood at a sectoral level.

  One of the most significant features to come out of this pillar has been the development of Smart grids, technologically integrated electrical grids that track and monitor the consumption, distribution, and waste of electricity, through a series of interconnected sensors and feeders, with digital communications technology enabling it to detect, react and pro-act to changes in usage.

  Smart grids are enabled to automatically detect grid problems and ensure quick recovery after disturbances. Through smart city's innovation in sensor technology and integrated communication technology, the shift to these new forms may positively impact the management and curtailment of global energy demand.



Source: Making Indian cities energy smart - TERI[10]

- **Smart Buildings / Green Buildings –** Globally buildings account for 40 percent of all carbon dioxide emissions, which is higher than the carbon footprint of transportation. Buildings in major metropolitan areas consume extraordinary amounts of energy; lighting alone accounts for 30 to 40 percent of municipal electricity budgets.[11] Hence, via the pillar

[10] Making Indian cities energy smart, Policy brief, The Energy and Resources Institute (TERI), 2019

[11] Smart Cities in South East Asia, Mckinsey Global Institute, Discussion paper, 2018

of the smart building, smart cities explore ways to improve energy efficiency and reduce carbon footprint.

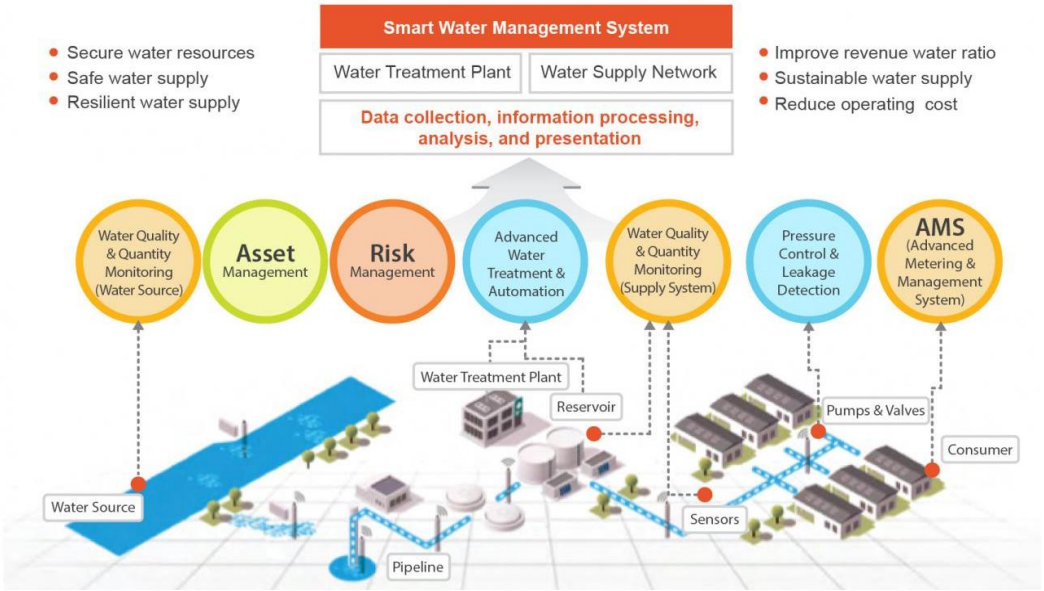
Smart buildings use automated processes to control the building's operations such as heating, ventilation, air conditioning, lighting, security, and other systems, but at the same time also focus on reducing energy consumption, energy dependence, and waste generation. Smart buildings are endowed with the technology to communicate with surrounding buildings within a grid to create localized energy "microgrids" that help stabilize supply fluctuations and reduce and manage overall energy demand.

It is also worth exploring the technology of ecological building design, as an add-on component to smart buildings. This includes the passive house concept, which has built in design characteristics that make buildings naturally cool in the summer and naturally warm in the winter, with significantly less energy input.

- **Waste management** – Smart waste management is mostly focused on usage of technology to improve operational efficiency, such as to plan better faster and streamlined routes for the movement of trash collectors, regularizing pick up and drop off of waste at designated waste compactors. Smart waste management solutions at termination points can include segregation and monitoring and management of waste, to reduce pollution, the number of open landfills and informal waste dumps.

- **Water and Sanitation** – Smart water management is essentially a system designed to gather meaningful and actionable data on the flow, pressure, and distribution of a city's water. Its goal is to ensure that the infrastructure and energy used to transport water are managed effectively, improving resilience, reducing operational costs, and improving system sustainability. In the water sector especially, smart systems allow water managers to make informed and systematic decisions based on validated data and limit the influence of human error in the decision-making process.

  The most popular smart water solutions are digital meters, sensors, Supervisory Control and Data Acquisition (SCADA) systems, and geographic information systems (GIS). More detail on these technologies are provided in Module 5.



Source: You Kwangtae, CEO, UnU Civil & Environmental Engineering, Republic of Korea.

- **Smart Surveillance –** makes use of automatic video analysis technologies in video surveillance applications and integrating them to a central command and control centre monitored by police and security task forces. Surveillance also includes the monitoring of the overall environment, including street lighting, emergency helpline systems, tracking of ambulances and ensuring the accessibility of support for those in need. All these services are delivered through the development and implementation of applications. Advances in Artificial Intelligence (AI) and Computer Vision come from Edge Computing and embedded components, which have improved the integration of Smart Surveillance. This development created a strong relationship between IoT and Edge Computing. AI systems are becoming more and more advanced, leading to numerous enhancements in applications of new technologies.

4.6 Smart City Technologies and Solutions

This relates to the widespread use of smart technology for integration, digitization, monitoring, and management.

A smart city uses Information and Communication Technologies (ICT), Internet of Things (IoT), 5G, Artificial Intelligence (AI), robotics and sensors, blockchain, and big data to increase operational efficiency, share information to monitor, control, analyses and connect various urban systems and services thereby improving the competency and quality-of-life of urban dwellers. In a smart city traditional networks and services are made more flexible, efficient, and sustainable with the help of information, digital, and telecommunication technologies to improve its operations in systematic, adequate, and sustainable manner. Smart technologies provide cities with the opportunity to become safer and more inclusive, resilient, and sustainable society (United Nations, 2015, 2017).

There is a need to promote the use of clean technologies that utilize renewable energy sources and renewable materials that help to reduce carbon footprint. IoT devices, such as drones, sensors, automated devices, and robotics – all these smart city digital technologies can be included to improve the safety of the city. There is also a need for integrating surveillance and security cameras to aid with crime detection and prevention. These smart applications are crucial for serving the urban police force.

At the same time, safeguards need to be in place that protect the privacy of citizens, and prevent unwanted intrusiveness.

4.7 Smart Mobility

Cities all over the world have become overrun by automobiles, pollution, loss of public space, crashes along with a cumulate heavy loss of life, and many city dwellers lack vital exercise while being stuck in traffic. There is no other way around it: additional road space will not save the day and cities need to institute concerted plans for reducing automobile dependence.

If city spaces can be transformed into places where automobiles no longer dominate, then finally green and public space, active travel, the 15-minute city and children-friendly city concepts will come back into vogue. In this pillar, Smart Mobility links up with green and ecological transportation, to lead a determined effort to turn around cities, bringing huge wins not only to citizens, but also to the climate.

In fact, concerning the future of Asian cities, in 2021, at the UNCRD Environmentally Sustainable Transport (EST) Forum, the 2030 Aichi Declaration was agreed upon. This is a noble initiative to bring together leading cities in Asia, with the determination to transform urban transportation. The declaration focuses on many aspects. These range from land use, integrated transport planning, and improving transport efficiency, while looking at cross-sectoral funding and financing arrangements that favor sustainable transportation, and remove fossil fuel subsidies.

From the point of view of "Smart Mobility" – this focuses on increasing the efficiency and service quality of urban transportation to enhance the use and adoption of new mobility solutions, through improved mobility management and targeted infrastructure investments. This has the potential to develop and achieve cheaper, faster, and environmentally friendly urban mobility, with specific emphasis on integrated multi-modal transportation.

The different services supported under this module are rapid mass transit systems, on-demand mobility solutions, ridesharing, vehicle-sharing, electric vehicles, biking and walking, and Mobility as a Service (MAAS).

Smart Mobility addresses specifically the movement of people, services, and goods. With the emergence of many new forms of shared mobility options and the expansion of electric vehicles, it is essential that technology is smartly employed to increase the desirability of sustainable transport options and help reduce the sector's environmental impact.

Box 2: Smart Mobility in Asia

Singapore Driverless Mass Rapid Transit (MRT):

A growing number of residents (over 5.6 million people) and vehicle population (almost 1 million motor vehicles) have brought Singapore's Land Transportation Authority (LTA) and the Intelligent Transportation Society Singapore (ITSS) together to create an intelligent transport system to improve commuters' travel. Singapore's Smart Mobility 2030 strategic plan is an example of a smart plan that focuses mainly on transportation. The project aims to be informative, interactive, assistive, and to use green mobility. The LTA and ITSS have outlined three key strategies to achieve their goals:

- *To implement innovative and sustainable smart mobility solutions.*
- *To develop and adopt intelligent transport system standards.*
- *To establish close partnerships and co-creation*

4.8 Smart Economy – Innovation and Entrepreneurship

This field can be understood as an economy based on innovation and entrepreneurship, high productivity, labor market flexibility, openness to international and inter-regional cooperation and capacity for change.

Smart Economy describes actions aimed at transforming the local economy, by improving the environment for business, start-ups support, investment in new innovations, and new highly skilled talent. This also includes focusing on ways to increase the competitiveness and sustainability of businesses in the city.

Attracting Micro Small Medium Enterprises (MSMEs) is a priority for smart cities and thus the focus is on local partnerships, the creation of joint platforms for engagement, entrepreneurship cells, skill development programs, and also technology commercialization workshops.

4.9 Smart Living – People, Planet, and Prosperity

Here we see the use of technological solutions to improve the overall quality of life in a city. This includes technology for monitoring air quality, green spaces, quality of public spaces, pollution, health, and others. Smart living prioritizes and encourages its citizens to adopt an active and healthy lifestyle, high-standard high standard urban amenities, and a vibrant public realm including safe and pedestrian-friendly streetscapes, as well as access to sustainable mobility options in city centers and neighborhoods, for all ages.

Smart living also encompasses the use of technology integrated with local parks to monitor and promote healthy and balanced urban ecology; including lake management, urban greenery monitors, and sound and air quality monitors, all integrated into public spaces to increase citizen awareness and action.

Questions for Trainers

1. List several benefits to society that can result from progress made in 1-3 Smart City pillars.
2. What are areas within governance that could readily be optimized in a digital platform? In what areas would that be more difficult?
3. Design your own pilot project for a smart and green building. How can ecological principles and smart buildings work in tandem? Which features would make sense to import?
4. Smart mobility encompasses electric mobility (E-mobility, Automatic vehicles) but goes beyond that. How can this field support pedestrians and active transport?
5. Will smart living options provide people with an incentive to live a healthier more environmentally conscious life?

Module 5: Smart City Technologies and Solutions

"Smart city solutions are the practical use of data and digital technologies to deliver infrastructure or services in the urban setting, all with the goal of improving outcomes that relate to livability, sustainability, and productivity."

- McKinsey Global Institute

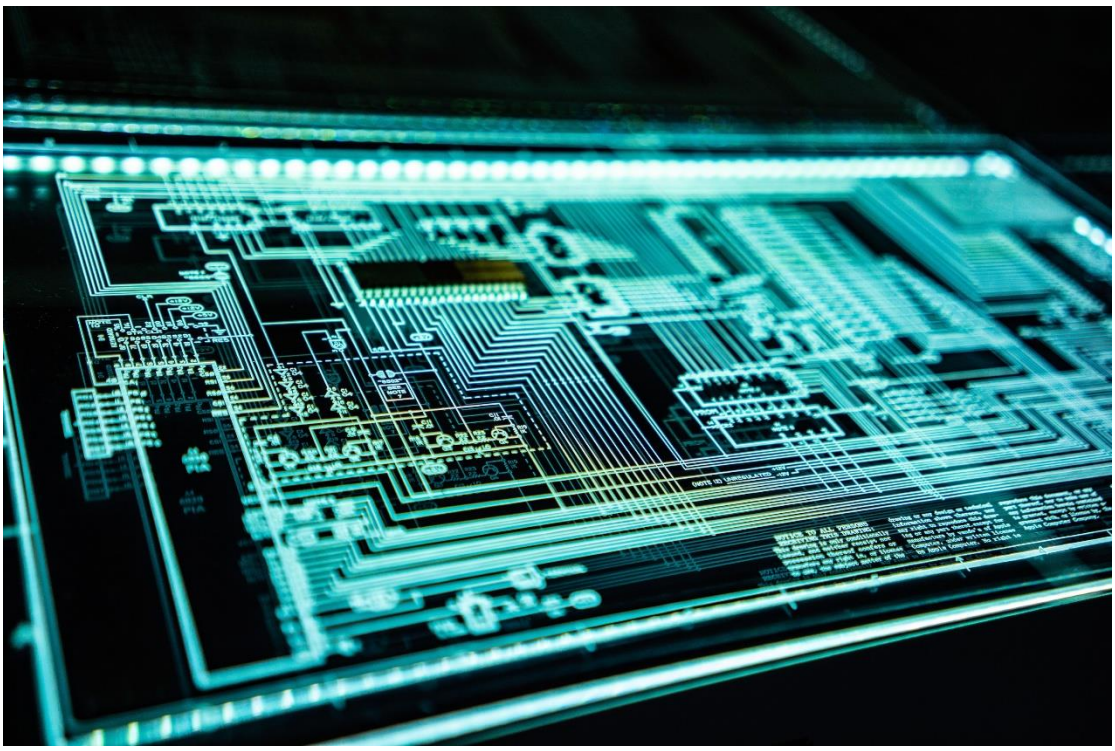


Figure 6 - Photo by Adi Goldstein. Smart LED panel is an important smart city solution

5.1 Purpose of this module

This module dives into the tools and technologies (smart technologies) involved in the making of Smart Cities, and the solutions that have been developed from the use of these technologies (smart solutions). This could be seen as an eye-watering box full of technology candy, although it must be remembered that all of the technologies are subjugated to the high level objectives, and should aid cities in their quest to improve urban services and help achieve their SDG goals.

5.2 Key learnings Points

1. According to the smart cities framework, smartness refers to the use of technology and the Internet of Things (IoT) in a holistic manner, with a clear purpose and list of desired outcomes.
2. Smart Cities consist of more than just technology, gadgets, and networks. The success of smart cities is seen in the innovative solutions developed through informed, inclusive, and data driven processes.
3. Smart city initiatives are focused on core objectives – efficiency, ease of use, integrated management of city services, better monitoring and sustainable consumption of resources, data-informed decision making, and increased quality of life for all citizens.

4. Capacity development on how to use, manage and run IoT-enabled infrastructure is needed to ensure the long-term sustainability of smart city projects. This is especially for government staff who will be responsible for running and maintaining this infrastructure
5. Understanding how to manage large amounts of data produced as a result of the Smart infrastructure, is essential to the success of smart city projects. Hands-on workshops are needed to bridge this knowledge gap.
6. The success of Smart Cities is also dependent on the environment around them, namely, the state of governance and government policies. National governments can play a significant role in the success of smart city initiatives, by providing support in the form of creating an enabling environment – policies, guidelines, laws, and frameworks that ensure the orderly adoption of smart city concepts by local governments
7. The role of public-private engagement and partnerships is also important in ensuring the successful adoption and implementation of Smart city solutions.
8. Big Data is changing the way cities function, and it is important that city governments understand in full detail the potential benefits and pitfalls of the use of big data, in order to ensure future use and access to public data is safe, secure, and inclusive. The monetization of data should also be clearly regulated, ensuring adequate policies are in place and enforced.
9. The true strength of smart city initiatives can be evidenced when collaboration is nurtured. This should involve the full spectrum of stakeholders and ensure that all members of society are represented and able to contribute to innovative solutions.

SECTION ONE – SMART TECHNOLOGIES

Smart branding is a widely recognized approach for using technology, the internet, and networks as tools to tackle pressing urban challenges. Beyond technology, a major highlight of smart city initiatives has been the use of *smart solutions* – solutions that are holistic, inclusive, comprehensive, practical time-bound, grounded by participatory citizen engagement, and informed by data. In this way, the multiple tools and outcomes of smart city initiatives fall into two categories – Smart Technologies and Smart Solutions.

Smart technologies, in combination with association with different policy and planning efforts, have stimulated the development and implementation of multiple solution frameworks across sectors of energy, water, waste, safety, health, and governance.

The needs, demands, and aspirations of today's urban citizens exceed the public sector's capacity and reach; but through the implementation of smart solutions, this can be significantly improved.[12]

5.3 Internet of Things (IoT)

Definition: According to Oracle, the Internet of Things (IoT) is the network of physical objects "things" - that are embedded with processors, sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.[13]

[12] Smart Cities in South East Asia, Mckinsey Global Institute, Discussion paper, 2018

IoT has been defined as "The network of connected devices that communicate and enable the seamless collection, analysis, and prediction of data sets".[14]

Impact and use: The application of IoT is widespread, and in the last two decades this has increased significantly. A research paper on improve IoT and Software defined networking reveals that there will be more than 75.44 billion connected IoT devices globally, by 2025.[15] As one of the champion features of the smart cities initiatives, the application of IoT has shown urban leaders a host of the advantages by making data-informed decisions. IoT developments have also steered the necessary systems to foster and enable improved intergovernmental cooperation and coordination.

The IoT system comprises a basic set of devices, intelligent sensors, monitoring devices, actuators for automation, and AI programs that evaluate, monitor, and provide a useful extra layer of monitoring and control of many processes inherent in urban systems. The large-scale manufacturing of these devices at affordable, reliable, and energy-efficient states, has enabled the widespread adoption of IoT technology. Along with wireless networks and high-speed internet, the integration of sensors to the cloud and to other IoT devices ensures efficient data transfer. Conversely, cloud computing platforms enable IoT to engage with smart infrastructure and improve overall infrastructure management. IoT is especially important concerning the integration of artificial intelligence (AI) and robotics within the different sectors of urban development such as housing, energy, transport, economy, and governance.

The International Telecommunication Union (ITU) estimated that approximately 4.9 billion people (63%) of the world's population used the Internet in 2021. An increase of 17% from 2019. However, 2.9 billion people did not have direct access to the internet.[16]

Best Examples: IoT is the backbone of many successful initiatives. The most popular are integrated public transport, traffic monitoring and management, water level and flood monitoring, video surveillance and analytics, and intelligent street lighting systems. Shenzhen PR China has implemented IoT technology to encourage multiple institutions to share data on public services and city management services. To this end, the city installed surveillance cameras, smart streetlights, water quality sensors, and other devices to be connected to a cloud cloud-based IoT platform.[17]

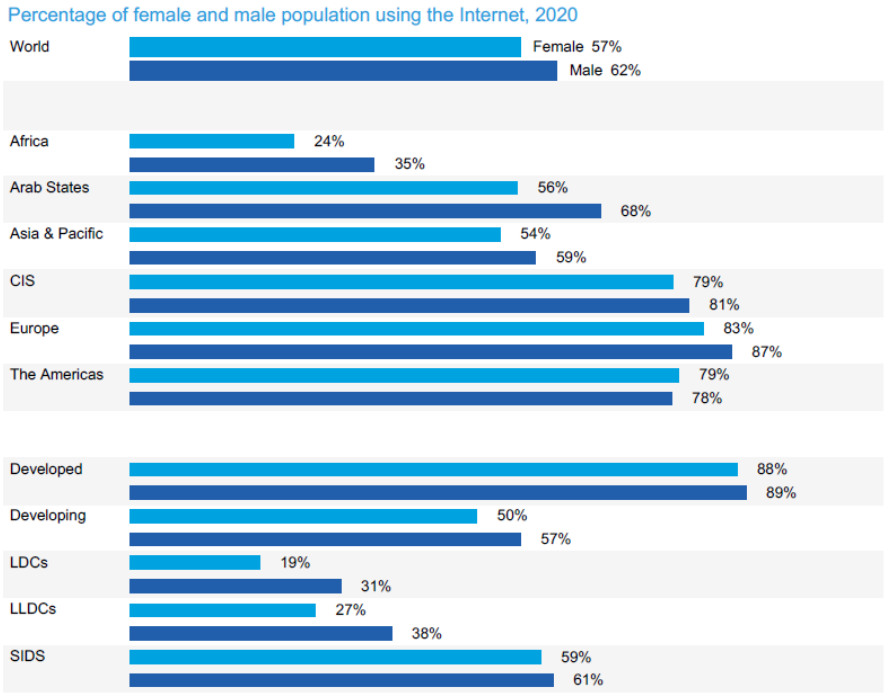
[13] https://www.oracle.com/internet-of-things/what-is-iot/

[14] https://hub.beesmart.city/en/solutions/what-is-iot-and-why-is-it-important-for-smart-cities

[15] Improving Internet of Things (IoT) Security with Software-Defined Networking (SDN), 2020, - https://www.researchgate.net/publication/339121533_Improving_Internet_of_Things_IoT_Security_with_Software-Defined_Networking_SDN

[16] Measuring digital development, Facts and figures, 2021, ITU publications

[17] Bauer, M.; Sanchez, L.; Song, J. IoT-Enabled Smart Cities: Evolution and Outlook. Sensors 2021,



Source: Measuring digital development, Facts and figures, 2021, ITU publications

Figure: Smart City Objectives Real-World Use Cases of IoT [18]

Smart City Objectives	Real-World Use Cases of IoT
Efficient management of cities lighting systems	*Smart street lighting adapts its intensity to match the conditions of the day (morning/evening/etc) or sudden change in weather conditions*
Improving traffic flow	*Automated traffic management systems redirect traffic to manage congestions, inform authorities of crashes, capture license plates of offenders*
Better road safety and public transport	*Making autonomous vehicles possible in the future, including automated public transport*
Better allocation of city utilities	*Energy resource meters (water, gas, electricity) automatically send consumption data to the relevant service providers*
Reduction in resource use and improvement to the environment	*As resource use is optimized and processes are automated, it leads to a smaller carbon footprint and hence better environmental results*
Centralized monitoring of city operations	*Integrated Command and Control Centers (ICCCs) are the brains of the smart cities where all inputs are processed and analyzed*
Aggregated data on urban functions	*Data generated from different IoT sensors, devices, and cameras can be combined to use in new applications. Data can be open to the public to enable innovation*
Waste collection and disposal	*Smart garbage bins can notify fill levels to help waste collection authorities optimize garbage collection routes*
General increase in standard of living	*Informed and digitally literate citizens who can use eGovernance services for most of their needs*

[18] https://www.techtarget.com/iotagenda/definition/Internet-of-Things-IoT

Source: How the Government Can Use IoT to Drive Smart City Development, 2022[19]

The subsequent module dives deeper into the making and impacts of these innovative solutions.

Challenges: Without a doubt, IoT has resulted in a heightened level of connectivity in cities the world over. Increased connectivity however brings along a unique set of challenges, such as increased demand for energy to run data centers and support systems. A lack of knowledge within governing bodies on how to manage these networks, data centers, and how to establish data privacy and protection guidelines, further impacts long-term planning. Hence capacity development on how to use, manage and run IoT-enabled infrastructure is needed. Further, a thorough understanding of how to manage the large amounts of data produced as a result is essential to the success of an IoT system. It should also be noted that simply "managing" data is not enough. Management and stewardship of data require a scientific approach that is based on establishing theories and working models, with a precise framework that has been well thought out and serves clearly defined purposes in a transparent manner.

Active private sector participation has addressed these challenges to a certain extent, but to ensure the long-term sustainability of smart systems, more research, policy debate, and more hands-on workshops and training need to be held regularly. This will address upskilling requirements and refresh knowledge on working with IoT systems and infrastructures.

5.4 Information and Communication Technologies (ICT)

Definition: IoT and ICT are very closely related and often referred to interchangeably. But for the sake of breaking down the smart city approach, Information and Communication Technologies is the overarching system that enables full scale digitization of urban systems. This includes IoT applications, and software services. Where IoT refers to the full spectrum of individual components and their specifications, the ICT system addresses the network, the systems, how they connect and communicate with each other and how this communication is made accessible, understandable, and useable for people and organizations (i.e., businesses, non-profit agencies, governments, enterprises).

Impact and use: Conventional urban planning approaches have focused on developing infrastructure in silos, and sectoral departments have operated without direct communication or sharing of information. But with the integration of ICT tools, there is a renewed cooperation and coordination between different levels of governance, to improve the overall delivery of urban services. Within smart city initiatives ICTs have changed how data is managed and used, as most smart city applications and smart solutions run on ICT infrastructure. This data, recorded and monitored in real-time, helps improve the quality, performance, and interactivity of urban services. Reducing costs aids the monitoring of resource consumption. ICT has also been a key factor in improving participatory governance by providing an active platform for citizens and stakeholders to engage. ICT infrastructure also plays a vital role in developing a city's resilience and preparedness, as it empowers cities with tools to monitor, evaluate and respond to disasters effectively and immediately.

Challenges: The setting up and running of efficient and functional ICT systems has not been smooth sailing across all geographies. Smart City initiatives from developed nations have been

[19] How The Government Can Use IoT to Drive Smart City Development, 2022, https://hsc.com/Resources/Blog/How-The-Government-Can-Use-IoT-to-Drive-Smart-City-Development

better able to rely on a strong digital infrastructure base and have gained more from ICT, seizing many advantages and opportunities to improve the way their cities run.[20]

Example: Los Angeles is well known as a global hub for business and technology innovation. It is however also known to be one of the most traffic-affected cities in the world, which comes with numerous negative externalities. The city has begun implementing smart traffic solutions, involving a combination of road-surface sensors and closed-circuit television cameras. This network is supported by advanced ICT infrastructure, sending real-time updates to a central traffic management platform that analyses the data and notifies users of traffic congestion incidences, via an app. In addition, traffic lights are controlled by a network of smart devices, based on changing traffic conditions in real-time. This comes on top of complementary efforts to provide a better bicycle network for active mobility and increasing the quality and density of the public transport network, including metro and light rail.

Similarly, countries with advanced policies and guidelines on data use, and frameworks for the setting up of digital infrastructure have been able to reap significant benefits and advance in their goal of creating highly integrated, intelligent, and responsive urban systems.[21] National governments play a significant role in the success of smart city initiatives, by providing support in the form of creating an enabling environment. Some examples follow.

1. Allocating a share of infrastructure investments to specifically target smart infrastructures, such as intelligent transportation systems and smart grid systems.

2. Developing policies and common standards for smart city technologies that encourage interoperability and data sharing to increase the effectiveness of smart city applications and increase the value proposition for smart technologies.

3. In 2017 the U.S. government published, through their Networking and Information Technology Research and Development (NITRD) Program, a strategic plan to support smart cities with accelerating R&D in software-defined networking, automation, and cybersecurity. With the aim to establish a foundation for applied research that can in the future help with adoption of Smart city technology solutions. [22]

4. In 2014, the European Commission and Japan launched the FESTIVAL project with the focus on creating formal testbed platforms for smart city technologies. Similarly, national governments can develop platforms for inter-city exchange of tools and ideas. [23]

However, in developing nations the integration of digital infrastructure within the urban sphere (including governance) is yet to fully take hold, and so the full-scale deployment of ICT has struggled. Especially in the case of interoperability, where applications and devices from diverse service providers working on diverse platforms are unable to connect to each other or to a primary smart city data center. This was witnessed in Japan, where after the Tōhoku earthquake and tsunami hit in 2011, turning into a nuclear disaster at the Fukushima plant, it was noted that "a *lack of interoperability between the first respondents and other corresponding civic agencies significantly hampered rescue efforts*".[24]

[20] Bellini, P.; Nesi, P.; Pantaleo, G. IoT-Enabled Smart Cities: A Review of Concepts, Frameworks and Key Technologies. Appl. Sci. 2022,
[21] Personal Data Protection Singapore-Annual Report 2014-15,
[22] How National Governments Can Help Smart Cities Succeed, J. New, D. Castro, and M. Beckwith, 2017
[23] FESTIVAL: Federated interoperable Smart ICT services development and testing platforms." 2017,
[24] An Overview of Smart Sustainable Cities and the Role of Information and Communication Technologies (ICTs)"

"From charging stations to connected parking and security solutions, a variety of service providers rely on platforms to deliver their services. Each platform uses a proprietary data model and has its own particular interface. This one most often requires onerous integration work to be able to interact with other platforms." Lena Dorsch, Bosh

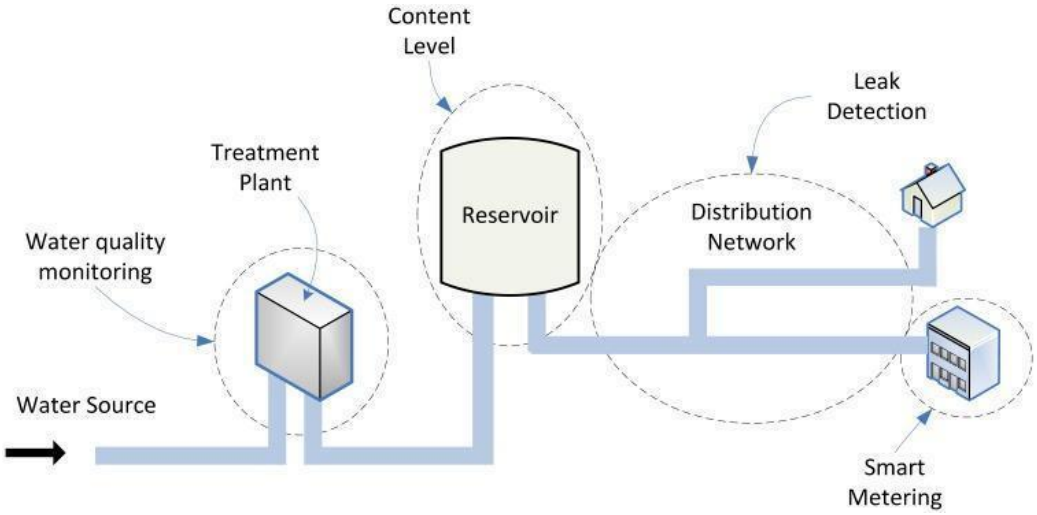
Nevertheless, through a continuous exchange of best practices between cities and businesses from across the globe, nations are taking action to establish ground rules such as guiding frameworks and standards, to steer the digitization movement, and ensure all new infrastructure works within their cities. [25] In India, the Ministry of Housing and Urban Affairs (MOHUA), has taken steps to guide cities to use the right tools and strategies, through frameworks and white papers, such as the "ICT Deployments and Strategies for India's Smart Cities",[26] that explain the need for establishing high functional ICT systems and detail the steps involved to develop, plan, implement, integrate and monitor the systems.

5.5 Automation and Sensors

Definition: Sensors are at the heart of Smart City infrastructure. Using sensors to monitor public infrastructures, such as bridges, roads, and buildings, increases awareness by generating relevant data, which further enables the efficient use of resources. Real-time monitoring eliminates the need for scheduled inspections, therefore reducing capital costs and reducing losses incurred from mismanagement. [27] Sensor technology validates the goal to make urban governments take decisions in real-time as events or emergencies occur, improving hands-on responsiveness.

Impact and use: Sensors have led to the creation of a multitude of technology solutions for energy management, waste management, water management, smart streetlights, transport management, pollution and air quality monitoring in real time, and others. This has been possible by the linking of sensors, through a WSN (Wireless Sensor Network) - a network of end sensor nodes, routing nodes, and a collector sink node, which also allows for scalability of services, and provides place based, dynamic information. This continuous data feed further enables cities to actively monitor and control the delivery of services. Sensor applications in water distribution systems enable error detection. The locations where sensors are deployed are essential and depend on interest parameters, as shown in the figure below. Such applications are best used for monitoring level of water in tanks, monitoring leak detection and monitoring the water quality at specific points along the distribution system.[28]

[25] IEEE International Conference on Advanced Networks and Telecommunications Systems, 2020
[26] ICT deployment and strategies for India smart cities, Technical report, Dept. of Telecommunications, GoK, 2015
[27] Hancke GP, Silva Bde C, Hancke GP Jr. The role of advanced sensing in smart cities, 2012
[28] Hancke GP, Silva Bde C, Hancke GP Jr. The role of advanced sensing in smart cities, 2012



Source: Hancke GP, Silva Bde C, Hancke GP Jr. The role of advanced sensing in smart cities, 2013

5.6 Geospatial Technology and Digital mapping

Definition: This is a multidisciplinary field involving numerous tools such as surveying, photogrammetry, remote sensing, mapping, geographic information systems (GIS), geodesy, and global navigation satellite system (GNSS), to visualize, track and monitor the impact of smart solutions. The rapid integration of geospatial technologies with urban infrastructure has been possible due to advances in supporting technologies like 3D modeling and LiDAR, mobile mapping technologies, and remote sensing technologies. "*Geospatial standards are also becoming a vital component of building information modelling (BIM)".*[29]

ESRI defines the Geographic Information System as *"A tool that integrates all aspects of city planning and management providing a common operating picture to all. As a smart city involves multiple stakeholders, the integration, coordination and synergistic functioning of different participants of the smart city ecosystem is key for the project to be successful"*

Impact: GIS has enabled a wide range of solutions including, route mapping, monitoring traffic flows, monitoring congestions, mapping real-time information about available parking spaces and adjusting prices dynamically based on demand and need. GIS applications are also being used in the health sector, where hospitals and emergency services use geospatial analytics to pinpoint the best locations to dispatch facilities based on projected ambulance transport time.[30]

Examples: In Boston, a Citizen Connect program was developed, to allow citizens to report municipal problems, such as vandalized or damaged public property, through a GIS enabled website and mobile application; all reports were geotagged, directed to the appropriate agency, and resolved promptly.

Likewise, in Uji City, Japan, GIS based mapping was used by city planners to determine the location for setting up new child-care centers.[31] And in Hong Kong Special Administrative Region of China an online street map was developed, with the help of geospatial analytics, to demarcate historical sites, cycling tracks, and other public facilities. Citizen users navigate the

[29] P. Padode, Role of Geospatial Technologies in Building Smart Cities, 2015
[30] Role of Geospatial Technologies in Building Smart Cities, 2015,
[31] Satoh, K. , Tsukahara, K. and Yamamoto, K. Location Evaluation of Childcare Facilities Focusing on Transportation in Japanese Urban Areas, 2018,

map and obtain real time place-based information.[32] This kind of interface is being developed globally in multiple cities, as a prerequisite for setting up more advanced smart city projects.

Challenges: A particular challenge with use of geospatial technology is that it demands specialized skills, knowledge and understanding, of not only the software, but also of spatial analysis, data management, representation, and interpretation. Only experts with significant experience working with the software and knowledge of spatial data analysis can partake in the analysis and provide prompt and effective solutions. Furthermore, in many developing countries, due to a lack of political will, knowledge and understanding of mapping and spatial analysis – "cities are yet to attain sustained access to digital technology, internet connection, and computer literacy, needed to contribute to this kind of spatial data analysis". [33]

5.7 Big Data Analytics and Cloud Computing

Definition: With digitization and data collection becoming an integral part of everyday life, huge amounts of data are being collected and stored. The effective analysis and utilization of big data is a key factor for success in the smart city domain. It is estimated that the amount of global data generated per year will grow at a rate of 40%, whereas global spending on IT infrastructure will grow by 5%. But in the last two years, over 90% of the world's digitized data was captured, and as a result, many governments have started to formally recognize and utilize big data to support the development of their cities. [34]

Impact: The mainstream adoption of Big data analysis is connected to its potential to help with: efficient resource consumption, better quality of life, and improved transparency and openness. But to reap these benefits requires the implementation of more sophisticated applications, demanding more resources, and greater human resources and skills. This further calls for investing in more advanced technology, better development efforts and effective use of big data; and to develop policies that ensure data accuracy, data quality, security, privacy, and control. There is also a need for standardizing data collection and documentation processes, so that datasets are used to their fullest capacity.

Examples: There are many, especially in the fields of education, energy efficiency, healthcare management, and natural resource management. For example, The South Korean Ministry of Food, Agriculture, Forestry, and Fisheries and the Ministry of Public Administration and Security (MOPAS) launched the *Preventive Foot and Mouth Disease Syndrome System* to harness big data related to animal disease overseas, customs/immigration records, breeding farm surveys, livestock migration, and workers in the livestock industry to map and monitor and curb the spread of the disease.[35]

Challenges: Big data, in its collection, processing and analysis, is also subject to divergent systems and types of governance, each with their own security protocol. In a smart and fair city, data collection and use is handled in the most transparent fashion, with the protection of citizens and their privacy a non-negotiable policy, in effect setting the bar high for democratic governance. The monetization of data should also be clearly regulated, ensuring adequate

[32] How GIS technology and geospatial analytics can improve city services, Mckinsey, 2018
[33] The Integrated Geospatial Information Framework, Bridging the Geospatial Digital Divide, Department of Economic and Social Affairs United Nations, 2019
[34] Al Nuaimi, E., Al Neyadi, H., Mohamed, N. et al. Applications of big data to smart cities, 2015
[35] Kim GH, Trimi S, Chung JH. Big-data applications in the government sector. Commun ACM. 2014

policies are in place and enforced. Governments and administrations should therefore be assertive in their policies and arrangements with large tech companies.

5.8 Artificial Intelligence (AI)

The Policy Department for Economic, Scientific and Quality of Life Policies (IPOL) defines AI as *"Artefacts operating in cities, which are capable of acquiring and making sense of information on the surrounding urban environment, eventually using the acquired knowledge to act rationally according to predefined goals, in complex urban situations when some information might be missing or incomplete"* [36]

Definition: AI is expected to enable over 30% of smart city applications by 2025. Modern AI empowers city officials with accurate tools to measure different city processes, make data-informed decisions faster, and enact changes that improve quality of life. Presently AI is being integrated and used to monitor and manage three main urban systems – Intelligent Traffic Management Systems, public security through improved video surveillance systems, and energy efficiency in urban buildings.

Example: In the city of Suwon, South Korea – government buildings were fitted with various sensors to monitor energy consumption over months. After full optimization, some buildings saw a 30% rise in energy efficiency, and 35% reduction in carbon emissions.

[36] Artificial Intelligence in smart cities and urban mobility, IPOL, 2021.

SECTION TWO – SMART SOLUTIONS

This section highlights a number of solutions to come out of different smart city initiatives. Smart solutions take the form of a wide variety of individual applications. They can be hardware solutions, software, and systems-related applications, mobile applications, and even sensor integration solutions. The main aim of smart solutions is to capture or measure readings from the physical world (encapsulated in data) and then utilize them in the planning process.

Source: Smart City Guidelines, Government of India, Ministry of Urban Development, (June, 2015)[37]

The following are listed as some of the most significant smart solutions impacting cities globally.

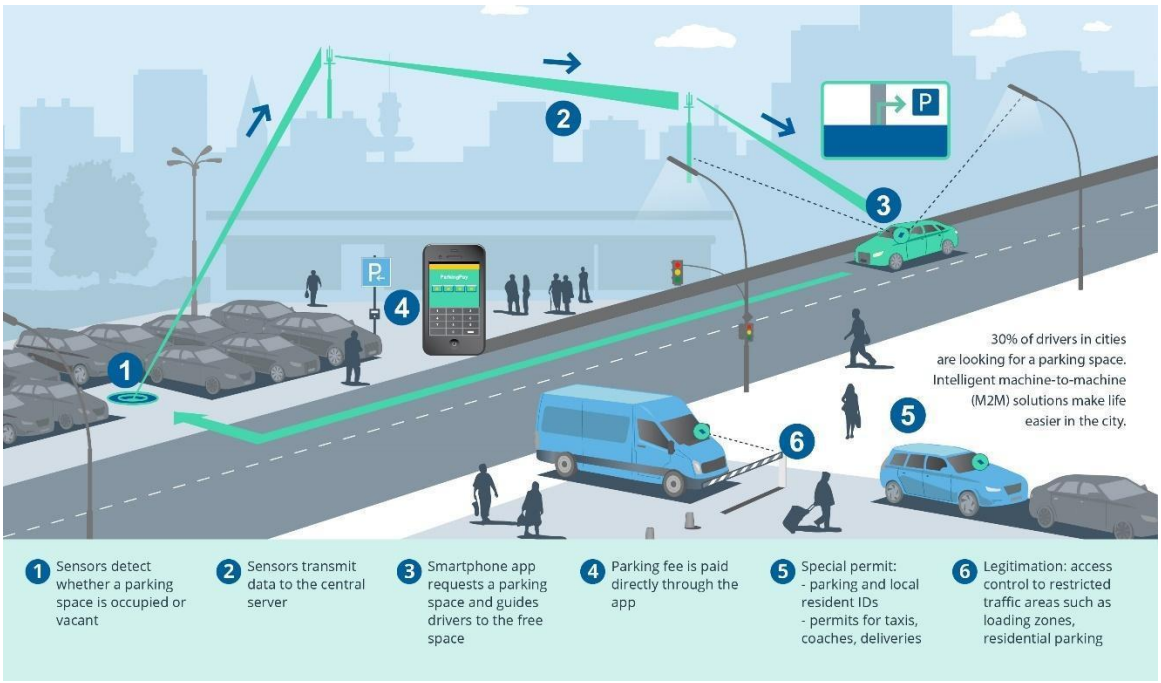
5.9 Intelligent Transport Systems (ITS)

"*ITS contributes to increased transport safety, seamlessness, and convenience while reducing their environmental impact, thereby supporting core elements of the 2030 Agenda for Sustainable Development."*[38] The application of IoT technology and data analytics is significant for improved management and operation of the transport sector. ITS systems gather data to provide the transport user with timely, relevant information to aid with transport related decisions. It is important to consider ITS, not as an end in itself, but as a means to achieve and shape transport policy objectives. Some of the applications of ITS are:

1. To provide real time information, both for public transport and private road transport
2. The use of Geographical Information Systems (GIS) and relational databases to keep inventories of transport infrastructure within an area

[37] Smart City Mission Statement and Guidelines, Ministry of Urban Development, Government of India, 2015
[38] Guidelines for the regulatory framework of ITS in Asia and the Pacific, UN ESCAP, 2019

3. To develop detailed route planning information and passenger information systems
4. To develop parking guidance systems
5. To monitor and manage traffic signal control, in real time, to improve the efficiency of traffic flows
6. To create sophisticated booking and scheduling software that maximise vehicle utilisation in a Demand Responsive Transport (DRT) scheme.



Source: How Intelligent Mobility Is Solving Challenges for Smart Cities, Intellias, 2021[39]

While ITS can be used for multiple solutions, the key focus of cities the world over has been to develop efficient urban transport systems that encourage sustainable multi-modal transportation. As a lot of modern civilization has been characterized by polluting and inefficient use of single transport systems, it is paramount that the smart city of the future corrects these failures by incorporating smart mobility solutions with a low carbon footprint.

5.10 Smart Traffic Management Systems

In Thailand, Area Traffic Control (ATC) systems have been implemented in multiple cities, such as Bangkok, Chiang Mai, Phuket and Pattaya), to improve adaptive signal control, by employing real-time traffic data in adjusting timings of traffic signals. Similar systems have also been developed in major cities in Viet Nam.

5.11 Intelligent Parking Management System

One way to mitigate the negative effects of heavy vehicle traffic in urban and metropolitan areas is by improving and managing road vehicular parking.[40] Intelligent Parking Management (IPM) systems are based on wireless networks of photoelectric sensors, deployed on the access roads,

[39] https://intellias.com/intelligent-mobility-how-technology-is-solving-challenges-for-smart-cities/

[40] An Intelligent Parking Management System for Urban Areas, Juan A. Vera-Gómez, Alexis Quesada-Arencibia, Carmelo R. García, Raúl Suárez Moreno, Fernando Guerra Hernández, 2016

which then detect passage of vehicles on the roads and communicate information to the main data centre. Often this solution is integrated with passenger information systems, to provide real time information on parking availability, which further influences overall travel behavior and travel patterns of the end user.

5.12 Smart Mobility apps (passenger information)

To improve the overall service of mobility, by integrating all information on transport options such as public transport, on-demand services, vehicle sharing, bike sharing and ride-hailing on a single platform, not just as an information portal, but to also showcase the efficiency of multimodal transportation, and thereby influence travel behavior.

Delloit defines this simply as *"Reducing congestion, and fostering faster, greener, and cheaper transportation options."*[41] This solution has resulted in the development of new forms of mobility services, such as, on-demand ride-sharing services, carpooling, car-hailing, bike rental, and bike sharing applications.

In early 2003, Seoul adopted smart mobility solutions, namely advanced intelligent transportation systems, bus management systems, and GPS, to increase mass transit ridership from 30% to 70% modal share. This further catapulted the city as a world leader in smart mobility, and thanks to the creation of the World Smart Sustainable Cities Organization in 2010 the city began sharing transport solutions with the world.

To tackle growing congestion issues due to increasing populations, many Asian cities, such as Kuala Lumpur, Singapore, Jakarta and Manila, have begun adopting mobility apps to monitor traffic flows. *Waze traffic app, Beeline, Go-Jek,* to name a few.

5.13 Smart Waste Management Systems

By 2030, the amount of garbage produced by city dwellers is expected to reach six million tons. The World Bank predicts global garbage collection expenses will top $375 billion in the next five years. As a result, more sustained efforts are needed, first to reduce the sheer amount of waste being produced, then to manage and monitor waste disposal. Through IoT technology smart waste management provides real time data on waste generation patterns and behavior. This empowers municipalities, cities, and waste collectors to optimize their waste collection operations, plan better routes, schedule best timings for the sustainable collection of waste, and make more intelligent business decisions.

1. *Songdo International Business District, South Korea,* developed a truck-free waste management system, wherein sensor-equipped garbage bins and pneumatic pipes suck waste directly from building premises, separate organic and non-organic waste, and send it further to an underground network of pipes and tunnels that lead straight to a fully automated waste collection plant.

2. *Amsterdam*, in 2014, equipped waste collection trucks with a sensor that weighs and predicts fill levels based on historical data. The city further installed 12,500 Enevo fill-

[41] P. Viechnicki, A. Khuperkar, T.D Fishman, W.D Eggers, Smart mobility, Deloitte Consulting LLP, 2015

level sensors in waste containers and tested the system on plastic waste. By scaling the IoT solution from trial to city-wide deployment, the city sought to reduce annual waste collection costs by €3 million.

3. *Santander,* a northern Spanish coastal town, deployed 6,000 sensors and RFID and NFC tags that collect real-time data on waste levels of public waste bins and containers. The system is harnessed by GPS/GPRS tracking and optimizes fleet route management. Additionally environmental sensors on board municipal vehicles gather information about air quality, temperature and pollution, and feed into the city's "Cuida Santander " App, to be viewed and used by citizens and visitors.

5.14 Smart Water Management Systems

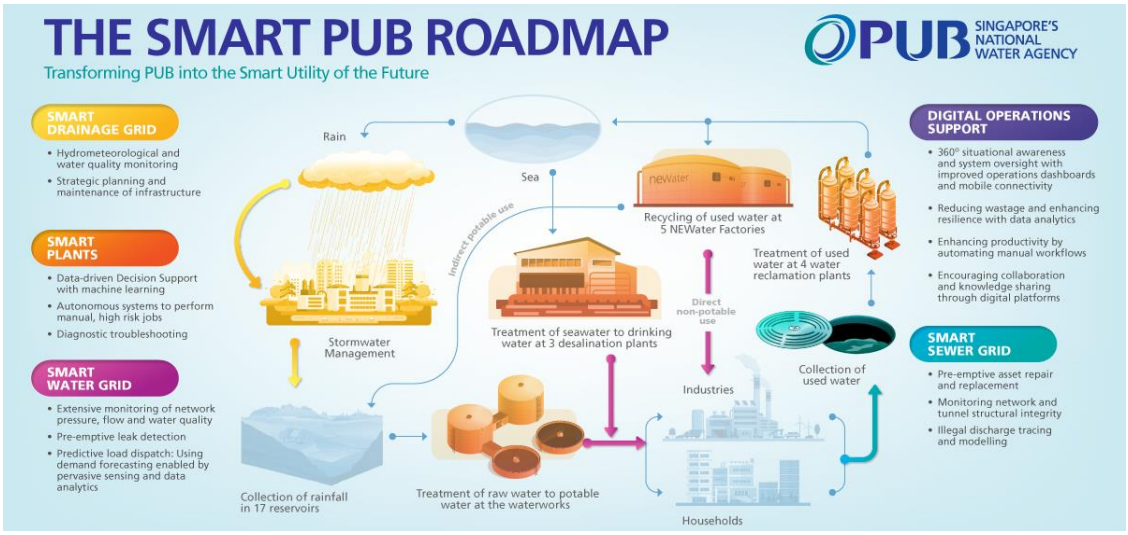
According to the World Health Organization, almost 50 percent of the world's population will be living in water-stressed areas by 2025. Thus, water comprises a very distinct challenge and an equity issue, making it a central theme as a Sustainable Development Goal. It is thus essential for cities to manage water in ways that ensure its universal accessibility, safety, and affordability. Smart City initiatives have been able to make use of digitization and automation technologies to enable improved monitoring, analysis, and operational processes of water distribution systems. This includes IoT and cloud computing to further support automatic remote data collection and transmission, which greatly enhances the efficiency of water management [42].

Smart water management systems enable more resilient and efficient water supply systems, including reducing costs and improving sustainability. Some of the significant solutions to come out of this section include digital meters and sensors, supervisory control, and data acquisition (SCADA) systems, and integration of geographic information systems (GIS) for mapping of the overall water network. [43]

Singapore is a best-case example for integrated water management and water technologies. The figure below shows how the Singapore National Water Agency has incorporated an integrated, effective, and cost-efficient approach for managing the nation's demand for water. The country's approach to water management can be divided into three strategies: a) Collecting every drop of rainwater; b) reusing water as much as possible: and c) desalinating seawater on a feasible budget.

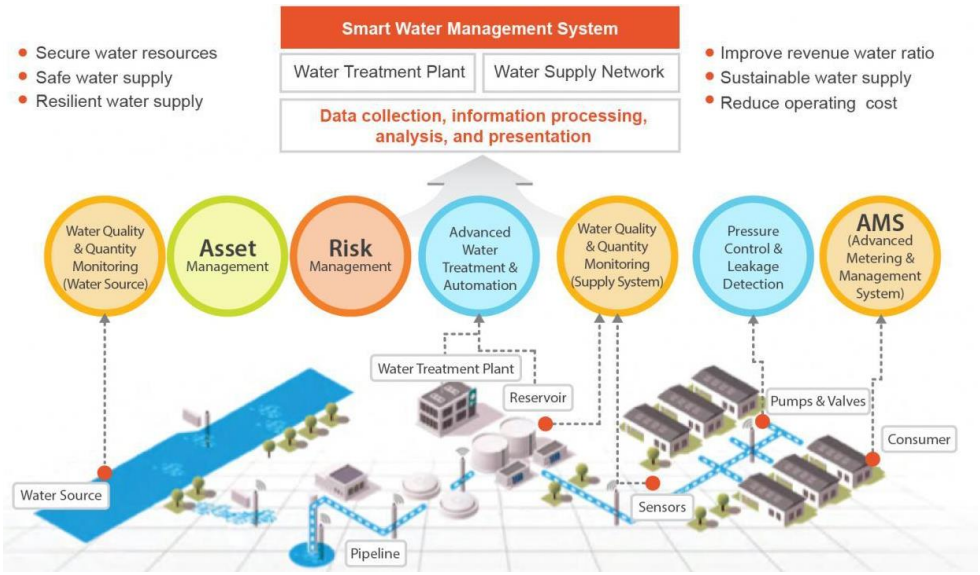
[42] https://smartwaterjournal.springeropen.com/track/pdf/10.1186/s40713-016-0004-4.pdf

[43] Asian Development Bank. 2018. Public-Private Partnerships and Smart Technologies for Water Sector Development



Source: *SMART PUB roadmap, Smart grid and water supply road map of Singapore, 2018*

A strategic step involved in the country's no waste policy has been to increase the water catchment area. For instance, since 2011, almost two-thirds of Singapore's land surface has utilized as a water catchment area. Beyond collection, the country also aims to reuse water effectively and efficiently. As a result, household water consumption has been reduced from 165 litres per person per day (in 2000) to 141 litres per person per day in 2018. The new target of the country is to reduce it further to 130 litres by 2030. In order to do so, the country is looking to create a smart water grid and a supply system.



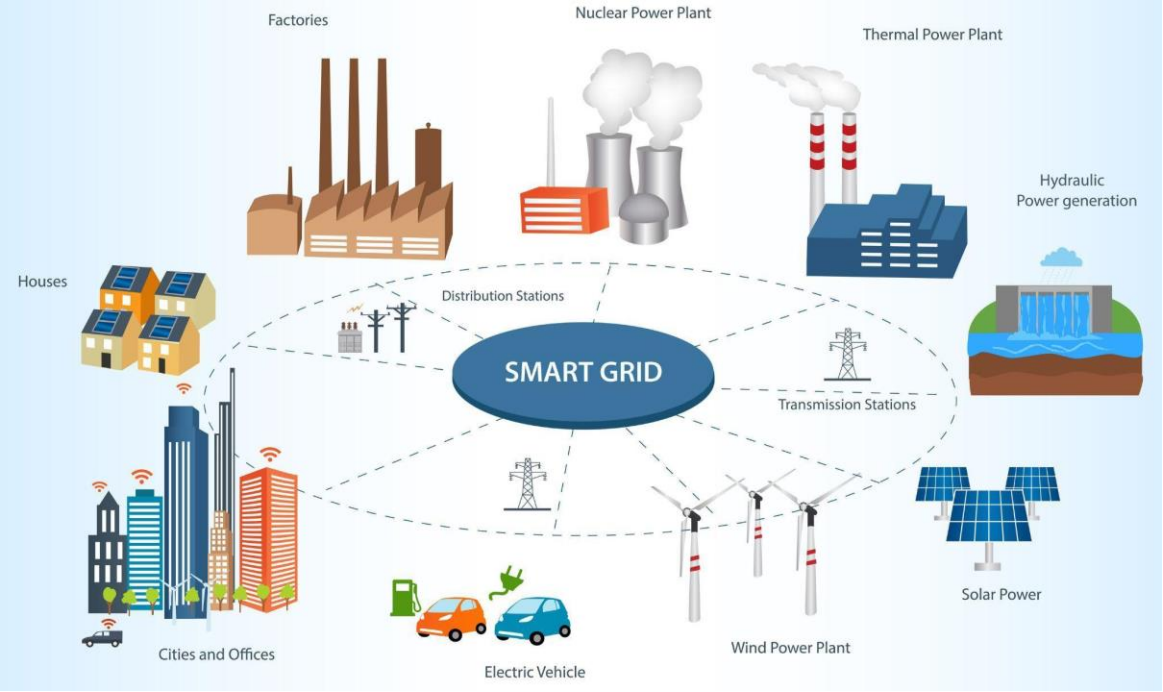
Source: You Kwangtae, CEO, UnU Civil & Environmental Engineering, Republic of Korea

5.15 Smart Grid

The Smart Grid can be described as the seamless and instantaneous two-way delivery and monitoring of energy, enabling the better and sustainable management of energy distribution. Smart grids are equipped with IoT technology to transmit energy more efficiently and allow providers and distributors better access to data on energy consumption. This empowers consumers to have more control over their individual energy decisions.

The concept of Smart Grid combines a number of technologies, and customer solutions and addresses several policy and regulatory drivers. According to the U.S. Department of Energy (Department of Energy, U.S. 2009): *"A smart grid uses digital technology to improve reliability, security, and efficiency (both economic and energy) of the electric system from large generation, through the delivery systems to electricity consumers and a growing number of distributed-generation and storage resources."*[44]

A smart grid enables a two-way flow of electricity and data with digital communications technology capable of detecting and reacting to changes in consumption as well as other grid management issues. The smart grid connects a variety of distributed energy resources to the power grid. Internet of Things (IoT), sensors, and real-time communication enable controlled distribution of energy, especially during peak demand. Smart meters provide real-time data to help cities align their energy supply according to demand.



Source: *Holland, Glesni. (1 April 2018). How sustainable tech is transforming Middle East utilities.*[45]

5.16 Green building development

Buildings are responsible for 30% to 40% of a city's total emissions. In 2019, the Coalition for Urban Transitions estimated that it would be feasible to reduce emissions in cities by roughly 90 percent by mid-century, using proven technologies and practices.[46] Specifically, 36.5% can be cut from residential buildings and 21% from commercial buildings. It is for this reason that the COP21 set priorities for the reduction in emissions from buildings and laid out a road map for 80-90% reduction by 2050.

The World Green Building Council defines a green building as one that "*in its design, construction or operation, reduces or eliminates negative impacts, and can create positive*

[44] Department of Energy, U.S. Smart grid system report, 2009

[45] Holland, Glesni, How sustainable tech is transforming Middle East utilities, 2018

[46] UN-Habitat: World Cities Report 2016. (2016)

impacts, on our climate and natural environment; preserve precious natural resources and improve our quality of life".[47]

Fukuoka, Japan has been an international inspiration for green building and landscape design. The city developed a system that can monitor and control the water flow and pressure to each area of the city via special sensors integrated into all buildings. The sensors help increase and decrease water pressure in specific areas as per demand, and also monitor and control leakage. Additionally, using prediction models based on analytics from the system, forecasts on how much water each area and each building needs is determined, which helps improve overall efficiency of water distribution.[48]

Another example is the development of net zero neighbourhoods that produce zero waste (water and solid waste). Such neighbourhoods harvest rainwater and process sewage onsite. Some best examples of this form of urban design are the *Kaupuni village affordable housing project in Hawaii,* and the *Sonnenschiff solar city in Freiburg, Germany*. Both developments produce more energy than they consume. This is similar to the passive house design, already mentioned in module 4.

Green buildings also include other technologies such as solar panels and green roofs. The latter uses green foliage cover on roofs to provide living insulation and cooling that reaches up to 50 percent of needs. Green roofs also sequester carbon through soil and biomass, filter air as well as reduce rainwater runoff. Green roofs may also include gardens, farms, and recreation zones and allow for the creation of community gardens and social spaces.[49]

5.17 Smart air quality monitoring system

Air pollution is accountable for the premature deaths of 7 million persons worldwide each year, the equivalent of one in eight premature deaths.[50] Almost 570,000 children under the age of five die every year from a respiratory infection linked to indoor and outdoor pollution and second-hand smoke.[51] Through the adoption of IoT systems in smart cities, and advancements in wireless communication and sensors, the technology for monitoring air pollution is rapidly changing.[52] A smart air quality monitoring solution is able to detect carbon dioxide levels, noxious gases, and pollutants, sending real-time data to a central management dashboard.

5.18 Smart Street Lighting Systems

It is estimated that 80% of electrical power produced globally is used to supply urban services, of which 60% is used for street lighting.[53] Thus, energy saving is a key feature of smart cities, and smart lighting control systems play a crucial role in enabling better energy consumption. Advances in wired and wireless network systems, control technologies, and embedded systems

[47] UN-Habitat: World Cities Report 2016. (2016)

[48] Urban Future With a Purpose, Deloitte, 2021

[49] Drawdown – The Most Comprehensive Plan Ever Proposed to Reverse Global Warming, Paul Hawken, ed., 2017

[50] Nghi Dam, Andrew Ricketts, Benjamin Catlett, Justin Henriques , "Wearable Sensors for Analyzing Personal Exposure to Air Pollution," IEEE , 2017

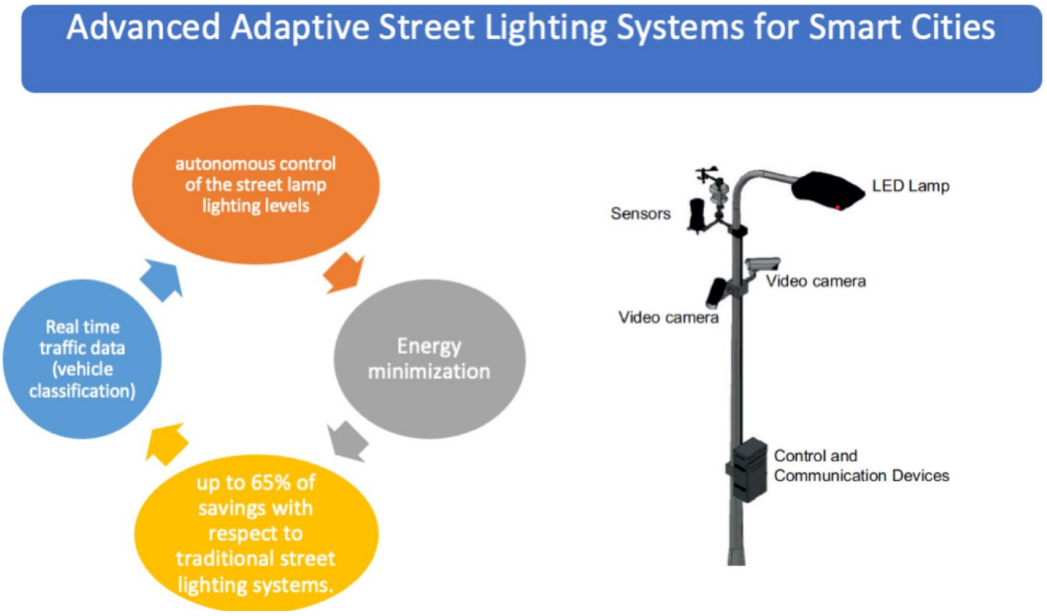
[51] Etinosa, N.-O., Okereke, C., Robert, O., Okesola, O. J., and Okokpujie, K. O., "Design and Implementation of an Iris Biometric Door Access Control System," in Computational Science and Computational Intelligence (CSCI), 2017

[52] Snyder, E.G., Watkins, T.H., Solomon, P.A., Thoma, E.D., Williams, R.W., Hagler, G.S., Shelow, D., Hindin, D.A., Kilaru, V.J. and Preuss, P.W., 2013. The changing paradigm of air pollution monitoring.

[53] Jagadeesha, Y.M.; Akilesha, S.; Karthika, S. Prasantha, Intelligent Street Lights. Procedia Technol. 2015

have made it feasible to design modern lighting systems integrated with smart technologies, where energy saving can be efficiently dealt with.

In recent years, smart lighting systems have received global attention and several projects have been carried out to show the potential and the positive impact of smart technologies to increase energy efficiency. Most of the solutions explore augmenting street lamps with sensors, control algorithms and wireless communications to enable autonomous and remote control of the systems. [54]



Source: Advanced Adaptive Street Lighting Systems for Smart Cities, MDPI, 2020

The Pune Smart City Mission in India has successfully converted over 77800 conventional streetlights (HPSV, HPMV, T-5, Flood Lights) to Energy Efficient LED Lights & all existing Manual based Feeder Panels to SCADA based Energy Monitor and Control Panels. All the Street lights within the Pune Municipal Corporation are controlled from a single location in the centralised command & control centre. The city also developed a mobile application where citizens can log and report on the functionality of the Street Lights.

5.19 Cyber Security

The increasing reliance on digital infrastructure is also leading to an increase in cyber risks. This is of particular importance, especially for transaction services. For instance, in 2020 a digital payment system – which is a primary pillar of smart city infrastructure – suffered a major cyberattack, resulting in numerous illicit withdrawals at regional banks. This highlighted the vulnerabilities of e-commerce amid rising digitalization.

Tokyo, Japan – As a result, in September 2020 the Japanese government increased its focus to strengthen cyber defense strategies and developed plans to set up a formal government entity, the National Digital Agency, to lead digital transformations in Japan.[55] These technologies and solutions further influence the efficiency and functioning of the overall urban environment,

[54] Gagliardi, G.; Lupia, M.; Cario, G.; Tedesco, F.; Cicchello Gaccio, F.; Lo Scudo, F.; Casavola, A. Advanced Adaptive Street Lighting Systems for Smart Cities. 2020

[55] Digital-Transformation-Japan-Assessing-opportunities-forEU, 2022

impacting different sectors of living – safety, quality of life, economy and job opportunity, time management, health (people and environment), connected and informed governance.

5.20 Smart Participation and Citizen Engagement

Open data platforms are an essential tool that ensures that the three principles of open government (participation, collaboration, and transparency) are maintained. Through the smart city framework, some cities have taken the initiative to provide citizens with an ecosystem with real-time access to information, to keep them informed about changes that affect where they live. For example, the Seoul Metropolitan Government launched a first-of-its-kind digital administrative smart city platform.

Madrid City council used the Decide Madrid platform to facilitate participatory budget decisions, to engage the city population at scale and combine physical and virtual interactions whenever possible. Through the platform, citizens decided how EUR 360 million could be spent between 2016 and 2019. Over 400,000 residents have provided input via Decide Madrid on matters affecting the city's three million residents.

5.21 Smart and Online Education System

The focus includes digital skills to enable greater participation in the digital economy; e-learning apps and digital equipment provide additional tools. Education is the most important lever for an inclusive and competitive city. Without adequate education, cities run the risk of being left behind, leading to large gaps in general workforce preparedness and further lags in economic and social development. Smart education systems may include digital literacy and education in schools, which can be augmented by digital equipment, such as smart boards, tablets, and interactive whiteboards. E-learning apps and programs make it possible to provide education at a distance, bringing learning to a wider population. Vocational training and upskilling may be offered to the current workforce, which is seen as an urgent requirement in those fields that have experienced rapid digital and ICT growth, yet where the staff training was inadequate.

5.22 Smart and Effective Health Care

Refers to cloud computing, and interconnected information flows for doctors, patients, and other health stakeholders, telemedicine and mobile phone applications, etc. Affordable health care is a basic service that all residents should be able to access. Smart city planning for health care provides numerous ways to decrease the risk and incidence of chronic health issues. This is reached in part by better and more comprehensive health information, using technologies such as mobile phone apps, cloud computing, robotics, and big data analytics. Telemedicine connects patients and doctors, thus spreading the reach of health care services to remote areas, provided sufficient internet bandwidth is available.

In Pakistan, a nationwide program provides tailored health information via mobile phones and sms services, bringing increased health awareness and reducing health expenditures.

5.23 Smart and Advanced Agriculture

Focus includes more efficient food supply and streamlined supply chains, including urban agriculture; minimizing food waste; tools for small-scale food producers in rural areas. Food supply systems that are inefficient and cause excessive waste or entail complex supply chain

management cost society both in terms of loss of income and time. Environmental costs are significant as well, with high costs and emissions leading to large ecological footprints and negative impact on the climate. Digital technologies can serve agricultural production systems (including urban agriculture) to become more precise and therefore more efficient. This includes drones, robotics, and IoT, with an example being laser and camera guided robots that assist in precision farming.

Zero waste platforms (via mobile phone apps) help to minimize food waste by alerting customers to adjusted food prices based on expiration dates. Other applications provide up to date information and connect end users with producers and buyers in order to better optimize supply chains. The United Nations SDGs consider excess waste in the food chain as "orphaned food" and are calling for reducing global food waste by 50% by 2030.

In urban agriculture, vertical farms use hydraulic systems for food cultivation where there is generally less space. Another aspect of this is multi-strata agroforestry, which is where food production maximizes both horizontal and vertical space. Such systems support biodiversity and carbon sequestration, while producing food as an added benefit. Home gardens bear similarities to multi-strata agroforestry and can be considered a related approach. In some countries this has a long history, such as in Indonesia, which counts more than 12 million home garden acres. Agroforestry expert P.K. Nair has called home gardens "*the epitome of sustainability*."[56]

Yet in the Asian smart city context, urban agriculture has so far not been prioritized, although this may be changing. As new farming methods have been growing in salience, together with the increasing challenge of feeding urban populations, governments are starting to pay more attention to this field, which has enormous potential for progress in the smart city and sustainability context.

5.24 Disaster Preparedness and Resilience

The Philippines is home to an average of 20 typhoons every year. Some of the worst typhoons have reportedly cost hundreds of millions of dollars in agricultural, infrastructure and social damages. For this reason, the Philippines government launched the National Operational Assessment of Hazards (NOAH) app to improve the country's disaster mitigation systems. The app acquires data from rainfall and water sensors, imaging technologies, and landslide assessment systems and makes them available to the public. Damage is inevitable when it comes to disasters, through proper advance planning communities can be safe and take necessary steps to minimize damages.

> *"Data-driven decisions can help government agencies, private sectors, and private citizens in planning evacuation and making preparations in anticipation of the effects of storms."*

The NOAH app was recognize as a "Top Smart City Initiative in Public Service" by the International Data Corp (IDC), 2016 Smart City Asia Pacific Awards.

These technologies and solutions further influence the efficiency and functioning of the overall urban environment, impacting different sectors of living – *safety, quality of life, economy and*

[56] Drawdown – The Most Comprehensive Plan Ever Proposed to Reverse Global Warming, Paul Hawken, ed., 2017

job opportunity, time management, health (people and environment), connected and informed governance.

Questions for Trainers

1. Why is smart technology so indispensable to the functioning of smart cities?
2. What fundamental infrastructures and systems are required for using smart technologies?
3. How can smart technologies contribute to the achievement of SDGs?
4. Which advanced solutions would bring the most direct benefits to inhabitants of your city?
5. Does Big Data live up to the hype? What are some of its best applications? Does it need to be better managed?
6. What are some ways to regulate the presence of technology better in our societies, balancing it with equity and environmental needs? How can citizens or civil society become actively engaged in questions related to present and future technology?

Module 6: Institutional Set-up and Governance

Better institutional setup and good governance substantially help the implementation of policies and planning for the smart city framework.

Figure 7 - Drawing by Claudio Schwarz. Stylistic interpretation of human connection

6.1 Purpose of the Module:

This section highlights the need for smart city institutional set-up, funding and financing options, collaboration, and networking opportunities, skilled manpower and capacity building for smart city development.

6.2 Key Learnings Points

1. Smart city institutions and regularity frameworks are essential for smart city development. Better institutional setup and good governance substantially support the implementation of policies and planning for the smart city framework. The main objective of the smart city institutions is to formulate planning, implement operations, and manages different smart city projects.

2. A comprehensive strategic plan is required for attracting investors and funding opportunities. A creative and aspirational approach for funding and financing of smart city projects will help to attract revenue, generate new business models and develop innovative financing structures for investors.

3. There are several types of funding structures that can be explored. These include Public-Private Partnerships (PPP) where a specific setup is called Revenue Sharing Financing.

There are other models as well, including fees and charges, loans, equity financing, and more.

4. Mobile phone technology can be seen as an avenue for leap-frogging, with some lower income countries (in Africa) able to bypass major infrastructure investments, and use advanced telecommunication. This is turn has allowed for micro payment systems to flourish.

5. Policymakers, planners, city leaders, municipal staff, administrative officers and other stakeholders will have the opportunity through partnership to cover new ground and find innovative ways to solve urban problems. Strong collaboration models will greatly benefit a successful Smart City project.

6.3 Institutional Set-up for Smart City projects

Smart city institutions and regularity frameworks are essential for smart city development. Better institutional setup and good governance substantially help the implementation of policies and planning for the smart city framework. Many cities in developing countries lack a specialized and dedicated smart city institutional framework. In some cases, no relevant institution capable of organizing such a program even exists. In such cases, planning should proceed cautiously and emphasis should be made in the first place on capacity building and institutional setup.

The main objective of the smart city institutions is to formulate planning, implement operations, and manage different smart city projects (such as mobility and transport, water and energy supply, housing, urban development, waste management, and more). A smart city institution should be scaled up to meet the needs of the present and future development.

Smart city institutions include land use development authorities, urban and transport planning and research institutes, air pollution and emission control board, urban safety institutions, housing, urban design, and more. These institutions further support coordination and collaboration with different agencies, such as coordination among national, state, and city governments, different department and government agencies, public and private partnerships, and collaboration with different stakeholders.

All the smart city institutions need to consider innovative policies, inclusive planning, and sustainable development to promote transparent governance and cost-effective infrastructure. Smart city institutions should be innovative, technology-oriented, transparent, and implement strategies for green growth and sustainable development. They should encourage public participation and citizens engagement. As issues for smart city development differ throughout Asia and the Pacific, it is important to identify the urban challenges (issues and problems), capacity (human and technical), resources (people and capital), and establish appropriate institutions in support of the smart city program.

6.4 Preparing a Funding Plan

On the path from a conventional to a smart city, a smart city needs to develop advanced technology with robust infrastructure and modern public services. Existing urban infrastructures should either be updated or be fully overhauled, with the installation of new infrastructures. As

this may require significant investment, a comprehensive strategic plan is required for attracting investors and funding opportunities. A creative and aspirational approach for funding and financing of the smart city project is often needed – one that includes new sources of revenue, new business models for recovery and value capture—and innovative financing structures for investors[57]. Before investing in a smart city project, it is important to understand the different limitations and the scope of the funding and financing. Financing is commonly arranged by multilateral development banks, financial institutions, or any organizations that provide capital to the project.

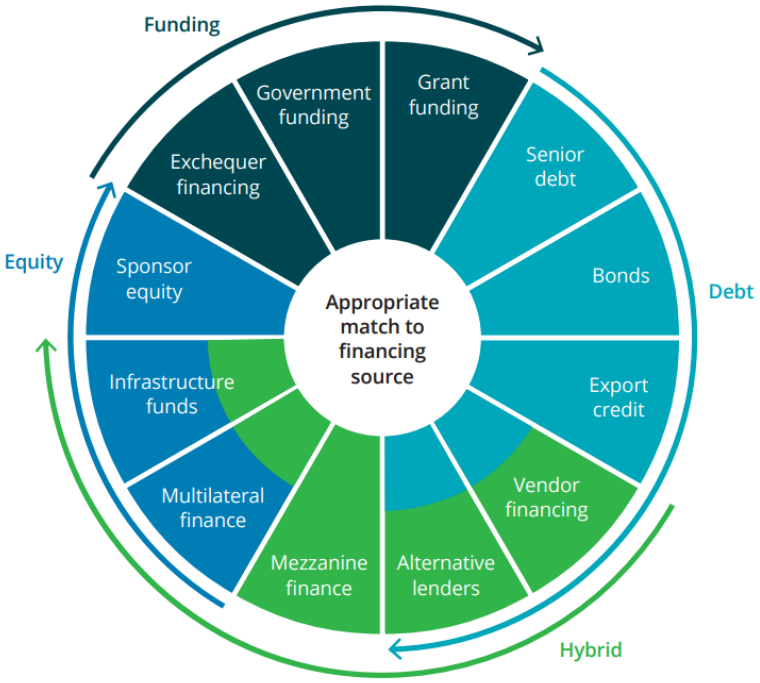


Figure 8 - Different types of funding and financing models adopted from Deloitte's' new report-the challenge of paying for smart cities projects.

Usually, smart cities have several projects: from traditional physical infrastructures such as roads, bridges, and railways to technology-related safety and security improvement projects or social education and health projects, economic development projects, and environmental or sustainability projects. All these projects have different requirements and criteria. Therefore, it is important to make a strategic financial plan as well as business plans before advancing to financial partnerships.

6.5 Funding Mechanisms

The development of high-quality urban infrastructure is becoming more complex, as populations increase and demands for urban services are likewise on the rise. Especially in developing nations, high priced projects are considered extremely risky. Financing such projects then becomes one of the top challenges for cities. Very few cities are able to fund infrastructure and urban development projects independently, [58] especially with scarce public and private capital.[59]

[57] https://www2.deloitte.com/us/en/pages/public-sector/articles/smart-cities-funding-and-financing-strategies.html

[58] ADB. Forthcoming. Contemporary Issues for Liveable Asian Cities. Manila

[59] European Commission. 2017. The making of a smart city: policy recommendations. https://smartcities-infosystem.eu/sites/default/files/document/the_making_of_a_smart_city_-_policy_recommendations.pdf.

To overcome these challenges, robust cooperation in the form of Public–Private Partnerships (PPPs) may likely be the best foot forward. Here, the private sector provides funding, technical expertise, and innovation as per the needs of the public sector, and in the process also creates avenues for joint financing and risk sharing. A common financing structure used in this model is Revenue Sharing Financing. Revenue streams are particularly important, *"as they represent a risk to the feasibility and bankability of the project"*.[60] In the PPP structure, this risk is better managed, as it is shared through different arrangements between the government and concessionaire.

Other forms of financing mechanisms include project financing, traditional loans and leases, vendor finance, consumption-based financing, concession financing, equity financing and also As-a-service based financing.

Local governments can leverage revenue by means of fees and charges. Contrasting this option for the Bangkok Metropolitan Administration in 2016, where only 2% of total revenue was generated this way, with the average of 14.9% for subnational governments in OECD member countries in the same time frame, it is evident that this area provides room for growth.[61]

6.6 The role of technology in enabling innovation in financing

Globally mobile phones have been acknowledged as one of the most robust technologies to support smart city initiatives. For example, mobile and smart phone users in China accounted for 38% of the country's population in 2015, and in 2019 was estimated to be nearly 675 million users. In India alone, the number of smartphone users is estimated to be over 748 million (2020). The number of users worldwide is forecasted to exceed to 1.5 billion users in 2040.[62]

Looking for insights from Africa: *"Mobile phone-based technological innovations in Africa have allowed countries in the region to surpass or leapfrog challenges in both communication and financial infrastructure."* – Deloitte[63].

Developing countries such as South Sudan, India, and Ethiopia, have not had to invest in substantial telecommunication infrastructure, and instead have directly implemented infrastructure for the latest 5G/LTE networks.[64] Further, the development of multiple mobile based applications for transactions and banking has reduced the need for common financial sector infrastructure and instead enabled easy and simple transfer of money through phone accounts, which has resulted in more business and economic transactions. This flexibility has also resulted in a boom in the development of applications for use by MSMEs and small-scale businesses.

6.7 Collaboration and Partnership

Strong collaboration and partnership are important to achieving effective smart city development. Collaboration among diverse stakeholders provides a unique opportunity to utilize their knowledge, experiences, and resources to innovate, create, cooperate, and solve urban problems. One of the key successes of the smart city project development is to build a strong

[60] Sharing Risk and Revenues from PPPs: Perspectives from current practice in the road sector, IISD, 2015

[61] https://www.oecd.org/dev/EMnet-Asia-Policy-Note-2020.pdf

[62] Shangliao Sun, Statista.com, Jun 29, 2022

[63] Smart Cities Funding and Financing in Developing Economies, Deloitte, 2018.

[64] Africa is ready to leapfrog the competition: Through Smart Cities technology, Deloitte & Touche, 2014

collaboration model among different stakeholders: national, state, and local governments authorities; private, business, and industry sectors; education, research institutions, and universities; financing institutions, and development banks; bilateral and multilateral organizations, non-government organizations, civil society, as well as the private sector.

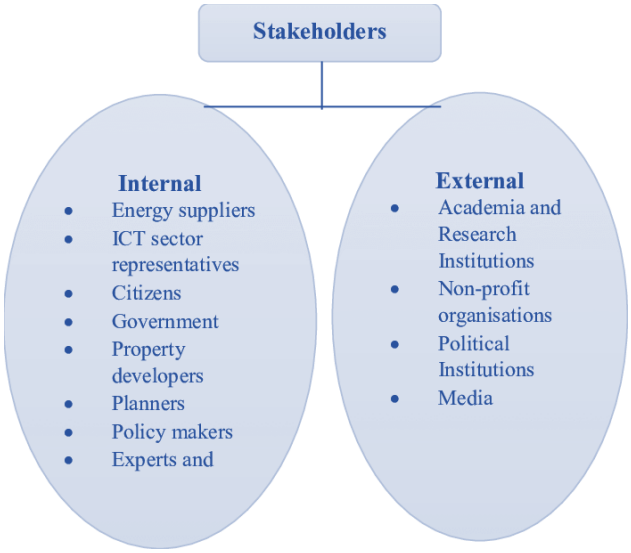


Figure: Smart city stakeholders adopted from Jayasena et al

Questions for Trainers

1. What kind of institutional set up has best served your city in the past, in terms of partnerships? What new forms of partnerships would be worth exploring?
2. How is setting up a financial plan or funding plan a separate task from securing partnerships? What is the best logical process to follow?
3. What is the role for capacity building in the implementation of a smart city project?
4. How would a multi-stakeholder collaboration function in practice? Who would be the most important local partners?
5. Are there any leap-frogging technologies that could be considered more intensely in your country's investment climate?
6. What could some effective ways be to mobilize resources from the international organizations, donor agencies and multilateral development banks?

Module 7: Smart City Case Studies and Best Practices

Figure 9 - Photo by Julien de Salaberry. Skyline of Singapore

7.1 Purpose of the module

The final module in this training resource provides a few additional examples of Smart City best practices. These involve case studies, particularly from Asia. These will hopefully serve as positive examples for other cities in Asia. However, numerous examples have already been given all throughout this guide

7.2 Case Study: Hong Kong a Special Administrative Region (SAR) of PR China Smart City Initiative

The Hong Kong Administrative Region of PR China published the Smart City Blueprint in December 2017, which set out 76 project initiatives under six smart city components including smart mobility, smart living, smart environment, smart economy, smart people, and smart government. The vision of the Hong Kong smart city is "*Embrace innovation and technology to build a world-famed Hong Kong city characterized by a strong economy and high-quality of living*"[65].

The main objective of the Hong Kong smart city is to bring benefits and convenience to the residents through innovative solutions and smart technologies. The mission of the smart city is for making people happier, healthier, smarter, and more prosperous. The city will be greener, cleaner, more livable, sustainable, resilient, competitive, and business-friendly to foster

65 -[4]https://www.smartcity.gov.hk/modules/custom/custom_global_js_css/assets/files/HKSmartCityBlueprint(ENG)v2.pdf

innovation, and transform the city into a living lab and test bed for development. The project further provides better care for the elderly and youth and fosters a stronger sense of community and makes the business, people, and government more digitally enabled and technology versatile. The idea is to reduce excessive consumption, thus making Hong Kong city more environmentally friendly, while also maintaining its vibrancy, efficiency, and livability.

The Hong Kong SAR of PR China smart city project introduced several digital infrastructure projects like free public Wi-Fi hotspots, a faster payment system, smart lamp posts, the iAM Smart- a one-stop personalized digital services platform that turned into the most impressive and fruitful project in the city[66]. The smart lamps are multifunctional and inserted with sensors that serve as bases for measuring traffic conditions, monitoring weather and air quality, and tracking illegal waste dumping, among others. In 2020, Hong Kong smart city project commercially launched 5G technology that enables a high-quality rapid internet system.

In 2020, the 5G technology was also adopted by China Mobile Hong Kong (CMHK) which provides the 5G facility in Hong Kong International Airport.

The smart city portal (www.smartcity.gov.hk) serves as a bridge of communication between the public and government entities. Smart City Hong Kong further enhances tourism platforms, established Law Tech Fund and developed Traffic Data Analytics System and smart village pilot programs.

After COVID-19, the city introduced "Stay Home Safe" system to support home quarantine.

Figure 10 - home quarantine system "StayHomeSafe"[67]

[66] https://www.smartcity.gov.hk/modules/custom/custom_global_js_css/assets/files/HKSmartCityBlueprint(ENG)v2.pdf
[67] https://www.smartcity.gov.hk

Hospital Authority (HA) has promptly developed and rolled out the “Book DC” module in “HA Go”, which allows all confirmed patients in Hong Kong to make appointment at the 23 Designated Clinics for COVID-19 Confirmed Cases. Users can check the clinic quota status, manage their booking by enquiring or canceling their appointments via “Book DC”. Members of the public can also use “Book for others” option in “Book DC” to help make appointments for other confirmed patients in need

7.3 Case Study: Japan Recycles!

With an advanced and ultra-modern society, Japan is a natural leader in terms of Smart City initiatives and efficiency in many areas of daily life, also concerning production and consumption. Therefore, it should come as no surprise that Japan has committed itself to supporting the circular economy by means of zero waste management.[68]

To move things forward, a partnership was set up between a smart waste and recycling company and a larger group of companies that includes transportation, retail, and real estate. To round things off, an international strategy consulting company is advising in the matter.

The recycling company is called Rubicon Global, the business consortium is called Odakyu, while the international consulting company is Monitor Deloitte Japan. These three companies found each other, as each had something unique to offer and as a joint effort are able to effectively handle all of the facets of the project. It will start as a pilot program, and then will be able to scale.

To prove that more recycling is always possible, a town named Kamikatsu has already been recycling most of its materials since 2003, and has set a zero waste policy as its main driver. The town doesn’t employ garbage trucks, as the inhabitants have learned to wash, sort, and deliver the waste items to the recycling station. As of 2019, the town was already recycling 80% of all materials.

68 https://smartcity.press/zero-waste-management-in-japan/

Figure 11- Photo: Zero Waste Academy, Japan

7.4 Case Study: Singapore Smart Nation Program

The Singapore Smart Nation Program was launched in 2014 by Prime Minister Lee Hsien Loong. PM Lee visualized a Smart Nation Program: *"where we can create possibilities for ourselves beyond what we imagined possible*.[69]"The aim of the Smart Nation is to empower Singaporeans to live meaningful and fulfilled lives, enabled seamlessly by technology offering exciting opportunities for all. It is where businesses can be more productive and grasp new opportunities for developing in the digital economy through digital and technical solutions that benefit people and businesses in the city. The smart nation is to make Singapore a digital nation that brings opportunities for Singapore to enhance its strengths, overcome national challenges and physical limits and build an advanced and sustainable economy. It was assumed that the new era of digital transformation is a key direction for transforming different sectors of health, education, housing, energy, transport, urban development, finance, and much more. The smart nation will involve every citizen and organization to learn, adapt and utilize digital technology so that the nation will be safe, livable, and sustainable.

With advanced digital technology, sensors, and cameras, Singapore aims to collect a unique amount of daily live data that will allow the monitoring of numerous important urban functions in real-time. For example, road sensors, smart parking, phased traffic lights, and electronic tool systems help to improve traffic flow, reduce traffic congestion and road crashes, and improve the national economy. To make Singapore a digital economy, digital governance, digital society, and smart nation, Singapore has made numerous mutually reinforced plans. To achieve this, government agencies, industry and businesses and citizens are accelerating digital efforts to drive the whole nation to build digital infrastructures and service delivery.

69 -7 https://www.smartnation.gov.sg/files/publications/smart-nation-strategy-nov2018.pdf

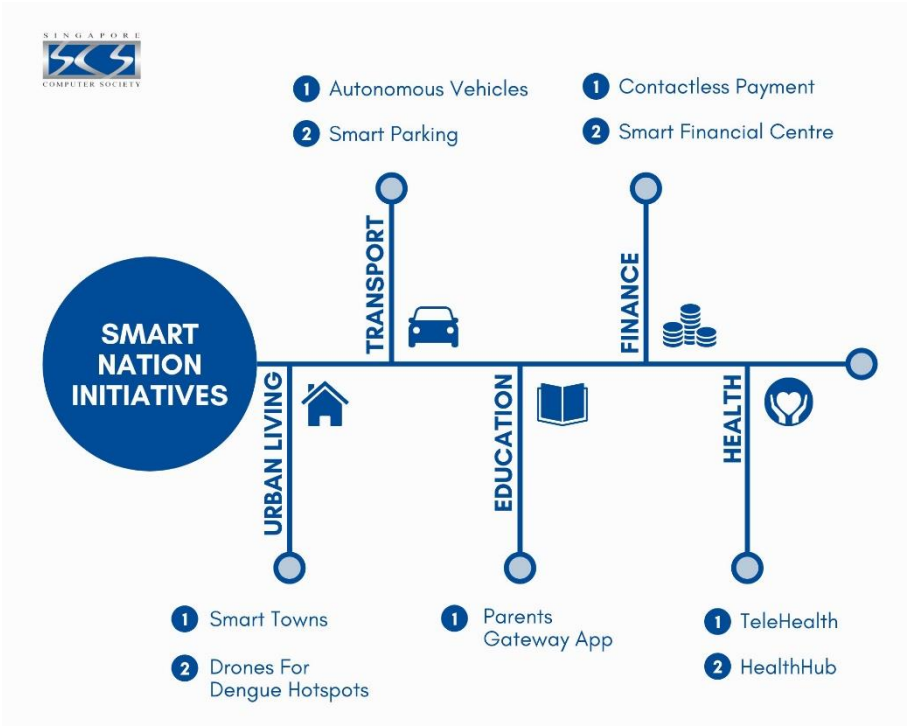


Figure 12 - Singapore Smart Nation Initiatives[70]

7.5 Case Study: Smart City Tokyo

The capital city of Japan has high ambitions as a smart and sustainable city. Or it could call itself a smart and green city. A host of different initiatives and programs are intended to catapult it into being one of the greenest cities anywhere, with energy efficiency policies and smart urban programs helping it to become a climate champion.

A specific step taken to help it reach its goals involved doing an environmental audit on its performance in key areas, such as energy consumption, greenhouse gas emissions, green mobility, water management, and more.[71]

As things turned out, the report that was released (by consulting firm Solidiance) showed Tokyo to indeed be a leader among Asian cities. Encouraged by this, the city went on to establish a green building code, which stipulated the energy efficiency requirements (and other aspects) of buildings having a floor area of more than 5000 square meters.

Other initiatives followed, including requirements for mandatory environmental performance evaluations (for buildings) and a cap-and-trade program to limit the emissions from every sector. Further initiatives involve cash rewards for installing solar panels on roofs and planting half a million trees in the city. Ecological districts and urban forests also fit into this picture.

Having set the bar high, it will be interesting to see how many other cities can approximate Tokyo's good results in the dynamic and fast-paced Asia-Pacific region.

[70] https://www.scs.org.sg/articles/smart-nation-singapore
[71] https://smartcity.press/asia-pacifics-greenest-city-tokyo/

Recommendations for Practitioners and Policymakers

This section provides a number of recommendations that are intended to help plant one foot forward for practitioners working on smart city projects, for trainers delivering knowledge and know-how, and for policymakers creating or updating policies.

1. Before embarking on a smart city project, be sure that the top level ambitions, aspirations and priorities have been set. This should involve intense soul-searching, with the inclusion of members of the local community and affected populations. A smart city program in the pipeline should have a wide level of support, otherwise its legitimacy could be challenged.

2. Always embed a smart city project within the broader policy field. This might involve anchoring project goals to social or sustainability goals. It is then useful to call an approach by an integrated name. Thus a “smart and resilient city framework” or a “smart mobility project” can be used, or the aspiration can be set to be a “smart and inclusive city.”

3. At the very beginning of a project, all of the factors and collaborative environment should be prepared. The widest possible level of stakeholders need to be consulted with and invited to participate, and where possible, co-create. Plans for monitoring and evaluation should be ready from day one.

4. Couple vigorous environmental and climate goals with any Smart City framework or project. There are hundreds of options available for cities to do things better. A great starting point can be found in Paul Hawken’s “Drawdown – The Most Comprehensive Plan Ever Proposed To Reverse Global Warming.” Smart City managers can easily draw up a list of measures that can be implemented in the near term. Divesting from fossil fuels should always be a top priority. Dimming lighting in buildings or reducing the overuse of refrigeration in buildings could be easy wins. Planting trees and parks and reducing the surface covered by concrete and cement is another great project. The options are nearly endless.

5. Set up neighborhood planning centers, if possible catering to specific neighborhoods, making them centers that are welcome to the public and inviting for a better understanding of local plans. Such centers can be equipped with augmented reality design tools, and multiple resources for citizens to familiarize themselves with upcoming plans and procedures. Such centers can also serve as venues for periodic meetings. Augmented design tools may be digital simulations, but they can be 3D mockups. If urban transformation projects are in the pipeline, this will become a very useful resource.

6. Protect the important aspects of local culture and tradition. Whenever a project relates to placemaking or spatial planning, make sure that the local culture and customs are pronounced, and allow tech solutions to emphasize and support these. Avoid a scenario of simply replicating the same formats and universal patterns inspired by good smart city concepts, yet void of local flavor. Celebrate the local dimension, and make sure that globalized characteristics as well as technology aspects are discreetly blended in.

7. Following the cue of point number 2, when planning a smart city project, set a number of specific goals that connect to the companion objective. Thus, if working towards a smart and green city, then set targets in several categories for improving the environmental components. This might include policies or regulations that set stricter environmental standards, limit the funding for projects with a high carbon footprint. By that logic, a suburban neighborhood without a viable public transport option amounts to a no-go.

8. A smart city with substantial gridlock is not a smart city. Every city that plans to be smart and sustainable needs to find the right mobility mix to ensure a healthy environment, based on active travel modes as well as shared travel. A range of transport solutions can be chosen from, and reducing the overall transport demand, as well as the number of vehicles parked or in circulation, should be a top priority. There are many solutions available, ranging from congestion charge schemes (with digitized control) to eliminating subsidies for fuel or internalizing the externalities connected to driving, which would thus make public or non-motorized transport more economically appealing. Smart circulation plans can also help to drastically reduce automobile trips.

9. Local governments are often said to underperform when it comes to communication. Increasing the quality and frequency of communication with the public can reap large rewards. Make it a goal to help local governments prioritize communication, and make sure that it has the right skillset to effectively speak to younger people. When large projects are being planned, better communication is essential.

10. Many people are mistrustful of automation and smart solutions because they fear that jobs will disappear. While this certainly can’t be avoided completely, governments should prepare plans for supporting the local workforce in finding was to gain new skills and opportunities, or find solutions for people who are out of work. While financial support is helpful, simply providing money is not enough, as people also need to have meaningful ways to spend their time. Community service programs could be one way to go, where time-sharing arrangements provide credits or other benefits.

11. Everyone needs to be able to unwind and experience regenerating moments in nature. Make it easy for the local population to access recreation points, nature and peaceful areas, without a lot of noise, transportation, or other disturbances. Spending time in nature is best when one is completely disconnected from smartphones, smart devices and the internet. Establish wifi-free zones or places where technology is largely absent. Barefoot zones in gardens and wild meadows (even in the city!) can be a place to start.

Reading List

The following list is a selection of sources and reference material that was used for these training materials. It is also a list of recommended readings, as each one of them provide unique insights into the many topics covered in the modules.

1. Herbert Girardet, A New Age - Creating regenerative urban systems is a key to solving the many interconnected crises of our times, Resurgence & Ecologist Nov/Dec 2021, https://www.resurgence.org/magazine/article5816-a-new-age.html
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19. Artificial Intelligence in smart cities and urban mobility, IPOL, 2021.
20. Smart City Mission Statement and Guidelines, Ministry of Urban Development, Government of India, 2015
21. https://smartcity.press/zero-waste-management-in-japan/