INFORMATION AND COMMUNICATION TECHNOLOGY FOR URBAN CLIMATE ACTION

In collaboration with:

ERICSSON

UN HABITAT
FOR A BETTER URBAN FUTURE

Acknowledgements

This report has been produced as part of a collaboration between UN-Habitat and Ericsson, with contributions from the International Telecommunication Union (ITU).

In 2014 UN-Habitat and Ericsson entered into a three-year partnership aimed at providing valuable insights on the role of ICT in sustainable urbanization to city leaders and policymakers.

This report was researched, compiled, and written by:

UN-Habitat:
Faderr Johm
Marcus Mayr
Frederic Saliez
Pontus Westerberg

Ericsson:
Matilda Gennvi Gustafsson
Jens Malmodin
Marcus Nyberg

International Telecommunication Union (ITU):
Cristina Bueti
Mythili Menon

1. Introduction

"Cities are engines of dynamism and creativity. In many respects, cities are the proving ground for our efforts to combat climate change, build resilience and achieve faster, more equitable development progress." **United Nations Secretary-General Ban Ki-moon**

The world is rapidly urbanizing. More than half of the world's population already lives in cities, a figure expected to grow to over two-thirds by 2050. As a consequence of this urban expansion, urban land area is expected to triple between 2000 and 2030, an enormous challenge and opportunity from the perspective of climate change mitigation and adaptation (Seto et al. 2012). Cities are the world's foremost socio-economic centres, generating around 80 percent of global GDP and housing the majority of social and economic infrastructure. However, this conglomeration of human activities comes at a price; cities emit significant and growing amounts of greenhouse gases, accounting for 37–49 percent of global greenhouse gas emissions (IPCC, 2014), and as much as 71–76 percent of energy related CO_2 emissions. The International Energy Agency's projections indicate that urban energy-related greenhouse gas emissions will rise from around 67 percent today to 74 percent by 2030 (IEA, 2008). Other emissions, such as short-lived climate pollutants (SLCPs), also contribute to global warming but impact public health, food and water. It is estimated that 3.3 million people die annually due to exposure to air pollution (Lelieveld, et al., 2015). Therefore, emissions from human activities affect the global population indirectly though climate change and directly through pollution that affects public health.

Although cities are beginning to tackle the climate challenge in a strategic and forward-looking manner, much remains to be done. As cities invest in reducing emissions through urban planning, public transport, energy efficiency measures, low carbon infrastructure and other ways, they are also highly vulnerable to the effects of climate change. With high concentrations of people, industries and infrastructure, cities are likely to face the most severe impacts of the changing climate, with hundreds of millions of people, particularly the urban poor, affected by rising sea levels, floods, droughts, storms, health impacts, and changing temperatures in cities across the world. Low-lying and coastal cities such as Dhaka, Lagos and Dar es Salaam are particularly vulnerable. The World Bank (2013) projects that in cities in developing countries alone, the number of people exposed to risks from cyclones and earthquakes will more than double between 2000 and 2050. The needed low carbon and resilience-oriented urban development requires public and private investment at approximately $1 trillion per year to meet the climate challenge according to the World Economic Forum (WEF, 2013). The World Bank estimates that about half of the total cost for "climate-proofing" infrastructure will be for urban-specific infrastructure investments, and it is clear that among them, information and communications technology (ICT) will be a crucial component.

Today's connected, mobile and increasingly digital life is expanding into more areas of society. Innovation opportunities across society seem endless. Over the coming years, ICT infrastructure performance will increase rapidly, fuelled by technology advances, bringing new opportunities for people and business to create, learn, and innovate. The transformative change currently underway will fundamentally change the way in which society collaborates, creates goods and services, is governed and sustained. Our cities are entering a new phase of technological development, driven by the emergence of near ubiquitous broadband, cloud-based services, mobile devices, sensors, big data, internet of things (IoT) and analytics. As the world becomes increasingly defined by new digital infrastructures and the interactions they empower, intelligent networks may become critical to the basic functioning of advanced cities. The road ahead for urban life holds ICT-enabled development and the rise of new opportunities in most sectors of society (Ericsson, 2012). Cities are places where climate friendly technologies and practices are often developed, tested and scaled up. When properly planned and managed, and with the help of ICT, cities can play a key role in our efforts to curb, halt and reverse climate change and build resilience.

2. Urbanization and climate change

"Linking climate change responses with urban development offer abundant opportunities, but they call for new philosophies about how to think about the future and how to connect different roles of different levels of government and different parts of the urban community."
UN-Habitat Global Report on Human Settlements 2011

Since the industrial revolution, urban centres have concentrated industries, construction, transportation, households and other activities that release greenhouse gases. The size, growth, structure and density of population are key determinants of cities' greenhouse gas emissions and other environmental impacts. It is clear that a negative correlation exists between population density and atmospheric greenhouse gas emissions; for instance, a 1 percent increase in the density of urban areas results in approximately 0.7 percent decline in carbon monoxide (CO) pollution at the city level, with other factors held constant. (UN-Habitat, 2011).

As a result, there is a need to promote compactness through mixed land use and maximized land efficiency and UN-Habitat recommends that urban areas should have a proper and well-designed density of at least 150 people per hectare. This requires well-planned streets and public spaces that shape the urban structure and help support local economy, connectivity, culture, creativity and future developments. A good street network works well for vehicles and public transport as well as for pedestrians and cyclists. At least 50 percent of urban land should be used for public space; 30 percent allocated to streets and 20 percent to squares, parks and open spaces. Spatially compact and mixed-use urban developments have significant benefits in terms of emissions. They offer an opportunity for reduced costs for heating and cooling resulting from smaller homes and shared walls in multi-unit dwellings; reduced average vehicle kilometres travelled in freight deliveries and private motor vehicles per capita; and savings related to energy production and transmission.

Through their high concentrations of people, industry and infrastructure, urban areas are also highly vulnerable to the effects of climate change, including rising sea levels, floods, droughts, storms, health impacts, and changing temperatures. These effects are likely to be highly uneven in their distribution. For example, low-lying coastal areas such as small island developing states, the Bangladesh delta and the Netherlands are at particular risk of rising sea levels and sub-Saharan Africa due to desertification. There is a high likelihood of major increases in the number of environmental refugees and increased pressure on sources of fresh water and vulnerable ecosystems such as coral reefs, tundra and coastal wetlands. Action is urgently needed, both to address current risks and to begin building into urban fabrics and systems resilience to likely future risks. The UNFCCC definition of adaptation as, "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" is appropriate to remind us that there are two sides to adaptation, risk and opportunity. Adapting urban areas to climate change requires changes in the way that most areas of government, business and households behave and invest. Discussions of climate change adaptation should consider how climate change-related risks fit within other risks. What is needed is not a climate change adaptation programme but a development programme that meets already existing deficits in service delivery, within which measures for climate change adaptation are integrated.

Well planned and designed cities can help reduce emissions and support mitigation and adaptation strategies to deal with climate change. Three key pillars are crucial for driving action: strategic policies, legislation, rules and regulations; innovative, responsive urban planning and design; and robust financial planning. The development of sustainable cities requires strategic policies and smart governance that recognizes complementary assets and linkages of urban and rural areas, advance partnerships and bottom up approaches ensuring the inclusion of all stakeholders. Furthermore, sustainable cities require urban planning and design that minimize transport needs and service delivery costs, optimize the use of land, enhance mobility and space for civic and economic activities, and provide areas for recreation and social interaction to enhance quality of life. Lastly, there is a need for robust financial planning and investments to be anchored in knowledge informed by the local context and a solid municipal finance structure is essential to ensure success.

With more than 60 percent of the total area expected to be urban in 2030 still remaining to be built, there is a great opportunity to develop sustainable cities that minimize greenhouse gas emissions and their climate impact. Two current global processes – the newly agreed Sustainable Development Goals (SDGs) and the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) in 2016 – are important to consider in this context. Goals 11 and 13 of the 17 SDGs, relate specifically to sustainable and climate resilient urban development.

CITIES IN THE POST-2015 FRAMEWORK

Sustainable Development Goal 11

Goal 11: "Making cities and human settlements inclusive, safe, resilient and sustainable'"

This Goal is related to sustainable urbanization. It is accompanied by 10 action oriented targets, including housing and slum upgrading, sustainable transport, human settlements planning, cultural heritage, disaster resilience, environmental impact of cities, public spaces, urban and rural linkages, climate change mitigation and adaptation and sustainable buildings.

Sustainable Development Goal 13

Goal 13: "Take urgent action to combat climate change and its impacts"

This Goal is directly linked to climate action. It is accompanied by five action oriented targets. The areas covered by the targets include climate financing, improved institutional capacity to plan for climate change and strengthened adaptive capacity and resilience.

3. ICT for climate change mitigation and adaptation in cities

"A smart sustainable city is an innovative city that uses information and communication technologies (ICT) 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 and environmental aspects" **International Telecommunication Union (ITU) and United Nations Economic Commission for Europe (UNECE)**

Urbanization trends pose a need for strategic and innovative approaches to urban design, planning, management and governance. The accompanying trends in ICT play a significant role in 21st Century urbanization as ICT increasingly support business functions, city logistics and grids, transport, delivery of basic services, environmental management systems, government operations, data-driven industries like finance, and people-to-people interactions. Today, there are more than 7 billion mobile subscriptions worldwide, up from 738 million in 2000. According to International Telecommunication Union (ITU), the United Nations specialized agency on information and communication technologies, globally 3.2 billion people are using the Internet, of which 2 billion live in developing countries.

There is a growing recognition of ICTs' potential to achieve desired outcomes in urban development: high-quality public spaces, well-connected grids, well-designed density, increased resource efficiency, improved quality of life, growth with reduced carbon emissions, and knowledge creation and management that address emerging needs and risks – the contours of cities that are smart and sustainable, are inclusive, safe and resilient. ICT in 21st century urbanization enable digital platforms that support the creation of information and knowledge networks. These networks make aggregation of information and data possible, not only for the purpose of data analysis but also to enhance understanding of how cities function (e.g. resource consumption, service delivery, mobility patterns) as well as help inform policy and decision-making processes.

The multiple infrastructure systems in cities are in fact a "system of systems," or a network of systems that support interlocking operations or functions. They have become more integrated using ICT, leading to the "*internet of things*" (IoT) and enabling integrated management of operations. Harnessing the potential of these networks for sustainable urbanization is a crucial feature of smart sustainable cities.

Smart sustainable city approaches requires a combination of ICT efforts to improve inhabitants' quality of life, promote economic growth, and protect the environment from degradation. Key systems of smart and sustainable cities include: smart energy, smart buildings, smart transportation, smart water, smart waste, smart physical safety and security, smart health care, and smart education. In fact what makes something "smart" is the integration of ICT based concepts such as big data, open data, Internet of things, as well as data accessibility and management, data security, mobile broadband, and ubiquitous sensor networks. These are essential in smart and sustainable cities and all of their possible services and benefits are predicated on a well-functioning ICT infrastructure.

Cities that consider ICT as part of the critical 21st century infrastructure will be better equipped to achieve the Sustainable Development Goals (SDGs), particularly Goal 11, to make cities and humans settlements inclusive, safe, resilient and sustainable. ICT-based approaches can support and strengthen government in part by enhancing transparency through open data and by improving citizens' access to services through online platforms. Governments' use of technology however, including smart cities that rely on digital technology, need to be mindful of the risks and challenges of digital divides. A more inclusive smart sustainable city vision also needs to consider human rights, with a special focus on people's freedom of expression, privacy and data security.

ICT has a vital role to play in both climate change mitigation and adaptation. It can support mitigation by helping some sectors reduce their greenhouse gas emissions through dematerialization, for example through substituting travel with collaborative tools, or removing the need to produce physical products by delivering e-products and services. It can also support climate change adaptation through changes in processes, practices and structures to increase the resilience of natural and human systems to climate change effects. Broadband can provide viable information and solutions, such as weather information, disaster alerts and support emergency efforts.

Today, the ICT industry's proportion of global greenhouse gas emissions is around 1.6 percent, expected to grow to around 2 percent by 2020, partly due to increased uptake in many developing countries. However the growth in ICT attributed greenhouse gas emissions is slowing, mainly due to advances in technology and an industry-wide effort to reduce energy consumption; however, in absolute terms the emission levels from the industry are still considerable. A concerted focus on prioritizing energy performance throughout the entire network is needed to help identify opportunities to reduce energy consumption

and associated greenhouse gas emissions. In addition, as mobile device usage grows, the use of larger, less energy-efficient fixed devices declines, thus reducing the energy and carbon footprint of ICT overall.

Urban et. al. (2014) show that in OECD countries with high ICT use, the total energy footprint (and consequently the carbon footprint) has started to decrease. An earlier study by WWF Sweden and HP (2008), based on data from older studies, estimates that ICT implementation offers a total CO_2 reduction potential between 1.2 and 8.7 billion tonnes of CO_2 emissions, representing 2 percent to 14 percent of projected global GHG emissions in 2030[1]. A more recent peer reviewed research paper by Ericsson (Malmodin 2015) sees a reduction potential of up to 9.7 billion tonnes (including direct and indirect reductions), representing an abatement potential of 15 percent of global greenhouse gas emissions in 2030. According to this research, the largest reductions in emissions from ICT implementation are likely to come from smart work and smart service solutions, smart grid and smart building solutions, and smart travel and transport solutions.

Smart service solutions: Smart services for the healthcare, education and governmental sectors and private sector work offer the possibility to provide these services at a lower cost. Smart services also include services with a dematerialization effect, of which digital media and the internet itself is a good example. Other smart services shift the focus from owning and using products sparsely to using services that provide the same function when needed, for example the sharing economy or collaborative consumption, or increasing the efficiency of products and ultimately natural resources, for example car pools, consumer peer-to-peer rental market and other similar services.

Smart grids and buildings: Smart metering for homes as well as smart power grid solutions can help households and building managers reduce their energy consumption and avoid energy losses in transmission and distribution. They also provide opportunities for local integration of small-scale local renewable energy sources, for example solar panels, and help utility companies to generate electricity, better plan and optimize the grid to reduce losses. Solutions for automated heating, ventilation and air conditioning (HVAC) systems as well as light control, building management, building auditing and voltage optimization can also offer significant reductions.

Smart travel and transport: ICT-optimized travel solutions can enable better route and traffic optimization, improved vehicle and fleet management, and vehicle sharing, and support shifts to low emission alternatives like public transport. ICT can also support the shift in transport modes from truck or air transports to more efficient train and ship transport. Within travel, ICT can optimize routes, provide variable speed applications and support self-driving vehicles. In addition, individual travel planning can be enabled through travel planning applications, often based on open data, which show traffic congestion or provide information about travel modes and travel routes.

Regarding climate change adaptation, ICT has the potential to play three enabling roles. First, utilizing ICT for enhanced disaster risk management, for example by strengthening vulnerability and risk assessments in susceptible locations in the city (e.g. through the use of GIS and modelling techniques). Second, ICT can improve city resilience and adaptive capacity, that is, by gathering city-specific evidence on adaptation practices (e.g. using satellite and mobile-based applications). Third, it can be used as a tool for informed adaptation decision making, strengthening institutions and contributing to capacity development (e.g., through online training, improved knowledge access) to inform the implementation of sectoral and local programmes.

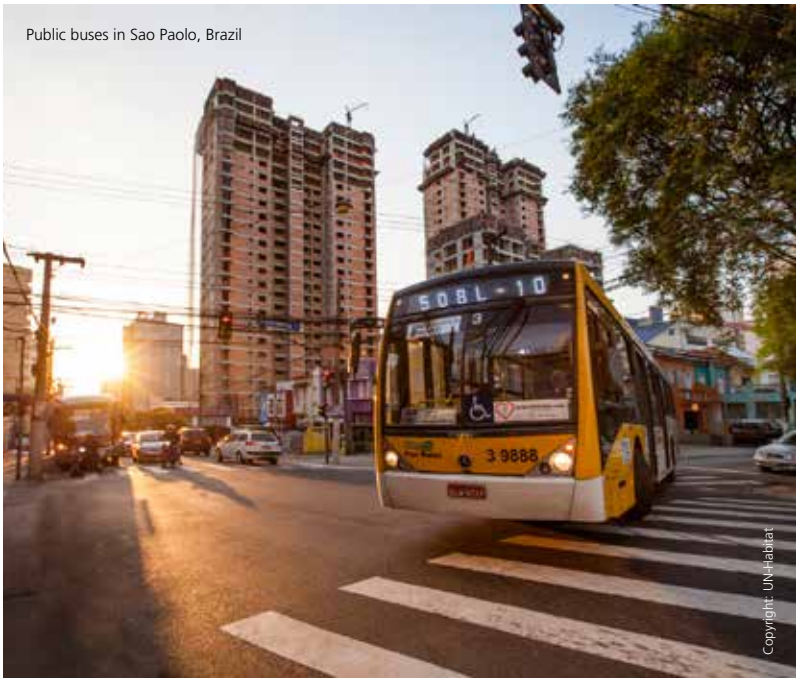
Increasingly the impact of ICT must be understood within broader frameworks, including cities, businesses and wider society. As ICT infrastructure has its foundation in flexible and scalable networks that serve as the backbone between data, services, application and subscribers, the transformative potential of ICT lies in the synergies, transparency and inclusion it enables (Broadband Commission, 2015). This can be seen in ICT's capacity to dematerialize and drive efficiency, and in the speed with which they can globally and cost-effectively scale sustainable solutions. The establishment of new ICT spanning connectivity, enabling capabilities as well as information layers and architecture, can be used for everything from Internet of Things and connected vehicles to secure cloud-based e-government services and personal high quality media services.

1. The WWF study only looked at CO_2 emissions and did not include all sectors e.g. agriculture.

Case story: Connected buses in Curitiba, Brazil

The city of Curitiba in Brazil was the first in the world to connect public buses to a 3G mobile-broadband network. While providing better and safer services to millions of passengers each day, this connected public-transport system makes for more efficient fuel usage and a corresponding reduction in CO_2e emissions. The operation of buses in Curitiba resulted in emissions of approximately 100 tonnes of CO_2e annually per bus. Based on 1,928 buses in operation 2012, this is equal to about 200,000 tonnes of direct CO_2e per year based on the total of fuel purchased per year, and about 30,000 tonnes of embodied CO_2e from fuel extraction, production and distribution. The cars driven in Curitiba (about 850,000 of them in 2012), produce 1,500,000 tonnes of direct CO_2e each year, and their fuel supply is estimated at 300,000 tonnes of CO_2e.

If the bus operation can be made 1 percent more efficient in terms of fuel use (and CO_2e), the potential direct CO_2e savings would be about 2,000 tonnes of CO_2e per year or 2,300 tonnes of CO_2e per year if also considering embodied emissions. This will far exceed the amount of CO_2e that is added as a result of ICT-enabled efficiency measures, for example the new 3G technology Furthermore, if car travel is reduced by only 0.1 percent, the potential related direct reduction of CO_2e would be about 1,500 tonnes per year or about 1,800 tonnes of CO_2e if embodied fuel-supply emissions were also considered.



Public buses in Sao Paolo, Brazil

Case story: Smart meters CO_2 reduction scenarios

Energy sources, demand for heating and cooling, house sizes, building materials and building practices vary around the world. This means that studies on the possible impact of smart meters must be country and context specific. Smart meters can reduce the need for physical car travel through remote meter readings and reduce transmission and distribution losses in electricity grids. However, the savings from these innovations are quite small – around one kg of CO_2 per household a year through remote readings and up to one percent of electricity production through loss reduction. However, bigger savings are expected to come from households using smart meters to monitor and reduce their own energy consumption more easily. The EU study on smart meters from 2014 concludes that "Consumers' energy saving potential is a strong driver in the decision for smart metering deployment" and summarizes that "CO_2 emissions reduction due to first energy savings and then more efficient electricity network operation (reduced technical and commercial losses) results in benefits accrued to the whole society."

In order to explore the potential CO_2 emission reductions from smart meters, Ericsson carried out research which showed three possible future scenarios – low, medium and high reductions.

In the low reduction scenario, only electricity and gas smart metering are included and the energy savings are moderate, about 2.5 percent. This is similar to the estimated EU average for 2020.

In the medium reduction scenario, only electricity and gas metering are included but with average reductions estimated to about four percent for both electricity and gas consumption. Home energy and management system (HEMS), temperature monitoring and control or smart grid solutions were not included in this scenario.

Finally, in the high reduction scenario, home energy and management systems, temperature monitoring and control and smart grid solutions were included. This increases the added energy consumption and CO_2 emissions related to the technology itself, but the potential reductions is now increased to 10 percent. However, the high reduction scenario is not likely to be achieved in the near future, at least not across average households. Nevertheless, especially if combined with visualization systems and feedback mechanisms for users, it is a realistic scenario for the future.

Case study: Securing safe, accessible and affordable water in informal settlements

(A research concept targeting water supply – Nairobi City Water and Sewerage Company in Kenya, the Water and Sanitation branch at UN-Habitat Basic Urban Services and Ericsson)

For many countries that have always faced hydrologic variability, climate change will make water security even more difficult and costly to achieve. Climate change may also reintroduce water security challenges in countries that have enjoyed reliable water supplies.

In Nairobi, 38 percent of the water is so called non-revenue water. Some of it is lost due to leaks, but some of it is informally sold to residents for up to 10 times the recommended price. These losses in combination with unsustainable revenue flows hinder new water infrastructure investments. The ultimate purpose of the concept is to help people in informal settlements get access to safe and affordable water. It combines multi-functional sensors to monitor and improve water supply with an innovative ICT-based governance model where the skills and capacities of residents in the local community are utilized. One of the key aspects is the increased transparency through real-time information sharing between the water service provider and slum communities.

With real-time information available, the water service provider could better understand the system behaviour and necessary operational actions, and key interventions. Furthermore, based on this understanding, service providers are able to interact with both field staff and citizens, engaging them in work orders ranging from infrastructure maintenance to observations. One way to engage the citizens is in the collection of sensor data and other types of information. The citizens could be responsible for the safety of a certain piece of sensor equipment and make sure that the battery always is charged. Or they could be given channels to report problems they encounter or ideas for opportunities that they have. Or they could be responsible for water access points and regular quality samples being taken at these outlets.

To analyse potential social impacts of the concept, the concept includes a scenario planning approach. This method helped to improve the systemic understanding of future challenges and opportunities. To structure the scenario analysis an identified set of indicators that the scenarios could be built around were set up and by which the sustainability potential of the concept could be evaluated.

UN-Habitat, Nairobi Water and Ericsson are now entering the second phase of this joint research project in order to investigate, evaluate and possibly test a connected water infrastructure in informal settlements in Nairobi. In this phase, the concept and the scenarios serve as a way to frame the conversations with stakeholders. And to develop the concept as one component in a sociotechnical system, recognizing the interaction between human behaviour, society and its institutions (i.e. informal and formal laws, structures, hierarchies, regulation and norms) and technology.

Residents of Mathare, Nairobi, buying water from a water kiosk.

Case study: Using Minecraft for community participation in urban planning

Climate action often requires new ideas and integrated approaches across city sectors, requiring new ways of involving multiple stakeholders to understand their needs and priorities. This means that traditional representative democracy may not be enough as people want more participation and collaboration with local and national governments (C40 Cities, 2015).

One way that UN-Habitat is exploring the use of digital technology for citizen participation and collaboration is through the video game Minecraft. In participatory design workshops, young people are brought together to visualize urban design ideas in Minecraft, and present these to city authorities and local government officials. UN-Habitat and local implementing partners then work with local governments to implement the ideas generated through the Minecraft process in real life.

The experiences from 15 projects in Africa, Asia, Latin America and Europe show that providing youth with digital tools, such as Minecraft, can improve civic engagement and citizen action. A social impact assessment of a project in Nepal, carried out by Ericsson and UN-Habitat, showed that using digital technology as a tool for participatory urban planning and design can be a powerful way to include non-traditionally stakeholders in decision-making processes. The game has the potential to increase youth's interest and engagement in urban planning and design, promote creativity, innovation and visual learning, help encourage dialogue between different groups and opinions and contribute to the development of important skills such as collaboration, public speaking and negotiation. Minecraft also provides a platform to explore the merit of different design alternatives and visualize ideas, potentially resulting in better design and ownership by the local community and users during the final implementation.

ITU's Focus Group on Smart Sustainable Cities

Through its Focus Group on Smart Sustainable Cities (FG-SSC), ITU has developed 21 technical specifications and reports on the topic of smart sustainable cities. The ITU specifications on smart sustainable cities include international key performance indicators (KPIs) focusing on the elements of a smart city that rely on ICT. These KPIs offer a credible measure of the progress relevant to ICT aspects of urban development master plans for cities aiming to become smart and sustainable. Based on ITU's work in the smart city domain, the cities of Dubai and Singapore have recently collaborated with ITU, seeking international assistance for the transition to smart sustainable cities. With reference to these collaborations, ITU will be assisting these cities in the Smart Dubai and Smart Nation (Singapore) initiatives respectively.

ITU has been assisting urban administrators in their journey towards becoming "smart" and "sustainable" since the inception of FG-SSC The ITU-T Study Group number 20 on Internet of Things (IoT) and its applications including smart sustainable cities is also catering to improving the overall understanding of the functioning of smart sustainable cities through its publications and events.

It is important that urban administrators ascertain their commitment to the smart sustainable cities goal along with grasping in-depth understanding of the topic. This will allow urban stakeholders to develop a long-term smart sustainable city vision before they embark on their individual smart sustainable city journey hoping to provide their citizens with an improved quality of life while also keeping environmental aspects in mind. In this regard, ITU has strengthened its commitment to helping cities in their respective smart sustainable city journeys by offering them the required support on a city-by-city basis.

4. Recommendations for urban climate action

To get the full benefits of ICT infrastructure, city leaders need to understand the potentials and boundaries of the applicability and usage of ICT to support sustainable city development. The following are recommendations for a successful transformation to climate smart sustainable urbanization.

1. Define and agree a vision, strategy, and targets

Technological development should be an enabler of urban development and sustainability objectives, not the objective. The first stage of any city's transformation is to explore, define, and communicate its smart sustainable city vision. In collaboration with citizens and other urban stakeholders, the city should develop a strategy and targets for achieving that vision. Premature fixation on specific technologies is a distraction, which can lead to decision making that constrains the ultimate success of the transformation. As in any form of planning, before defining what is needed to achieve the vision, the stakeholders need to analyse their current situation, for example benchmarking both their level of ICT maturity, capabilities and the sustainability of their current state of development. Then, at all stages throughout the transformation, measurements should be made in line with the guiding purpose, and all technology choices should support and enable the city's vision and implementation capabilities.

The choice of metrics, therefore, needs to include economic, social, and environmental factors and take into consideration the needs of all its citizens. For example, UN-Habitat has developed the City Prosperity Initiative, a conceptual framework which can be used by cities to assess prosperity beyond simply economic growth, by looking at indicators related to the environment, equity, quality of life as well as infrastructure and productivity. Therefore, in the initial phase, it is important for planners and stakeholders to retain a goal driven approach, with a clear focus on outcomes and risks. Only then can a city select the tools that are best placed to achieve those goals.

2. Promote sustainable urbanization through comprehensive urban planning, legislation and financing

Urbanization poses numerous complex and interrelated challenges, particularly related to climate change. However, if managed well it also provides an opportunity to achieve more equity, environmental sustainability and economic prosperity. In order to harness this potential it is fundamental to focus on achieving multiple interconnected policy objectives related to effective urban planning and design, legislation with adequate rules and regulations and a financial plan to sustain the functioning of the city.

Urban design and mobility is crucial for reducing greenhouse gas emissions. The relationship between urban density and climate change are clear, with lower emissions in denser cities in which citizens use more public and non-motorized transport. Compact cities can be ensured through mixed land use and maximized land efficiency, promoting sustainable, socially diverse, and thriving communities. This planning should include high quality streets and public spaces; proper and well-designed compact neighbourhoods to meet the challenge of rapid urbanization and benefit from the economies of scale; mixed urban uses and limited land-use specialization has been shown to help create local jobs, promote the local economy and reduce car dependency and commuting; and increased connectivity to create access to jobs and services for all and to boost local economies.

Legal frameworks and the institutional structures they establish are foundational elements in urban development strategies. They are the means for implementing the policies determined by legislative and executive authorities and are central to delivering the reductions in greenhouse gases, most often set at national level, required for a sustainable future. Many existing legal structures focus on broad planning and development processes and pay little attention to the core elements of design that make a difference on the ground. Often they rely on high levels of local technical expertise to deliver their objectives and tend to reflect a major disconnect between national aspirations and local realities when it comes to climate change mitigation. As a result, they frequently struggle with 'implementation' or 'enforcement'. Urban resilience can be achieved through policies, disaster preparedness strategies, frameworks, and plans and designs that promote the adaptation to climate change, mitigation of greenhouse gas emissions, energy and resource efficiency, and practical and enforceable norms and rules to cope with the rapid urban growth that cities are experiencing.

Local action is crucial in order to ensure that climate change commitments are realized. This requires the establishment of mechanisms through which local governments, stakeholders and actors participate in climate change mitigation and adaptation strategies. Towns and cities should plan urban developments in relation to climate change, establish relevant legal frameworks, find ways to supplement municipal finance with international climate change funding and expand

the scope of community participation and action to representatives of the private sector, neighbourhoods (especially the poor) and grassroots groups. Urban policies and financial plans should be developed that promote compact and mixed-use urban development while ensuring that economic opportunities are available for all citizens.

3. Create informed networked governance structures

It is to be expected that many stakeholders have a narrow set of expectations for urban transformation. For example, it is natural for those responsible for roads to be tightly focused on traffic solutions, or for waste management authorities to focus mainly on waste-related infrastructure.

However, urban areas are multi-sectoral, multi-stakeholder systems which call for networked and coordinated forms of governance and coordination – uncoordinated pursuits of multiple problem areas is likely to result in siloed, vertical solutions whose value is constrained to each single area. To ensure a successful enabling environment requires adequate legal frameworks, sufficient municipal finance and efficient political, managerial and administrative processes in addition to ICT solutions which support local government responses to the needs of citizens. For example, if common and planned platforms, data formats, and monitoring systems are in place, along with the corresponding legal and financial frameworks, then local government departments may be able to share information for mutual benefit in ways that were previously impossible (such as more efficiently managed, less disruptive services and activities). This also enables new ways of innovation. For example, the Greater London Authority's datastore has thousands of developers subscribed and 360 transport applications have been developed using its open transport data.

Within the city ecosystem, it becomes necessary to create a networked governance structure capable of retaining a holistic macro view of the city's needs and ensure that all projects follow a common vision, integrating both ICT and environmental priorities. The understanding and buy-in of all stakeholders is vital to secure uniform decisions and avoid mismatched implementations. Creating such a structure requires open and collaborative approaches, taking into consideration the needs of all stakeholders, particularly youth and women. It is also important to consider the unequal access to technology, with digital divides still remaining in many parts of the world, both in the North and South.

Ideally, the governance mechanisms should understand and appreciate the long-term value of standards-based and interoperable technologies designed not only to solve current problems, but also to scale and adapt to future, as-yet-unknown problems. Reflecting the distributed, decentralized nature of networking technologies, the governance structure itself needs to actively involve multi-stakeholder participation and embrace partnership models for more efficient, responsive bottom-up management.

To this end, a productive strategy is to encourage pilot programmes within the city that are able to test new sustainable business models, new ways of working and innovative technology solutions and services. In some cases, this may mean developing new mechanisms, including legal mechanisms, for cities to approve pilot programmes. Often the complex or inappropriate nature of technically driven legal frameworks means that they are not implemented as intended and activity on the ground becomes a series of ad hoc 'one-offs' instead of part of a predictable and systematic pattern. Complexity and administrative discretion also creates a prevalent trend of unaccountability and lack of access for vulnerable groups.

4. Engage with all relevant stakeholders

The day-to-day work of any city is to balance overlapping and often competing interests in every aspect of city policy and service delivery. At no time will this be more evident than in large-scale ICT projects. The city's multiple and diverse constellations of stakeholders – public and private, individual and collective – will all be affected by the transformation, so their participation will be crucial to the success of the development. A particular focus should be placed on engaging with hard to reach groups such as the urban poor, youth and women, who may otherwise face structural barriers to participation.

Communication is the key to maximizing stakeholder understanding and buy-in of the city's vision of smart, sustainable development. Effective outreach and engagement should be a major part of the planning, decision making, and evaluation phases of urban transformation projects, ensuring inclusive development that takes into consideration the needs of all stakeholders and provides source of ideas and solutions that can help shape the overall vision.

Smart sustainable cities comprise several interconnected ICT layers – infrastructure, enablers, devices, and applications – which can also help to shape engagement models. For example, consultation with appropriate stakeholders at the infrastructure and enabling layers can build awareness of the long-term business case advantages for open, shared, standards-based infrastructure as opposed to closed, vertical deployments.

Likewise, engagement at the device and application layer can spark third-party development of innovative

city-based services that build upon the synergies and data created by smart sustainable development. This could include such things as transit planning apps, car-pooling services, or crowd-sourced municipal fault reporting.

The digital technologies which enable smart, sustainable development also provide new possibilities for creative stakeholder engagement. Cities can use digital platforms to crowdsource information from citizens on the real-time functioning of the city, incorporate online engagement in the planning of climate-related projects and make city data available to unlock community climate change actions. Many cities have established innovation labs bringing together programmers, designers, and citizens in events and programmes focused on innovation and urban challenges. Gamification is another emerging method to inspire alternative forms of civic participation and engagement. UN-Habitat, for example, uses the networked game Minecraft as a way of directly engaging young citizens in urban planning and design.

However, it is important to consider that integrating ICT into society could pose serious societal challenges and ethical dilemmas – in particular regarding internet security, privacy, integrity and the protection of human rights in the use of ICT. In the discussions around big data, questions arise as to who should have access to data, and to what extent the individual should have a right to know what information is distributed about them, to whom, and how it is used. To avoid adverse human rights outcomes and to ensure that the positive benefits of ICT are fully realized, the challenge can be addressed by using multi stakeholder dialogues. Through better understanding of the complex interrelationships between members of the ICT ecosystem and engaging with stakeholders, it becomes easier to map the boundaries of responsibilities and possible courses of action.

5. Forge and foster long-term partnerships

As highlighted by Goal 17 of the Sustainable Development Goals, a successful sustainable development agenda requires partnerships between governments, the private sector and civil society. This is also evident in the development of smart sustainable cities, which are inherently complex and require multi-stakeholder partnership in order to build infrastructure, systems, and processes that develop synergies across sectors, creating new levels of efficiency, coordination, innovation and service delivery, while engaging citizens effectively.

By forming strong multi-sectoral partnerships with the private sector and civil society, thus accessing high levels of ICT-related expertise, cities are able to access that body of knowledge, benchmark their visions and progress against other comparable cities, and employ best practices. Establishing partnerships between governments, the private sector, and civil society is a complex challenge which requires long-term thinking and commitment, particularly in contexts of competing stakeholder needs and preferences and varying degrees of legacy infrastructure and systems. Partnerships therefore need to be established to ensure capacity to operate in multi-stakeholder, mixed technology and complex urban systems.

UN-Habitat's Cities and Climate Change Initiative (CCCI). CCCI seeks to enhance the preparedness and mitigation activities of cities in developing countries. It emphasizes good governance, responsibility, leadership, and practical initiatives for local governments, communities, and citizens. Building on UN-Habitat's long experience in sustainable urban development, the Cities and Climate Change Initiative supports over 40 cities in more than 25 countries to address the climate challenge by developing and implement pro-poor and innovative climate change policies and strategies. CCCI also is developing a suite of tools to support city leaders and practitioners in addressing the impact of climate change (adaptation) and to help to reduce greenhouse gas emissions (mitigation).

5. Conclusion

The role of ICT in networked urbanization and the dynamism of cities in the 21st century is becoming increasingly a field of research, practice and policy making. ICT has ushered significant and irrevocable changes in the way people live, boosted social prosperity, and had significant impact on the growth and competitiveness of economies and cities. For a majority of the world's population, being connected is a *de facto* way of living. There is also growing recognition of ICT's potential to support desired urban development outcomes in high-quality public spaces, well-connected grids, well-functioning compact communities, increased resource efficiency, improved quality of life, growth with reduced carbon emissions, and knowledge creation and management that address emerging needs and risks – the contours of cities that are smart and sustainable.

The cities of tomorrow will depend even more on a highly capable infrastructure that guarantees the performance, the scale, the privacy, the inclusion, connectivity and the security required for robust solutions in an open environment which guarantees interoperability. Technology can allow more and more cities globally to leapfrog by avoiding expensive and increasingly obsolete physical infrastructure and instead deliver relevant services. Recent developments in, for example, smart technology, data analytics and Internet of Things provides possibilities to produce more adaptive and individualized solutions as well as providing greater transparency around service quality and results. They also provide a foundation for more radical innovations that can fundamentally change how sustainable urbanization challenges are dealt with.

Since 2010, Ericsson has developed a yearly report on the Networked Society City Index (NSCI), which rates the performance of cities with regards to their ICT maturity (infrastructure, affordability and usage) and their performance in social, economic and environmental dimensions. These reports show that there is growing investment in ICT infrastructure, greater affordability and increased ICT use in cities. Interestingly, cities with a low ICT maturity rating seem to be maturing quicker than high-performing cities, indicating a catch-up effect. Some cities also have the opportunity to leapfrog others by avoiding expensive and increasingly obsolete physical infrastructure and instead moving straight to innovative applications, for example advanced mobile technology. Recent developments in, for example, smart technology, data analytics and Internet of Things provides possibilities to produce more adaptive and individualized solutions as well as providing greater transparency around service quality and results. They also provide a foundation for more radical innovations that can fundamentally change how sustainable urbanization challenges are dealt with.

To fully realize the potential of ICT for sustainable urban development an enabling environment has to be created, with participatory governance models, the right infrastructure and technical platforms, as well as capacity building and inclusion. Overcoming the digital divide and empowering all citizens to participate in the global digital economy will require scaling solutions for greater impact. This will mean expanding from beyond where there is a traditional business case to finding models for public-private partnerships and innovation environments that extend where traditional business models do not. It should also be noted that an increased focus is required to fully realize the potential of ICT to ensure people's needs for basic services, to complement the ongoing, extensive work around smart sustainable cities focusing on more high-end markets and industrialized countries.

References

C40 Cities (2015) *Polisdigitocracy – Digital Technology, Citizen Engagement and Climate Action*, C40

Broadband Commission (2015) *Transformative Solutions for 2015 and beyond*

Ericsson, (2015) *Ericsson Mobility Report 2015 – On the pulse of the networked society*, Stockholm: Telefonaktiebolaget LM Ericsson

Ericsson (2014) *Ericsson Mobility Report 2014 – On the pulse of the networked society*, Stockholm: Telefonaktiebolaget LM Ericsson

Ericsson, (2015 b) *ICT & SDGs – How information and Communications technology can achieve the Sustainable Development Goals*, Stockholm: Telefonaktiebolaget LM Ericsson

Ericsson (2015 c), *"Exploring the effect of ICT solutions on GHG emissions in 2030"* presented at the International Conference on Informatics for Environmental Protection (EnviroInfo 2015) and the Third International Conference on ICT for Sustainability (ICT4S 2015)

Ericsson (2012) *On the pulse of the networked society*, Stockholm: Telefonaktiebolaget LM Ericsson

European Commission (2014). C*ost-benefit analyses & state of play of smart metering deployment in the EU-27*. Report from the Commission. Brussels June 2014.

International Energy Agency (2008) *World Energy Outlook*, Paris: OECD/IEA

International Telecommunications Union, *ITU ICT Facts and figures* 2015

Lelieveld, J., Evans, J. S., Fnais, M., Giannadaki, D & Pozzer, A. (2015) *"The contribution of outdoor air pollution sources to premature mortality on a global scale"*, in *Nature*, No. 525, pp. 367–371

Malmodin, J., Bergmark, P. (2015), *Exploring the effect of ICT solutions on GHG emissions in 2030*, Proceedings for ICT for Sustainability conference, Copenhagen, Denmark, September 7–9, 2015.

Revi, A., D.E. Satterthwaite, F. Aragón-Durand, J. Corfee-Morlot, R.B.R. Kiunsi, M. Pelling, D.C. Roberts, and W. Solecki, 2014: Urban areas. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 535-612

Seto, K, Güneralp, B & Hutyrac, L (2012) "Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools" in *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 109, No. 40, Washington: PNAS

UN-Habitat (2011) *Global Report on Human Settlements 2011: Cities and Climate Change*, Earthscan, London

UNISDR (2013) *From Shared Risk to Shared Value – The Business Case for Disaster Risk Reduction. Global Assessment Report on Disaster Risk Reductio*, Geneva, Switzerland: United Nations Office for Disaster Risk Reduction (UNISDR)

Urban, B. et. al. (2014). *Energy consumption of consumer electronics in U.S. homes in 2013. Final report to the consumer electronics association (CEA). Fraunhofer USA center for sustainable energy systems*. June 2014.

WEF (2013) *The Green Investment Report – The ways and means to unlock private finance for green growth*, Geneva: World Economic Forum

World Bank (2013) *Turn down the heat: climate extremes, regional impacts, and the case for resilience*, Washington: World Bank

World Bank (2010) *Cities and Climate Change – An Urgent Agenda*, Washington: World Bank

WWF Sweden and HP (2008). T*he potential global CO_2-reductions from ICT use*. WWF Sweden Solna. 2008.

The United Nations Human Settlements Programme (UN-Habitat) is the United Nations programme for sustainable urban development. It is mandated to promote socially and environmentally sustainable towns and cities while advocating adequate shelter for all and is is the focal point for sustainable urbanization and local governments within the UN system.

UN-Habitat works to expand understanding of inadequate shelter and poverty and to facilitate the tracking of progress in urban development. It sets out norms and best practice for sustainable urbanization and urban poverty reduction, promoting realistic urban planning, municipal finance and urban legislation as the keys to harnessing the economic potential of cities.

www.unhabitat.org
www.twitter.com/unhabitat
www.facebook.com/unhabitat
www.youtube.com/unhabitatglobal

United Nations Human Settlements Programme (UN-Habitat)
P.O. Box 30030, Nairobi 00100, Kenya
www.unhabitat.org

Ericsson is the driving force behind the Networked Society – a world leader in communications technology and services. Our long-term relationships with every major telecom operator in the world allow people, business and society to fulfill their potential and create a more sustainable future.

Our services, software and infrastructure – especially in mobility, broadband and the cloud – are enabling the telecom industry and other sectors to do better business, increase efficiency, improve the user experience and capture new opportunities.

With approximately 115,000 professionals and customers in 180 countries, we combine global scale with technology and services leadership. We support networks that connect more than 2.5 billion subscribers. Forty percent of the world's mobile traffic is carried over Ericsson networks. And our investments in research and development ensure that our solutions – and our customers – stay in front.

Founded in 1876, Ericsson has its headquarters in Stockholm, Sweden. Net sales in 2014 were SEK 228.0 billion (USD 33.1 billion). Ericsson is listed on NASDAQ OMX stock exchange in Stockholm and the NASDAQ in New York.

www.ericsson.com
www.ericsson.com/news
www.twitter.com/ericssonpress
www.facebook.com/ericsson
www.youtube.com/ericsson

Telefonaktiebolaget LM Ericsson
SE-126 25 Stockholm, Sweden
www.ericsson.com

UN HABITAT
FOR A BETTER URBAN FUTURE

ERICSSON