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# The role of STPs and AOIs in meeting sustainable development challenges faced by cities in developing countries

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*New roles and opportunities for STPs in cities, regions and AOIs*

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**The role of STPs and AOIs in meeting sustainable development challenges faced by cities in developing countries**

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***Executive Summary***

Cities and pre-urban areas in developing countries face a diverse range of challenges. Rapid urbanization, poverty, inequality, unequal access to, and inefficient use of, public services, as well as financial fragility and the harm inflicted by natural hazards, etc. are some of them. These challenges threaten the ability of cities to become viable pillars of sustainable development. At the same time, cities have science, technology and innovation (STPs & AOIs) at their disposal to become more sustainable. This paper provides an overview of how science, technology and innovation (STI) can address these key challenges. It proposes sustainable practices that make use of science, technology and innovation in order to produce wider economic, social and environmental benefits for cities. It explains how cities that prioritize sustainable growth patterns can improve employment and competitiveness, enhance social cohesion and create a healthy and livable urban environment.

**Introduction**

Today, more than half of the world's population live in cities. By 2030, it is projected that 6 in 10 people will be urban dwellers. Despite numerous planning challenges, cities offer more efficient economies of scale on many levels, including the provision of goods, services and transportation. With sound, risk-informed planning and management, cities can become incubators for innovation and growth and drivers of sustainable development. Cities are constantly evolving as a result of dynamic processes heightened by population mobility, natural population growth, socioeconomic development, environmental changes and local and national policies.

It has been suggested that the building of a "green" city is equivalent to the building of sustainability (Beatley, ed., 2012). Many countries are planning and engaged in building green cities and "eco-cities" as starting points for the building of sustainable development. Yet, it is important to understand cities' sustainability as a broader concept which integrates social development, economic development, environmental management and urban governance, which refers to the management and investment decisions taken by municipal authorities in coordination with national authorities and institutions.

The 1987 report of the World Commission on Environment and Development, also known as the Brundtland Commission, defined sustainable development as development that meets the needs of the present, without compromising the ability of future generations to meet their own needs. The report included a chapter on urban issues. In 1991, the United Nations Centre for Human Settlements (UNCHS) Sustainable Cities Programme attempted to define a sustainable city as one "where achievements in social, economic and physical development are made to last" (United Nations Human Settlements Programme (UN-Habitat), 2002, p. 6). However, this definition was still too general and neglected the fact that a sustainable city must have a low ecological footprint and reduce risk transfer (economic, social and environmental) to other locations and into the future (Rees, 1992).

The concept of sustainable cities and its links with sustainable development have been discussed since the early 1990s. Sustainable cities should meet their "inhabitants' development needs without imposing unsustainable demands on local or global natural resources and systems" (Satterthwaite, 1992, p. 3). In this sense, consumption patterns of urban middle- and high-income groups are responsible for the use of a significant portion of the world's finite resources and contribute significantly to the production of polluting wastes. Sustainable development should focus on better living and working conditions for the poor, including affordable access to, and improvement of, housing, health care, water and sanitation, and electricity.

The first approximations to a concept of city sustainability noted above were reflected in the 1992 Rio de Janiero Conference on Environment and Development (United Nations, 1993) attended by more than 178 Governments. The 1992 Rio Declaration integrated the economic, social, environmental and governability dimensions of sustainability and argued for the eradication of unsustainable patterns of production and consumption, the eradication of poverty, and the role of the State, civil society and international community in protecting the environment.

Another outcome of the United Nations Conference on Environment and Development was Agenda 21 (United Nations, 1993), which aimed at preparing the world for the challenges of the twenty-first century. Agenda 21, which was built upon at subsequent United Nations conferences, defined sustainability in the context of economic, social, environmental and governance issues, noting the decisive role of authorities and civil society at the local, national and international levels for the implementation of sustainable development policies. Yet, Agenda 21 did not explain how the concept of sustainability could become the basis for the creation of sustainable cities.

The Habitat Agenda (United Nations, 1997), adopted by the United Nations Conference on Human Settlements (Habitat II), held in Istanbul from 3 to 14 June 1996, echoed the concerns expressed in Agenda 21 with respect to the multidimensionality of development, and discussed

urban sustainability as requiring a harmonious integration of economic, social and environmental issues. At this summit, nations reported on the progress towards achieving the sustainability of their cities. Yet, this Agenda still needed to include climate change as one of the main threats to building sustainable cities and to development in general.

At the first session of the World Urban Forum convened at the headquarters of the United Nations Human Settlements Programme (UN-HABITAT) in Nairobi from 29 April to 3 May 2002, an in-depth discussion was held on urbanization in the context of sustainable development. The Forum affirmed that addressing economic, social, environmental and governance issues was integral to the creation of sustainable cities, and that the inability to address those issues would prevent the achievement of sustainable development (United Nations Human Settlements Programme (UN-HABITAT), 2002). The main messages of the Forum were comprehensively discussed and reaffirmed at the World Summit on Sustainable Development, held in Johannesburg, South Africa, from 26 August to 4 September 2002. More recently, this approach to sustainable cities has been echoed in the Rio+20 Declaration[1] (United Nations, 2012b, p.26) and by the United Nations System Task Team on the Post-2015 UN Development Agenda (2012), which includes governance under the broader umbrella of peace and security issues. In an increasingly urbanized world which demands more sustainable ways of living, urban governance entails the fostering of urban planning and environmental management, which includes the reduction of ecological footprints, and the decentralization of decision-making, and resource allocation, as well as enhanced policy coordination between local and national authorities.

In 2015, the United Nations General Assembly adopted a set of Sustainable Development Goals (United Nations 2017a). For the first time in history, sustainable urban development was unanimously acknowledged as a central objective of the global community. The New Urban Agenda adopted in Quito in October 2016 can be understood as a basic document to translate the Sustainable Development Goals into the urban and regional context (United Nations 2017b). It will serve as a point of reference for urban planners and managers, strongly influencing urban development worldwide over the coming 20 years.

This paper builds on the sectoral analysis of the above-mentioned documents and brings a fresh perspective to the sustainable cities discussion, drawing on current research and cases around the world. It analyzes those sectors of urban management where developing countries face the biggest challenges. The objective of this research is first to identify the main challenges faced by cities, especially in developing countries towards being sustainable and then to illustrate the key role of STPs and AOIs in how to tackle those challenges and in the design, development and management of sustainable cities. In other words, This paper provides an overview of how science, technology and innovation can address key challenges of rapid urbanization, particularly in developing countries. It proposes technological and scientific options for consideration by national governments and the international community with a view to promoting sustainable urban development. We try to emphasize the need for greater attention to be paid to the role of STPs and AOIs or science, technology and innovation (STI) in making sustainable cities and communities.

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[1]. The UN Conference on Sustainable Development (Rio+20), held in June 2012 in Rio de Janeiro on the occasion of the 20th anniversary of the Earth Summit, concluded with an outcome document entitled “The future we want”. This document raised the political importance of sustainable cities and human settlements. Member states confirmed that cities, if well planned and developed, could promote economically, socially and environmentally sustainable societies. In this context, member states recognized the need for integrated urban planning, urban regeneration, adequate basic services and affordable housing for all. The outcome document also reaffirmed the importance of implementing the Habitat Agenda, which was adopted in the United Nations Conference on Human Settlements (Habitat II) held in Istanbul in 1996 and has “Adequate shelter for all” and “Sustainable cities” as two key priorities.

Chapter I discusses global key urbanization trends and their links to the 2030 Agenda for Sustainable Development. Chapter II examines challenges in key sectors and proposes science, technology and innovation options with examples to policy implementation on the path towards sustainability. In other words, it elaborates on some challenges encountered in the implementation of sustainable development goals, especially Goal No. 11, and the role of STI in addressing them. Chapter III concludes and emphasizes the need to follow a cross-sectoral approach in urban planning to make cities more livable and sustainable.

## I. Urbanization and Sustainability

### A. Urbanization Trends

Developing countries are urbanizing at an unprecedented pace. It has accelerated in the last 50 years both as a result of high fertility rates and migration to cities from rural areas. In 2010, for the first time ever, more than half of the global population lived in urban areas. By 2050, urban areas will be home to more than two-thirds of humanity. More than 90 per cent of the world's urban population growth is already taking place in developing countries, especially concentrated in Africa, Asia and Latin America. Urbanization is mainly stimulated by economic factors, but also occurs as a result of political events. Most new investment and economic opportunities are located in cities and other urban zones that represent epicenters of economic growth. (Gapper 2012). Meanwhile, in Africa, urbanization is driven more by political necessities than industrialization. Already 40 per cent of Africa's one billion people are located in urban areas, of which more than half live in informal settlements where water supply and sanitation are severely inadequate. Slums absorb around three quarters of sub-Saharan urban population growth. It is expected that the urban population of sub-Saharan Africa will double to reach almost 600 million by 2030 (UN-DESA 2012b, Satterthwaite 2007, FAO 2012).

Cities in many developing countries have not been able to cope with the rapidly surging requirements for housing, physical infrastructure (including roads and telecommunication technologies), and social services such as health and education to address the needs of growing populations. Moreover, cities contribute to approximately 70 per cent of global energy use and greenhouse gas emissions but occupy only 5 per cent of the Earth's land mass.[2] These trends are accompanied by an unprecedented increase in demand for water, land, building materials, food, pollution control measures and waste management. Cities are therefore under constant pressure to provide better quality services, promote local economic competitiveness, improve services delivery, increase efficiency and reduce costs, increase effectiveness and productivity and address congestion and environmental issues. Such pressures are motivating cities to turn to smart solutions and experiment with various smart infrastructure applications.

Science, technology and innovation can help achieve sustainable urban development by taking into account the economic, environmental and social dimensions of urbanization. Designing and building sustainable cities in developing countries will play an important role not only for sustainable development, but also to achieve several of the current Millennium Development Goals, especially those related to poverty, education and health. This fast pace of urbanization, mainly in developing countries, is creating cross-sectoral challenges for urban governance that

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[2]. Scientific and Technical Advisory Panel, 2014, Sustainable urbanization policy brief, Global Environment Facility; and United Nations Environment Programme, 2015, Cities and climate change, available at http://www.unep.org/resourceefficiency/Policy/ResourceEfficientCities/FocusAreas/Cities and Climate Change/tabid/101665/Default.aspx.

need to be addressed through scientific mechanisms. Key challenges are urban sprawl, lack of infrastructure, depletion of resources, environmental deterioration and the risk of natural disasters.

The economic, social and environmental effects of uncontrolled, rapid urbanization are increasing the awareness of the need for sustainable practices. New "ecocities" are being planned and constructed that fully rely on sustainable technologies. Cities are increasingly setting goals and measuring their sustainability by using indicators such as urban density, public space as a percentage of the urban area, share of renewable energy sources, energy efficiency of buildings, access and proximity to mass transit, road traffic fatalities, availability of shelter, safe drinking water, wastewater treatment, solid waste management and recycling (UN-HABITAT 2012c).

## B. Sustainable Development Goals and the New Urban Agenda

In 2015 the United Nations General Assembly adopted the Sustainable Development Goals (SDGs). These will form the basis for new initiatives, programs and actions over the coming years until 2030. They build on the previous Millennium Development Goals (MDGs): On the one hand, they are supposed to complete the tasks which the MDGs did not achieve. On the other hand, the 17 goals with their 169 targets are much broader than the MDGs, incorporating new aspects and perspectives ranging (a) from poverty eradication to inclusive and equitable quality education and ensuring healthy lives for all age groups; (b) from ensuring the availability and sustainable management of water and sanitation to promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; (c) from building resilient infrastructure to ensuring access to affordable, reliable, sustainable and modern energy; (d) from taking urgent action to combat climate change and its impacts to protecting, restoring and promoting the sustainable use of terrestrial ecosystems and halting and reversing land degradation and halting biodiversity loss. These goals are each underpinned by a number of targets and indicators, and are seen as integrated and indivisible, balancing all dimensions of sustainable development (United Nations 2017a).

With the SDGs, for the first time in history, sustainable urban development has been unanimously acknowledged as a central objective of the global community. One of the goals, Goal No. 11, is entirely dedicated to make cities and human settlements more inclusive, safe, resilient and sustainable. The associated targets are quite ambitious: e.g. to ensure access to adequate, safe and affordable housing and basic services; to provide universal access to safe, inclusive and accessible green and public spaces; to promote the construction of sustainable and resilient buildings; to strengthen efforts to protect and safeguard the world's cultural and natural heritage; to substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement holistic disaster risk management at all levels; to support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning; and to enhance inclusive and sustainable urbanization and the capacity for participatory, integrated and sustainable human settlement planning and management in all countries (United Nations 2017a).

The New Urban Agenda (NUA) adopted in Quito in October 2016 (United Nations 2017b) corresponds very well to the SDGs and comes at the right time. Although 40 years after the Habitat I conference in Vancouver and 20 years after the Habitat II conference in Istanbul, the NUA is a document in its own right, yet it can be understood as a basic document to translate the SDGs as a whole to the urban and regional context, and in particular to interpret and concretize Goal No. 11. One of the major principles of the NUA is to foster the environmental sustainability of cities.

The promotion of clean energy, the strengthening of resource and land use efficiency in urban development, the protection of ecosystems and biodiversity, the building of urban resilience as well as the mitigation of and adaptation to climate change are some of its elements. The Quito Implementation Plan lists a number of transformative commitments regarding environmentally sustainable and resilient urban development. Planning and managing spatial development are regarded as decisive tools for an effective implementation (United Nations 2017c).

The NUA will strongly influence urban development worldwide over the coming 20 years. Although it is still much too early to evaluate whether it will—as stated in the document—really lead to the paradigm shift committed to by the global community, the NUA will be a point of reference for urban planners and managers worldwide. The demonstration of good examples towards a more sustainable urbanization in different contexts and under distinct development conditions will be of the utmost importance, e.g. regarding how to deal with environmental challenges, how to prepare for and deal with the effects of climate change, how to establish age-responsive policies and measures; also in the context of risk prevention and mitigation measures, how to implement effective urban rehabilitation, how to foster more energy- and resource-efficient settlements, and how to plan and manage the related processes.

## II. Challenges and opportunities in key sectors

Some believes that achieving the sustainability of cities can be conceived as entailing the integration of four pillars: social development, economic development, environmental management, and urban governance. These four pillars for achieving urban sustainability encompass the balanced accomplishment of social and economic development, environmental management and effective governance. Yet, the ways in which a city is able to build sustainability will reflect its capacity to adapt, within the context of its particular history, to the policy priorities and goals defined by each pillar.

**Pillars for achieving sustainability of cities:**

**Social development** ◆ Education and health ◆ Food and nutrition ◆ Green housing and buildings ◆ Water and sanitation ◆ Green public transportation ◆ Green energy access ◆ Recreation areas and community support

**Economic development** ◆ Green productive growth ◆ Creation of decent employment ◆ Production and distribution of renewable energy ◆ Technology and innovation (R&D)

**Environmental management** ◆ Forest and soil management ◆ Waste and recycling management ◆ Energy efficiency ◆ Water management (including freshwater) ◆ Air quality conservation ◆ Adaptation to and mitigation of climate change

**Urban governance** ◆ Planning and decentralization ◆ Reduction of inequities ◆ Strengthening of civil and political rights ◆ Support of local, national, regional and global links. (UN/DESA, Development Policy and Analysis Division.)

The integration of the four pillars can generate synergies, for example, between waste and recycling management (environmental management) and access to water and sanitation (social development); between air quality conservation and green public transportation; and among production and distribution of renewable energy sources, green energy access, and adaptation to and mitigation of climate change, as well as between the goal of reducing inequities (urban governance) and that of ensuring adequate access to green housing, education and health (social development). Investment is the catalyst behind the realization of each of the component goals of urban sustainability.

To build upon the four pillars can be a challenge for many cities and countries. Cities are often at different stages of development and have their own specific responses to policy priorities at the local and national levels. In this sense, the sets of sustainability challenges to be overcome by cities are diverse.

This Chapter identifies key and main social, economic and environmental challenges associated with building sustainable cities in developing countries and explains how science, technology and innovation can contribute to sustainable urban development. As outlined in the Rio+20 Conference outcome document and NUA, the challenges cover a wide range from urban sprawl and traffic congestion to inefficient buildings and unplanned informal settlements, from lack of infrastructure to depletion of resources, from environmental deterioration to risk of natural disasters. Several cities around the world are already using innovative planning, technology and governance models in sectors ranging from spatial planning to mobility, from energy to waste management and from the built environment to disaster resilience in order to address these complex challenges.

**Challenges to and opportunities for building sustainable cities**

| | *Developing countries* | | *Developed countries* | |
|---|---|---|---|---|
| *Main urban trends* | *Challenges* | *Opportunities* | *Challenges* | *Opportunities* |
| **Social** | | | | |
| By 2025, urban population will live mainly in small cities (42 per cent) and medium-sized cities (24 per cent) | Improve access to housing, water, sanitation; improve public infrastructure; foster institutional capacity | Investment in public infrastructure (including transportation); construction of compact buildings in middle-income countries; strengthen links between cities and rural areas | Social cohesion | Investment in *compact* urban development and decentralization |
| Number of urban people living in slums continues to grow | Reduce number of urban poor and disease risk; improve social cohesion; reduce youth unemployment | Investment in universal access to affordable water and sanitation; establishing public transportation, and creation of jobs to reduce growth of slums; employment of the "youth" dividend in low-income countries | Reduce urban unemployment due to economic crises (of youth in particular); provide adequate housing in poor neighbourhoods | Strengthening and widening social safety nets; upgrading investment in social protection for an effective response to crises and their aftermath |
| Inefficient use of public services (water, electricity) | Improve waste and recycling management; support consumption of local produce; change overconsumption patterns of high-income households | Subsidies to households and small firms to reduce non-saving water systems and waste; incentives to local communities to improve recycling systems | Change overproduction and overconsumption styles; improve waste and recycling management | Investment in retrofitting of buildings; in water- and energy-saving devices; upgrading of public infrastructure |
| Ageing | Create productive employment for older persons | Investment in universal pensions; extension of working age; support for family networks | Fiscal pressure to reduce health costs; improve productivity | Investment in retraining older persons, and extending the working age |
| **Economic** | | | | |
| Inequality and financial fragility | Create policy space for inclusive development; reduce underemployment; promote economic diversification | Investment in green industry, adaptation to climate change, structural economic change (industrial and service *leapfrogging* for least developed countries); strengthening regional cooperation | Reduce unemployment; boost economic growth; strengthen international cooperation | Investment on green infrastructure; policy coherence and coordination |
| Food insecurity | Improve access to food; increase productivity | Investment in urban agriculture, local crops, storage facilities; R&D | Reduce food waste | Investment in storage infrastructure; reducing food subsidies; policy coordination |
| **Environmental** | | | | |
| Energy access | Provide access to clean energy and reduce use of "dirty" energy in poor households (e.g., least developed countries); discourage high-energy consumption in high-income households | Investment in capacity development, energy-saving devices, production and use of renewable sources of energy; subsidies and incentives for efficient energy use and water use for middle- and high-income households | Reduce overproduction and overconsumption to sustainable levels | Investment and incentives to produce and use renewable energy sources; decentralization of energy production |
| Climate change | Reduce impact on livelihoods; reduce carbon emissions; generate financial resources for adaptation | Investment in health and education infrastructures and facilities; adaptation and mitigation technology, early warning systems, green public transpor- tation; strengthen regional cooperation for green technology transfer | Upgrade disaster risk prevention systems; reduce carbon emissions to sustainable levels | Investment in mitigation, industrial green transformation; retrofitting of buildings; policy coordination |

**Source:** UN/DESA, Development Policy and Analysis Division.

### *A. Density, land use and spatial planning*

The sectoral analysis of sustainable urban development starts with spatial planning because it is a cross-cutting theme that affects all other sectors. Current research in urban planning points towards more compact and dense spatial planning for cities.

Urbanization in developing countries is taking place with little long-term spatial planning and driven by short-term profitability expectations of the real-estate sector. Unplanned urbanization often results in 'urban sprawl', which is commonly defined as single-use, low-density urbanization and has several negative dimensions. Whereas urban sprawl was previously associated with North American cities, it is rapidly extending to cities across the developing world (UNESCAP et al. 2011). The density of urban areas in terms of number of people per hectare is decreasing across the world due to uncontrolled urban sprawl. Lower density makes it more challenging and expensive to provide adequate public services such as transport and utilities (UNHABITAT 2012c: 32). Unplanned urbanization results in investments that dictate future urban land and resource consumption patterns. It is costly to replace such investments with more sustainable infrastructure later on since they "lock in" the options of urban planners (UN-HABITAT 2012c).

As a result of unplanned urbanization, millions of people live in informal settlements in the periphery of cities without access to basic services, water and sanitation due to the lack of funds to carry out important infrastructure projects. For example, large shortfalls in water supply have increasingly been experienced in Lagos, Nigeria, where official supplies barely meet half of demand due to population growth, insufficient infrastructure, illegal connections, poor maintenance and inadequate access to limited supplies (World Watch Institute 2007: 46).

Urban sprawl is also damaging the environment and affecting the livelihood of communities located in the immediate vicinity of cities by covering land that could otherwise be utilized for agriculture, tourism and recreational activities. For example, significant damage has been caused to environmentally sensitive areas in Latin America around the cities of Caracas, San Jose, São Paulo and Panama City (UNESCAP et al. 2011).

**Technology and innovation**

Cities can accommodate growing populations in accordance with their land use, spatial design and density plans by combining several regulatory instruments(UNEP, 2011:481;Wheeler,2008:107). Below are examples of regulatory instruments for land use and spatial planning that can contribute to sustainable growth in cities:

(a) Urban growth boundaries: Drawing clear limits to any form of building development around cities to limit urban sprawl; creating green corridors that protect ecosystems;

(b) Land-use regulation for infill development: introducing zoning regulation that prioritizes the development of inner city, previously developed (brownfield) land over greenfield development at city-wide level;

(c) Promoting mixed-use settlements: designing neighborhoods that include residential, service and local employment elements and are adequately covered in terms of basic services and infrastructure;

(d) Density regulation: providing minimum rather than maximum density standards; establishing clear density standards at city-wide level, such as floor area ratios, in support of compact city development with a hierarchy of higher-density, mixed-use clusters around public transport nodes;

(e) Density bonus: providing development bonuses that allow increased development rights (for example, extra floor area with respect to standard planning regulations) for green projects that support citywide and local sustainability;

(f) Special planning powers: establishing urban development corporations or urban regeneration companies to promote and enable green projects.

City planners can use simulation, modeling and visualization technologies to aid long term planning and investment decisions (Dogdson and Gann 2011: 107). Geospatial tools can be used to identify infill zones like abandoned land or buildings that are suitable for redevelopment and to plan for their reallocation. Geospatial data can also be used for scenario planning to envision future urban development that is in cohesion with a city's historic and current development path. Geospatial tools, with their ability to display multiple layers of information on a map, can combine statistical information with satellite maps to run analyses such as poverty targeting, urban infrastructure and transport planning and socioeconomic analysis like crime statistics and tracking illegal settlements (UNCTAD 2012a).

For cities with even higher growth rates, establishing so-called satellite towns in the vicinity of major cities may be an appropriate solution, as envisaged in the Comprehensive Plan of Shanghai, which includes nine satellite towns that will receive migration from rural areas (UN-HABITAT 2012c: 27).

Spatial planning can optimize the density of cities according to urban development goals and enable public services that achieve economies of scale. Increasing urban density can save costs arising from the provision of basic services to scarcely inhabited and extended city outskirts. It can also be beneficial in terms of encouraging public transport. Central Hong Kong's high density allows 85 per cent of all trips to be made by using public transport (UN-HABITAT 2012c: 48). At the same time, too much density is also not advisable since it can result in overuse of public infrastructure that will depreciate early. Research in 247 large counties in the United States identified that public spending first decreases with higher density, but then can increase after a tipping point (UN-HABITAT 2012c: 32).

Densification policies can be coupled with innovative models of urban development. In high-value public land that is covered by slums, local governments can implement slum-upgrading programs to the benefit of all stakeholders. They can propose improved housing for occupants of slums in higher, modern buildings on parts of the same land. The private sector can construct these buildings free of cost in return for development rights in other zones of the city. As a result, the city can upgrade infrastructure at no cost, optimize land use and create open space on valuable land with the help of vertical resettlement (Gill and Bhide 2012).

### *B. Mobility*

This section analyzes the issues resulting from inadequate transportation infrastructure in cities, including economic losses. It provides examples of technologies that can improve urban mobility and reviews their application in different cities. Last, the section identifies policy approaches that can be useful in facilitating sustainable mobility planning.

Rapid migration to cities and population growth make it harder to predict and plan potential public transport routes that can answer the needs of inhabitants. in low-density cities, it is more difficult to introduce cost-efficient public transport due to increased distances and decreased number of people per trip. It takes years to reverse transport strategies that do not answer the needs of citizens due to the cost and scale of the underlying investments. Investing in car infrastructure causes lock-in that multiplies investment needs for switching to means of public transport later on. Moreover, low density results in higher per capita transport energy consumption.

Mobility based on fossil-fuel powered cars is increasingly becoming a liability for the world's cities. In many cities, car ownership is too costly for the majority of inhabitants. For example in Nairobi, only 1 in 7 inhabitants have a car (UNHABITAT 2012c).

Traffic congestion causes economic damage to cities. For example, Bangkok is losing 6% of its GDP to congestion - a percentage comparable to the tourism sector of the city which produces 7% of GDP. In Mexico City, the average daily commute time is 2 hours 30 minutes, creating a loss of 2.6% of GDP (Glaeser 2011). While the cost of traffic congestion is 10% of Lima's GDP, in Buenos Aires, the loss is 3.4% (UNESCAP et al. 2011). Most of this economic loss originates from the value of time lost by car drivers and passengers. Moreover, congestion worsens carbon emissions and air pollution, resulting in negative effects on health. Moreover, Car travel requires vast land for roads and parking areas.

**Technology and innovation**

Cities can make use of technology to promote the use of public transport and ease traffic. Below are some examples to current and upcoming technologies that can help in moving to cleaner fuels in transport vehicles, improving the flow of traffic and enabling regulatory measures:

- Use of alternative fuels and advanced technology for transport vehicles (**LPG, natural gas or biofuels, Hybrid vehicles**, **Electric automobiles, Hydrogen fuel cells)**
- Public transit (**Mass rapid transit, Light rapid transit, Bus rapid transit)**
- Technologies for automated traffic control (**Personal rapid transit, Advanced driving assistance)**
- Transit control systems (**Global navigation satellite systems, Electronic Road Pricing)**

Information and communication technologies (ICTs) can be used to improve mobility. There are various applications such as traffic management systems, open access and multimodal trip planning services. Several cities including New York, San Francisco and London are opening up core city data to the outside world and enabling the development of applications that help citizens make more informed decisions in terms of travel, like finding the closest bike share or car-share station (World Watch Institute 2012: 68). ICTs can also be used so that citizens can look up how to plan a door-to-door journey by integrating different modes of public transport such as walking, biking, buses, trains and car sharing. Online commercial tools are already available in the United States that provide multimodal routing services, like Open Trip Planner3 and Moovel4. Last, ICT tools that combine geospatial mapping with crowd sourcing data collected from mobile phones or transport tickets can play a role in relieving traffic and optimizing transport efficiency.

Mobility in cities can be improved through the combination of three strategies, namely, "Avoid, Shift, Improve", that can transform behavior and influence technology choices (Asian Development Bank (ADB) and German Agency for International Cooperation (GIZ), 2011:85). The "Avoid" strategy is for reducing journeys and avoiding the need to travel. "Shift" represents a move to more environment-friendly modes of transport. "Improve" is the improvement of energy efficiency of transport vehicles used.

The "Avoid" strategy aims to avoid or reduce the number of journeys by means of:

(a) Urban planning, creation of land use and transportation plans that facilitate walking and biking for the majority of trips and make transit a practical mode for most longer trips;

(b) Traffic demand management: alternating odd and even number plates, electronic road pricing, low emission zones in city centers, parking zone charges;

(c) Economic incentives such as taxing fuel use and emissions;

(d) Traffic calming to slow auto traffic and create more humane urban environments better suited to other transportation modes: altering road layout and design such as narrowed entries to streets, planting trees, variable street surfaces, speed-restricting devices and visual signs for cautious driving, reducing the speed of traffic.

Shifting to more environmentally efficient forms of mobility includes:

(a) Prioritizing non-motorized transit in cities (walking and biking) by putting in place infrastructure and a legal framework, as well as incentives such as reward programmes. For instance, bike-sharing programmes require parking spots and bike tracks as well as a legal framework that protects the rights of cyclists;

(b) Bus rapid transit – a dedicated lane bus signal with signal priority at intersections, prepaid fares and fast boarding platforms – is a relatively low-cost and sustainable transit solution. It already operates in several large urban areas across the world with successful results in reducing congestion, air pollution and travel time;

(c) Light rapid transit (tramways) and mass rapid transit (metros or subways) systems require higher investment and are more suited to high-density districts alongside other transport modes.

### *C. Urban resource management (energy, water, solid waste)*

Energy, water and food consumption in urban areas of developing countries is rapidly rising in parallel to growing incomes, putting pressure on limited resources. At the same time, higher consumption leads to higher amounts of waste. Long-term urban sustainability depends on technologies that conserve these resources and minimize waste.

Energy is one of the most important sectors for sustainability in cities. Cities are major consumers of energy, and therefore vulnerable to energy scarcity and energy price increases. Adequate energy supply for growing urban zones is increasingly becoming a challenge. It is largely expected that in cities of emerging countries, demand will continue to exceed capacity in the coming years. This brings up questions such as how to improve energy efficiency, regulate the electricity market, involve the private sector and revise the mechanism of subsidized energy pricing (Globescan and MRC McClean Hazel 2007: 37). With rapid urbanization, it will be more and more challenging to provide access to electricity in a centralized manner for growing cities.

**Technology and innovation**

Various clean, low-carbon energy technologies compatible with use in cities are available to improve energy efficiency and enable the transition to renewable energy sources in cities. Each of them faces technical, market, institutional, political, social and environmental challenges on the way to mainstream usage. Cost competitiveness with fossil-fuel energy sources is a major issue. Technical limitations of clean energy technologies, such as battery efficiency of solar photovoltaic technology, and issues such as lack of infrastructure or trained workers as well as lack of public acceptance also need to be overcome (OECD 2012: 127-128). Below are some examples of innovative energy technologies that could be considered for densely populated urban areas (UN-HABITAT, 2012b):

(a) Partnerships between ICT networking and lighting companies are making possible smart, networked ICT-based street lighting with light-emitting diodes (LEDs). LED technologies can save electricity in a relatively effortless and immediate way;

(b) Decentralized renewable energy storage technologies such as solar thermal power plants and micro hydropower systems can reduce some of the pressure on centralized urban energy networks (Totty, 2011). Innovative solutions such as pavements that can harvest kinetic energy of footsteps for electricity can be used to power off-grid applications such as pedestrian lighting, way-finding solutions and advertising signage;

(c) District heating systems can distribute heat and power from a centralized location. The heat often comes from combined heat and power plants and therefore can achieve higher efficiencies and lower emissions than separate heat and power production (UNEP, 2011:344).

Applying a range of techniques and practices on new buildings or retrofitting buildings can optimize energy consumption and heating needs (Jastrup and Drique, 2012:88–89; UN-HABITAT, 2012b):

(a) Sustainable building design (windows, orientation and insulation) can provide for passive solar heating and day lighting, natural ventilation and reduced temperature fluxes. Natural ventilation techniques, which use natural convection currents within air flow to direct air into and out of buildings in order to replace rising warm air with cooler air, can function with no or minimal mechanical parts or energy consumption;

(b) Ambiators can cool interiors by using thermodynamic technology based on evaporation at a fraction of the energy consumption of conventional air conditioning;

(c) Innovative clean energy solutions (solar panels, wind turbines, heat pumps and thermal installations) can generate energy and provide heating for buildings.

Innovative construction technology such as prefabricated and modular techniques and making use of local building materials and local know-how can optimize resource efficiency of construction. Using building materials without harmful chemicals has a large positive impact on the health of the user. Recycling building materials can reduce the environmental impact of the building process dramatically.

Cities are constantly trying to solve water scarcity problems with innovative technologies and the better management of water. Improved metering and flow management are key to a good water distribution system. A smart water management system uses digital technology to help save water, reduce costs and increase the reliability and transparency of water distribution. Physical pipe networks are overlaid with data and information networks. The system typically analyses available flow and pressure data to determine anomalies (such as leaks) in real time to better manage water flow. Customers may be provided real-time information on the water situation and relevant information to help conserve water, leading to lower water bills. For example, Mumbai, India, as part of improvements to the water supply system, has installed smart water meters that may be controlled remotely, leading to a 50 per cent reduction in water leakage.[3]

Waste generation is increasing at a rate faster than that of urbanization. Cities are increasingly finding it difficult to source, separate and use different kinds of waste that can potentially be returned to a consumer life cycle. Waste management typically includes the monitoring, collection, transport, processing, recycling and disposal of waste. Growing cities generate higher amounts of waste per inhabitant. Rates of solid waste growth are fastest in China, other countries in East Asia, parts of Eastern Europe and the Middle East (Hoornweg and Perinaz 2012). The amount of solid waste generated in rapidly growing cities of developing countries is a

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[3] . J Polson, 2013, Water losses in India cut in half by smart meters, Bloomberg News, 15 March, available at http://www.bloomberg.com/news/articles/2013-03-15/water-losses-in-india-cut-in-half-by-smart-meters itron.

serious health risk for their populations. Using landfills reduces the attractiveness of cities. Landfills produce methane, which heavily contributes to greenhouse gas emissions, and do not decompose easily. Incineration of solid waste is also not preferable as it can cause air pollution. Although waste is an energy source that could be reused, it is not seen that way in many countries. Smart waste management systems reduce waste and categorize the type of waste at the source, and develop methods for the proper handling of waste. Such systems may be used to convert waste into a resource and create closed-loop economies. Their primary benefits are in improving the efficiency of waste collection, pick up, separation, reuse and recycling. One of the primary inefficiencies of waste management is the inability to predict when waste is to be picked up; trucks are often sent to collect waste when bins are not full. Sensors, connectivity and the Internet of Things offer ways to mitigate additional costs arising from such inefficiency. Smart waste management systems enable the movement of different kinds of waste to be monitored, and technology may be leveraged to better understand and manage the flow of waste from source to disposal. Such projects are currently being piloted in Santander, Spain and Sharjah, United Arab Emirates.

## D. *Resilience against natural risks*

A resilient city is one that can predict and react to natural disasters in order to minimize loss of lives and disruption of city utilities and services. Developing country cities will be those most affected by the increased frequency of natural risks induced by climate change. This section discusses ways to increase resilience in the face of these risks.

Cities in developing countries undergoing unplanned urbanization are facing the risk of huge economic and human losses from natural hazards. The effects of climate change are exacerbating the issue by instigating more frequent urban climate-related hazards. On the one hand, more and more people are moving into vibrant metropolises that are situated on or close to the coast. On the other, these cities are increasingly at risk due to climate-change induced natural disasters. Especially informal settlements at city fringes and other lower-quality buildings that are products of rapid, unplanned urbanization represent a resilience issue for developing countries, although they play an important role in terms of meeting shelter needs of the urban poor. Their low construction standards and poor drainage result in serious vulnerability to natural risks.

Most disasters tend to occur in developing countries and the human cost in terms of both the number of persons affected and the loss of human lives is much higher in these countries. Yet, some developed countries have also started to be affected despite their generally greater resilience (United Nations, 2011b). Mutizwa-Mangiza (2012) indicates that 40 per cent of the world's urban population, many of them poor and vulnerable to storms, floods and sea-level rise (e.g., southern Brazil, China, Viet Nam and Honduras), live less than 100 kilometres from the coast (see also World Bank, 2009).

The combined impact of sea-level rise, floods, heatwaves and storms have adversely affected millions of livelihoods, homes and lives in different countries, with projections indicating that the trend will continue and, in some cases, worsen (United Nations, 2011b). Middle-income countries such as China, India, Indonesia, the Philippines and Viet Nam had the highest number of floods and storms combined during 2000-2009. Cities located along the west Coast of Africa and the coastlines of South, East and South-East Asia have been affected by sea-level rise, flooding and salt intrusion in river flows and groundwater, compromising the quality of clean water. Endemic morbidity and mortality due to diarrhoeal disease are projected to increase in these regions.

Stronger storms and saltwater intrusion in water systems have weakened adaptive capacities in coastal cities of both developed and developing countries. The damages to infrastructure in the former and the weakening of resilience in the latter threaten their policy space for taking effective adaptation measures and developing capacities for rebuilding.

The integrated effects of the challenges described above threaten the economic resilience of cities and heighten their vulnerabilities. Cities have to start perceiving those challenges as opportunities for investment and building cities to serve as the main pillars for a sustainable world.

**Technology and innovation**

The use of technology plays an important role to improve resilience against natural hazards. Hazard monitoring and surveillance techniques can be beneficial for early warning and land use planning. ICTs that combine data from different departments can enable cities to monitor risks in an integrated manner. Geospatial tools can be beneficial for assessing disaster risk. For example, they were used by the International Organization for Migration in Haiti after the January 2010 earthquake to identify appropriate buildings and sites that could be used as shelter (UNCTAD 2012b: 22). Lower technology solutions such as insulating subway entrances to prevent rainwater from flowing in can also be useful to improve resilience.

Cities need to invest proactively into infrastructure for adaptation to natural hazards. As oceans get warmer and sea levels rise due to the effects of climate change, they will have to continuously revise their risk assessments and adapt their infrastructure. Many of the policies mentioned in previous sections can help increase resilience. For example, spatial plans can take into account risks of natural disasters, while improved buildings can reduce human losses. In addition to the necessity to save lives when disasters occur, adaptation has a financial dimension. Investing into adaptation earlier can reduce the scale of economic losses and financing required to repair damage. Considering that the economic damage that New York City suffered due to Hurricane Sandy is estimated at 20 Billion US Dollars, the human and economic cost of inaction in less-prepared cities of developing countries will be massive. In Manila, Bangkok and Ho Chi Minh City, the cost of repairing damage from climate-change related flooding is estimated at 2 to 6 percent of regional GDP (UN-HABITAT 2012c: 107).

Cities can mainstream adaptation into urban planning. Possible measures include building new developments outside of risk areas, upgrading informal settlements, and addressing the lack of infrastructure and the degradation of the environment (UNHABITAT 2012c: 106-107).

Risk assessments map the areas that are most vulnerable to hazards and help to adjust land use and development strategies. The Urban Risk Assessment, developed by the World Bank, UNEP and UN-HABITAT with the support of Cities Alliance, is a standardized tool to assess urban risk and identify areas and populations that are most vulnerable, which are typically those living in informal settlements. It provides a framework for both qualitative and quantitative assessments that enhances a local government's capacity to identify hazards arising from disaster and climate change risks. It assesses exposure and vulnerability of specific assets and populations, analyzes institutional capacities and data availability, and quantifies city vulnerabilities through the application of a baseline-benchmarking approach to assess progress over time and space (UN-HABITAT 2012c: 106).

Integrating spatial planning with infrastructure can also improve resilience. Dhaka accompanied infrastructure measures such as reinforcing river and canal embankments with efforts to prevent the encroachment of buildings to the vicinity of canals for improved protection against major floods. Similarly, regulatory measures based on risk assessments can guide future developments to avoid disaster risk. Singapore requires new land reclamations to be at least 2.25 meters above the highest level of recorded tides (UN-HABITAT 2012c:109).

## III. Conclusion

This is a good moment to underline the fact that science and technology parks are increasingly connected and intertwined with cities, and this entanglement is already happening at an increasing pace and using different formulas and mechanisms. It is indisputable that STPs are mainly an urban phenomenon, regardless of whether they are located in downtown areas or in urban peripheral areas, and even parks that may be located far from big cities are striving to add urban elements and ingredients to their model. Furthermore, Science, technology and innovations are fundamental ingredients that allow improving efficiency in both economic and environmental senses, developing new and more sustainable ways to satisfy human needs, overcoming historical divides, as well as empowering people to drive their own future.

Unexpected and dramatic events can change the general course of development or a single city or an entire region. Urban resilience, therefore, has been pronounced as one of the key elements of goal 11 of the Sustainable Development Goals as well as the New Urban Agenda. However, there still is a lack of operationalizing the idea of urban resilience and its implementation (Schiappacasse 2018). While cities and people are facing a number of new challenges, it is worthwhile to look back to what we can learn from past developments in preparing for the future through learning processes, adaptation and proactive measures.

This Paper outlines sustainable development challenges faced by cities in key sectors. It proposes sustainable practices that make use of science, technology and innovation in order to produce wider economic, social and environmental benefits for cities. It explains how cities that prioritize sustainable growth patterns can improve employment and competitiveness, enhance social cohesion and create a healthy and liveable urban environment.

In its sectoral analysis, the Paper focuses on those sectors that harbor the greatest potential contribution of STI for positive change. For example, spatial planning goes hand in hand with transport to create compact and adequately dense urban environments with infrastructural cost efficiencies. STI can be used to manage energy, waste, water and buildings more efficiently and avoid resource depletion. Risk assessments and the use of technology can help reduce the effects of natural disasters. Last, synergies between urban and peri-urban areas can provide benefits in terms of food security, water management and employment.

Moreover, it aims to underscore the need for enhanced cooperation and knowledge exchange on science, technology and innovation to the benefit of sustainable urban development, in full coherence, coordination and synergy. It will show that cities, if well planned and developed, could promote economically, socially and environmentally sustainable societies. Cities need to consider how best to use existing innovation infrastructure such as science parks, technology incubators and innovation hubs to develop new smart city ideas and adapt smart city concepts.

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