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Science, technology and innovation for sustainable cities and peri-urban communities

Report of the Secretary-General

Executive summary

This report provides an overview of how science, technology and innovation can address key challenges of rapid urbanization, particularly in developing countries. It proposes technology and policy options for consideration by national governments and the international community, with a view to promoting sustainable urban development.

Contents

Introduction

1. Developing countries are urbanizing at an unprecedented pace. More than 90 per cent of urban population growth in the next 30 years will occur in Asia, Africa and Latin America. While urbanization is increasing the standard of living for many, it has not been inclusive, and urban growth patterns create several challenges for policymakers. Particularly, urban population growth and steadily rising incomes result in higher resource consumption. 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.

2. 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.

3. At its fifteenth session, held in May 2012, the Commission on Science and Technology for Development (CSTD) chose "Science, Technology and Innovation for Sustainable Cities and Peri-urban Communities" as one of its priority themes for the 2012–2013 intersessional period.

4. To contribute to a better understanding of this theme and to assist the Commission in its deliberations at its sixteenth session, the CSTD secretariat convened a panel meeting in Lima, Peru, from 7 to 9 January 2013. This report is based on the findings of the panel, national reports contributed by CSTD members and other relevant literature. Section I examines challenges of urbanization. Sections II and III propose science, technology and innovation choices to address the challenges. Section IV summarizes findings and concludes with suggestions for consideration by the Commission, member States and the international community.

I. The urbanization challenge

5. In 2010, for the first time ever, more than half the global population was living in urban areas. In keeping with this trend, it is estimated that by 2050, urban areas will be home to more than two thirds of humanity. This fast pace of urbanization, mainly in developing countries, is creating cross-sectoral challenges for urban governance that need to be addressed through integrated, multi-stakeholder mechanisms. Key challenges are urban sprawl, lack of infrastructure, depletion of resources, environmental deterioration and the risk of natural disasters.

A. Urban sprawl and rapid motorization

6. Lack of urban spatial plans or not adhering to them leads to unplanned, uncontrolled urbanization, also known as urban sprawl, which creates single-use, low-density settlements. Urban sprawl is a common phenomenon in developing countries. Haphazard urbanization dictates future urban land and resource consumption patterns, and limits the choices of urban planners (United Nations Human Settlements Programme (UN-HABITAT), 2012a). As a result, urban areas end up with inefficient infrastructure and resource usage patterns that are costly and time-consuming to change.

7. Rapid urbanization causes areas in the immediate vicinity of cities, known as peri-urban areas, to undergo fast transformation in terms of land allocation, social structure and economic activity. In the absence of planning and regulatory frameworks, peri-urban areas face severe environmental, economic and property-related challenges and gradually lose their role in supporting cities with food, energy, water, building materials and ecosystem services. For instance, some cities release waste into peri-urban areas without facing any legal consequences. Urban sprawl also causes property speculation to increase land prices to unaffordable levels for peri-urban farmers (United Nations Population Fund, 2008:49).

8. Rapid migration of people to expanding cities and the resulting population growth make it harder to predict, plan and build efficient public transport services. In cities with low population density, it is more difficult to introduce cost-efficient public transport due to increased distances and dispersed trip origins and destinations, resulting in a decreased number of people per route or per vehicle trip. Prioritizing automobiles multiplies investment needs for switching to means of public transport later on. Low population density also results in higher per capita transport energy consumption and vehicle emissions.

9. In cities of the developing world, large segments of urban populations lack adequate means of public or private transport, which results in social and economic exclusion. Public transport remains largely inefficient. As a result, even while automobiles are very expensive for most city inhabitants, motor vehicle ownership is continuously increasing in parallel to rising per capita income. Often, two-wheelers are a first step toward motorization. Currently, in many cities, the ratio of cars per head of population is relatively low, even in middle-income urban areas, hinting that the car fleet will grow significantly in coming years, especially in Asia.

10. Traffic congestion as a result of the growing number of private vehicles is a common trend that will continue to cause severe economic and environmental damage to cities unless public transport is improved. For example, Lima, Bangkok, Mexico City and Buenos Aires all suffer significant economic loss due to the value of time lost by car drivers and passengers (Glaeser, 2011; Economic and Social Commission for Asia and the Pacific et al., 2011). The quality of air in cities is also affected by exhaust fumes, leading to a surge in respiratory and other diseases among inhabitants. Motor vehicle traffic disrupts and delays buses, surface rail systems, as well as pedestrian and bicycle flows. Motor vehicle crashes are a major cause of death and injury in many countries. The means to implement traffic demand management or road pricing to deal with congestion may be unavailable in many countries.

B. Lack of infrastructure

11. Urban infrastructure in a number of developing countries, and particularly least developed countries (LDCs), is inadequate and insufficient to meet the needs of rapidly growing populations and economies. The lack of affordable housing furnished with basic services such as water, sanitation and electricity, especially for lower-income groups, results in informal shelter being built with no infrastructure, little sanitation and no compliance with planning or building regulations.

12. LDCs have particularly high urban growth rates and require special attention in terms of covering shelter, sanitation and other infrastructure needs. Most LDCs are located in sub-Saharan Africa and South-East Asia, where natural disasters pose constant risks. 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. In sub-Saharan Africa, where more than 30 LDCs are located, slums absorb around three quarters of urban population growth. The urban population of sub-Saharan

Africa will double and reach 600 million by 2030 (Department of Economic and Social Affairs, 2012; Satterthwaite, 2007; Food and Agriculture Organization of the United Nations (FAO), 2012).

13. In rapidly growing urban environments, low-density sprawl causes per capita distribution and maintenance costs for energy and water to increase rapidly. Large, centralized energy production facilities require costly, long distribution systems that are currently mostly unavailable, harder to monitor and vulnerable to misuse and natural disasters. Moreover, centralized energy production follows a supply-driven approach, prioritizing the sale of energy over saving energy, creating no incentives for energy efficiency practices that can reduce consumption.

C. Depletion of resources

14. Growing incomes in developing countries lead to increased consumption of resources. As a result, the pressure on energy, food and water resources is steadily rising.

15. Buildings represent a resource efficiency challenge, as they account for 40 per cent of global energy use, 38 per cent of global greenhouse gas emissions, 12 per cent of global potable water use and 40 per cent of solid waste streams in developed countries (United Nations Environment Programme (UNEP), 2012). The absence of resource-efficiency measures for buildings is resulting in a missed opportunity, imposing unnecessarily high costs on consumers as well as lasting resource burdens, environmental damage and social inequality that will burden future generations.

16. The lack of healthy nutrition remains an important issue in growing urban areas of developing countries, in particular LDCs, and is partly the result of haphazard urbanization of agricultural land. More than half of urban residents in Africa live in slums, are undernourished and have scarce employment opportunities. Commercial horticulture, a source of nutrition and employment that is widely practised in peri-urban areas especially in Africa, risks becoming unsustainable due to lack of support, recognition and regulation. Agricultural lands are converted to urban uses, fragmented and sometimes polluted, as sprawl development takes place. As a result, an important opportunity for healthy nutrition of urban populations and a source of employment, especially for female workers, remains underutilized (FAO, 2012).

17. Water scarcity can turn into a serious health issue for both rapidly growing cities and peri-urban areas. The lack of water is negatively affecting access to sanitation. The number of inhabitants in cities of sub-Saharan African countries without access to adequate sanitation more than doubled between 1990 and 2010, reaching 180 million people (FAO, 2012:14).

18. Peri-urban areas on city fringes compete with urban residential and industry demand for water. Urbanization endangers water resources that are critical for agriculture and food production. Increased urban demand for water raises its price. Urban water usage can lead to excessive groundwater extraction, causing longer periods of drought (Thapa et al., 2010). Water leakages and abuse are also severe problems in many countries. As much as half of total water supply can be lost in city distribution networks due to leaks and thefts.

D. Environmental deterioration

19. Urban sprawl results in the urbanization of land at higher rates than urbanization of people. It damages the environment and affects the livelihood of peri-urban communities by covering land that could otherwise be utilized for agriculture, tourism and recreational

activities. While rural and peri-urban populations benefit from new economic dynamism in manufacturing and services brought by urbanization, they do not always enjoy improvements in quality of life due to adverse environmental consequences of urbanization such as air pollution and lack of green space.

20. Uncontrolled solid waste is another serious environmental issue for cities in developing countries. Global solid waste generation is due to increase from 1.3 billion tons per year to 2.2 billion tons by 2025. 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). Solid waste management can be costly, reaching up to half of the total municipal budget of medium-sized cities in lower-income countries. Solid waste is a serious health risk for urban populations and damages the environment. For example, incineration of solid waste is not preferable, as it can cause air pollution. Landfills produce methane, which heavily contributes to greenhouse gas emissions. Many discards in landfills do not decompose easily, and many leach pollutants into water and soils, sometimes travelling long distances. Landfills can also be breeding grounds for infestation through rats, mosquitoes and other disease vectors. They can reduce the attractiveness of cities, creating visual blight and nauseating odours.

E. Risk of natural disasters

21. Cities in developing countries that are undergoing unplanned urbanization currently face the risk of huge economic and human losses from natural hazards. Climate change-related calamities that will affect urban areas include sea-level rise, storm surges, extreme rain, heat waves/heat–island effect, water scarcity and air pollution. These hazards will threaten health, the environment and urban infrastructure and resources further in the coming decades (World Bank, 2012:14).

22. Urban areas in developing countries that have large populations and are situated on the coast, such as Mumbai, Guangzhou, Shanghai, Ho Chi Minh City, Kolkata and Alexandria, are particularly exposed to climate-related hazards. In the past 20 years, floods have become the most frequent natural disaster. The average annual number of floods has increased at a higher rate than any other natural hazard (Green Media, 2012:139). Other natural disasters such as earthquakes have also been on the rise, and cities in developing countries with low-quality buildings are unable to cope with the damages caused by such events.

23. Informal settlements at city fringes and other lower-quality buildings remain a critical challenge to overcome for developing countries due to their low construction standards and poor drainage systems. In some countries, informal settlements are commonly built on low-lying areas subject to floods, as well as sites that are vulnerable to landslides, subsidence and other natural disasters. This situation leaves those social groups that are already very vulnerable most exposed to disaster risk.

24. Many developing countries, particularly LDCs, lack financial and human resources as well as institutional capacity required to develop and administer disaster risk management strategies. Few have procedures to mainstream disaster risk management and climate change adaptation into urban planning or monitoring city performance in terms of reducing risk (World Bank, 2012:16). Overall, a number of common institutional issues require urgent attention. These include the limited understanding of risk and the need for methodologies aimed at assessing risk and devising solutions tailored to urban growth areas and informal settlements.

II. Science and technology for sustainable urbanization

25. Science, technology and innovation can provide a variety of solutions in the urban context, ranging from high technology-based solutions to retrofitting and other innovative approaches to urban planning and governance that employ more basic technologies. Each urban setting faces different challenges and has different technology needs. In some cases, inexpensive and readily available technologies may be the best solution to urban problems. It is also important to integrate various technologies in harmony. For example, intermodal transport services can be designed without necessarily requiring expensive, high technology means of transport.

26. Choices in the developing-country context differ from those in developed countries due to limitations such as know-how, financing and human resources. Constraints are particularly acute in LDC's, limiting their ability to cope with the challenges of rapid urbanization and to ensure even the bare minimum – food, water and electricity – needed to sustain the livelihoods of their citizens. This section focuses on technology, while the following section presents innovation choices for sustainable urbanization in developing countries.

A. Information and communications technology for cities

27. Information and communications technologies (ICTs) have a key role to play in the urban context because they can be applied to solve a variety of cross-sectoral urban problems, and most of the time they do not require large, expensive capital infrastructure. Potential urban uses of ICTs include geospatial tools for spatial planning, simulation and visualization modelling, mobility tools, solutions for optimizing energy and water management, disaster monitoring and response, and social inclusion.

Geospatial tools for spatial planning

28. Geospatial tools such as satellite maps and data layers of geographic information systems can be used in the urban context for various purposes:

(a) Mapping underground utilities, mines, tunnels and other city infrastructure to identify issues, improve efficiency and design extensions;

(b) Mapping areas at risk of earthquakes, floods, landslides and other natural disasters, and adjusting development plans;

(c) Identifying infill areas such as abandoned land or buildings that are suitable for redevelopment and planning for their reallocation;

(d) Mapping natural resources such as prime agricultural land and unique or endangered habitats;

(e) Mapping historic and cultural sites that should be protected, and designing future urban development that is in cohesion with a city's cultural heritage;

(f) Providing virtual addresses to houses and business enterprises that lack formal addresses;

(g) Combining multilayer statistical information with satellite maps to run analyses, for example, poverty targeting, urban infrastructure and transport planning, and socioeconomic analysis such as crime statistics and tracking illegal settlements (UNCTAD, 2012).

Simulation and visualization modelling

29. City planners can use simulation, modelling and visualization technologies to aid long-term planning and investment decisions. Simulation tools can help conduct urban development planning, siting and design of buildings, traffic and energy analysis as well as emissions calculations.

ICTs for mobility

30. ICTs can be applied in various ways to improve mobility in cities, including traffic management, multimodal trip planning and congestion pricing. In the context of low income and informal areas of developing countries, ICTs can help by allowing transit companies and cities to collaborate on transit priority systems and by timing traffic signals to ensure safe movement for pedestrians and bicycles, not just cars.

31. ICTs and smartphones make it possible for city dwellers to benefit from new mobility business models such as carpooling, car sharing and incentive programmes that encourage biking to work. ICTs also make it possible to run transport subsidies for individuals and households with low incomes that might not be able to afford the standard rate for transport services.

ICTs for optimizing energy and water management

Smart grids

32. Smart grids are intelligent electric systems that integrate demand management, distributed energy generation, and transmission and distribution grid management (Villa and Mitchell, 2010). They provide real-time information to utility companies with the help of sensors, enabling them to respond to changes in power demand, supply, costs and emissions, and prevent major power outages. Smart grids increase flexibility of energy production and distribution by allowing for decentralized, individual energy producers, for example households with micro wind turbines or solar panels on their roofs, or batteries of electric vehicles to feed surplus energy back into the electricity grid (Cosgrave, 2012). In order to make the best use of existing energy sources, it has been proposed that local governments can put in place energy marketplaces that make use of smart grid technology so that individuals can trade excess power produced by their private facilities and reduce the need to invest in new centralized electricity-generation capacity (Robinson, 2012; Organization for Economic Cooperation and Development (OECD), 2012:10).

Monitoring resource consumption

33. ICTs can help encourage more sustainable energy and water consumption patterns for individuals, for example by proactively tracking and distributing information on personal carbon footprints and consumption patterns (Robinson, 2012; Mitchell and Casalegno, 2008). Likewise, monitoring and controlling energy demand in buildings with sensors can reduce energy consumption. ICTs can also be used to monitor water losses at relatively low cost. Coupled with improved pricing and enforcement policies, it can help manage water more effectively.

ICTs for disaster monitoring and response

34. ICTs can improve resilience against natural hazards. ICT-based hazard monitoring and surveillance techniques can be used for early warning and land-use planning. ICTs that are used for so-called “dashboards” or operations centres combine data from different departments and allow cities to monitor risks in an integrated way. ICTs can also analyse data from sensors that are established throughout the city to detect and resolve some critical

infrastructure and safety issues, including water leaks and power spikes. Below are notable examples of applying ICTs for disaster resilience in cities:

(a) Rio de Janeiro (Brazil) set up an operations centre that displays real-time integrated data from 30 agencies, which helped improve coordination and reaction times;

(b) Mumbai (India) has 35 automatic weather stations that measure real-time rainfall intensity, and flow gauges on the Mithi river to monitor water flow;

(c) Chacao (Bolivarian Republic of Venezuela) has a wireless early warning system that connects civil protection and environmental institutions with cameras that monitor four river channels crossing the city and shares online real-time hazard information with citizens.

ICTs for social inclusion

35. Among the people who inhabit informal settlements in and around cities, the lack of postal addresses makes it difficult for them to receive health and emergency services or to buy or avail of public utilities. The use of smart identity cards and debit cards, as well as offering services through inexpensive cell phones, which have high penetration even among the poor in countries of sub-Saharan Africa, India, and China, can help to open up new ways to obtain such services.

B. Sustainable mobility

36. Mobility in cities can be improved through the combination of three strategies, namely, “Avoid, Shift, Improve”, that can transform behaviour 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.

37. 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 centres, 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.

38. 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.

39. The “Improve” strategy denotes improving vehicle and fuel technology by switching to low-emission vehicles and alternative fuels to reduce adverse environmental effects such as pollution and resource depletion. This can be done in various ways such as:

(a) Using liquefied petroleum gas, natural gas or biofuels such as biodiesel or ethanol;

(b) Hybrid vehicles that combine electric power with diesel, natural gas, liquefied petroleum gas , ethanol, biodiesel or common gasoline;

(c) Electric vehicles based on rechargeable batteries.

C. Sustainable urban resource management

40. 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

41. Cities can encourage leapfrogging to advanced renewable energy sources and efficient transmission technologies through regulation, incentives and subsidies (UNCTAD, 2011). 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).

42. 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.

43. 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.

Water and agriculture

Market gardening

44. As the spread of urban areas results in a lack of space for food production, small-scale peri-urban market gardening can make up for shortages of healthy, fresh food and generate employment. Peri-urban farms can even reuse urban wastewater for irrigation purposes. Production of fruit and vegetables in private, small farms close to cities can be less costly than supplies from rural areas due to lower transport costs. It can also help contain urban sprawl by creating urban green belts. Mozambique demonstrates the best example for successful market gardening in Africa. The Government created so-called "green zones" by organizing horticulture cooperatives in the capital city Maputo and other major cities. They play a key economic role through healthy small-scale production and supply of fresh vegetables, the creation of employment opportunities and use of urban wastewater for irrigation purposes (FAO, 2012:71–73).

Water technologies

45. Since peri-urban communities in developing countries largely depend on agriculture, water is a key resource for their economic well-being. Water storage, irrigation and water lifting technologies can help tackle water shortages. Grundfos, a Danish pump manufacturer, developed a solution to bring sustainable access to water for rural and peri-urban communities in the developing world. The solution, as implemented in Kenya, uses solar energy to activate a pump that extracts groundwater and distributes it through a payment system that is managed locally. The revenue from the pump is used for maintaining the solution.

46. An innovative method for reusing urban wastewater is called phyto-remediation, that is, the use of trees and plants to clean water. This works with the help of a drainage system that channels wastewater into a catchment that is filled with trees, which then capture the water and hold the waste. The cleaned water is then reused for irrigation purposes. This method is commonly used on a smaller scale by placing swales that contain reeds and other small plants along city streets or parks.

47. Rooftops cover one fifth of urban surface areas. Green roofs can be used to provide insulation and thereby reduce heating and cooling costs for buildings, while at the same time absorbing rainwater and filtering pollutants so that the cleaned water can be reused. Adding plants to rooftops, walls and balconies improves aesthetic qualities while reducing noise and the heat island effect in urban areas (Totty, 2011).

48. Reusing water from washbasins or showers for water closets can cut water consumption. Likewise, rainwater can be held in fascines or tanks, reducing runoff during heavy rainfall. It can then be reused in water closets.

49. Reducing the amount of ground covered in buildings, pavements, roads and parking lots reduces both the local heat island effect and the pressure on sewerage and drainage, as the earth can soak up more rainwater under heavy rainfall.

Solid waste

50. Integrated solid waste management (ISWM) refers to a shift from less preferred waste treatment and disposal methods (incineration) and different forms of landfilling towards reducing, reusing and recycling waste (Municipal Government of Shanghai et al., 2011). The long-term vision under ISWM is to create a circular economy in which the use of materials and the generation of waste are minimized, any unavoidable waste is recycled or remanufactured and any remaining waste is treated in a way that causes the least damage to the environment and human health, or even recovers energy (UNEP, 2011:294–295; Totty, 2011).

51. Cities can make use of technologies to convert certain types of waste into energy as mentioned in the ISWM approach. Integrated energy and waste management infrastructure can optimize energy efficiency while disposing of waste and produce significant savings. São Paulo carried out a landfill emissions control programme that renovated two solid waste landfills. Methane-rich biogas from decaying waste was used to produce electric power on site (Goldenstein, 2008).

52. Managing solid waste in combination with spatial planning can help optimize energy consumption and reduce waste in cities (UN-HABITAT, 2012a:76–85). For example, the location of landfills can minimize negative effects, and providing sorting and recycling space close to locations where waste is generated can help reduce the size of disposal sites.

53. Public–private partnerships as well as joint initiatives of local communities and non-governmental organizations can be effective in launching waste management initiatives. Successful public–private partnerships and citizen initiatives have been launched in Bangladesh, Indonesia, Mauritius, Peru and Sri Lanka.

III. Innovation for sustainable urbanization

54. Innovation in the urban context refers to any new method, business model, policy, institutional design or regulation that meets the needs of urban populations in a more efficient, effective and sustainable way. It may refer to improved rules or legislation as well as improved institutions, models of stakeholder participation or new means of delivering services. This section proposes innovation choices for urban governance, spatial planning and design, buildings and managing natural disasters.

A. Innovative urban governance

55. Rapidly urbanizing regions need new ways of planning and governance based on inclusive leadership, addressing regional needs holistically and providing long-term perspectives. Urban governance can be improved both vertically and horizontally. Innovative ways of governance include the following:

(a) Regional governance entities can provide an overall framework for equitable, strategic metropolitan regulation and planning that protects the environment, provides basic services to the poor and resolves land disputes that may arise from urban sprawl. Coordinating city planning and expansion with regional governance is especially important to ensure sustainable development of peri-urban communities. Peri-urban communities can benefit from regional governance, for instance through ecosystem assessments that map their composition, contributions to urban well-being, interlinkages and changes induced by urbanization;

(b) Urban infrastructure systems are interconnected. Changes or disruption in one service often affects the provision of others. Electricity outages affect water supply, heating and cooling, communications and even transport. The high complexity of interconnected urban systems requires integrated management. Integrating spatial design, land use, mobility and building design makes it possible to identify efficiencies and opportunities that may be overlooked when each sector is managed separately. For example, coordinating street design with building layout can create new possibilities for energy and transport efficiency;

(c) Formal means of public participation in decision-making can play a key role in preventing resource conflicts between urban, peri-urban and rural stakeholders during the urbanization process. Some countries have already managed to set up successful forms of participation in urban decision-making. For example, in Brazil, more than 70 cities have a participatory budget system that allows citizen participation in decisions of resource allocation (Marshall et al., 2009:44). In Peru, the Coalition to Fight Poverty (Mesa de Concertación para la Lucha Contra la Pobreza) is a council made up of government, non-governmental organization, church and community organization members that identifies priorities for community development (Marshall et al., 2009:45);

(d) Water governance of urban and peri-urban areas by a single, unified authority can help resolve water conflicts. Singapore centralized all of its water management in the Public Utilities Board in 1963. Within 40 years of centralization, two thirds of Singapore's land surface became a water catchment area that stored water in 17 reservoirs. Singapore also collects wastewater to produce drinking water, which covers 30 per cent of the city's needs (Tan, 2012);

(e) Horticulture can be supported through policies of urban zoning, building irrigation systems and setting up cooperatives that protect small-scale farming. Agricultural cooperatives can sustain agricultural production and the livelihood of the peri-urban farming community and industry in the face of urbanization. Cooperative structures improve the accessibility of markets and provide logistical support for individual farmers. Governments can also support peri-urban farming, for instance through tax policies, which help sustain peri-urban food production and reduce the need for transporting food.

B. Spatial planning and design

56. Spatial plans are strategic decisions of cities on spatial design and density that take into account population growth estimates, topographic characteristics and capacity to carry out these changes (UN-HABITAT, 2012a). 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 sparsely inhabited and extended city outskirts. It can also help encourage public transport. At the same time, too much density is also not advisable, since it can result in overuse of public infrastructure that will depreciate early.

57. Cities can accommodate growing populations in line with their land use, spatial design and density plans through a combination of regulatory instruments (UNEP, 2011:481; Wheeler, 2008:107):

(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 neighbourhoods 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.

58. Spatial planning that takes the needs of urban transport into consideration from the beginning is a key factor to help prioritize public transport. Cities can be designed by locating mixed-use developments and jobs near intermodal public transport connections, thereby minimizing dependence on cars and reducing the distance that people need to travel. Likewise, spatial design should plan for integrating the incoming population into the public transport system. Each mode of public transport requires a minimum density to be economic. The choice between buses, trams and light rail can be identified in line with density. Various innovative regulatory instruments for land use and spatial design have the objective of improving mobility:

(a) Establishing polycentric cities with so-called “urban villages” that are self-sufficient in terms of employment and recreational activities, linking these centres via rail and reducing the need to travel by car;

(b) Intermodal transport can be encouraged through park and ride/park and ride and bike systems that make it possible for commuters to park their automobiles and switch to public transport and/or bicycles before arriving at congested city centres;

(c) Vehicle and traffic regulation: regulation for vehicle types, emission standards, speed limits and road space allocation that favours green transport, especially walking, biking and green public transport;

(d) Minimum emission standards: regulating minimum carbon emission and energy efficiency standards at the local level for buildings and vehicles;

(e) Car-free developments: providing planning incentives for car-free developments in higher-density areas with high public transport accessibility;

(f) Parking standards: providing maximum rather than minimum parking standards; reducing private car parking standards to a minimum – for instance, less than one car per household – especially in areas of high public transport accessibility.

C. Innovation for buildings

59. Local governments in developing countries can address housing shortages by providing construction initiatives that aim to create affordable, sustainable housing and by upgrading informal settlements. Peri-urban areas can also benefit from social inclusion programmes that upgrade existing informal settlements and prevent the formation of new ones through adequate spatial planning. They can be integrated into the urban transport network as well. Soweto, a large township in South Africa that was part of greater Johannesburg as a separate municipality, was successfully integrated into Johannesburg as a result of a planning and investment effort that improved infrastructure, accessibility,

safety and public spaces and provided new economic opportunities (UN-HABITAT, 2012a:86).

60. Local authorities can provide construction companies incentives, such as cash payments, loans or lower taxes, so that they can benefit from some of the long-term savings resulting from lower resource usage of ecological construction. For building owners, added building costs can be recuperated in the long term due to lower operating costs.

61. Standard measurement and reporting requirements for building performance in terms of energy efficiency and greenhouse gas emissions can drive the spread of sustainable construction practices in the real estate sector. They can also make it easier to embed the environmental performance of buildings into their financial value. Initiatives that facilitate voluntary publication of emission reduction commitments can also be useful in encouraging resource efficiency of the construction sector.

62. Setting up multi-tier building rating systems can guide the real estate sector in terms of adopting comprehensive green building standards. Green building rating systems that certify environmental building design strategies are starting to be implemented globally. Notable examples are the Building Research Establishment Environmental Assessment Method, commonly known by its acronym BREEAM (United Kingdom of Great Britain and Northern Ireland); Green Mark (Building and Construction Authority of Singapore); GRIHA, which stands for Green Rating for Integrated Habitat Assessment (India); and Leadership in Energy and Environmental Design, or LEED (United States of America).

D. Managing natural disasters

63. Cities can mainstream adaptation to natural disasters 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 (UN-HABITAT, 2012a:106–107).

64. Cities need to invest proactively into infrastructure that enhances their adaptation capabilities, particularly to natural hazards. As oceans get warmer and sea levels rise as a result of climate change, cities will have to continuously revise their risk assessments and adapt their infrastructure. Investing into adaptation strategies for such risks well ahead of time can reduce the scale of economic losses and finances needed to repair damage if the event does materialize. The human and economic cost of inaction in less-prepared cities in developing countries can be enormous. For example, in Manila, Bangkok and Ho Chi Minh City, the cost of repairing damage from climate-change related flooding is estimated at 2 to 6 per cent of regional gross domestic product (UN-HABITAT, 2012a:107).

65. Integrating spatial planning with infrastructure can also improve resilience. Dhaka (Bangladesh) put into force infrastructure measures such as reinforcing river and canal embankments along with regulatory safeguards that sought to prevent the encroachment of buildings around water canals in order to provide improved protection against major floods. Singapore requires new land reclamations to be at least 2.25 metres above the highest level of recorded tides – this requirement is another example of how city planning can anticipate and provide for risks (UN-HABITAT, 2012a:109). Similar regulatory measures based on risk assessments can help city planners forecast and guard against future developments to avoid disaster risk.

66. Risk assessments map the areas that are most vulnerable to hazards and help adjust land use and development strategies. Some cities or city areas are more vulnerable than others, and risk assessments make it possible to demarcate and provide extra safety for these. Sorsogon (Philippines) is a city that is affected by five tropical storms on average each year. The city undertook a climate change vulnerability assessment, as a result of

which it directed urban development plans to safer inland areas. According to the adjusted plans, settlements in high-risk coastal zones will be incrementally relocated through local shelter relocation projects or voluntary resettlement. Inland areas will be incentivized through infrastructure investments, the construction of new residential units and new industrial sites for employment. (UN-HABITAT, 2012a:114–115).

IV. Findings and suggestions

67. This section summarizes the findings presented above and proposes a set of key issues for consideration by the Commission.

A. Findings

68. The findings are as follows:

(a) The use of science, technology and innovation in the urban context implies the application of high technology as well as low technology and innovative approaches to urban planning and institutional innovation;

(b) The challenges of cities in developing countries, in particular LDCs, differ widely from those of developed countries and require special analysis in the context of this issue;

(c) Regional planning is a key consideration to ensure that the needs of urban and peri-urban zones are addressed in an integrated way;

(d) An intersectoral approach is necessary for sustainable cities;

(e) Science, technology and innovation are necessary for sustainable urban development, including providing solutions to mitigate the impact of climate change on vulnerable urban populations;

(f) Design and engineering go hand in hand when building cities, along with city planning. Ultimately, cities should be places where people feel comfortable to live in;

(g) Local and indigenous culture and knowledge accumulated through the centuries are crucial in solving local problems. For example, indigenous knowledge can be put into use to construct sustainable buildings or to manage natural resources;

(h) It is necessary to develop business models that scale technological innovation and make sure that it reaches beneficiaries.

B. Suggestions

69. The Commission should consider the following:

(a) Providing a forum for the sharing of good practices and experience on the use of science, technology and innovation for sustainability in key urban sectors in developing countries with a special focus on LDCs;

(b) Sharing and analysing evidence on successful examples of local innovation models that provide solutions based on science, technology and innovation (including serving as incubators) to pressing urban challenges;

(c) Sharing and analysing evidence on business models that scale these innovative interdisciplinary solutions to city management and provide them to the beneficiaries;

(d) Raising awareness among urban policymakers about the role of science, technology and innovation, and ICTs in facilitating integrated regional planning, spatial design and informed resource consumption.

70. Member States should consider the following:

(a) Establishing governance mechanisms that facilitate integrated, multi-sector and multi-stakeholder urban planning. Urban projects should include participation from departments responsible for spatial planning, mobility, energy use, waste management, environmental protection, buildings and disaster resilience;

(b) Putting in place regulatory frameworks at the national, regional and local levels that mainstream issues of sustainability into urban projects and support business models that scale innovative solutions;

(c) Encouraging municipalities to join national and international networks of cooperation to learn from best practices in cities of other regions and countries;

(d) Providing support for research and encouraging cooperation with universities and municipalities on the socioeconomic impact of urbanization, in order to support informed public policies;

(e) Analysing market trends on the use and impact of technology and innovation and ensuring that these are taken into consideration when envisaging public policies driven by science, technology and innovation for sustainable cities;

(f) Using ICT-based simulation tools that estimate requirements for future transport; energy, food or water consumption; waste generation and housing in expanding urban areas, also taking into account the estimated growth of income;

(g) Establishing regional expansion plans that take into account the estimated demand for basic services and infrastructure of growing populations in cities and surrounding peri-urban and rural zones;

(h) Promoting technologies and business models that scale affordable, resource-efficient housing for lower-income groups living in slums, as well as new inhabitants of urban areas;

(i) Exploring potential bilateral or multilateral cooperation, especially between municipalities and other types of local government, on improving the resilience of cities and peri-urban areas against natural disasters and the impacts of climate change, for example with the help of early-warning systems.

71. The international community should consider the following:

(a) Exploring innovative financing models, including the investment of pension and sovereign wealth funds, to promote the greater integration of solutions based on science, technology and innovation for sustainable development and the management of cities in developing countries;

(b) Establishing platforms, such as open repositories, to share experiences and knowledge that addresses the particular urbanization needs of LDCs.

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