EMBO reports

More science in urban development

Scientific evidence is crucial for managing health and infrastructures of megacities

Philip Hunter

Cities worldwide grow at an unabated rate. In 2009, the global urban population reached 3.42 billion and surpassed the number of people living in rural areas (http://www.un.org/en/development/desa/population/publications/urbanization/urban-rural.shtml). This unprecedented growth of cities and towns places great strains on public health, infrastructure and ecosystems; not surprisingly, these problems are most acute in developing countries, where nearly all population growth takes place in urban areas. This is particularly relevant for megacities with more than 10 million people in their greater metropolitan area, the number of which has increased from 10 in 1990 to 28 at the latest count in 2014 and is set to reach 41 by 2030, according to the United Nations (http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html). Megacities pose particular threats to health, ecosystems and sustainable development, not only on account of their size and population density, but also their rate of growth, as infrastructures are often unable to keep up.

These issues were discussed at the recent UN conference on future sustainable development of towns and cities. The conference takes place only every 20 years and the latest, Habitat III held in Quito in October 2016, was the third, with the aim of establishing a global agenda for urban development. It was meant to address a variety of factors including poverty, quality of life, climate change, the environment and health. The outcome was the New Urban Agenda (NUA), replacing the old agenda developed at the previous 1996 Habitat II conference in Istanbul.

A lack of science

Many scientists though were dissatisfied by the lack of attention paid to science and ecology at the conference. "Yes, it was absolutely disappointing", said Susan Parnell from the African Centre for Cities at the University of Cape Town in South Africa. "Science was just dumped in with everything else and there was no provision for taking account of updates to the science as it evolves over the next 20 years". However, Parnell conceded that the scientific community itself had failed to get its message across, partly because it had not developed a roadmap or even worked out what the research priorities should be. "It's a bad thing that we missed a perfect opportunity, because we didn't get our own act together for Habitat III", she said. "But in some ways the silver lining is that if we weren't ready to jump in, we now have the opportunity to sit back and think what we need to do. It is more complex than many thought, because firstly it's new, secondly it's multi-sectoral and thirdly it doesn't have an obvious set of data".

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On the other hand, Timon McPhearson, Assistant Professor of Urban Ecology at The New School, New York, a private research university, argued that it at least helped clarify the next steps at a time when various technologies had matured to the point to make significant advances in urban planning. "Habitat III did a great job of putting issues on the table, highlighting what needs to be thought about in terms of global policy and identifying loads of challenges that need to be overcome", he said.

The impact of global warming

One of those challenges is the impact of climate change, as global warming combined with urban expansion amplifies the temperature rise in densely built areas. Temperatures are on average higher in urban than in surrounding rural areas because constructions absorb more radiation and have a higher thermal capacity, while human activities generate additional heat. As McPhearson noted, a welcome outcome of Habitat III was the decision by the IPCC (Intergovernmental Panel on Climate Change) to hold a follow-up conference in 2018 to address the implications of climate change for cities. Cities are also highly vulnerable to other impacts of global warming such as rising sea levels, given that many are located in low-lying coastal areas. A study recently published by the National Academy of Sciences of the USA warns that low-lying coastal cities, including Miami and many in SE Asia, are at risk of being submerged even if temperatures rise only as predicted [1].

The combination of temperature rise, urban growth and lack of planning could increase the risk of many diseases, including those directly transmitted like influenza, those transmitted by vectors like malaria or dengue and zoonoses from domestic or farm animals. Zoonoses have been associated more with rural conditions, with cities even considered to offer some protection, but that is less the case now. Large cities in developing countries in fact offer ideal conditions for contracting diseases from domestic pets such as dogs, which often run wild, or livestock, which often also roam the streets. It is a problem shared by many Asian,

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African, Latin American and just about all Indian cities with free-ranging dogs and urban livestock, according to Harini Nagendra, who specializes in sustainable cities and forest management at Azim Premji University in Bengaluru, India.

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In fact, a recent study found that rapid urbanization can give rise to new diseases by interfering with ecosystems previously largely undisturbed by humans [2]. Such settlements create new and closer encounters with wildlife, which can be a potential source of zoonoses. The study calls for better surveillance to monitor the burden of disease and give both local authorities and the global community the chance to respond quickly to emerging public health threats.

Controlling mosquitoes

Vector-borne diseases also pose an escalating challenge for many tropical cities according to Nagendra. "Malaria, chikungunya, dengue, Japanese encephalitis, and other diseases, some known, others unknown, have swept across Indian cities from north to south and from east to west. We do know that it is a wicked combination of heat, rainfall, poor sanitation, and poor drainage that play a role in the spread of mosquitoes".

Controlling the mosquitoes has proved difficult; many cities resort to insecticide fogging around lakes, garbage dumps and other places where stagnant water persists. "Fogging is only a short-term solution, and a partial one at that because it leads to other problems of toxicity and insecticide resistance over time", Nagendra said. "What we need instead is better insight into the altered mechanisms of spread of the mosquito in urban areas. Anecdotal reports suggest that the *Aedes aegypti* mosquito (the main carrier of dengue and chikungunya), which was originally a daylight feeder, has adapted to urban environments with artificial light, and now actively bites at night in areas that are well lit". Interestingly, Nagendra cited studies suggesting that urban mammal companions, such as dogs, cattle, pigs and goats, actually act as incompetent or dead-end reservoirs for the virus and slow down disease transmission. "Both these points suggest that some diseases may, ironically, spread faster in wealthier environments with bright night lights, and which are kept free of stray dogs and free ranging livestock", he commented. "But in the absence of research on the social and ecological factors that influence the spread of mosquitoes in crowded urban environments, we can only speculate. Cutting edge research on urban diseases is urgently needed, and requires focus by municipal authorities, public health officials, and epidemiologists".

The bad side of biodiversity

Nagendra was also disappointed by the lack of focus on science and ecology at Habitat III. "Biodiversity, the importance of maintaining ecological processes like soil and air renewal, and of ecosystems as urban commons for provisioning services such as food, fodder and fuelwood, which are widely used by millions of the most vulnerable urban residents, were all rarely, if at all, mentioned", he said. He expressed particular concern over the Indian Smart Cities programme (http://smartcities.gov.in/). "It will get off the ground next year, most likely, in a slew of smart cities which have been identified across India", Nagendra explained. "The emphasis is clearly on infrastructure and technology, especially information technology, heavily driven by private investment". He was concerned that the approach prioritized technology and infrastructure growth over ecology and the environment, which would be bolted on later. "Cities are social-ecological systems, and the social and the ecological aspects need to be designed together as an interacting system, to benefit people as well as nature", Nagendra said. "The planning has to be integrated right from the start".

Such planning should be conducted at a global and local level, according to Michael Osterholm, Director of the University of Minnesota's Centre for Disease Research and Policy, because disease arising within a tropical city can rapidly propagate with worldwide travel. He pointed out that many large cities in developing tropical countries have affluent areas in close proximity to poorer slum zones that are incubators of disease. That is particularly the case in countries with a lot of poverty and rich in mineral resources, which brings in outside investment. Angola in Africa, for example, is rich in diamonds, iron ore, manganese and copper, and its capital Luanda is one the most expensive cities in the world for expat foreigners to live, despite poverty and sprawling slums (http://www.bbc.co.uk/news/business-16815605). "If you have a lot of transportation and movement between that more affluent part of the city and the rest of the world, that raises challenges", Osterholm explained. "Diseases such as TB or from drug resistant bacteria can spill over from adjoining slum areas of cities to that more mobile population".

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For this reason, it requires more efficient measures to prevent any emerging pandemic from travelling, according to Thomas Fisher, Director of the Metropolitan Design Centre at the University of Minnesota. "During previous epidemics, such as SARS and Ebola, airports did put in place security precautions, so this is a real issue that airports are concerned about", he said. Of course, measures at airports do little to help the local population. Nonetheless, Fisher was optimistic about current efforts: "There is a lot of work on prevention in the developing world through better sanitation, separation of humans and animal slaughtering, and so on, that makes sense in order to stop a zoonotic disease right at its source".

Architectural solutions to improve health

Proper planning of individual buildings and neighbourhoods can also help to mitigate disease. At least one significant urban building project, Architecture for Health in Vulnerable Environments (Archive), focuses on designing housing specifically to improve health and reduce the risk of chronic and infectious diseases. Most of its activities take place in cities of developing countries, but Archive Global also has projects in deprived areas of affluent cities such as London or

New York, where the state of housing contributes to transmittable disease or allergic and inflammatory conditions.

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One ongoing project in Camden, NJ, USA, aims to reduce the incidence of asthma by repairing and improving houses in deprived areas (http://archiveglobal.org/camden-new-jersey/). Nearly 40% of residents live in poverty, including 52% of the children, which correlates with high asthma levels in large part because of the conditions at home. Mitigating measures include improved ventilation and new flooring, which can be taken anywhere in the world on a relatively limited budget. Such activities also provide evidence for the role of architecture and design in city development.

Greener infrastructure

Buildings are again parts of the wider urban organization, which plays a role in just about all aspects of life, including health, the water cycle, transportation and what are loosely called ecosystem services. A lot of these are the so-called grey elements: concrete drainage, water treatment and transportation systems that provide little support for wild life and biodiversity and that are often susceptible to flooding during storms. Accordingly, there is growing momentum to replace these conventional elements with what is called green-blue infrastructure. Green infrastructure refers to an ecological framework at different levels including more open terrains to absorb water, along with wetlands, botanical gardens and other features more in sympathy with nature. Blue infrastructure refers to water supply and drainage, which should be coupled with green infrastructure, hence the term "green-blue". In practice, though, green-blue will always combine with grey elements. The challenge is to strike a balance and compromise between urban growth and creating more open "green" spaces.

The profile and role of these spaces remains an open question in urban planning. While almost everyone agrees that green spaces are essential for any city, research has challenged the commonly held notion that they are always "green" in an environmental sense, according to Xuemei Bai, Professor of Urban Environment and Human Ecology at the Australian National University in Canberra. She cited a study of the Montjuïc Park in Barcelona, Spain, which refuted one of the most heavily cited benefits from green parks in cities, their carbon sequestration ability [3]. Energy flow analysis showed that a land area more than 12 times larger would be required to absorb the carbon emissions just from the activities needed to maintain the park. While there are other benefits of parks, Bai argues that the notion of the carbon sequestration capability of green spaces was an example of lazy thinking all too common in the whole environmental domain. Instead, she argues that, because urban systems are dominated by humans to a greater extent even than agricultural land, it makes no sense to apply concepts that work in natural ecosystems to cities [4]. "Biogeochemical cycles of nutrients such as carbon, nitrogen and phosphorus, or the flow of energy through food systems, are a key focus of ecosystem ecology, but they only comprise a small part of the large variety and magnitude of materials or energy flows in an urban system", she wrote.

There are other common fallacies about cities as ecosystems, one being that encouraging biodiversity automatically benefits everybody, a point made by Caroline Isaksson from the Evolutionary Ecology Unit at Lund University and an advisor to the city of Lund. "In many places, there has been an aim to increase biodiversity along roads, having a diverse flora that attracts butterflies and so on. That sounds good on paper but what about the bats, birds and other animals that are feeding on these resources, do we want them along our roadways as well?", she commented. "Another example is 'green roofs', which are indeed green but, in most cases, do not contribute to an enhanced natural biodiversity. This is because the plants are often either non-native or succulents that do not attract insects to the same degree as native plants".

Different problems, different strategies

Another fallacy is the idea of a "one-size-fits-all" strategy for sustainable development, which is clearly nonsense given the stark differences both within and between densely populated areas around the world. Tokyo in Japan and Kinshasa in the Democratic Republic of the Congo are both megacities, but face very different problems. Kinshasa is one of the fastest growing megacities that is expected to double its population from 10 million to 20 million by 2030 [5]. The same report highlights entrenched municipal dysfunction caused by "vague or unclear priorities".

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As it happens, Kinshasa has been subject to one of the world's most detailed mapping of malaria incidence across a major urban setting, which could inform mitigation measures in other cities, especially in sub-Saharan Africa [6]. This study confirmed the widely observed phenomenon that malaria is less prevalent in central or downtown districts where breeding grounds for the vector, here the *Anopheles gambiae* mosquito, are restricted, but much more so in densely populated suburbs or peripheral areas. Like other cities in the region, Kinshasa initially experienced increased malaria transmission stimulated by the human density and creation of favourable breeding sites for the mosquito. But in the second phase of urban growth, the dense housing eliminated those breeding sites and in turn reduced the mosquito population and transmission rate. The risk then spread out to peripheral regions, but left some pockets of transmission into the city near agricultural fields or large market gardens. These pockets tended to be near rivers crossing the city and flood zones conducive for mosquito breeding.

In Tokyo, vector-borne disease is virtually absent and the city has a different problem resulting from the low disease toll: a rapidly ageing population, which is intensifying pressure on social services. A recent study (http://www.policycouncil.jp/pdf/prop04/prop04.pdf) by the think tank Japan Policy Council highlighted Tokyo's unpreparedness for this demographic trend, which is steering building away from offices and apartments towards nursing homes. It has also led to a controversial proposal from the council to

relocate one million pensioners to rural areas to avert an impending "care crisis".

These may be First World problems, but addressing them still needs clear strategies based on evidence. The most pressing research needs though are around disease epidemiology in developing cities, as well as designing green-blue infrastructure and more effective ecological services. Inevitably all these aspects of urban planning involve balances and trade-offs between competing demands and pressures. Biodiversity, for example, may have to be compromised with amenity. But it is also clear that current urban planning needs to change and be driven by science to a much greater extent. As Osterholm put it, "we can't do business as usual any more".

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