Chapter 13

Urban zones: vulnerable megalopolises

© IRD/P. Gazin

Dhaka, an urban area with a population of some 12 million.
With rapid population growth of more than 5% per year, it is subject to serious natural risks (floods, cyclones and earthquakes).

While humid tropical forests and ocean areas play an important role in climate regulation, urban zones generate the major proportion of greenhouse gas emissions. Large cities are centres for industry and also for the consumption of fossil resources for transport, heating and air-conditioning. The countries in the North are historically the main contributors to these urban emissions. However, the economic slumps and mitigation policies set up in Europe in parallel with strong population and economic growth of the megalopolises in the South are gradually reversing the trend.

The cities in the tropics are particularly exposed to climate impacts, mainly because vulnerability is high and town planning policies and measures to combat natural risks are less developed there. The IPCC Fifth Assessment Report stresses the urgency of addressing urban areas with regard to both mitigation policies and capacity to adapt as the impacts on society—poorly assessed as yet—are worrying. The immediate consequences for the population are the effects of pollution as regards public health. The rapid rise in temperatures, related in particular to the urban heat island phenomenon, also has marked consequences. In the medium term, the increase in extreme events and the rise in sea level could have catastrophic results for the stability of societies in the

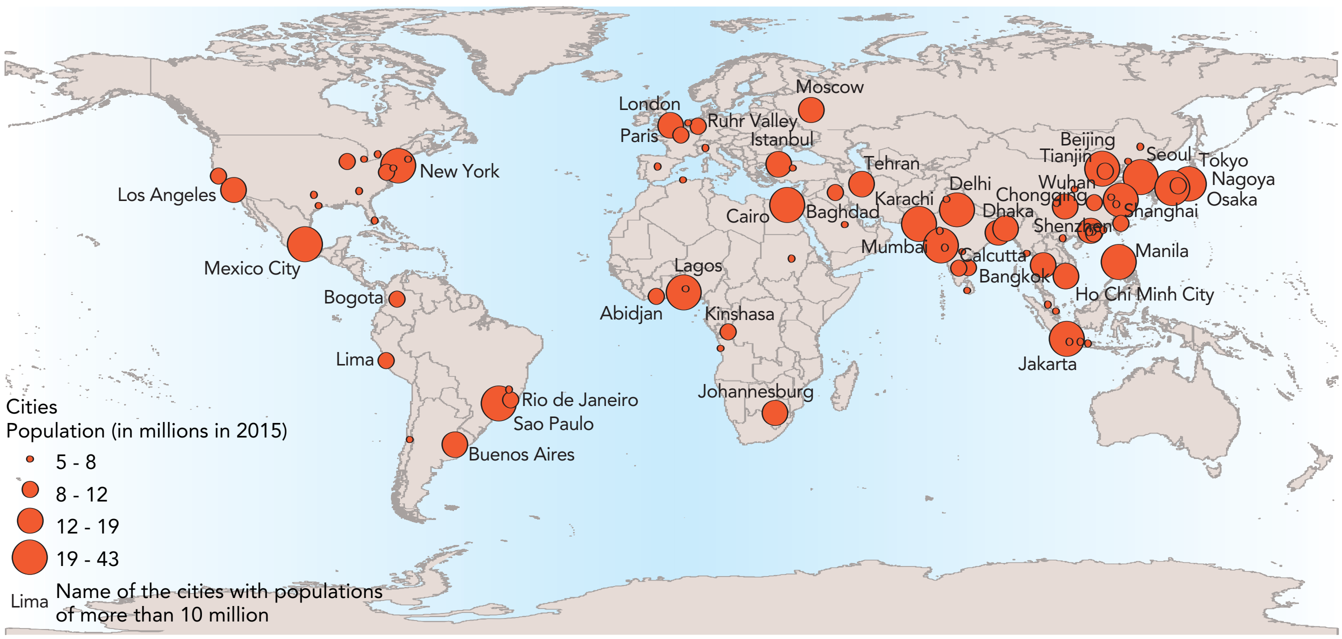
South, whereas with the extension of precarious districts and coastal towns, present urban dynamics increase the risks for populations.

The research sector must therefore gain better understanding of vulnerability and the impacts of climate change in cities in order to attempt to propose solutions adapted to increasing urban concentration. Such urban research is still little developed in countries in the tropics. IRD has long addressed similar themes such as population-environment relations, natural risks and public policies in cities and the trend today is that of refocusing these themes in a context of climate crisis.

An increasingly urban and coastal world

Nearly 4 billion people, that is to say 58% of the population of the world, now live in urban environments. This massive urbanisation is relatively recent dynamics as the urban population has increased nearly 5-fold since 1950. Urban growth has displayed two new features since the 2000s. First, it is accompanied by concentration in increasing large towns in the South (Fig. 27). In 1975, there were 18 megalopolises with populations of

Figure 27.
Evolution of large cities.
Exposure to 10 µm particles in the atmosphere in urban zones (2008-2013).
Source: IRD/LPED



© IRD/G. Roudaut

Lima, Peru.
One of five megalopolises in Latin America (the others being Mexico City, São Paulo, Buenos Aires and Rio de Janeiro), Lima houses a third of the population of Peru.

over 5 million, the whole totalling 170 million people. In 2014, there were 73 megalopolises with a total of 800 million people. The main megalopolises are on the American and Asian continents, mainly in emerging countries (Brazil, India and China). But many other cities in the tropics have become megalopolises at the regional level, such as Lima with 30% of the population of Peru and Lagos with three-quarters of the population of Nigeria.

Another major feature of this urban growth is the greater development of coastal cities. According to IPCC, nearly 145 million people live at an elevation of 1 metre above sea level and 397 million at less than 10 metres. The trend will become more marked in the coming decades because of the intensification of world sea trade.

Increased vulnerability in the face of natural risks

In spite of the lack of observation systems focused on the urban climate in countries in the South, impacts of warming, increased climate variability and extreme events and the rise in sea levels are observed. The IPCC Fifth Assessment Report lays particular stress on two phenomena: landslides and the rise in sea level.

Box 42

What is the relation of cause and effect between climate change and urban catastrophes?

The increase in catastrophes in the Andean capitals has led researchers to investigate the causes and especially links with climate change. But extreme climate events are not the only explanation of the increase in urban risks.

In the last three decades, La Paz, Lima and Quito have suffered a multitude of natural catastrophes involving flooding and landslides. The cumulated damage is very significant for humans and goods and penalises the economic and social development of these cities.

In La Paz for example, the floods of February 2002 caused one of the greatest urban catastrophes known in Bolivia: 69 deaths, the displacement of 200 families and very serious material damage evaluated at 10 million dollars. In February 2011, a landslide made it necessary to evacuate several neighbourhoods of the capital; 6,000 people were placed in shelters and much public infrastructure was destroyed in a 140-hectare zone. But the landslide, caused by precipitation that attained double normal depths, was in soft ground where urban development is not permitted. Urban growth in dangerous zones is often the cause of exposure of the population to risks that have been identified.

More than a hundred catastrophes are reported each year

Given the increase of natural catastrophes observed, the team at PACIVUR (*Programme andin de formation et de recherche sur les vulnérabilités et les risques en milieu urbain*) analysed the statistical pattern of the accidents and catastrophes that occurred in the three Andean capitals from 1970 to 2007. A total of 3,990 accidents and catastrophes—mainly floods and landslides—were recorded

Marine submersion

More than half of the cities in the tropics are on the coast—among other things a heritage of the trading centres of the old colonies. And current urban dynamics continue to encourage the growth of these coastal cities. Increasingly large urban populations are thus exposed to the rise in sea level and, more precisely, to erosion and marine submersion. Among others, this is the case of Nouakchott, Lagos, Lomé, Dhaka, Ho Chi Minh City and Rio de Janeiro. The rise in sea level of several tens of centimetres in the coming decades will accentuate these phenomena, with the destruction of housing and infrastructure and movements of populations. Marine submersion will also cause a loss of coastal resources that are important for local economies.

in the three cities: 76% concerned Lima, 14% Quito and 10% La Paz.
These catastrophes have become increasingly frequent with the passing of time.

It would seem from the scientific literature available that the increase in catastrophes is linked with climate change in the Andes.
The heavy rains recorded in recent decades are correlated with the increase in floods.
However, this kind of conclusion would ignore several difficulties in interpreting the increase in accidents.

Urban vulnerability

First of all, the actual assembly of data is partially biased: data collection varies from one city to another and some places receive more attention because of their strategic importance as regards politics and economics.
These disparities in data are obstacles to the understanding of vulnerability and risks and their links with climate change.
Furthermore, it is difficult to distinguish between phenomena with natural causes and those with anthropic causes because of complex series of events that are typical of urban environments.
What is certain is that accidents and catastrophes in these environments are related to very strong anthropisation (the ground rendered impervious, spread of built-up zones, etc.) and the vulnerability of complex, dense urban structures (high densities of population and activities, multiplication of technical networks, etc.).

Thus although climate change will certainly affect vulnerability in urban environments, it is still difficult to establish a causal relation.

Landslide in February 2011 in the city of La Paz (Bolivia).

Floods and landslides

Through more violent precipitation or serious drought, climate variability will also affect cities further inland. The increase in extreme rainfall events heightens the flood threat that is already accentuated by the imperviousness resulting from town development. Strong precipitations also increase landslide risks. The consequences of these phenomena are often amplified by the vulnerability of urban environments. Human activities over which there is little control, urban concentration in sometimes dangerous zones and precarious dwellings are all factors that can turn climate risks into urban catastrophes. The danger is particularly strong in highland cities. For example, most cities in the Andes are exposed to these phenomena that have been increasing steadily in recent decades.

The change in the rainfall regime also results in more floods, exposing towns near rivers to risk. The historic floods of the Amazon and its tributaries in 2009, 2012 and 2014, linked with exceptional precipitation and deforestation, affected several hundred thousand people. A state of emergency was declared in several regions of Peru, Brazil and Bolivia and numerous towns were flooded.

© IRD/F. Demoraes

Avenue Patria Quito, Ecuador.
Slightly more than 28,000 vehicles use this road every day. If it is blocked—by landslides or floods—traffic in the city is paralysed to a considerable degree.

Box 43

Informal neighbourhoods in the face of climate change

IRD studies in Damascus and Cairo show how informal neighbourhoods can bring as many problems as solutions in the face of climate change.

The informal neighbourhoods in both Damascus and Cairo display specific vulnerabilities with regard to risks connected with climate change. Unsurprisingly, the people there often live in areas at risk from floods and that are unstable and subject to landslides. The poor quality of dwellings and the absence of drainage increase the exposure of the population to floods. For lack of means, the people concerned have few alternatives for settling in safer areas.

Then marginalised neighbourhoods also receive less state aid in case of catastrophe. They also suffer from more limited legal and financial protection for lack of landholding rights, insurance cover, etc.

Finally, the informal zones are formed without respect of the regulations that are supposed to protect them. This means double vulnerability as when prevention and risk management policies exist, informal towns grow precisely outside these regulations.

Nevertheless, the IRD studies show the pertinence and flexibility of informal urban development. They highlight the know-how of the builder-occupiers who find solutions when public policies have shortcomings. In addition, some features of these neighbourhoods are considered increasingly as being partially adapted and/or adaptable to the climate changes expected. Their urban morphology makes them better adapted: narrow shaded streets, heat inertia of structures that touch each other, urban compactness; dense buildings and small plots. And they are also easier to adapt: flexible progressive construction, conservation of a pedestrian character, low traffic speed in dwelling zones, etc.

Without being a majority, some professionals underline these 'sustainable' features of informal neighbourhoods and the know-how on which strategies for adaptation to the risks of climate change can be based. These aspects are beginning to be integrated in projects for the rehabilitation of informal areas.

Makeshift accommodation in an outlying district of Cairo (Egypt).

© IRD/J.-P. Montoroi

Greater Bangkok has a population of more than 14 million, forming over 20% of the population of Thailand.
The city is regularly affected by serious flooding during monsoon rains.

The direct sanitary effects of emissions

The effects of climate warming must not hide the direct effects of urban emissions on air pollution and the warming of urban climates. These local effects are very marked today in cities in the South (Fig. 28). Mexico City, Sao Paulo, Cairo, Karachi, Dakar, Bamako, etc. seriously exceed the atmospheric pollutions thresholds accepted by the World Health Organization (WHO) in particular because of ageing public transport and vehicles and the absence of regulation of domestic use of wood or gasoil. The particle count in New Delhi is 153 $\mu g/m^3$, that is to say 15 times more than the WHO threshold and 10 times more than in Paris.

Mastering **urban heat islands** (UHI) is also a challenge in the face of climate change. Increased temperature operates differently in town and in the country. In town, the albedo effects on the surfaces of buildings and tarmac roads combined with heat emissions from transport, building heating or air-conditioning together with high pollution levels can cause local temperature increases of 4 to 6°C. The effects are felt especially at night when the energy stored in concrete walls is released. The phenomenon is particularly marked in Mediterranean and tropical environments where air-conditioning is used continuously.

The combined impacts of thermal stress, heat islands and air pollution form a new health risk, with increased respiratory disease and vulnerability in children and old people (dehydration and cardio-vascular diseases). These risks are particularly marked in zones where there is already thermal stress, such as the Sahel, and in the Mediterranean zone.

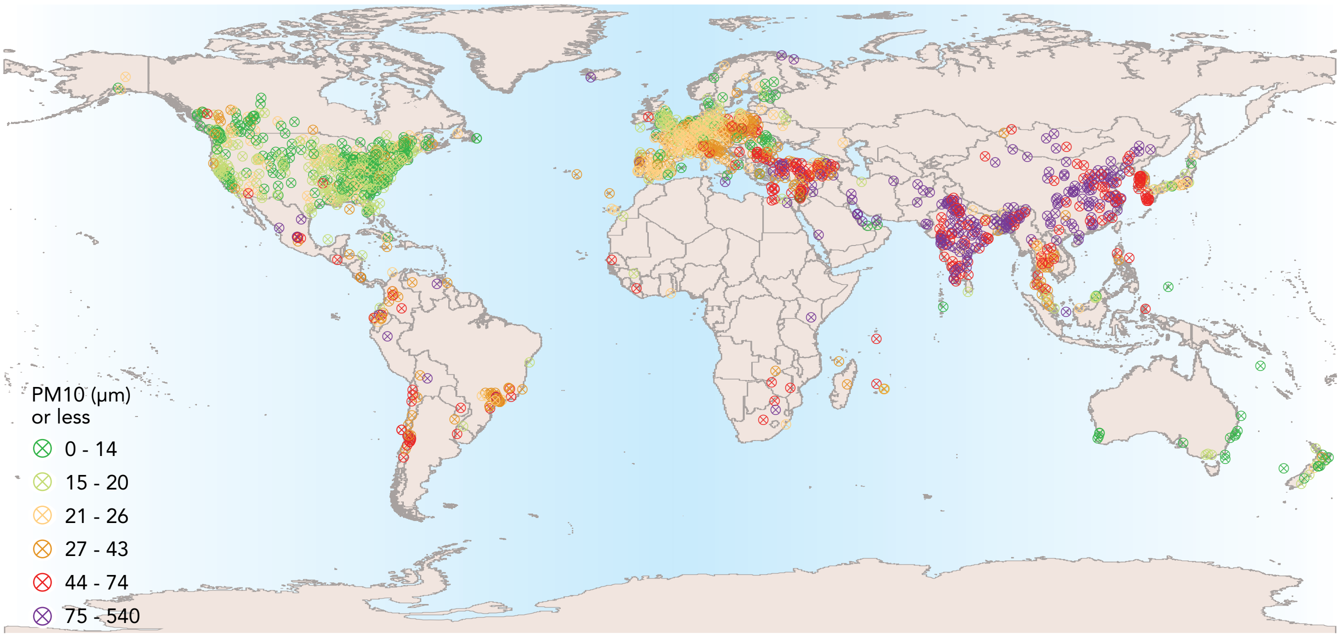


Figure 28.
Map of air pollution in large cities.
Exposure to 10 μm particles in the atmosphere in urban zones (2008-2013).
Sources: IRD/LPED/WHO, 2014

Access to resources endangered

Another impact of climate change in urban zones is the availability of resources to supply an entire city. Access to water is a particularly crucial issue with the threat of extreme climate events. This covers shortage of water during severe droughts, the pollution of groundwater following heavy rainfall (because of contamination resulting from poor treatment of sewage) or the destruction of infrastructure during natural catastrophes. Broken pipes can soon affect an entire city. After the La Paz landslide in 2011, the potable water supply for about 300,000 people was halted for several weeks. This example highlights the fragility that is a feature of centralised urban facilities (Box 44).

Another phenomenon related to climate change and that forms a threat to water supply is the retreat of glaciers. The melting of ice during dry periods is an important source of water. In arid regions, such as those in Peru and Bolivia, the contribution of glaciers to irrigation, hydroelectricity and water supply for the local population can be very significant. Although the melting of glaciers caused by warming is currently increasing the discharge of watercourses, the disappearance of the glaciers is a threat to this resource in the medium term.

Box 44

La Paz without water for 19 days

A long period during which the water supply was cut off after a landslide in 2008 is a good illustration of the fragility of the water supply system in the capital of Bolivia.

When focusing on the water supply for the La Paz urban area, the PACIVUR team showed the vulnerabilities of the urban environment. Climatic factors are marginal here in comparison with human management.

On 25 January 2008, a landslide damaged part of a pipe conveying water from the Hampaturi zone to the Pampahasi water treatment station. During the 19 days needed to make emergency repairs, more than a third of the population of La Paz (about 300,000 people) had no potable water supply, together with companies, health establishments, schools, etc. The event thus caused very serious malfunctions in part of the city.

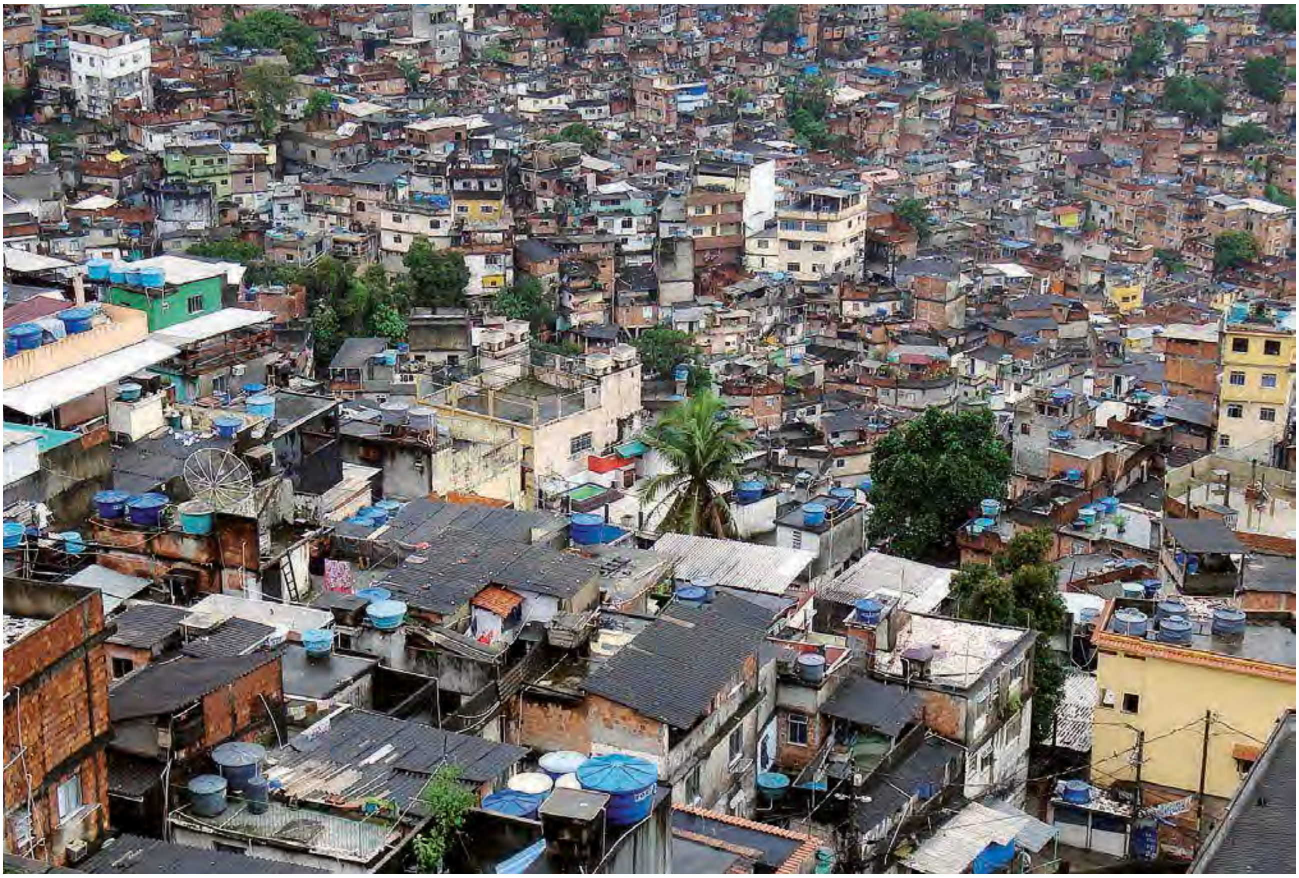
Distribution of food in a school used temporarily as a refuge for local victims in La Paz (Bolivia).

© IRD/S. Hardy

The fragility of centralised networks

The strong precipitations during the days preceding the accident undoubtedly played a role. However, work of the PACIVUR team showed that the fragility of the water supply system was also involved. The option of central production and distribution of potable water chosen in the early 20th century resulted in the construction of substantial infrastructure in risk zones (unstable land). This organisation considerably increased the vulnerability of the system.

But every crisis is also an opportunity to start considering solutions and alternatives. In the case of La Paz, does potable water production justify the continuation of very costly development work in areas exposed to risks whereas it would be possible to use numerous springs? On the contrary, recent studies show all the advantages of favouring small, more local systems.



© IRD/V. Simonneaux

A *favela* in Rio de Janeiro, Brazil.
The tanks on the roofs are for storing water as the favelas rarely have mains water supply.

More generally, the availability of resources raises the question of the population-environment relation in megalopolises. The context of demographic change (rural exodus) and change in agriculture (the replacement of family farming by commercial farming) is causing the reorganisation of the supplying of food but this affects the food security of city-dwellers when the distribution networks are down.

Modelling cities

Most of the effects of climate change in urban areas remain to be discovered. Several operations in which IRD is participating are beginning, aimed at observing and understanding changes in the urban environment under the effect of pollution and climate. For example, the operation for monitoring urban environments in Marseilles and Algiers set up by IRD is installing experimental set-ups for the monitoring of fauna and flora in urban environments. This is aimed at evaluating warming (especially in urban heat islands) according to urban structure (height, density, layout of urban components) and explaining their impacts on urban biodiversity.

One of the future challenges is that of modelling urban microclimates and their impacts according to urban structure and the ways of life of the population.

Clerc Valérie, Hardy Sébastien, Mazurek Hubert, Paquette Catherine. (2015).

Urban zones : vulnerable megalopolises.

In : Reinert M., Janicot Serge (ed.), Aubertin Catherine (ed.), Bernoux Martial (ed.), Dounias Edmond (ed.), Guégan Jean-François (ed.), Lebel Thierry (ed.), Mazurek Hubert (ed.), Sultan Benjamin (ed.), Sokona Y. (pref.), Moatti Jean-Paul (pref.).

Climate change : what challenges for the South ?.

Marseille : IRD, 161-171. ISBN 978-2-7099-2172-5