3.3
Cities at Risk from Rising Sea Levels

Raised slum dwellings built near the banks of the River Buriganga, Dhaka, Bangladesh. Cities in river deltas are particularly vulnerable to flooding.
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In the 20th century, sea levels rose by an estimated 17 centimetres, and conservative global mean projections for sea level rise between 1990 and 2080 range from 22 centimetres to 34 centimetres.[1] Oceans, which have been absorbing 80 per cent of the temperature increase attributable to global warming, are expanding as ice sheets in the North and South poles melt. These events have led to a rise in sea levels and increased flooding in coastal cities.

The projected rise in sea levels could result in catastrophic flooding of coastal cities. Thirteen of the world's 20 megacities are situated along coastlines. Coastal cities that serve as ports are a vital component of the global economy. In fact, the

importance of port cities in international trade has grown significantly, particularly in developing countries, as the volume of sea trade has more than doubled in the last 30 years. Port cities have, therefore, not only grown in terms of population, but in terms of asset value, as well.[2]

A recent study by the Organisation for Economic Cooperation and Development (OECD)[3] found that the populations of Mumbai, Guangzhou, Shanghai, Miami, Ho Chi Minh City, Kolkata, New York City, Osaka-Kobe, Alexandria, and New Orleans will be most exposed to surge-induced flooding in the event of sea level rise. By 2070, urban populations in cities in river deltas, which already experience high risk of flooding, such as Dhaka, Kolkata, Rangoon, and Hai Phong, will join the group of most exposed populations.

The same study found that the value of economic assets, including buildings and infrastructure, that might be lost in the event of severe flooding could amount to as much as US $3,000 billion (in 2005 dollars). Port cities whose assets are most exposed to rising sea levels are located mainly in three countries – the United States, Japan and the Netherlands – and include New York City, Tokyo and Amsterdam. By 2070, port cities in Bangladesh, China, Thailand, Viet Nam, and India will have joined the ranks of cities whose assets are most exposed. Any rise in sea levels is therefore potentially catastrophic for millions of urban dwellers and the global economy. Given the heavy concentration of people and assets in port cities, the failure to develop effective adaptation strategies risks creating not just local, but international, consequences.

Cities and urban populations at risk

The low elevation coastal zone – the continuous area along coastlines that is less than 10 metres above sea level – represents 2 per cent of the world's land area but contains 10 per cent of its total population and 13 per cent of its urban population.[4] Seventeen per cent of the total urban population in Asia lives in the low elevation coastal zone, while in South-Eastern Asia, more than one-third of the urban population lives in these extremely vulnerable zone. In Northern Africa, 18 per cent of the urban population lives in the low elevation coastal zone, while in sub-Saharan Africa, the figure is 9 per cent of the total urban population. And in the island states of Oceania, more than 20 per cent of the urban population inhabits the low elevation coastal zone.

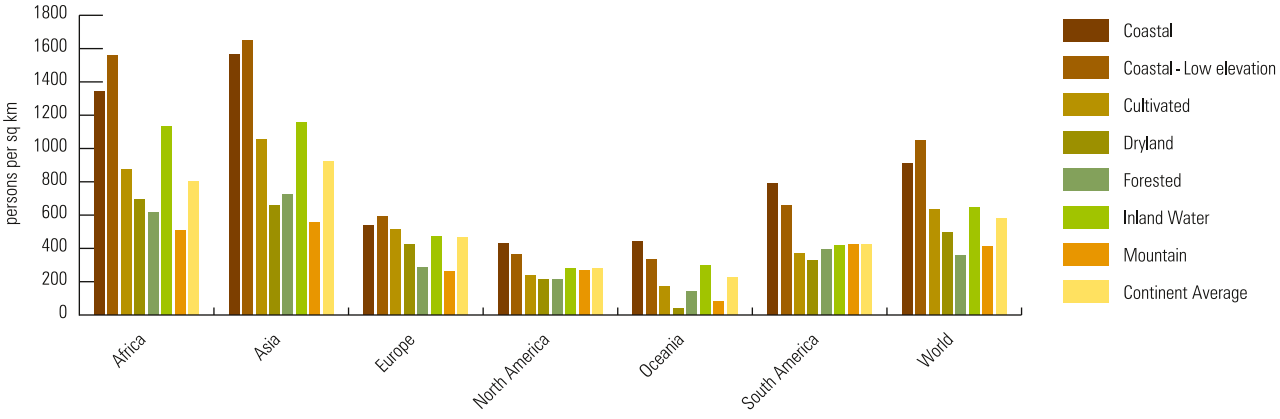
Coastal towns are by far the most developed of Africa's urban areas and, by implication, the concentration of residential, industrial, commercial, agricultural, educational and military facilities in coastal zones is high. Nearly 60 per cent of Africa's total population living in low elevation coastal zones is urban, representing 11.5 per cent of the region's total urban population. Major coastal African cities that could be severely be affected by the impact of rising sea levels include Abidjan, Accra, Alexandria, Algiers, Cape Town, Casablanca, Dakar, Dar es Salaam, Djibouti, Durban, Freetown, Lagos, Libreville, Lome, Luanda, Maputo, Mombasa, Port Louis, and Tunis.

Although the proportion and number of urban dwellers in coastal African cities is relatively smaller than in Asian cities, African cities will be among those most adversely affected by sea level rises, as they are poorly equipped to cope with its impacts. Many cities in Africa and other less-developed regions do not have the infrastructure to withstand extreme weather conditions. Lack of adequate drainage, embankments and preparedness could, therefore, lead to devastating consequences in coastal African cities.

Because the urban poor tend to live in hazardous locations, such as flood plains, and in poor quality housing, they are also most at risk of the health and property damages that accompany flooding. As Figure 3.3.9 illustrates, in Dhaka, slum settlements are already most vulnerable during cyclones and heavy rainfall. Climate change and rising sea levels would make these slum settlements more vulnerable to flooding, but they would also affect the city's non-slum areas.

There are 3,351 cities in the low elevation coastal zones around the world. Of these cities, 64 per cent are in

FIGURE 3.3.1: **URBAN DENSITY (PERSONS PER SQ KM) BY ECOSYSTEM, 1995**



Data reported in Figure 6, in Balk et al, 2008, "Urbanization and ecosystems: Current patterns and Future Implications"

developing regions; Asia alone accounts for more than half of the most vulnerable cities, followed by Latin America and the Caribbean (27 per cent) and Africa (15 per cent). In the developed world, 1,186 cities are at risk. Two-thirds of these cities are in Europe; almost one-fifth of all cities in North America are in low elevation coastal zones. However, Japan, with less than 10 per cent of its cities in low elevation zones, has an urban population of 27 million inhabitants at risk, more than the urban population at risk in North America, Australia and New Zealand combined.

Low elevation coastal zones host both rural and urban populations, but urban populations comprise the majority of those living at the edge of the world's coastlines. In the industrialized, developed world, up to 86 per cent of the populations living in low elevation coastal zones are urban dwellers. In Latin America and the Caribbean, nearly three-quarters of the population in coastal zones are urban inhabitants. Even in the least-urbanized regions of Asia and sub-Saharan Africa, the low elevation coastal zones have larger urban populations than rural populations (55 per cent and 67 per cent, respectively).

Urbanization levels in low elevation coastal zones are higher than in other types of ecosystems around the world. Globally, nearly 60 per cent of the people living in low elevation coastal zones live in cities, compared with 44 per cent in dryland ecosystems and 47 per cent in cultivated areas. In sub-Saharan Africa, more than two-thirds of the population living in low elevation coastal zones is urban; in contrast, only 30 per cent of the population living in cultivated areas is urban, and dryland ecosystems are the least urbanized, with only one-quarter of their populations living in cities.

Urban low elevation coastal zones also are more densely developed than urban inland zones. Global average density along coastlines is 1,100 inhabitants per square kilometre, compared to 500 inhabitants per square kilometre in dryland ecosystems and 700 inhabitants per square kilometre in cultivated areas. Densities in urban low elevation coastal zones are highest in the developing world, where an average of 1,500 inhabitants occupy every square kilometre. Some regions have denser urban low elevation coastal zones than others. In Southern Asia, for instance, densities in these zones average 2,600 inhabitants per square kilometre, which are comparable to densities in sub-Saharan Africa (2,500 inhabitants per square kilometre). In fact, the densities of urban populations in Southern Asia and sub-Saharan Africa are more than twice those of urban populations in dryland ecosystems and cultivated areas. In the developed world, on the other hand, the average density in low elevation coastal zones is 600 inhabitants per square kilometre, which is much lower than both the global and the developing-world average. This reflects a general condition of low urban densities in countries of North America and Europe. The exception is Japan, where the average density in urban low elevation coastal zones is the same as that of the developing world – 1,500 inhabitants per square kilometre – which is higher than the global average.

TABLE 3.3.1: **URBAN POPULATION AT RISK FROM SEA LEVEL RISE**

Region	Urban population (000s)	LECZ Population (000s)	Urban population in LECZ (000s)	% of LECZ urban to total urban	% of urban in LECZ
Africa Total	282,143	55,633	32,390	11.5%	58.2%
Northern Africa	88,427	30,723	15,545	17.6%	50.6%
Sub-Saharan Africa	193,716	24,911	16,845	8.7%	67.6%
Asia total	1,430,917	449,845	235,258	16.4%	52.3%
Eastern Asia	709,199	159,969	109,434	15.4%	68.4%
Southern Asia	415,209	140,964	56,023	13.5%	39.7%
South-Eastern Asia	169,099	137,245	61,201	36.2%	44.6%
Western Asia	102,655	11,472	8,482	8.3%	73.9%
CIS Asia	34,756	194	119	0.3%	61.0%
LAC	319,629	33,578	24,648	7.7%	73.4%
Oceania	2,017	852	442	21.9%	51.9%
Developing Total	**2,034,706**	**539,908**	**292,738**	**14.4%**	**54.2%**
Europe (inc. CIS Europe)	500,943	50,200	39,709	7.9%	79.1%
N.America	255,745	24,217	21,489	8.4%	88.7%
Japan	101,936	29,347	27,521	27.0%	93.8%
Australia & New Zealand	18,002	2,846	2,421	13.5%	85.1%
Developed Total	**876,627**	**106,611**	**91,140**	**10.4%**	**85.5%**
World total	**2,911,333**	**646,519**	**383,878**	**13.2%**	**59.4%**

Source: Coastal Analysis Data Set utilizing GRUMP beta population and land area grids (CIESIN, 2005), Low Elevation Coastal Zone created from SRTM elevation grid (CIESIN, 2006)
LECZ = Low Elevation Coastal Zone
LECZ: land area that is contiguous with the coast and 10 meters or less in elevation.

▲
The Thames Flood Barrier, London's first line of defence against floods.
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TABLE 3.3.2: **URBAN DENSITY BY ECOSYSTEM**

Region	Density in urban LECZ (000s/km^2)	Density in urban Dryland (000s/km^2)	Density in urban cultivated land (000s/km^2)
Africa Total	1.7	0.8	1.0
Northern Africa	1.3	0.8	1.2
Sub-Saharan Africa	2.5	0.8	0.9
LAC	0.6	0.4	0.4
Asia total	1.9	0.7	1.2
Eastern Asia	2.1	1.2	1.5
Southern Asia	2.6	0.9	1.1
South-Eastern Asia	1.7	1.0	1.2
Western Asia	0.5	0.4	0.7
CIS Asia	0.7	0.3	0.4
Oceania	0.4	0.9	0.3
Developing Total	**1.5**	**0.7**	**1.0**
Europe (inc. CIS Europe)	0.6	0.4	0.5
N.America	0.4	0.2	0.2
Japan	1.5	NA	0.8
Australia & New Zealand	0.3	0.0	0.2
Developed Total	**0.6**	**0.3**	**0.4**
World total	**1.1**	**0.5**	**0.7**

Source: Data Set utilizing GRUMP beta population and land area grids Source: (CIESIN, 2005) (All grids 1km resolution) constructed by Deborah Balk and colleagues at the City University of New York (CUNY) and Columbia University.
LECZ = Low Elevation Coastal Zone

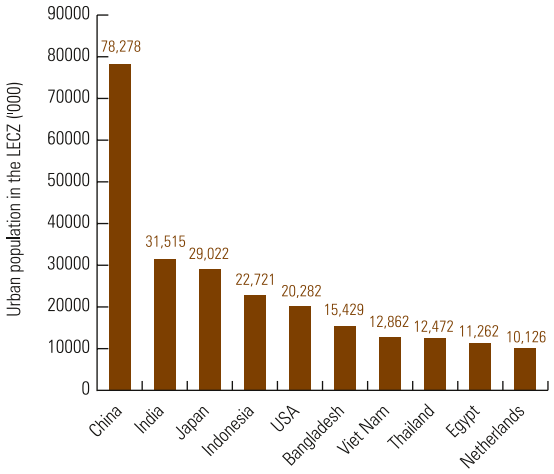
Countries with the highest proportion of their urban population living in the low elevation coastal zone include Suriname, Guyana, the Bahamas, the Netherlands, Bahrain, Viet Nam, Liberia, Senegal, and Djibouti, while those with the largest numbers of people living in the zone include China, India, Japan, Indonesia, the United States, Bangladesh, Viet Nam, Thailand, Egypt, and the Netherlands.[5]

The share of the urban population living in low elevation coastal zones vis-à-vis the total population living in low elevation coastal zones is highest in the developed world. For instance, 89 per cent of all people living in low elevation coastal zones in North America live in cities. However, in terms of numbers, Asia (excluding Japan) has the largest number of city dwellers at risk of flooding in the low elevation coastal zone, with more than 235 million people (15 per cent of the total urban population) living there. Japan alone has more than 27 million people at risk of the consequences of sea level rise in the event of global warming.[6] Heavily populated delta regions that contain large cities such as Dhaka, Shanghai and Bangkok are also particularly vulnerable to sea level rises. However, it is important to note that not all countries and cities are equally vulnerable to flooding in the event of a rise in sea levels, as some cities have better flood protection mechanisms than others. Nonetheless, in the event of large-scale flooding, it is difficult to predict which cities will remain safe.

In most Caribbean island states, 50 per cent of the population resides within 2 kilometres of the coast; these populations will be directly affected by sea level rise and other climate impacts on coastal zones.[7] Increased sea temperatures are already contributing to coral destruction around the islands. Climate change will affect the physical and biological characteristics of coastal areas, modifying their ecosystem structure and functioning, including loss of biodiversity, fisheries, and shorelines; and increased vulnerability of coastal mangroves and wetlands to storm surges, increased salinity and ecosystem change. The sub-region's mountainous areas are also at risk of serious impacts associated with climate change. Among other expected changes, mountainous areas will experience losses in many of the environmental goods and services they provide, especially water supply to urban areas, basin regulation, and associated hydropower potential. Caribbean cities, too, are extremely vulnerable to disasters borne of both natural and human activity, with negative microeconomic and macroeconomic consequences at the local, regional and national levels. Urbanization patterns, especially in low-income areas, further heighten urban vulnerability. The Economic Commission for Latin America and the Caribbean estimates that in the 2004 hurricane season alone, the total economic impact of natural disasters in the region amounted to US $7,559 million.

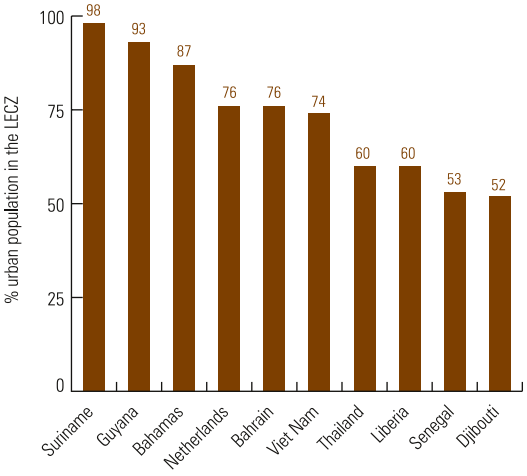
A warmer climate will generally increase the exposure of developing-world populations to tropical diseases and respiratory irritants. In Latin America, a large proportion of the population lives in mountain ranges, including large urban areas situated above 2,000 metres, normally not exposed to tropical diseases such as dengue and malaria. Increased temperatures will affect the prevalence of vector-borne tropical diseases in higher altitudes. Diarrhoeal diseases also may increase as a result of more frequent and severe floods and drought. An increase in the frequency and severity of extreme weather events will result in more frequent humanitarian emergencies, particularly affecting populations in high-risk areas such as coastal zones, river valleys and cities. Climate change is also expected to lead to an increase in rodent-borne

FIGURE 3.3.2: **URBAN DENSITY BY ECOSYSTEM**



Source: McGranahan, Balk and Anderson (2008), A summary of the risks of climate change and urban settlement in low elevation coastal zones. In The New Global Frontier: Cities, Poverty and Environment in the 21st Century, G. Martine, G. McGranahan, M. Montgomery and R. Fernandez-Castilla (eds). Earthscan: London. Based on data generated for McGranahan, Balk and Anderson (2007)
LECZ = Low Elevation Coastal Zone

FIGURE 3.3.3: **COUNTRIES WITH THE LARGEST URBAN POPULATION IN THE LOW ELEVATION COASTAL ZONE**



Source: McGranahan, Balk and Anderson (2008), A summary of the risks of climate change and urban settlement in low elevation coastal zones. In The New Global Frontier: Cities, Poverty and Environment in the 21st Century, G. Martine, G. McGranahan, M. Montgomery and R. Fernandez-Castilla (eds). Earthscan: London. Based on data generated for McGranahan, Balk and Anderson (2007)
** Countries with an urban population of fewer than 100,000 were excluded from this list.*

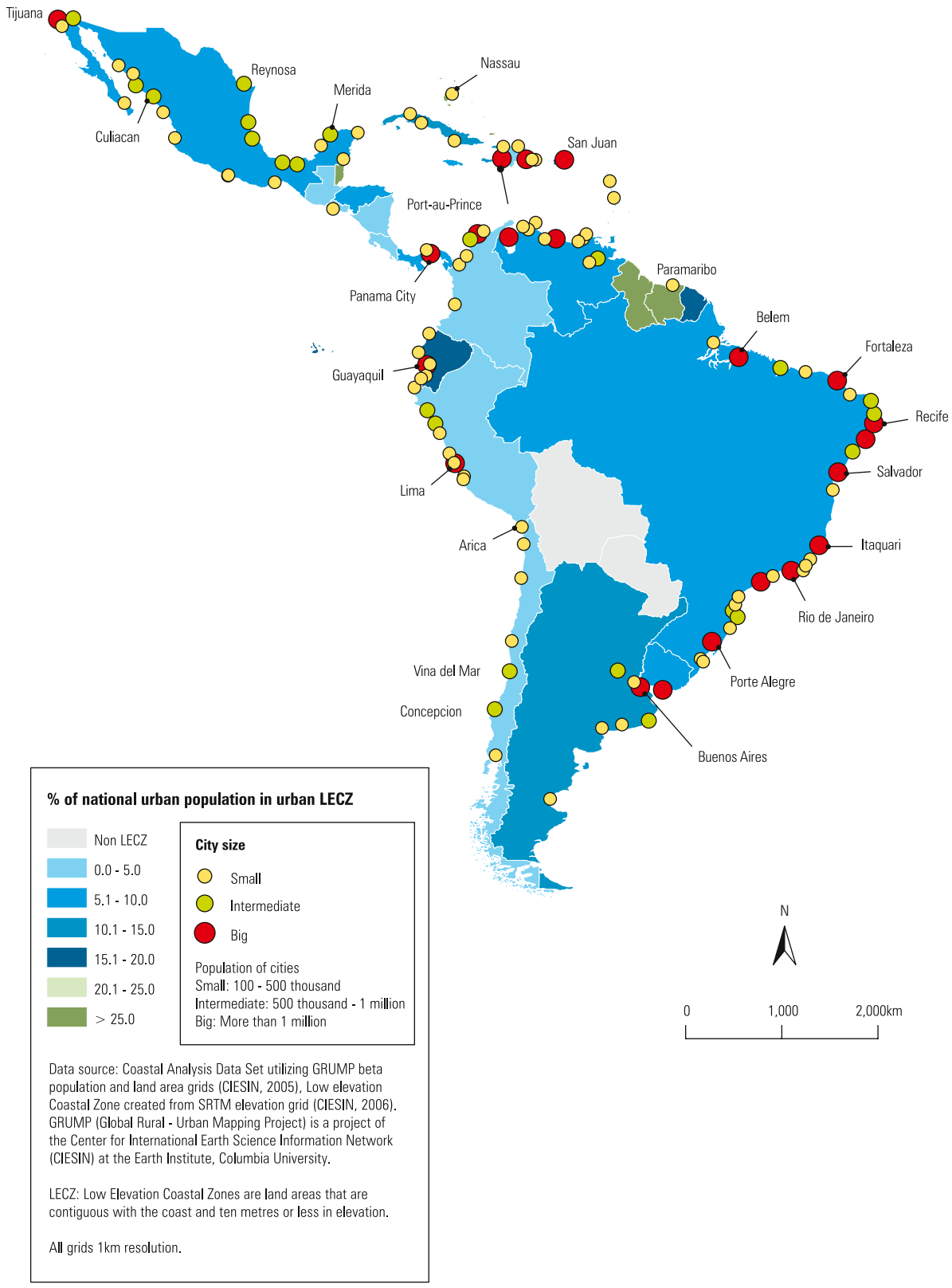
Sheffield floods, June 2007.
©Andy Green/iStockphoto

diseases: warmer climates and changing habitats have allowed rodents to move into new territories.

Many countries in Latin America and the Caribbean are at increased risk of natural disasters resulting from climate change. The region is subject to extreme climatic events and natural phenomena that take place in frequently recurring cycles – namely, earthquakes, tropical storms, hurricanes, floods, droughts, and volcanic eruptions. As these events become more and more frequent, the region's increasingly fragile ecological and social systems will be put to the test.

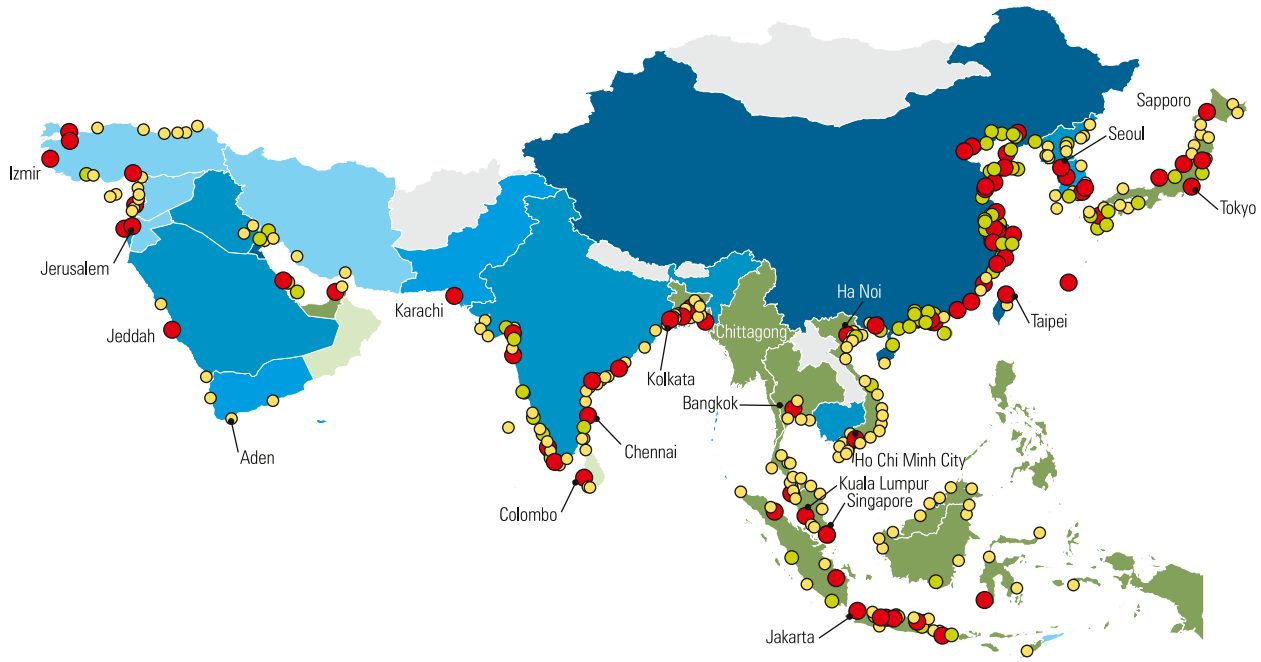
Actions in urban areas have a major influence on whether the risks arising from the direct and indirect effects of climate change can be reduced. Well-planned and well-governed urban areas can greatly reduce risks – while unplanned and poorly governed cities can greatly increase them.

FIGURE 3.3.4: **LATIN AMERICA AND CARIBBEAN CITIES AT RISK DUE TO SEA-LEVEL RISE**



Source: UN-HABITAT Global Urban Observatory 2008

FIGURE 3.3.5: **ASIAN CITIES AT RISK DUE TO SEA-LEVEL RISE**



% of national urban population in urban LECZ

- Non LECZ
- 0.0 - 5.0
- 5.1 - 10.0
- 10.1 - 15.0
- 15.1 - 20.0
- 20.1 - 25.0
- > 25.0

City size

- Small
- Intermediate
- Big

Population of cities
Small: 100 - 500 thousand
Intermediate: 500 thousand - 1 million
Big: More than 1 million

N

0 2,000 4,000kms

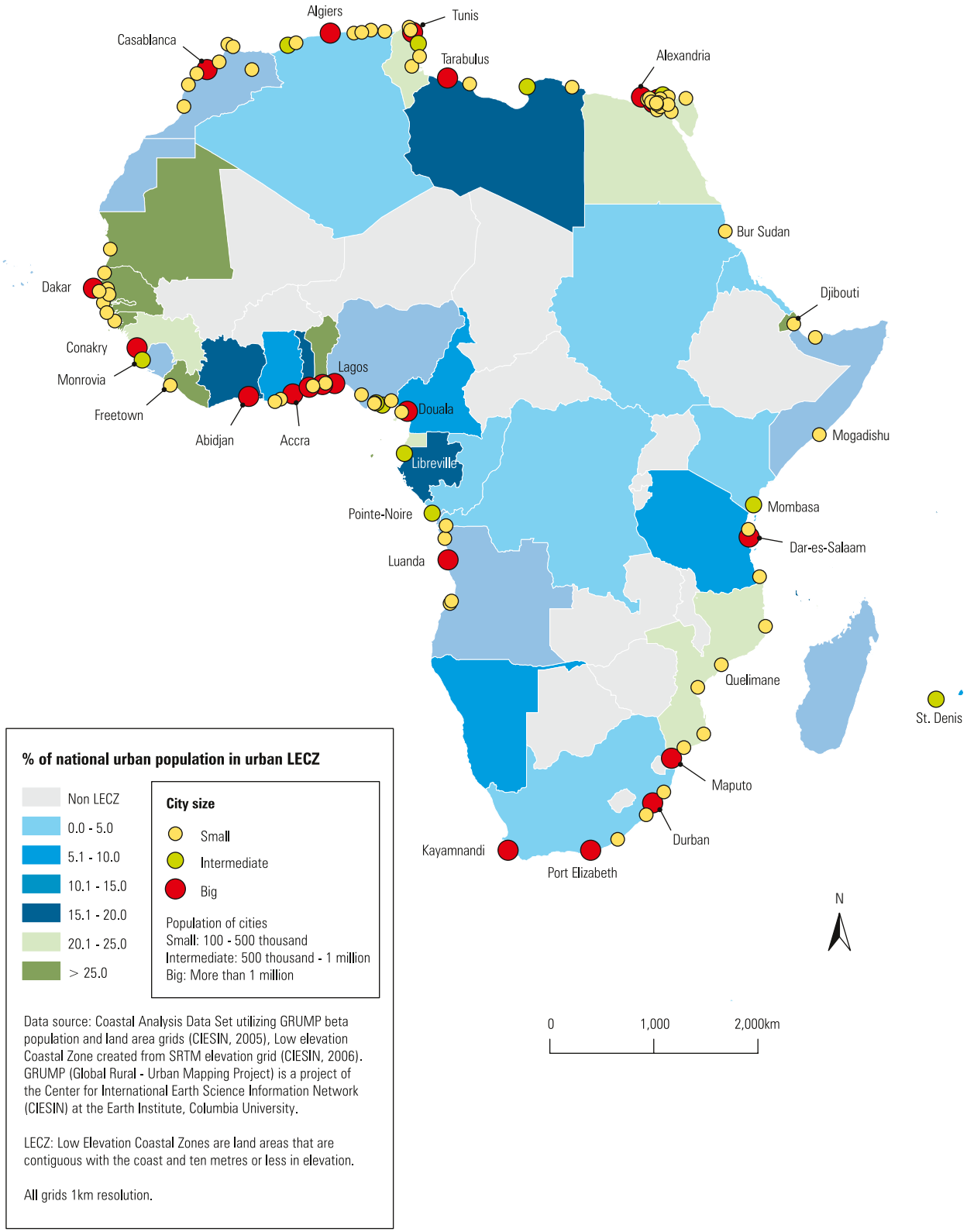
Data source: Coastal Analysis Data Set utilizing GRUMP beta population and land area grids (CIESIN, 2005), Low elevation Coastal Zone created from SRTM elevation grid (CIESIN, 2006). GRUMP (Global Rural - Urban Mapping Project) is a project of the Center for International Earth Science Information Network (CIESIN) at the Earth Institute, Columbia University.

LECZ: Low Elevation Coastal Zones are land areas that are contiguous with the coast and ten metres or less in elevation.

All grids 1km resolution.

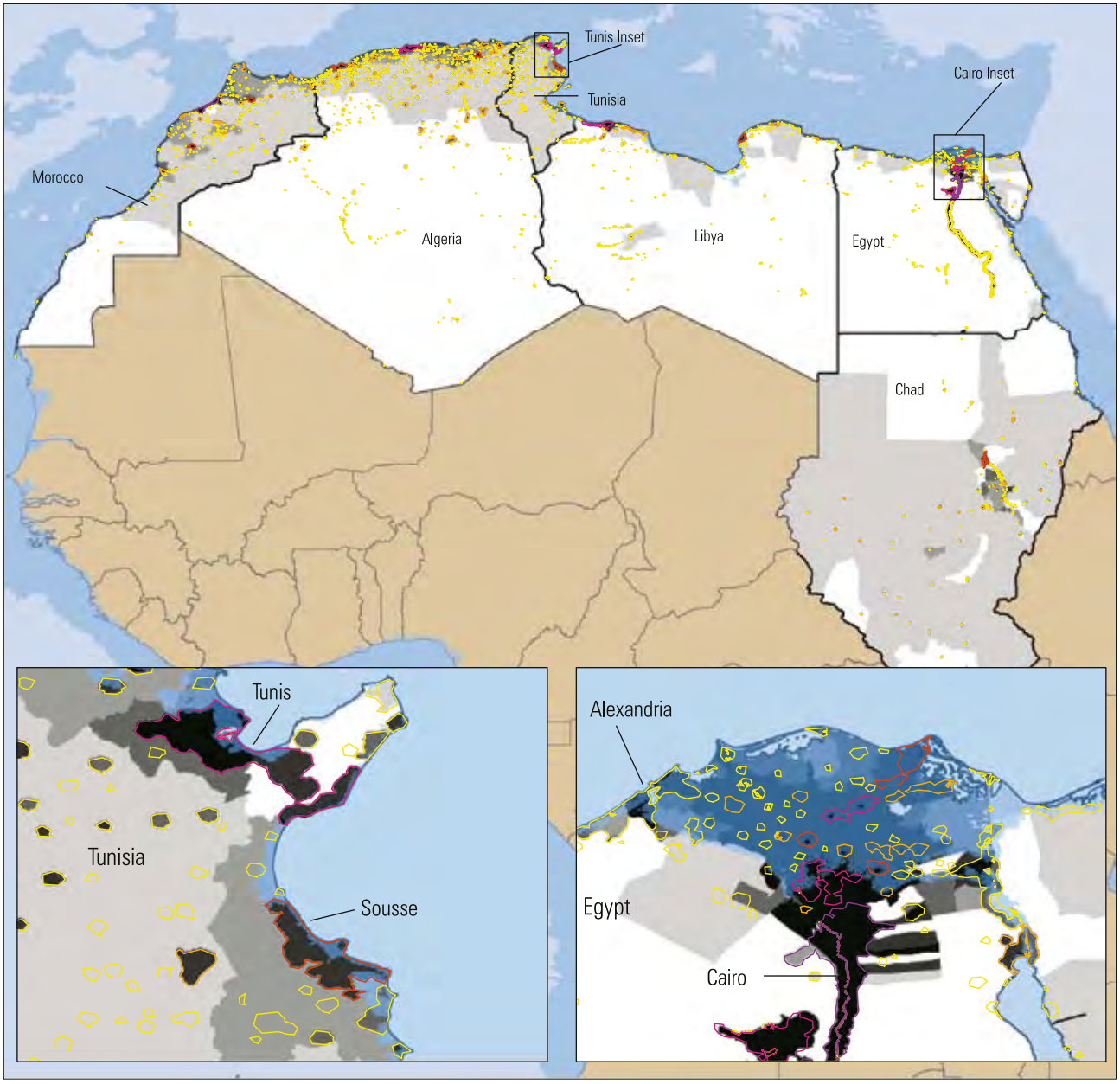
Source: UN-HABITAT Global Urban Observatory 2008

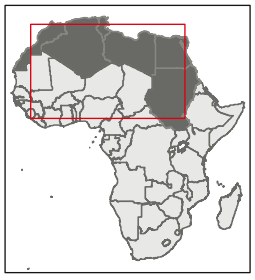
FIGURE 3.3.6: **AFRICAN CITIES AT RISK DUE TO SEA-LEVEL RISE**



Source: UN-HABITAT Global Urban Observatory 2008

FIGURE 3.3.7: **POPULATION DISTRIBUTION, URBAN PLACES, AND LOW ELEVATION COASTAL ZONES IN NORTH AFRICA**





Low Elevation Coastal Zone (LECZ)

NOTE: LECZ layer has been made semi-transparent to show the underlying layers. Thus the blue color is not uniform.

Urban Footprints by population size (2000)

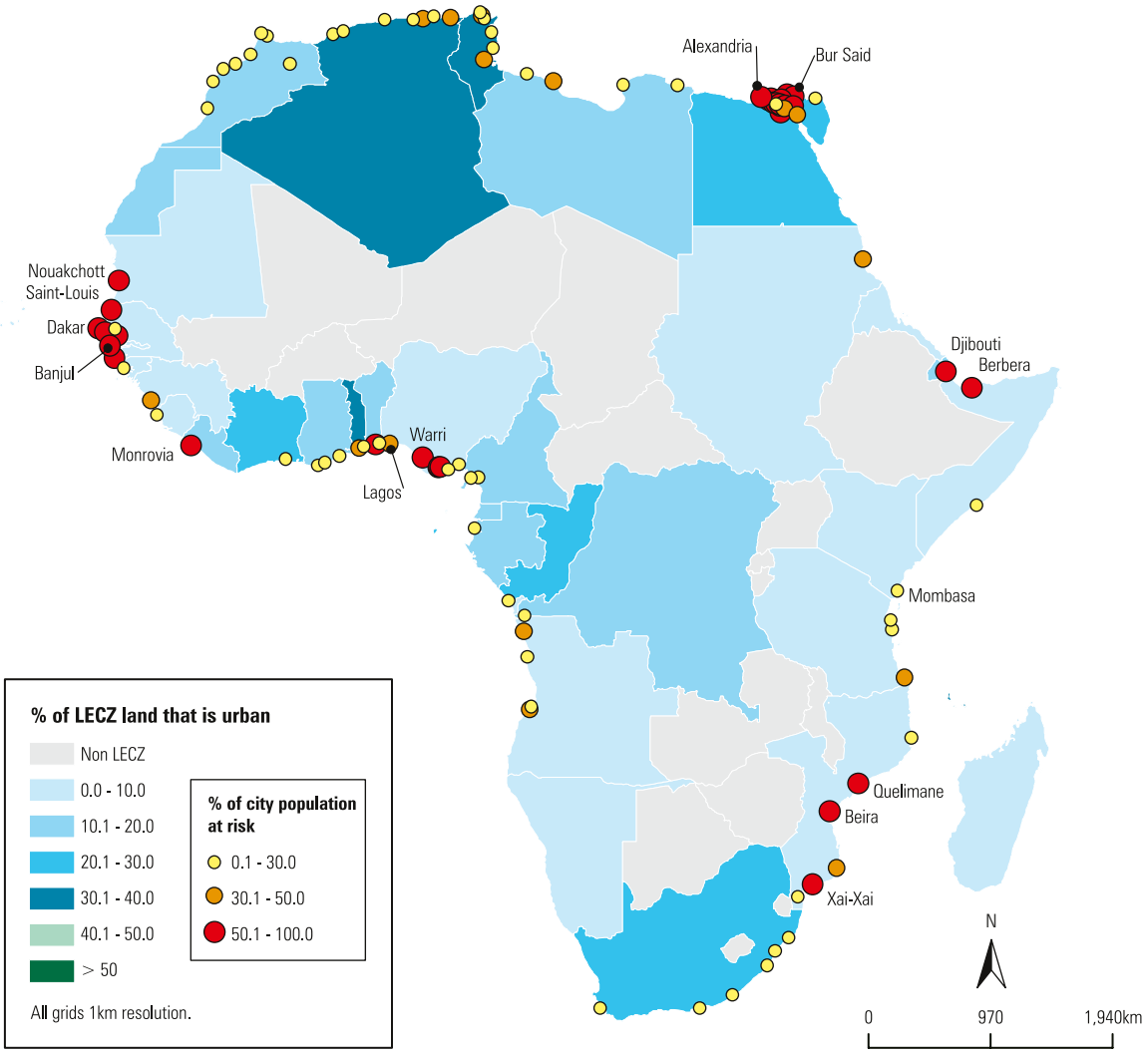
- 0 - 100,000
- 100,001 - 500,000
- 500,001 - 1,000,000
- 1,000,001 - 5,000,000
- 5,000,001+

Population Density persons per sq km (2000)

- 0 - 1
- 2 - 50
- 51 - 100
- 101 - 250
- 251 - 500
- 501+

Data Source: GRUMP 1KM population surface (BETA), 1KM urban extent mask (BETA), 2007 Available at http://sedac.ciesin.columbia.edu/gpw/Map produce by D. Balk and colleagues, Baruch College, and CIESIN, Columbia University. GRUMP (Global Rural - Urban Mapping Project) is a project of the Center for International Earth Science Information Network (CIESIN) at the Earth Institute, Columbia University.

FIGURE 3.3.8: **PROPORTION OF POPULATION AND LAND AT RISK DUE TO SEA LEVEL RISE IN AFRICA**



Country Name	City Name	Population (%) at risk in Low Elevation Coastal Zone	Land (%) at risk in Low Elevation Coastal Zone	City Size
Egypt	AlMatariyah	100.0	100.0	Small
Egypt	Damanhur	100.0	100.0	Small
Egypt	Dikirnis	100.0	100.0	Small
Egypt	Disuq	100.0	100.0	Small
Egypt	Kafr ashShaykh	100.0	100.0	Small
Senegal	Saint-Louis	100.0	100.0	Small
Egypt	Dumyat	99.6	99.7	Intermediate
Egypt	Diyarb Najm	98.7	98.7	Small
Mauritania	Nouakchott	98.6	98.2	Small
Mozambique	Quelimane	97.9	97.9	Small
Egypt	Abu Kabir	97.7	97.8	Small
Egypt	Bur Said	97.2	94.1	Small
Egypt	Kafr azZayyat	96.4	96.6	Small
Nigeria	Bugama	95.6	95.5	Small
Benin	Cotonou	94.7	85.4	Big
Egypt	AlMahallah alKubr	93.4	94.2	Big
Nigeria	Warri	90.8	92.0	Small
30-50% of population and land are at risk in 15 cities while 10-30% are at risk in 36 cities				

Country Name	City Name	Population (%) at risk in Low Elevation Coastal Zone	Land (%) at risk in Low Elevation Coastal Zone	City Size
Egypt	Tanta	88.	89.0	Intermediate
Egypt	Mit Ghamr	85.3	84.2	Small
Nigeria	Abonnema	85.2	86.5	Small
Egypt	Alexandria	85.1	68.8	Big
Senegal	Kaolack	82.6	80.6	Small
Egypt	AzZaqaziq	80.9	81.0	Intermediate
Liberia	Monrovia	80.6	83.1	Small
Senegal	Ziguinchor	75.4	75.3	Small
Mozambique	Beira	65.3	65.3	Small
Nigeria	Port Harcourt	64.4	61.9	Intermediate
Senegal	Dakar	61.6	47.6	Big
Mozambique	Xai-Xai	59.6	59.1	Small
Senegal	Mbour	56.9	57.0	Small
Gambia, The	Banjul	56.1	44.0	Small
Djibouti	Djibouti	55.7	55.5	Small
Somalia	Berbera	53.6	53.2	Small
Egypt	Ismailia	50.2	52.0	Small
30-50% of population and land are at risk in 15 cities while 10-30% are at risk in 36 cities				

Data source: Coastal Analysis Data Set utilizing GRUMP beta population and land area grids (CIESIN, 2005);
Low Elevation Coastal Zone created from STRM elevation grid (CIESIN, 2006).
GRUMP (Global Rural - Urban Mapping Project) is a project of the Center for International Earth Science Information Network (CIESIN) at the Earth Institute, Columbia University.

African cities at risk

▲
Alexandria, Egypt
©iStockphoto

ALEXANDRIA (Egypt): An assessment of the vulnerability of the most important economic and historic centre along the Mediterranean coast (the cities of Alexandria, Rosetta and Port Said) suggests that, with a sea-level rise of 50 cm, more than 2 million people would have to abandon their homes, 214,000 jobs would be lost, and the cost in lost property value and tourism income would be over US $35 billion, which does not include the immeasurable loss of world famous historic, cultural and archaeological sites.

LAGOS (Nigeria): Lagos, with a total population of nearly 10 million inhabitants, lacks adequate infrastructure to cope with flooding. "Normal" rainfall brings flooding to many areas of the city, largely as a result of inadequacies in sewers, drains and wastewater management. Any increase in the intensity of storms and storm surges is likely to increase such problems, as much of the land in and around Lagos is less than 2 meters above sea level. Many low-income settlements are built in areas at high risk of flooding (many on stilts), largely because safer sites are too expensive.

Source: Satterthwaite, et al., 2007.

BANJUL (Gambia): Most of Banjul is less than 1 metre above sea level. Flooding is common after heavy rains in the city in settlements established on reclaimed land in dried-up valleys, and in settlements close to mangrove swamps and wetlands. Problems with flooding are likely to intensify under a warmer climate with an increase in the strength and frequency of tropical storms.

ABIDJAN (Côte d'Ivoire): Although some important areas of Abidjan lie on a plateau and may escape the direct effects of sea-level rise, major economic centres, including the nation's largest port and much of the international airport, are on land less than 1 meter above sea level. A sea-level rise in Abidjan is likely to inundate 562 square kilometers along the coastline of the Abidjan region, as lowland marshes and lagoons dominate the coastal zone. Average retreat will vary from 36 to 62 meters.

MOMBASA (Kenya): Mombasa is Kenya's second-largest city, with a population of more than 800,000 and is the largest sea port in East Africa, serving many countries in the region. An estimated 17 per cent of Mombasa's area (4,600 hectares) could be submerged by a sea-level rise of 0.3 meters, with a larger area rendered uninhabitable or unusable for agriculture because of waterlogging and salt stress. Sandy beaches, historic and cultural monuments, and several hotels, industries and port facilities would also be negatively affected. Mombasa already has a history of disasters related to climate extremes, including floods that have caused serious damage and loss of life nearly every year.

BAMENDA (Cameroon): Approximately 20 per cent of Bamenda's 250,000 residents live on floodplains and roughly 7 per cent live in informal settlements on steep slopes. Land clearance for settlement and for quarrying and sand mining, along with other land-use changes caused by urban expansion, have further created serious problems of soil erosion. Soil that is washed down the hills blocks drainage channels and changes peak water flows. Degradation of the land has exacerbated problems with floods.

Dhaka's extreme vulnerability to climate change

A woman working at a tannery in Dhaka, Bangladesh.
©Manoocher Deghati/IRIN

Take one of the most unplanned urban centres in the world, wedge it between four flood-prone rivers in the most densely packed nation in Asia, then squeeze it between the Himalaya mountain range and a body of water that not only generates violent cyclones and the occasional tsunami, but also creeps further inland every year, washing away farmland, tainting drinking water, submerging fertile deltas, and displacing villagers as it approaches – and there you have it: Dhaka, the capital of Bangladesh and one of the world's largest megacities.

Add the expected impact of climate change to this cauldron and it's a recipe for disaster. Experts believe that the melting of glaciers and snow in the Himalayas, along with increasing rainfall attributable to climate change, will lead to more flooding in Bangladesh in general, especially in cities located near the coast and in the delta region, including Dhaka. Dhaka may also experience increased temperatures from rising levels of vehicle exhaust emissions, increased industrial activity and increased use of air conditioning.

Researchers studying the impact of climate change on Dhaka predict that the city will be affected in two major ways: flooding and drainage congestion, and heat stress. The elevation in Dhaka ranges between 2 and 13 metres above sea level, which means that even a slight rise in sea level is likely to engulf large parts of the city. Moreover, high urban growth rates and high urban densities have already made Dhaka more susceptible to human-induced environmental disasters. With an urban growth rate of more than 4 per cent annually, Dhaka, which already hosts more than 13 million people, is one of the fastest growing cities in Southern Asia, and is projected to accommodate more than 20 million by 2025. The sheer number of people living in the city means that the negative consequences of climate change are likely to be felt by a large number of people, especially the urban poor who live in flood-prone and water-logged areas.

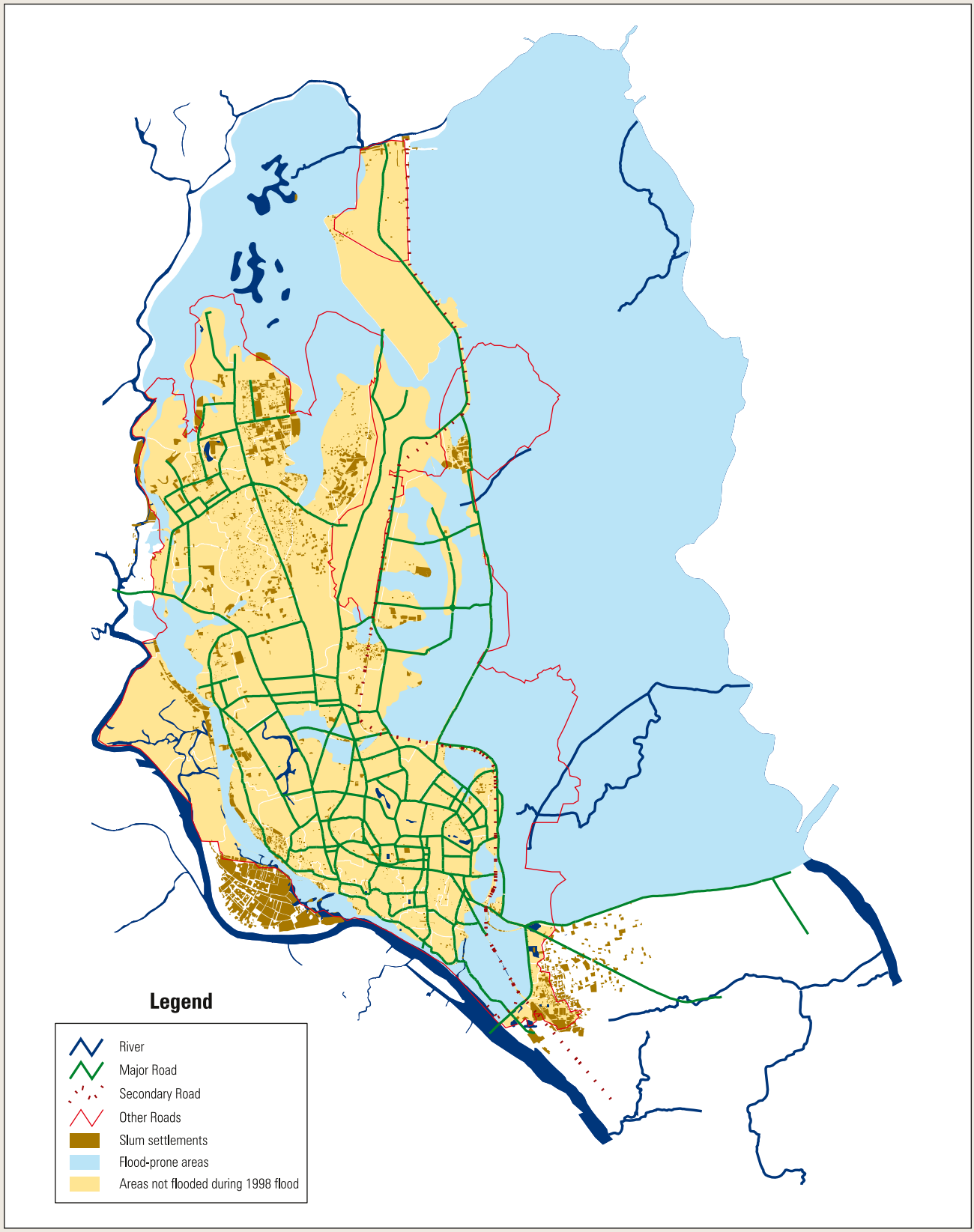
A recent mapping and census of slums conducted by the Centre for Urban Studies in Dhaka shows that nearly 60 per cent of the slums in the city have poor or no drainage and are prone to frequent flooding. The problems associated with flooding are compounded by poor quality housing and overcrowding. The survey found that more than one-third of Dhaka's population lived in housing where almost all the structures were too weak to withstand large-scale environmental disasters. Although Bangladesh has among the highest population densities in the world (at 2,600 persons per square mile), the population density in slums is roughly 200 times greater – an astounding figure, considering that nearly all slums are dominated by single-storey structures. Approximately 80 per cent of the slum population in Dhaka lives in dense slum clusters of between 500 and 1,500 persons per acre. Overcrowding is extremely prevalent; more than 90 per cent of slum dwellers share a single room with three or more people.

Floods in dense, poorly serviced settlements can lead to other hazards, which have a significant impact on the health of urban poor residents. Floodwaters in slums can mix with raw sewage and breed water-borne diseases, such as diarrhoea, typhoid and scabies. Water supplies also become contaminated during floods, as pipes in slum areas are likely to be damaged or to leak.

Experts generally agree that apart from taking active steps to reduce the possibility of global climate change itself, cities can take steps to prevent the harmful aspects of natural disasters by improving planning, putting in effective infrastructure and establishing disaster preparedness. Plans for flood protection are already underway in greater Dhaka; the government, as result of frequent flooding in the 1980s, has already completed construction of embankments, concrete reinforced walls and pumping stations in the most dense part of the city. Technical solutions are possible, but these solutions must also take into consideration unresolved development problems, such as the city's growing slum population, which has doubled in the last decade, and which shows no signs of abating.

Sources: OCHA/IRIN & UN-HABITAT, 2007; Rabbani, 2007; Centre for Urban Studies, National Institute of Population Research and Training & Measure Evaluation, 2006.

FIGURE 3.3.9: **FLOOD-PRONE SLUM AND NON-SLUM SETTLEMENTS IN DHAKA**



Sources: Centre for Urban Studies (Slum Map), Bangladesh, 2005 and Bangladesh Centre for Advance Studies (Flood Map), 1998.
Map adapted by UN-HABITAT Global Urban Observatory, 2008

Cuba: A culture of safety

Most local and national governments are ill-equipped to manage and adapt to environmental hazards, including climate variability and climate change. This is a developmental issue, and it makes large sections of urban populations vulnerable to any increase in the frequency or intensity of storms, to increased risk of disease or constraints on water supplies, and to increases in food prices, to which wealthier, better governed cities are typically quick to adapt. A shift from disaster response to disaster preparedness and disaster risk reduction, which would have significant relevance for urban resilience to climate change, has not yet occurred in most city and national level policies.

Cuba is a hurricane-prone island in the Caribbean. When Hurricane Wilma struck in October 2005, this small island managed to evacuate 640,000 people from its path, with just one fatality. The sea charged one kilometer inland and flooded the capital, Havana, yet no one died or was injured. This was not a one-time response, but built upon many years of experience in dealing with hurricanes. In the seven years between 1996 and 2002, six major hurricanes hit Cuba, yet a total of just 16 people died. In each case, hundreds of thousands of people – sometimes 700,000 to 800,000 at a time – were successfully evacuated, often within 48 hours.

The Cuban population has developed a culture of safety. Many ordinary people see themselves as actors with important roles to play in disaster preparation and response. Education and training, a culture of mobilization and social organization, and a government priority to protect human life in emergencies promote this vision. At the heart of Cuba's system is a clear political commitment, at every level of government, to safeguard human life. This allows for a centralized decision-making process alongside a decentralized implementation process equally necessary for effective emergency preparedness and response. The system has been tried and tested so many times that high levels of mutual trust and confidence exist between communities and politicians at every level of the system.

Tangible assets supporting disaster preparedness include: a strong, well-organized civil defense, an efficient early warning system, well-equipped rescue teams, and emergency stockpiles and other resources. Intangible assets are effective local leadership, community mobilization, solidarity among a population that is "disaster aware" and educated about what actions to take, and local participation in evacuation planning.

Source: Simms & Reid, 2006.

▲ Havana, Cuba: The city has developed a culture of safety in the face of frequent hurricanes.
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▲
Dhaka, Bangladesh
©Manoocher Deghati/IRIN

NOTES

1 Nicholss, 2004. The Intergovernmental Panel on Climate Change projects a worst case scenario of 1 metre sea-level rise by 2100.
2 Organisation for Economic Cooperation and Development (OECD), 2007.
3 OECD, 2007. The analysis focused on the exposure of population and assets to a 1 in 100 year surge-induced flood event (assuming no defences) rather than "risk" from coastal flooding.
4 McGranahan, Balk & Anderson, 2007.
5 McGranahan, et al., 2007.
6 Coastal Analysis Data Set utilizing GRUMP (Global Rural and Urban Mapping Program) beta population and land area grids (CIESIN 2005). Data as of October 2007
7 Vergara, 2005.