URBAN POPULATION DISTRIBUTION AND THE RISING RISKS OF CLIMATE CHANGE

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Future population growth will not only be predominantly urban and concentrated in Asia and Africa (United Nations, 2006), it will also face new challenges from a changing environment (McGranahan and others, 2005; Montgomery and others, 2003). In the twenty-first century, urban centres will not only need to sustainably provide safe water, sanitation, housing, health services and infrastructure for large numbers of current and new urban inhabitants, they will also need to do it in a manner that is compatible with current climate change scenarios. In particular, coastal cities–with increased risk of seaward hazards due to cyclones and flooding, not to mention longer-term expected sea level rise–may experience different challenges than cities in other environments (McGranahan and others, 2007). Large dryland cities will face new, perhaps more complex, challenges in the future than smaller counterparts in the past. The community of demographers, planners and development agencies need to embrace these new complexities if their efforts are to be of practical value to the well-being of urban dwellers of the twenty-first century.

A few years back, perhaps confirming ample casual evidence, the first systematic assessment of the distribution of human population found that people tend to live at low elevation and near sea-coasts and rivers (Small and Cohen, 2004). These estimates were further refined to show that nearly one in five persons globally lives in close proximity to a coast (i.e., within a coastal ecosystem) and that 65 per cent of the coastal population lives in urban areas (McGranahan and others, 2005). More than a quarter of the global urban population–or about 745 million persons in 2000–live in coastal settlements of more than 5,000 persons (with 90 per cent of these residents in settlements of 100,000 persons or more) (McGranahan and others, 2005). In further work, it was found that 75 per cent of countries with populations of at least one million persons have their largest city at close coastal proximity and at least partly situated at low elevation, i.e., below 10 metres (McGranahan and others, 2007). Furthermore, of the world's cities with more than five million inhabitants, at least one-fifth of their population and one-sixth of the land area are situated in a low elevation coastal zone.

The recent assessment by the International Panel on Climate Change (IPCC, 2007) finds that climate change is largely a consequence of anthropogenic factors. At the same time, people–and the environments that they live in–will also be the prime recipient of the consequences of climate change. In the 4th assessment, the IPCC clearly identified urbanization as a cause for concern, particularly in Africa and Asia, where the bulk of future population growth is expected to occur. In Africa, the IPCC anticipates that "towards the end of the twenty-first century, projected sea-level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10 per cent of gross domestic product" (IPCC, 2007, Table SPM 2, p. 10). In Asia, "coastal areas, especially heavily populated mega-delta regions in South, East, and Southeast Asia, will be at greatest risk due to increased flooding from the sea, and in some mega-deltas, flooding from the rivers." The IPCC expects this to raise morbidity and mortality due to diarrhoeal diseases. Furthermore, "climate change is projected to compound the pressures on natural resources and the environment, associated with rapid urbanization, industrialization and economic development" (IPCC, 2007, Table SPM 2, p. 10). The climate science community has clearly put urbanization on its agenda. Now it is time for the demographic community to put climate change on its own agenda.

This paper will focus on issues of urbanization and climate change primarily in coastal zones. Human settlement by definition, leads to environmental transformation. Coastal settlement can be environmentally damaging; among other, it may accelerate coastal erosion and lead to the development of misplaced landfill. In addition, coastal localities are environmentally vulnerable due to seaward hazards such as storm surges, coastal flooding and erosion. Climate change, which will bring sea-level rise and greater storm intensity, amplifies the risks to coastal settlements. Yet coastal zones are densely populated and appear to have experienced more growth than other ecological zones (Balk and others, forthcoming).

To address the potential consequences of urbanization with respect to climate change, a spatial framework is a necessary component. In McGranahan and others (2007), low elevation coastal zones are defined as contiguous coastal land less than 10 metres in altitude. All data, including population and urban extent (sources noted below) are spatially defined.

A. METHODOLOGY

McGranahan and others (2007) integrated recently-developed spatial databases of finely resolved global population distribution, urban extents and elevation data to produce country-level estimates of urban land area and population in low elevation coastal zones. By overlaying geographic data layers, the population and land area within the low elevation coastal zones were calculated and summarized by country, region and economic grouping. Shuttle Radar Topography Mission (SRTM) data were used to delineate a low elevation coastal zone, including land area, contiguous with the coast up to 10 metres in elevation. Urban extents were taken from Columbia University's Center for International Earth Science Information Network's Global Rural Urban Mapping Project (GRUMP). These urban extents were primarily delineated using the National Oceanic and Atmospheric Administration's night-time lights satellite data (city lights 1994-1995) verified with additional settlement information and represent urban agglomerations including surrounding suburban areas. Population and land area were also taken from GRUMP, which provides these data as gridded surfaces globally based on geo-referenced census data with population allocated between urban and rural areas as delineated by the urban extents. All data are expressed at one km resolution. Figure 1 illustrates the data layers with which the calculations were made for the Bay of Bengal region of Bangladesh.

B. FINDINGS

Low elevation coastal zones account for approximately only 2 per cent of the world's land area, but contain 10 per cent of the population and 13 per cent of the urban population. As illustrated in table 1, about two-thirds of the population living in low elevations coastal zones are in Asia. Yet even in Africa, which has only 1 per cent of its land in the zone and a comparatively high share of its population engaged in inland agriculture, 7 per cent of the total population and 12 per cent of the urban population live in these zones.

Figure 1. Map of Bangladesh identifying low elevation coastal zone and urban extents

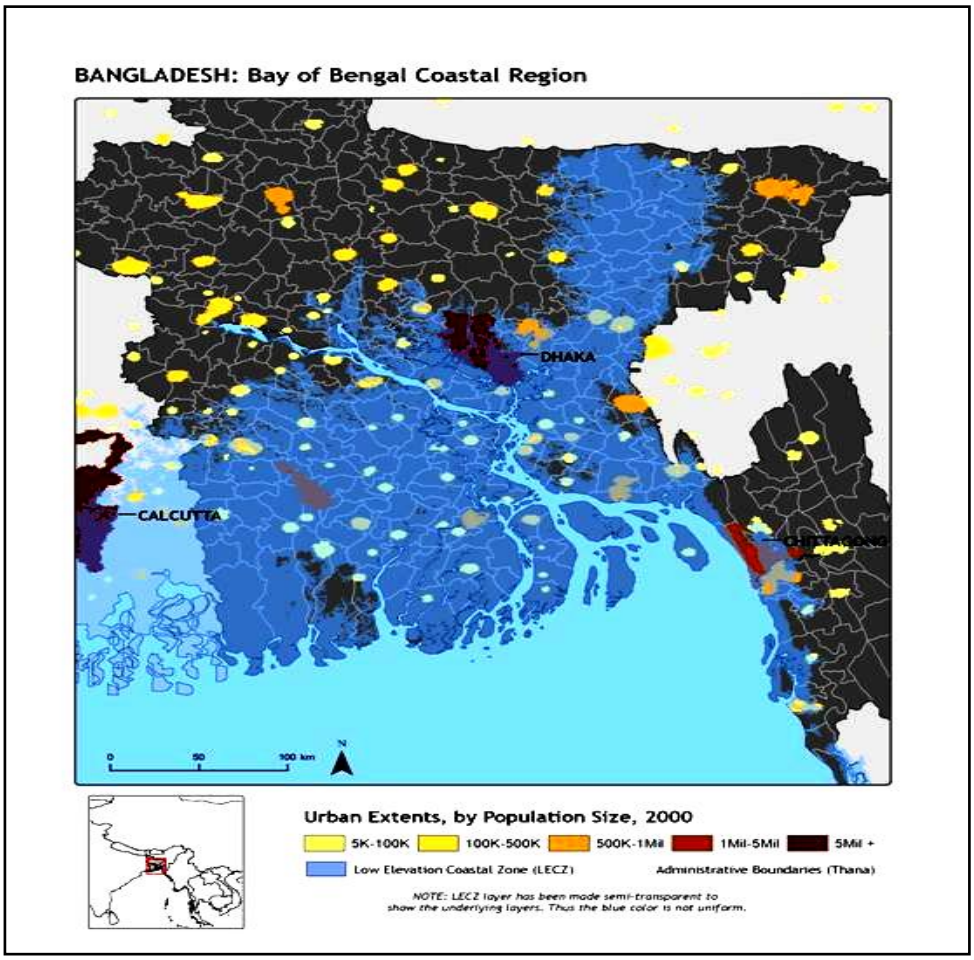


TABLE 1. POPULATION AND LAND AREA IN LOW ELEVATION COASTAL ZONE BY REGION, 2000

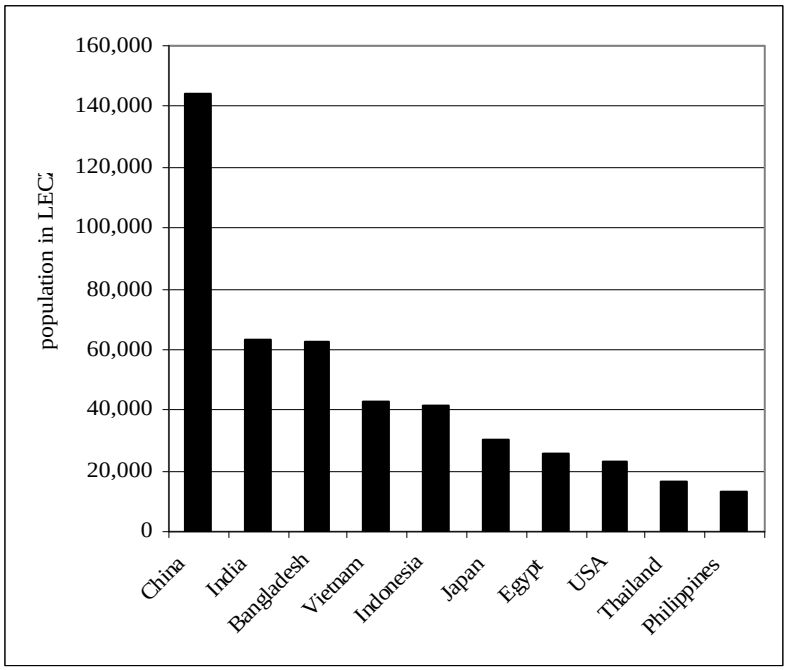
	Region's populations and land areas in low elevation coastal zones				Shares of region's population and land in low elevation coastal zones			
Region	Total Population	Urban population	Total Land	Urban Land	Total Population	Urban population	Total Land	Urban Land
	(millions)	(millions)	(thousand km^2)	(thousand km^2)	(per cent)	(per cent)	(per cent)	(per cent)
Africa	56	31	191	15	7	12	1	7
Asia	466	238	881	113	13	18	3	12
Europe	50	40	490	56	7	8	2	7
Latin America	29	23	397	33	6	7	2	7
Australia and New Zealand	3	3	131	6	13	13	2	13
North America	24	21	553	52	8	8	3	6
SIS	6	4	58	5	13	13	16	13
World	634	360	2 700	279	10	13	2	8

Source: McGranahan, Balk and Anderson (2007)

While the small island states have by far the largest share of land in these zones, the shares of population in these zones are not exceptional. This is in part because some of the most populous small island states have comparatively little settlement in the low elevation areas. It is also because small island states do not have large rivers, creating flat and fertile deltas where populations would otherwise locate.

Regional averages hide considerable national variation. The 10 countries with the most people living in low elevation coastal zones (figure 2) together account for about 463 million people, or about 73 per cent of the total population living in the zone globally. Most of these countries have big populations and contain large and densely populated delta areas, many of which are also susceptible to subsidence and already have large populations at risk of storm surges.

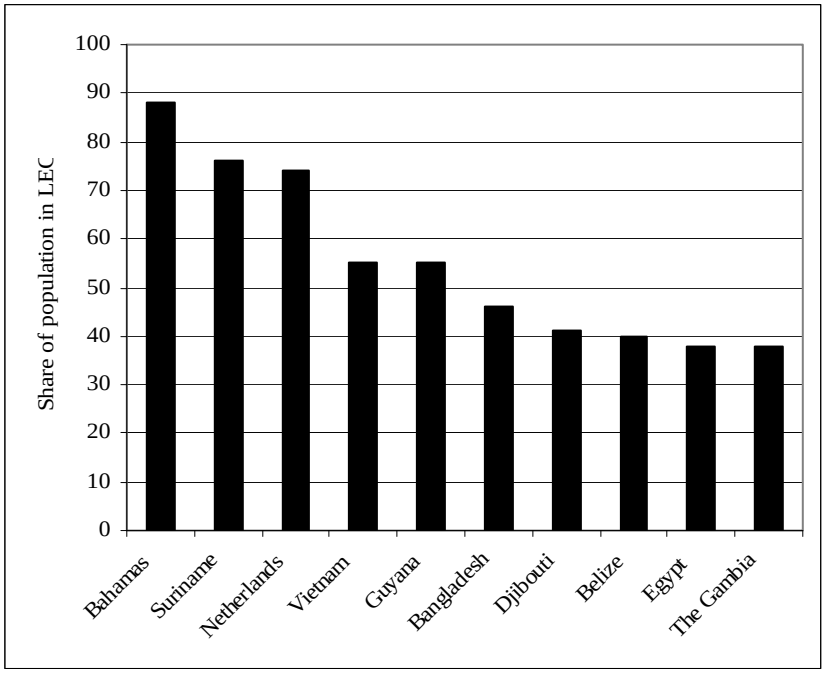
Figure 2. Ten countries with the largest populations in the low elevation coastal zones



Source: McGranahan, Balk and Anderson (2007).

The countries with the highest population shares in the zone (excluding those with total populations of less than 100,000 or land areas less than 100 square kilometres) are shown in figure 3. Three of these countries, Viet Nam, Bangladesh and Egypt, are also among the countries with the largest overall populations in the zone. Only one of them is a small island State–although there would have been several more had the very small countries with populations below 100,000 been included in this figure. Even more so than the countries with large populations in the low elevation coastal zones, those with high percentages of their population in these zones are overwhelmingly deltaic.

Figure 3. Ten countries with the highest population shares in the low elevation coastal zones



Source: McGranahan, Balk and Anderson (2007).

In the world as a whole, but most notably in Asia, not only are urban populations more likely to be in the low elevation coastal zones than rural populations, but larger urban settlements are more likely to overlap with these zones than smaller urban settlements. While only 13 per cent of urban settlements with populations under 100,000 overlap with low elevations coastal zones, 65 per cent among cities of five million or more do. Seven of the 10 largest cities identified in 2005 by the United Nations (Tokyo, New York, Bombay, Shanghai, Kolkata, Jakarta and Buenos Aires) extend into the zone. Indeed, more than 55 million people in these cities and their contiguous urban areas live in low elevation coastal zones.

Asia and Africa–the continents that will be home to the bulk of future urbanization–display different patterns of population distribution. Asia has 91 cities of more than one million persons within the low elevation coastal zones. China alone has 26 cities with over one million persons in these zones and Japan and Indonesia have 11 cities each. Despite this, most of the urban population in the zone lives in cities of 500,000 residents or less. In Japan, 78 per cent of urban dwellers in low elevation coastal zones live in these smaller cities, while in China, 91 per cent of urban dwellers in these zones do (the city-state of Hong Kong special administrative region (SAR) of China, is an exception to this pattern). In Africa, as in Asia, most of the urban population in low elevation coastal zones are found in cities of 500,000 or less inhabitants. Africa has 22 cities of more than one million persons in these zones. Although Egypt alone has 11 cities with over 500,000 persons, 79 per cent of urban dwellers in these zones are in smaller centres. Similarly, South Africa, Algeria, Libya and Morocco each have 3 cities with over 500,000 persons, but the majority of urban dwellers–from 73 per cent in Libya to 81 percent in Morocco–live in smaller urban centres.

Table 2 shows the top 10 countries in terms of the urban population residing within the low elevation coastal zones in Africa and Asia. Asia has seven countries where the urban population residing within low elevation coastal zones is greater than 10 million persons; Africa has one (Egypt). In both

regions, these top-10 lists include the region's most populous country as well as its most urban country (in terms of urban residents). In Asia, total population, urban population and urban population in low elevation coastal zones conform closely. In Africa, the pattern is much more mixed. The list of countries with the largest urban population in these zones , apart from Egypt and Nigeria, includes some countries with relatively small total population (Libya, Benin, Tunisia and Senegal) as well as countries that are not particularly urban (for instance, Benin and Libya).

TABLE 2 – TOP TEN COUNTRIES BY NUMBER OF URBAN PERSONS IN THE LOW ELEVATION COASTAL ZONES, 2000

Panel 1: Africa

Top Ten	Country	Population rank within continent	Urban population rank within continent	Total population (thousands)	Urban population in low elevation coastal zones (thousands)	Share of total population that is urban and in low elevation coastal zones (%)
1	Egypt	3	1	67 285	11 444	17.0
2	Nigeria	1	2	117 606	4 927	4.2
3	Senegal	24	16	10 343	2 400	23.2
4	Morocco (includes Western Sahara)	10	5	29 530	1 457	4.9
5	Tunisia	25	13	9 563	1 191	12.5
6	Benin	29	24	7 197	1 129	15.7
7	Mozambique	13	15	17 910	1 118	6.2
8	Ivory Coast	14	14	16 735	942	5.6
9	Algeria	9	4	30 462	727	2.4
10	Libyan Arab Jamahiriya	33	19	5 306	726	13.7
	Total urban population in low elevation coastal zones				32 390	
	Total urban population				282 143	

Panel 2: Asia

Top Ten	Country	Population rank within continent	Urban population rank within continent	Total population (thousands)	Urban population in low elevation coastal zones (thousands)	Share of total population that is urban and in low elevation coastal zones (%)
1	China	1	1	1 256 446	101 241	8.1
2	India	3	2	1 021 084	38 256	3.7
3	Japan	7	3	127 180	27 521	21.6
4	Indonesia	2	4	209 139	22 135	10.6
5	Bangladesh	5	9	128 916	13 063	10.1
6	Viet Nam	4	13	78 666	12 613	16.0
7	Thailand	10	12	61 410	10 571	17.2
8	Philippines	6	10	75 290	6 808	9.0
9	Myanmar	8	18	47 724	4 280	9.0
10	Taiwan	9	11	21 638	3 898	18.0
	Total urban population in low elevation coastal zones				262 779	
	Total urban population				1 532 853	

Source: Author's calculations based on GRUMP (Ciesin and others, 2004) and Isciences (2003)

The global picture is no less striking. Of the 183 countries with people living in the zone, 130 (or about 75 per cent) have their largest urban area extending into the zone. The world's large cities–those with more than five million residents–have, on average, one-fifth of their population and one-sixth of their land area within the zone. On the one hand, these proportions suggest that the urban population is at greater risk than the urban land; and on the other hand, they may suggest that for climate adaptation, migrating or resettling within existing cities but outside of the zone is an option for the population living in these zones.

Continued urbanization will probably draw still greater populations and population shares into low elevation coastal zones. In China, where export-driven economic growth has been associated with very rapid migration toward the coast, national population growth in 1990-2000 was approximately one per cent, while growth in low elevation coastal zones was 1.9 per cent and urban populations in the zone grew by 3.4 per cent. Even in Bangladesh, where urbanization is not so clearly a driver of economic development, movements towards the coastal zone are evident. For example, the country's total population growth rate is 1.2 per cent, while the growth rate in its low elevation coastal zones is 2.1 per cent and growth in the urban population living within these zones is 2.8 per cent (McGranahan and others, 2007).

C. IMPLICATIONS

The above analysis shows that the pattern of urban settlements in low elevation coastal zones is remarkably varied. Deltas clearly stand out as one common factor that many of these regions share (McGranahan and others, 2007), yet whether they alone can act as a unifying agent for policy directives in small and large cities alike is not clear. Governance structures are not oriented towards physiographic entities like deltas and regions, yet climate change may make regional alliances of this sort a necessity.

Looking to the future, the responses to the growing risks brought on by climate change in coastal settlements will need to include climate mitigation, human migration and modification (including adaptation)–all of which have a long lead-time. Cities tend to have short-term planning horizons. Though some cities are actively engaged in regional planning and some have sustainability plans that are medium-term in nature, such plans are not the norm, especially in poorer countries of Africa and Asia. Equity issues will also require attention, particularly because low-income groups often settle along the flood plains and are most at risk. At the same time, these same groups are most at risk from hastily constructed government policies.

D. DEMOGRAPHIC TOOLS AND METHODS

Urbanization and climate change are unavoidable features of the future, yet our ability to predict effectively future urban population growth–and locational implications such as those associated with climate change–is hampered both by methodological and data constraints. Thus, this final section makes recommendations on some of the necessary data and tools to improve future urban population estimates.

Urban areas are spatially delineated. Spatial data, therefore, would be extremely valuable to understanding future urban change. To be most useful, these data should be spatially explicit at the city-level (so that it is possible to determine how cities expand and contract) and within cities (so that it is possible to determine compositional differences between neighbourhoods). In the future, more of the urban world will be faced with issues that require a spatial framework. Three broad areas of inquiry are identified below.

To understand *where* cites are growing, and more generally, to consider urbanization in an environmental context, a spatial framework is necessary. For example, it is impossible to understand the likely implications of growth for urban areas that are situated near coasts or in a dryland vis-à-vis climate change, if one does not know where cities are located and how they are changing in spatial and demographic terms. There is ample relevant, spatial geophysical data (for instance, on rainfall, temperature, climate scenarios, ecosystems, hydrology and elevation) that could be accessed with a spatial framework, so much of the onus to foster this integration is on the demographic side–to render demographic data on cities in a spatial framework. At a minimum, estimates of total current and projected future population of cities is vital. Preferably, data that describe the age-structure, fertility, mortality rates, as well as other related socio-economic variables of cities would be an important addition. These data need to be specified by city or for sub-city units, not simply tallied for all urban areas within a country.

To understand *how* cities grow–horizontally or vertically–and by which causes–natural increase, *migration* and *administrative reclassification*–requires a systematic spatial view. Though case studies and some evidence (Chen and others, 1998) have been offered on these questions in the past, these issues cannot be fully understood in the absence of analysis of spatially coded demographic data. Towards this end, it is not only important that a system of population estimates associated with urban boundaries be established (such as those from the GRUMP project) but an understanding of how they nest within smallest available administrative boundaries with their associated population estimates (Champion and Hugo, 2004). To be most valuable to planners, these data should be collected, or at least estimated, more than once per decade.

Finally, recent evidence clearly finds that level of urbanization does not affect the rate of economic growth (Bloom and others, 2008), yet it also appreciates that many demographic and economic processes–migration, trade, and growth itself–implicitly occur along some sort of gradient of urbanization. One small and understudied part of the urban transformation is the relationship among cities of different sizes and the role of small and medium-sized cities in general (Montgomery, 2008). It is clear that the primate-city model of yesterday is now an outmoded means of understanding urbanization. Yet, whether the demographic and economic growth of the present and the future will occur by the transformation of already large cities into mega-urban regions, or by improved social and economic network of small and medium-sized cities, or any of a number of possibilities, is an open-ended question. Without embracing a spatial framework, this question will remain unanswered. Yet the answer to this question is closely linked to future economic development and sustainability throughout the world.

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