

Population and Land Area in Distribution in Urban Coastal Zones

A Systematic Assessment



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Preferences vs. Risks?

- Human settlement has long been drawn to coastal areas
 - Resource abundant
 - Trading opportunities
 - But also expose residents to seaward hazards
- Some seaward hazards are expected to increase as a result of climate change, including
 - sea level rise
 - extreme weather events
- The role of policy?
 - Increasing trade and market-driven movements (including incentives) may explicitly attract people towards the coast without accounting for associated risk

In addition to risk from seaward hazards, coastal population and expansion of urban built up areas can be burden for coastal ecosystems, which in turn can affect the availability of resources upon which residents rely.

What have prior studies shown?

- IPCC study documents that small Island states are clearly at risk.
- Estimates drawn from much coarser-resolution inputs find that
 - Populations tend to live near coasts and major rivers & at low elevation (Small and Cohen, 2004)
 - Coastal population experienced densities as much as 3x the average population density (Nicholls and Small, 2002)
- In our work for the MA, we have found that globally, coastal zones exhibit higher population densities:
 - In both urban and rural areas &
 - More than any other major ecologically defined zone

Bullet 3 goes with the table on the next slide.

Population Density for MA Ecosystems, by Urban and Rural (McGranahan et al. 2005)

System	Overall	Urban	Rural
	(persons per sq. km.)		
Coastal zone	175	1,119	69
Cultivated	119	793	70
Dryland	36	749	20
Forest	27	478	18
Inland Water	51	826	25
Mountain	36	636	26
World	46	770	25

Table from Millennium Ecosystem Assessment Urban Chapter showing population densities of MA Systems.

[Animation 1] Note that urban pop density is highest in coastal system—and much higher than any other ecosystem. Inland water is also higher [Animation 2].

In rural areas, [animation 3] population density is again more than twice the density of the overall world average in coastal zones—as well as in cultivated systems.

These are not mutually exclusive zones, so the density we see in rural coastal areas may be in fact because those areas are also highly cultivated, though we know that there are cultivated systems that are not coastal.

Why is this study different?

- New (and improved) data
- New method
- New findings
 - Aggregations by different types of coastal vulnerabilities
 - New evidence & implications for policy

Data sets are recently compiled – 2004 to the present

Combines census data with remotely sensed data

For a globally consistent dataset, the data have quite high resolution at 1km. This is over 4x the resolution of the previously used data (2.5 minute resolution).

New Data

- Study integrates several new spatial databases
 - Global Rural Urban Mapping Project (GRUMP)
 - Population surface
 - Much improved spatial resolution of inputs
 - Urban extents
 - First-ever globally consistent urban footprint
 - Based on NOAA's night-time lights
 - SRTM-based elevation data
 - Used to create a low-elevation coastal zone.

We combined the use of three datasets to generate these population estimates.

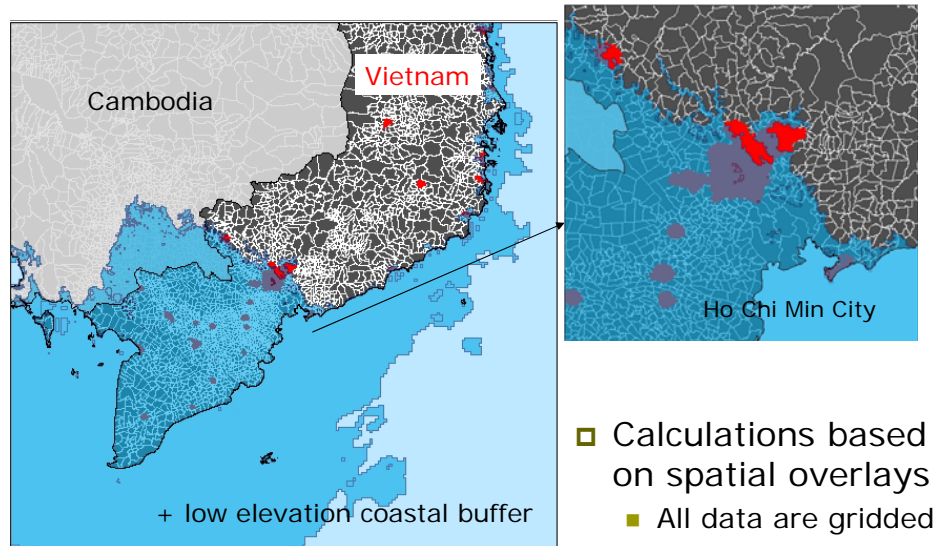
1. GRUMP urban extents mask, based largely on the NOAA night-time city lights dataset. This dataset coarsely, but consistently, delineates the spatial extent of urban areas globally.
2. GRUMP variable (population and land area) grids. The underlying population data comes primarily from country census data of sub-national administrative units and cities. This is the most detailed global compilation of geo-referenced census data to date.
3. Low Elevation Coastal Zone buffer created from SRTM data, provided by ISciences.
4. All datasets are gridded at 30 arc-second (about 1km) resolution.

New Method

- ❑ Given urban extents, and estimates of population in those areas, we ask
 - *What fraction fall within a low-elevation coastal zone (LECZ)?*
 - ❑ Choice of a 10-meter contiguous elevation buffer
- ❑ Yields exposures of urban land area and population in LECZ
 - Continent-level
 - Country-level
 - Coarse (national-level) poverty-level
 - By geographic feature
 - ❑ Delta vs. Island

- The low elevation coastal zone and urban extents layers are merged to delineate urban and rural portions of the low elevation coastal zone.
- The lecz includes land area, contiguous with the coast that is 10 meters or less in elevation.
 - The low elevation coastal zone is generated by choosing land area contiguous with the coastline that is 10 meters or less in elevation.
 - While it is understood that sea-level is not expected to rise to 10 meters, the measures below 10 meters could not be considered globally reliable, particularly in some types of coastal areas, characterized as mountainous bays. Thus, while 10 meters is a larger than expected in terms of long-term sea-level rise, it is not greater than some storm surges, and though it is greater than ideal for some scenarios, it is an improvement over prior global estimates.
- The urban/rural lecz is overlaid on top of the population and land area grids for each country and summary statistics are calculated.

Visualizing the Method



The admin boundary data shown here are rendered to a grid, taking into account the urban areas as detected by the night-time lights (shown in red). They are then overlaid with the 10 m elevation buffer.

Note the intra-urban detail within Ho-Chi-Min city; note that some parts of the city are not within the LECZ.

New Findings

- The following findings are based on:
 - countries with a population of at least 100,000 persons and land area of at least 1,000 square kilometres;
 - Regions as approximately defined by the IPCC.
 - In some instances, countries have been reclassified
 - E.g., American Samoa and Aruba are not IPCC Small Island States but for this analysis we consider them to be.

Differences in population in the LECZ by Region

Region	Total Population		Urban population	
	(10 ⁶)	(%)	(10 ⁶)	(%)
Africa	56	7%	31	12%
Asia	466	13%	238	18%
Europe	50	7%	40	8%
Latin America	29	6%	23	7%
Australia & N. Z.	3	13%	3	13%
North America	24	8%	21	8%
SIS	6	13%	4	13%
<i>World</i>	634	10%	360	13%

[First animation] About one person in ten persons lives in a coastal zone at less than ten meters of elevation; and a greater share of the urban population lives there
 [second animation]

Differences in land area in the LECZ by Region

Region	Total Land		Urban Land	
	(10 ³ km ²)	(%)	(10 ³ km ²)	(%)
Africa	191	1%	15	7%
Asia	881	3%	113	12%
Europe	490	2%	56	7%
Latin America	397	2%	33	7%
Australia & N. Z.	131	2%	6	13%
North America	553	3%	52	6%
SIS	58	16%	5	13%
World	2,700	2%	279	8%

[Animation 1] Though this low elevation coastal zone (the LECZ) only accounts for about 2.2% of the world's land area.

[Animation 2] Note that 4x that—or 8% of urban land is in the LECZ—and in much more in Asia, Australia, New Zealand and the Small Island States [Animation 3].

Which country has the greatest number of persons living in the LECZ?

Countries ranked by total population in the LECZ				
Rank	Country	Pop Rank	Population in LECZ	% of Population in LECZ
1	China	1	143,879,600	11%
2	India	2	63,188,208	6%
3	Bangladesh	8	62,524,048	46%
4	Vietnam	13	43,050,593	55%
5	Indonesia	4	41,609,754	20%
6	Japan	9	30,477,106	24%
7	Egypt	16	25,655,481	38%
8	USA	3	22,859,359	8%
9	Thailand	19	16,478,448	26%
10	Philippines	14	13,329,191	18%

Rank in the first column refers to the top-ten countries (in terms of population size) at risk, but the “Pop rank” column indicates the rank of the country’s population size with respect to all others. Populous countries tend to have a lot of persons at risk, though the share of a country’s total population is low—India at 6% to Vietnam, at 55%.

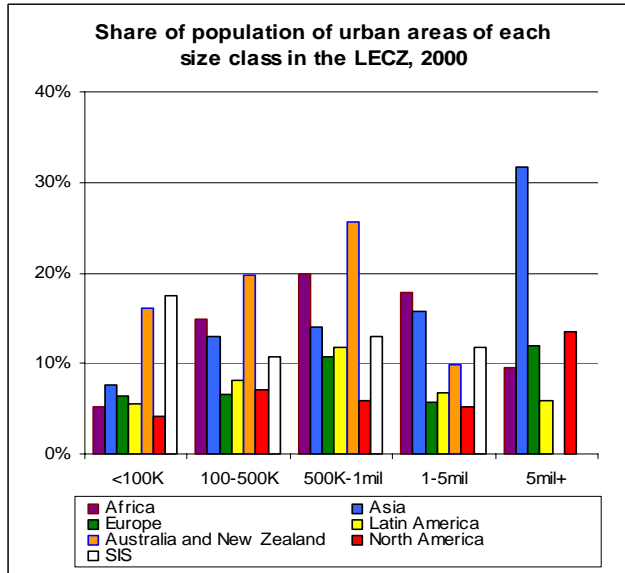
Which country has the greatest share of its population living in the LECZ?

Countries ranked by share of their population in the LECZ				
	Country	Rank ¹	Population in LECZ	% of Pop in LECZ
1	Bahamas	172	266,580	88%
2	Suriname	168	317,683	76%
3	Netherlands	58	11,716,861	74%
4	Vietnam	13	43,050,593	55%
5	Guyana	155	415,456	55%
6	Bangladesh	8	62,524,048	46%
7	Belize	177	91,268	40%
8	Djibouti	158	248,394	39%
9	Gambia	148	510,159	39%
10	Egypt	16	25,655,481	38%

In contrast, the countries with the highest share of their population living in the LECZ ranges widely from very populous nations such as Bangladesh, Vietnam and Egypt [animation 1]. This alone amounts to more than 100,000,000 persons.

Five countries have more than 50% of their population within the zone [animation 2]. With the exception of the Netherlands—where huge public investments have been made over more than a 50 year period to protect against seaward hazards—all of these countries are (more or less) poor.

Variation by city-size?

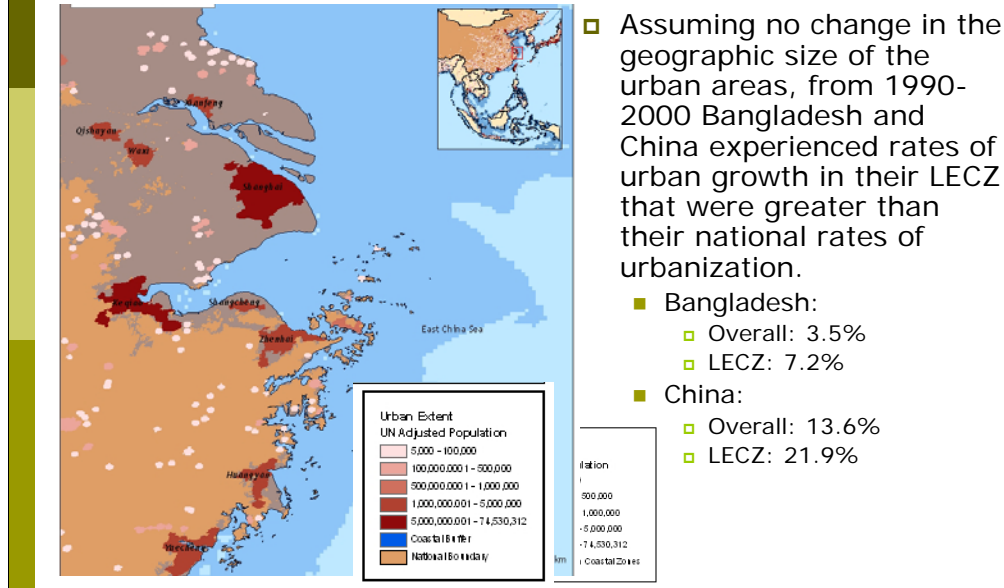


- Large cities tend to intersect the LECZ (perhaps obviously)
 - In fact, 71% of countries have their largest city in the LECZ.
- But except in **Asia** (blue bar), they do not necessarily have tend to have greater shares of their populations in the LECZ
- African (purple), Australian & New Zealand (orange) cities also tend to have the high share of their populations in the LECZ

[Animation 1] Colors indicate continent. Australia, New Zealand, and the small island states tend to locate much more of their urban areas within the LECZ. The 71% of countries excludes landlocked countries; ‘In’ means intersects.

The Small Island States (SIS) have no cities in the largest category—those cities with 5 million persons or more.

Urban Growth?



We assume no change in the size of the urban footprint in this analysis because only one observation—the NOAA night-time lights city-lights composite data is available from 1994/95—thus the growth scenarios take the urban area as fix, but ask what share of the population in 1990 and 2000 live in those areas, by country and LECZ.

Bangladesh was about 22% urban in 2000, but 27% urban in the LECZ. In China, at about one-third urban in 2000, it's LECZ were more than 50% urban (54%).

Implications for Policy

- Small Island States have done much to raise public awareness of their particular coastal vulnerabilities.
 - This analysis has shown that small island nations are not the only ones at risk.
- Deltaic countries are particularly vulnerable, as are populous ones.
 - Africa, whose small cities fall much more into the LECZ than other small cities, will need to be especially watchful as it experiences urbanization.
 - Asia's large cities are already disproportionately within the LECZ, so planning for future growth should internalize this information.