

Preference and Risks of Coastal Population Distribution:
A systematic assessment of population and land area in urban and rural areas of coastal zones.

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Human settlement has long been drawn to coastal areas (Cohen and Small 2004), which provide many resources and trading opportunities, but also expose residents to seaward hazards. Recent storms such as Hurricane Katrina provided a well-publicized demonstration of how vulnerable even comparatively affluent settlements can be. Some seaward hazards, including sea level rise and extreme weather events and their associated hazards (storm surges, flooding), are expected to increase as a result of climate change. Yet increasing trade and market-driven movements are still attracting people towards the coast. In prior studies, we have shown that globally, coastal zones exhibit higher population densities, in both urban and rural areas than any other major ecologically defined zone, except for urban systems themselves (McGrahaman et al. 2005). In this study, we show that about one person in ten lives in a coastal zone at less than ten meters of elevation, although this low elevation coastal zone (LECZ) only accounts for about 2.2% of the world's land area. Small Island States are raising public awareness of their particular coastal vulnerabilities, but, as we will describe, significant populations of many large countries also reside in the potentially vulnerable low elevation coastal zones.

Despite the spatial nature of many population and environment relationships, population distribution and the characteristics associated with population dynamics are not well understood in a spatially explicit context. Nevertheless, an understanding of demographic change with respect to environmental forces—such as those associated with consequences of climate change—requires finely-resolved and spatially-explicit demographic and environmental data. This study starts with several recently-constructed spatially-explicit databases, integrates them, and then analyzes them to assess population distribution and change over the past decade in low elevation coastal zones, that is, those zones at greatest risk of seaward hazards associated with climate change. Because coastal zones are disproportionately urban (McGrahaman et al., 2005), special attention will be given to understanding urban population distribution and densities in these higher risk coastal areas.

The paper reviews the methodology for data integration and analysis, presents new findings and summarizes them by different types of coastal vulnerabilities (poverty, delta regions vs. island, and city-sizes), and discusses implications for policy at the subnational, national and international levels. By all accounts, the physical aspects of climate change—and their interaction with anthropogenic conditions (e.g., agriculture, fisheries, industry,

urbanization)—are complex and will not affect all coastal areas equally (Eisma 1995). We conclude with a discussion of expected differential affects in coastal zones at greatest risk.

Data & Method

This study integrates several new spatial databases—delineating finely resolved global population distribution and urban extents, and elevation data—to produce country-level exposures of urban land area and population in LECZ.

We calculate population and land area in the LECZ by overlaying gridded geographic data and constructing totals within the zone by country. We defined the LECZ as contiguous land area up to a 10 meters rise elevation¹. Estimates for year 2000 population, urban area, and land area are based on the Global Rural Urban Mapping Project (CIESIN et al., 2005a, 2005b); elevation from Shuttle Radar Topography Mission (SRTM) elevation data (ISciences, 2003). All data are expressed at 1km resolution. Figure 1 demonstrates for Viet Nam the boundaries of the data layers for which the calculations were made.

[Details on the methodology forthcoming. The tables below refer only to year 2000 estimates. This paper will be expanded to include analysis of change occurring between 1990 and 2000.]

Results

Table 1 provides a selection of statistics by region, using the classifications of the International Panel on Climate Change, for Working Group 2. In absolute numbers, Asia accounts for about a third of the world’s land in the LECZ, but because of far higher population densities it accounts almost two thirds of the urban population, and three quarters of total population in the zone.

The region with the highest share of its total land area in the zone is, not surprisingly, the Small Island States, with about 16% - roughly five times the share in Asia. For the purposes of Table 1, this group has 66 members, some of which are not listed as Small Island States (SIS) in the IPCC regional listing.

What is more surprising is that the share of the total and urban populations of the Small Island States that are in the zone are only slightly more than the world average. On the other hand, Africa, the only region with less than one percent of its land in the zone, and one of the lowest population shares in the zone, has over 14% of its urban population in the zone.

Table 1: Populations and Land Areas in Low Elevation Coastal Zone by Region

Populations and Land Areas in LECZ					Shares of population and land in LECZ			
Region	Population	Urban population	Land	Urban Land	Share of Regional	Share of Region’s	Share of Region’s Land	Share of Region’s Urban

¹ As a validation to our LECZ zone, we generated summary statistics based on the Millennium Ecosystem Assessment’s (MA) coastal boundary which we also constrained to 10 meters or less in elevation. Though there were some boundary inconsistencies between the MA and population/land area data sets, the results were quite similar.

	(10 ⁶)	n (10 ⁶)	(10 ³ km ²)	(10 ³ km ²)	Population	Urban Pop.		Land
Africa	55	40	206	15	8.2%	14.5%	0.9%	7.9%
Asia	438	232	819	109	12.3%	17.7%	3.3%	11.7%
Europe	48	38	459	54	7.1%	8.1%	2.1%	7.0%
Latin America	28	22	372	32	6.1%	6.9%	2.0%	6.6%
Ausi/NZ	3	3	134	6	13.8%	14.4%	1.7%	13.4%
North America	25	22	523	52	7.8%	8.5%	2.8%	5.9%
SIS	6	4	56	5	13.1%	14.0%	16.3%	13.1%
World	602	361	2,571	274	10.5%	13.5%	2.2%	8.2%

In addition to geographic location, a country's vulnerability to coastal hazards depends in part on its per capita income. Table 2 provides summary statistics for countries grouped according to the World Bank's national income classification (the world totals are slightly less in this table due to missing income data).

The low-income group has a higher share of its population living in the zone than does the world as a whole, and the highest share of urban population of any group. Overall, there are about 246 million people in low-income countries living in the zone, of which some 107 million are urban.

Table 2: Populations and Land Areas in Low Elevation Coastal Zone by National Income Category

Income Category	Populations and Land Areas in LECZ				Shares of population and land in LECZ			
	Population (10 ⁶)	Urban population (10 ⁶)	Land (10 ³ km ²)	Urban Land (10 ³ km ²)	Share of Group's Population	Share of Group's Urban Pop.	Share of Group's Land	Share of Group's Urban Land
Low	246	107	646	36	11.0%	15.6%	2.7%	9.0%
Lower Middle	209	128	653	65	9.9%	14.1%	1.6%	7.6%
Upper Middle	36	29	375	40	7.8%	8.9%	1.9%	7.6%
High	107	93	890	129	11.7%	12.6%	2.9%	8.3%
World	598	357	2,563	270	10.4%	13.4%	2.2%	8.1%

In climate change negotiations, the group whose economic status is explicitly recognized as making them particularly vulnerable are the Least Developed Countries – a group of about 50 very low income countries. This group also has a particularly high share of its population and urban population in the LECZ (16 and 23 percent respectively), despite a comparatively modest land share (1.7 percent). OECD countries, in contrast, only have 10 percent of their overall population and 11 percent of their urban population in the zone, with about 2.7 percent of the land in the zone.

As indicated above, these averages hide a great deal of variation, with some countries having far larger shares or quantities of land and population in the zone than others in the same group. Thus, for example, the figures for the Least Developed Countries are heavily influenced by Bangladesh, which accounts for over half of the category's population in the LECZ.

Tables 3.1 and 3.2 present the ten countries with the most population and land area in the LECZ. The top-ten in LECZ population are mostly large Asian countries with significant delta regions. The LECZ's of these top-ten countries combine to account for about 435 million people, or about 72% of the people who live in the zone globally. As indicated in grey, there is considerable overlap between countries with high overall and high urban population in the zone. The top-ten by urban LECZ population together account for about 243 million urban dwellers, or 67 percent of the urban population in the zone. It is perhaps noteworthy that the United States has the largest share of urban land in the LECZ of any country, nearly 60% more than China with the next largest share.

As indicated by red font, eight countries appear in the top-ten for both population and land area in the LECZ.

Population						
	Total			Urban		
Country	Rank	Number	% of total population	Rank	Number	% of urban population
China	1	127,037,984	10.1%	1	70,979,456	16.8%
India	2	63,340,670	6.3%	2	31,937,678	10.6%
Bangladesh	3	53,111,287	38.7%	7	14,851,611	48.4%
India	4	41,806,958	19.7%	4	22,807,842	28.0%
Viet Nam	5	41,438,697	53.0%	9	12,188,933	70.0%
Japan	6	30,827,107	24.4%	3	29,362,380	26.0%
Egypt	7	24,410,913	36.0%	6	18,673,652	31.5%
United States of America	8	23,278,600	8.2%	5	20,637,960	9.0%
Thailand	9	15,689,150	25.1%	8	12,262,962	59.0%
Philippines	10	15,122,218	20.1%	11	8,424,700	0.34
Brazil	12	10,788,109	6.3%	10	9,540,809	7.7%

Land Area						
	Total			Urban		
Country	Rank	Land Area (sq km)	% of total population	Rank	Land Area (sq km)	% of urban population
Russia	1	249,427	1.5%	26	2,680	1.4%
Canada	2	243,913	2.6%	15	4,797	3.7%
United States of America	3	223,263	2.4%	1	47,191	6.3%
Indonesia	4	186,685	9.8%	8	8,299	25.6%
China	5	155,595	1.7%	2	29,428	11.3%
Australia	6	125,713	1.6%	12	4,943	13.5%
Brazil	7	97,176	1.1%	5	10,271	5.5%
Mexico	8	94,084	4.8%	7	8,688	8.5%
India	9	80,972	2.5%	4	11,710	5.7%

Viet Nam	10	63,578	19.4%	19	3,645	61.1%
Japan	17	27,191	7.3%	3	17,592	16.9%
Thailand	16	32,517	6.3%	6	8,812	32.0%
Netherlands	19	25,705	62.1%	9	7,791	62.9%
Italy	29	18,170	6.1%	10	7,040	9.6%

There are a number of features that can lead a country to have a large share of its urban and rural populations in the LECZ. These include long coastlines (relative to the country's size), wide and heavily populated coastal lowlands, and sparsely populated interiors. The results suggest that these factors relate to three different types of countries. There are the Small Island States, with their very long coastlines. There are countries with large delta regions and heavily populated coastal lowlands, such as Vietnam and Bangladesh. And there are a few countries, like Suriname and Guyana, with sparsely inhabited interiors, and populations concentrated on a small coastal strip. The ten countries with the largest share of their population and land area in the LECZ are shown in table 4.

Table 4 Countries with the greatest % of their total population and land area in low elevation coastal zones, 2000 (of countries with population larger than 100,000 or land area greater than 10,000 square km)

Country	Population			Land Area		
	Rank	%	Number	Rank	%	Number
Maldives	1	100.0%	290,923	(1)	100.0%	189
Bahamas	2	87.6%	266,615	1	93.2%	12,269
Bahrain	3	78.3%	500,962	(16)	55.0%	343
Suriname	4	78.0%	325,202	80	6.3%	8,958
Netherlands	5	60.5%	9,590,287	2	62.1%	25,705
Macao	6	59.4%	263,967	(12)	62.1%	12
Guyana	7	55.1%	418,776	107	4.0%	8,447
VietNam	8	53.0%	41,438,697	9	19.4%	63,578
Djibouti	9	39.6%	250,345	116	3.2%	665
Bangladesh	10	38.7%	53,111,287	3	31.3%	42,666
Denmark	40	27.7%	1,474,390	4	26.7%	11,465
Gambia	11	36.6%	476,414	5	25.0%	2,713
Qatar	32	33.5%	189,325	6	23.1%	2,534
Cuba	76	14.1%	1,574,307	7	21.2%	23,570
Guinea-Bissau	41	27.5%	330,335	8	20.7%	7,043
Belize	(26)	41.9%	94,795	10	17.8%	3,974

NB: () indicates country has a population smaller than 100,000 persons or 10,000 square kilometres of land area.

Discussion

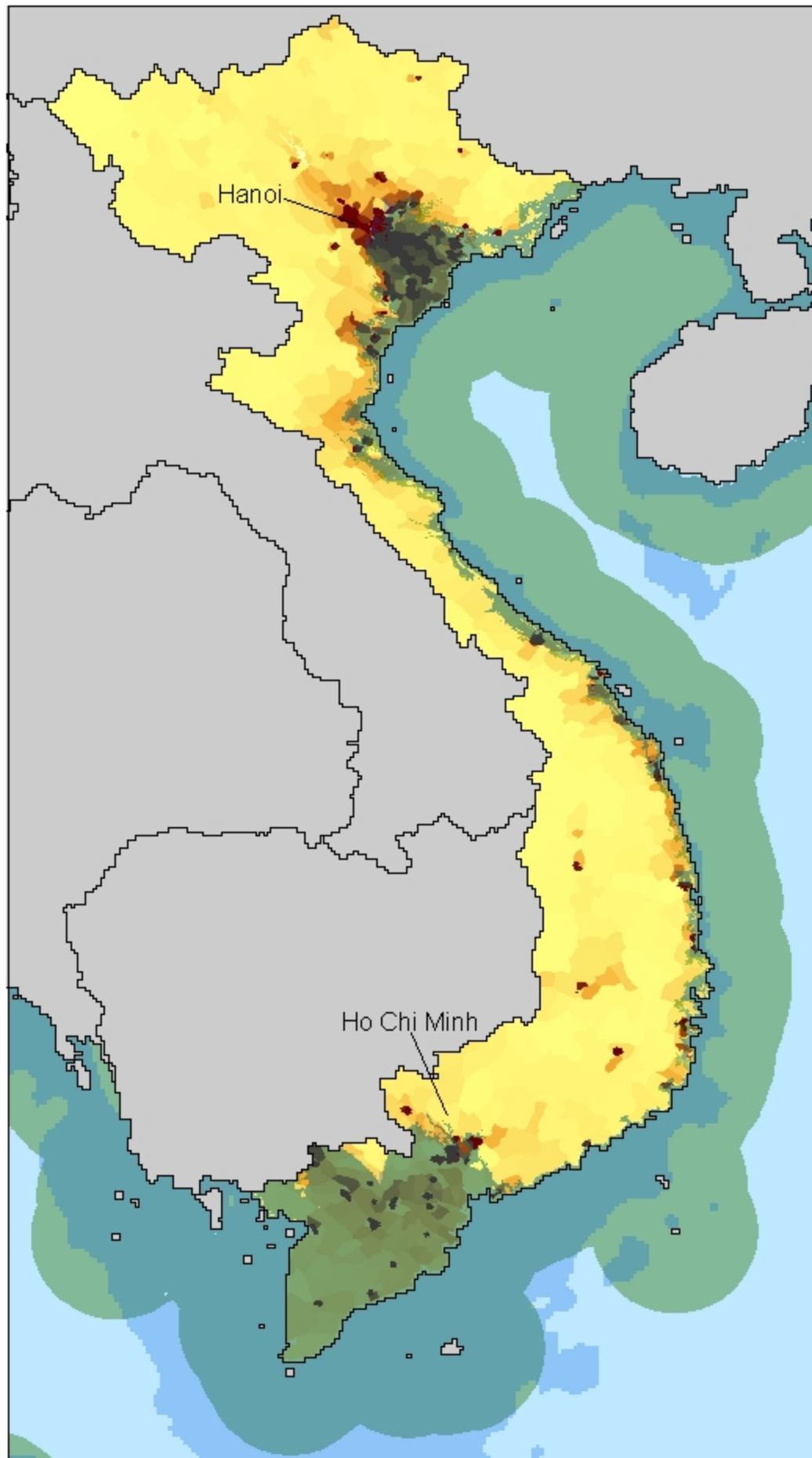
The vulnerabilities faced by these different types of countries are also likely vary. A large share of urban and rural populations in the LECZ are living in countries with large delta regions. It is far too early to say whether settlements in such regions contain most of the population vulnerable to seaward hazards associated with climate change. These results do, however, illustrate the importance of looking beyond the Small Island States.

To be expanded... (A preliminary and simplified version of these results were presented in the newsletter *Tiempo* (www.teimpcyberclimate.org). This paper will considerably expand upon those initial findings with updated data and more importantly new analysis.)

Vietnam:

**Low Income Country
with a large share of
coastal vulnerability**

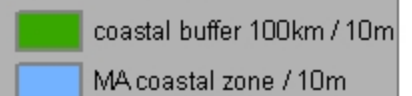
The two major population centers in Vietnam (Hanoi and Ho Chi Minh) as well as a large share of the overall land area are part of the Low Elevation Coastal Zone.



Population



Coastal Zones



The Low Elevation Coastal Zone (LECZ) is land 10 meters or less in elevation that is contiguous with the coast. Two versions of LECZ were developed (blue and green) and compared.

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