Revitalizing Urban Population Projections: New Data, New Methods

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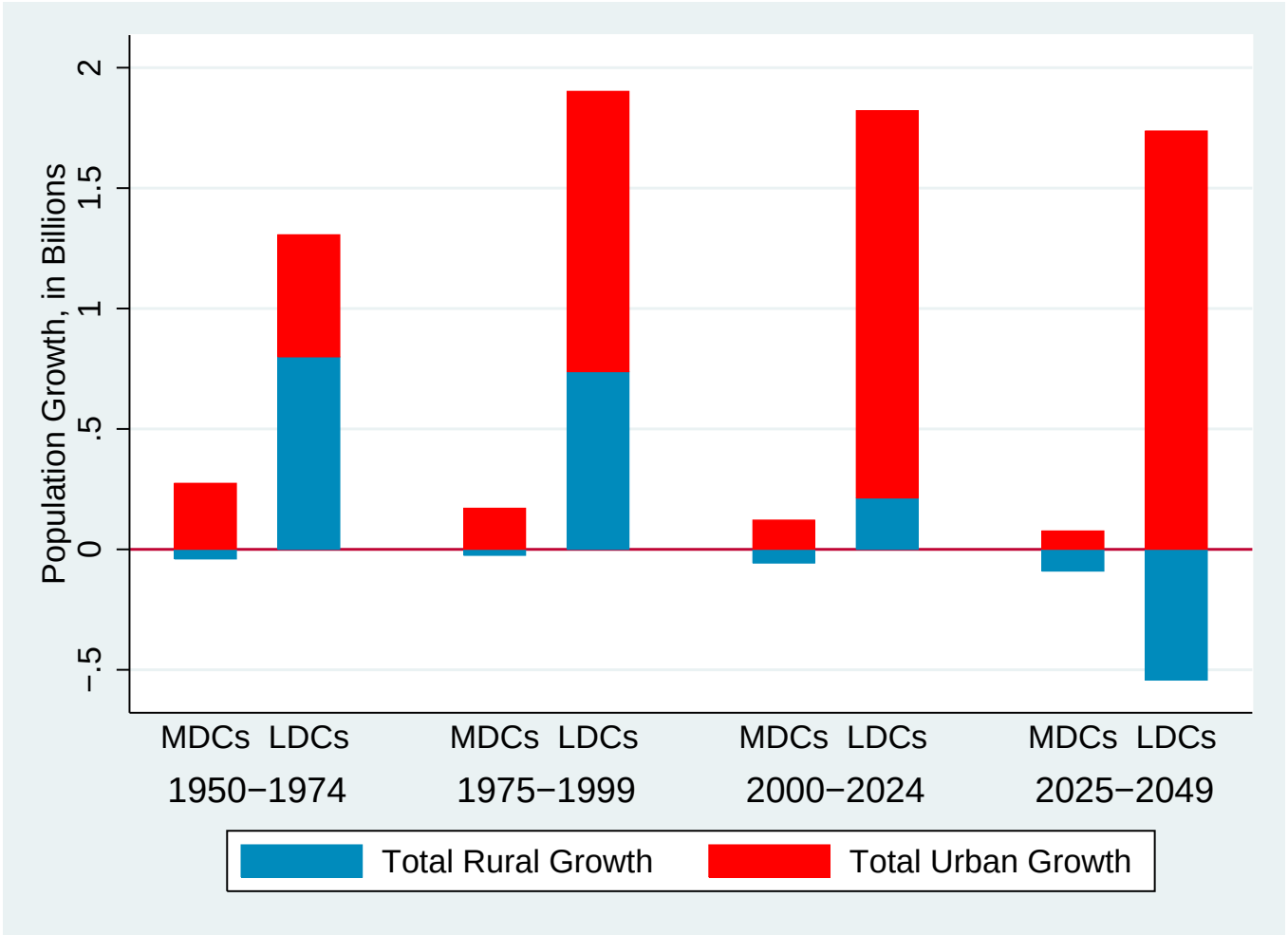
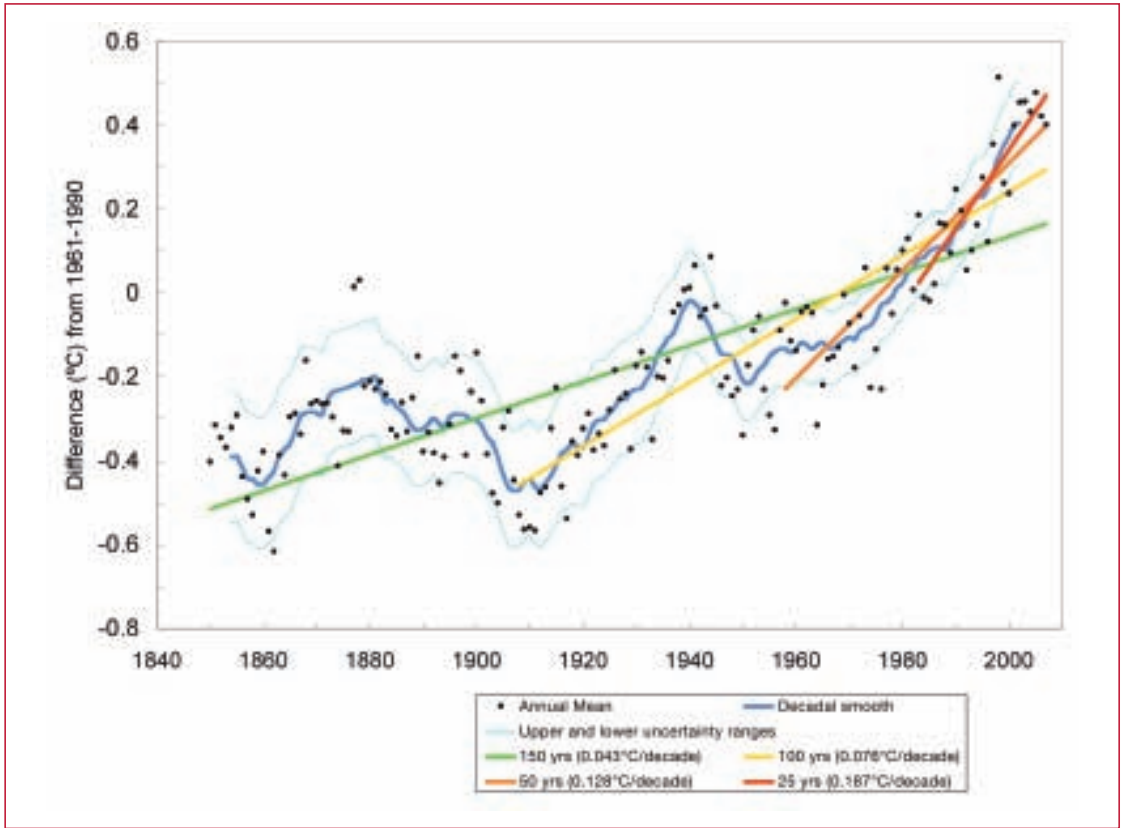
Enormous Growth Is Forecast in Urban Populations



Meanwhile, Global Temperatures Will Also Be Increasing

Annual global mean temperatures and decadal variations for the period 1850–2005, with linear trends for the last 25, 50, 100 and 150 years.



Source: based on data from the UK Hadley Research Centre.[2]

Poor Countries Will Be Challenged by Both Trends

- National, regional, and municipal governments in poor countries will need to formulate urban adaptation strategies that are spatially specific.
- *Exposure to climate risks* varies significantly over space—this is being documented by bio-geophysical scientists.
- But *vulnerability* also varies greatly across cities and among any given city's neighborhoods—yet this is *not (to date) being systematically documented by social scientists*.

Basic Data Needs for Urban Adaptation Going Unmet

With urbanization,

- Higher and higher percentages of national populations will be found in geographically small, dense units;
- National sample surveys *can* shed light on the determinants of city growth; but
- National sample surveys *cannot* reliably depict individual cities, to say nothing of city neighborhoods.

Use the Data Already at Hand!

To inform urban adaptation strategies, we must:

- Use the wealth of information that we already have at hand in the public domain—from national sample surveys and other sources—to specify city-specific models of population growth and forecasts; and
- Disaggregate national census data to the level of the political jurisdictions—municipal and even below—where many of the urban adaptation decisions will need to be made. This is an essential step in documenting vulnerability to climate-related risks.

Outline

The Research Team

- Deborah Balk (Baruch College), Gordon McGranahan (IIED, London), Thomas Buettner (United Nations Population Division)
- Gerhard Heilig (UN), Patrick Gerland (UN), Christopher Small (Columbia University, Lamont Doherty Earth Observatory), Susana Adamo (CIESIN, Columbia)
- Donghwan Kim (Stony Brook University), Valentina Mara (CIESIN), Megan Todd (Baruch), Sandra Baptista (Columbia, Earth Institute), S. Chandrasekhar (Indira Gandhi Institute, Mumbai), Audrey Dorelien (Princeton)

Quantifying Urban Climate-Related Risks

To quantify exposure, we draw upon three large, decades-long research programs:

- The Global Rural–Urban Mapping Project or GRUMP, housed at the Center for Integrated Earth Science Information Network (CIESIN) at Columbia University, which originates in work by Waldo Tobler and Uwe Deichmann in the mid-1990s;
- The UN Population Division's Cities Database, whose origins date to the early 1970s; and
- The Demographic and Health Surveys (DHS) and its predecessor, the World Fertility Surveys (WFS), also dating to the 1970s.

To quantify vulnerability, we draw from the World Bank's Small Area Poverty Mapping Project.

The Global Rural–Urban Mapping Project

For all low- and middle-income countries, this project supplies:

- Urban and rural population counts for finely disaggregated administrative units;
- Administrative unit boundaries rendered in shapefiles;
- Coordinates and population (approximate) for many tens of thousands of settlement points;
- Satellite imagery (night-time lights) indicating the spatial extent of urban agglomerations

GRUMP provides the essential spatial framework for our study.

The UN Population Division Cities Database

For all low- and middle-income countries, this remarkable project supplies:

- Time series of population size for each city that at some point reaches 100,000 population;
- Data on the unit (city proper, urban agglomeration, metropolitan area) for which this population is measured;
- Indicators of source and quality of each record.

The DHS and WFS Collection of Surveys

For many low- and middle-income countries, these surveys provide data on national, rural and urban, although not city-specific:

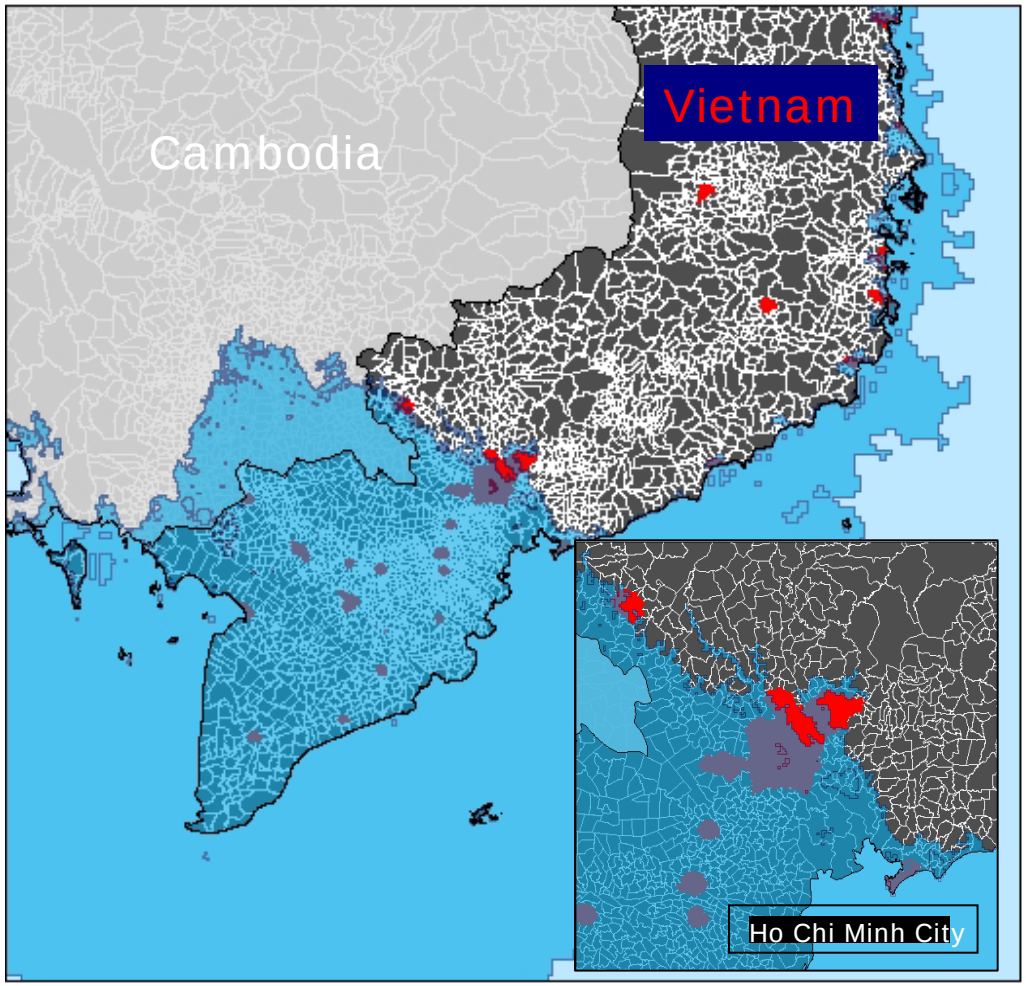
- Fertility rates—very important determinants of city population growth rates;
- Child mortality rates;
- Migration, albeit crudely measured.

These programs have already put over 200 surveys into the public domain. We will also be adding surveys from UNICEF's MICS survey program.

Seaward Hazards in Low-Elevation Coastal Zones

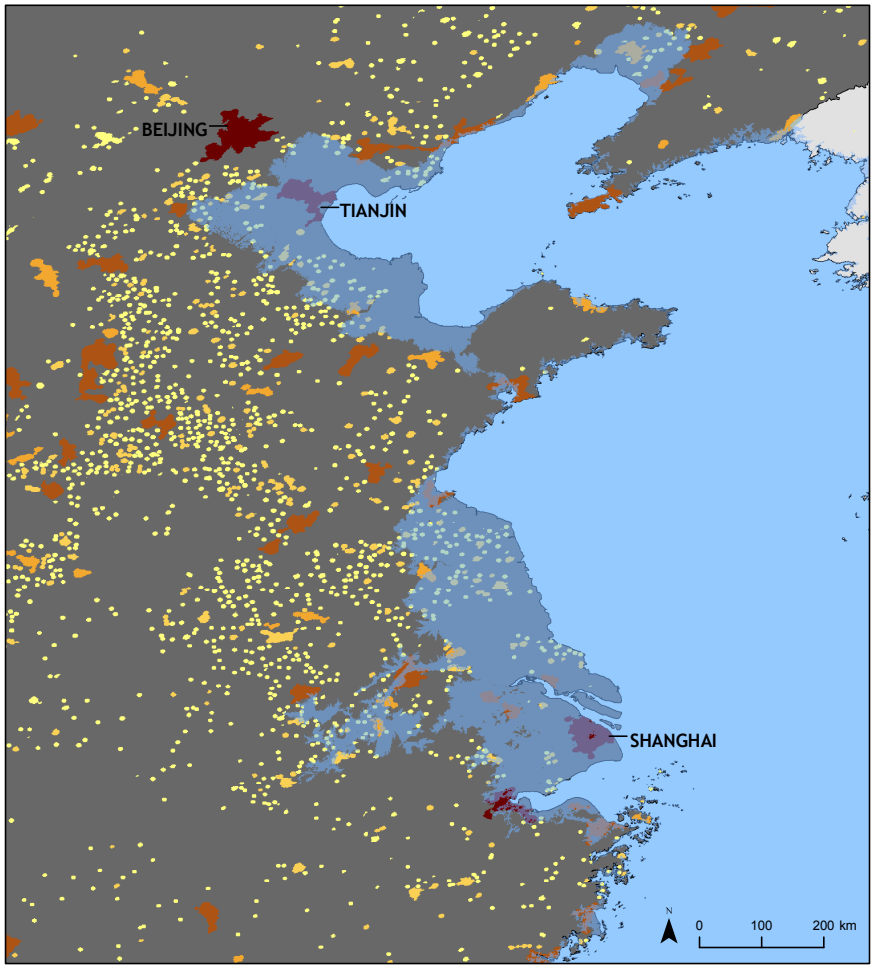
- Sea-level rise (recent forecasts of < 1 meter, but edging up); increased salinity of rivers, bays, groundwater; fresh water scarcity.
- More frequent and more intense tropical storms; storm surges—which often reach 1–5 meters and hit 9 meters during Hurricane Katrina;
- Coastal flooding and river flooding.
- More precipitation; landslides in some cities.

Southern Vietnam and Ho Chi Minh City



China's Economic Development Strategy at Risk

Source: McGranahan et al., 2007

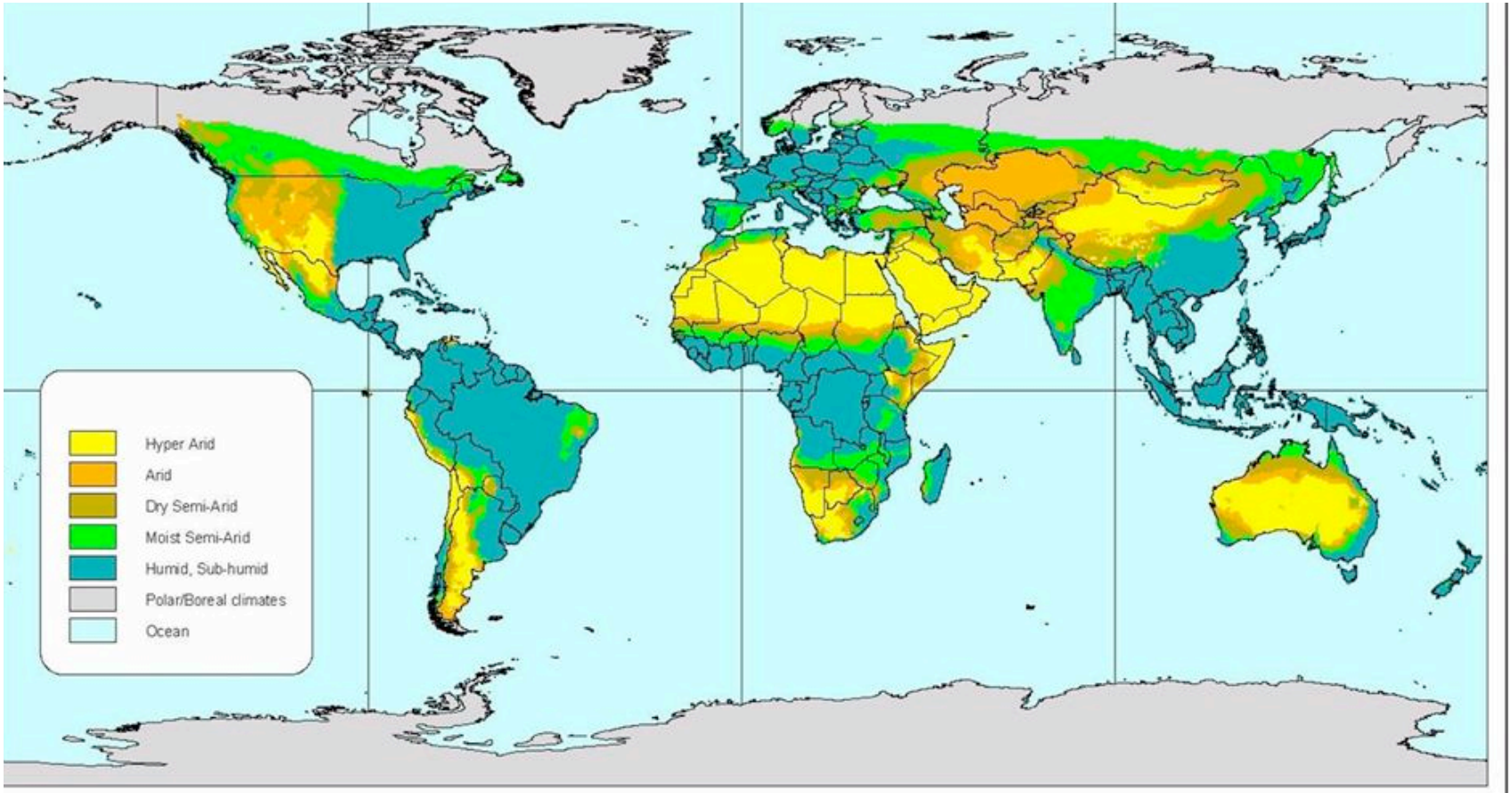


Drylands: Urban Water Scarcity and Rural Stress

Drylands are characterized by:

- Low, erratic precipitation, with a year's worth of rain often arriving via a few intense, erosive storms;
- Home to an estimated 2 billion persons world-wide, with developing countries account for about 72 percent of the drylands land area and 87–93 percent of its population;
- About 45% of residents are urban;
- Water scarcity already evident—an estimated 1300 cubic meters of water available per person per year, well below 2,000 cubic meters required for human well-being;
- Land degradation and "desertification" especially in areas with settled agriculture.

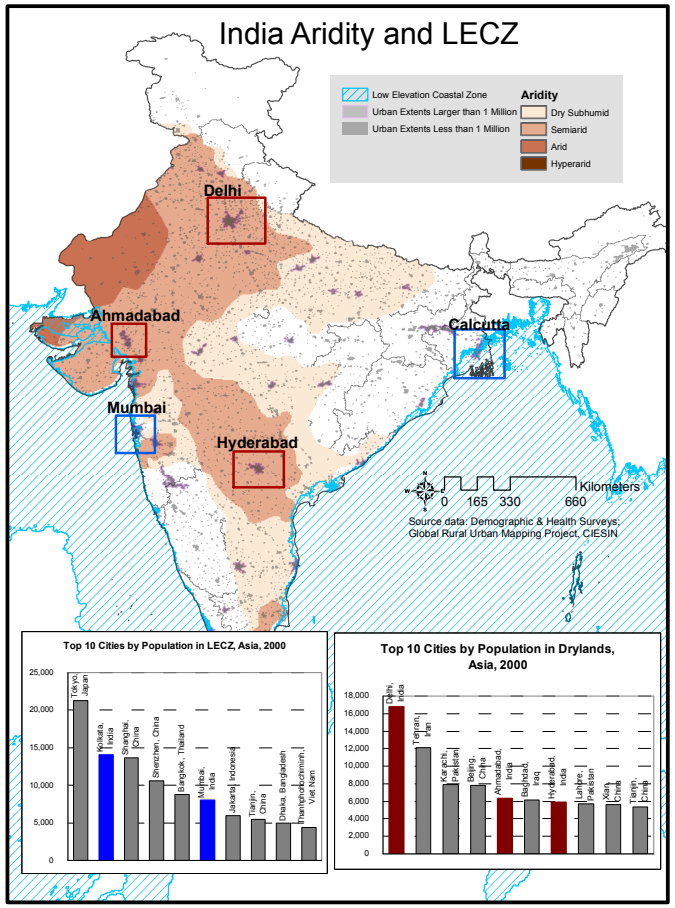
Drylands World-Wide



Source: Global Agro-ecological Zones (FAO-IIASA, 2000)

Geographic Projection (lat/long)

Drylands and the LECZ in India



Asia: Urban population and land in the LECZ and drylands

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Asia (including China & India)	Total		Dryland		LECZ	
City Size	Number of Cities	Population (000s)	Land Area (km2)	Population (000s)	Land Area (km2)	Population (000s)	Land Area (km2)
Less Than 100,000 persons	10,582	341,000	446,295	142,000	219,204	27,200	28,753
100,000 - 500,000 persons	1,470	301,000	279,866	122,000	141,552	37,000	26,061
500,000 - 1 million persons	180	124,000	94,797	48,500	46,348	15,700	8,689
1 million persons +	200	722,000	327,318	229,000	128,032	174,000	59,873

India	Total		Dryland		LECZ	
City Size	Number of Cities	Population (000s)	Land Area (km2)	Population (000s)	Land Area (km2)	Population (000s)	Land Area (km2)
Less Than 100,000 persons	2,845	77,100	113,396	51,700	76,986	2,839	3,733
100,000 - 500,000 persons	300	59,300	53,033	38,300	33,703	4,473	2,898
500,000 - 1 million persons	33	22,200	13,785	13,100	7,005	896	699
1 million persons +	37	126,000	41,800	68,500	24,355	29,400	4,321

China	Total		Dryland		LECZ	
City Size	Number of Cities	Population (000s)	Land Area (km2)	Population (000s)	Land Area (km2)	Population (000s)	Land Area (km2)
Less Than 100,000 persons	5,711	198,000	167,796	58,000	54,829	15,700	11,040
100,000 - 500,000 persons	690	141,000	81,895	40,300	30,713	15,300	6,803
500,000 - 1 million persons	81	56,400	29,438	13,100	9,502	8,406	3,164
1 million persons +	76	221,000	80,575	60,000	26,700	58,700	19,198

Asia (except China and India)	Total		Dryland		LECZ	
City Size	Number of Cities	Population (000s)	Land Area (km2)	Population (000s)	Land Area (km2)	Population (000s)	Land Area (km2)
Less Than 100,000 persons	2,026	65,900	165,102	32,300	87,389	8,661	13,980
100,000 - 500,000 persons	480	100,700	144,938	43,400	77,137	17,227	16,361
500,000 - 1 million persons	66	45,400	51,574	22,300	29,841	6,398	4,827
1 million persons +	87	375,000	204,943	100,500	76,977	85,900	36,354

Asia: In percentage terms,

Asia (including China & India)	Dryland		LECZ	
City Size	Population	Land Area	Population	Land Area
Less Than 100,000 persons	41.6%	49.1%	8.0%	6.4%
100,000 - 500,000 persons	40.6%	50.6%	12.3%	9.3%
500,000 - 1 million persons	39.2%	48.9%	12.7%	9.2%
1 million persons +	31.7%	39.1%	24.1%	18.3%

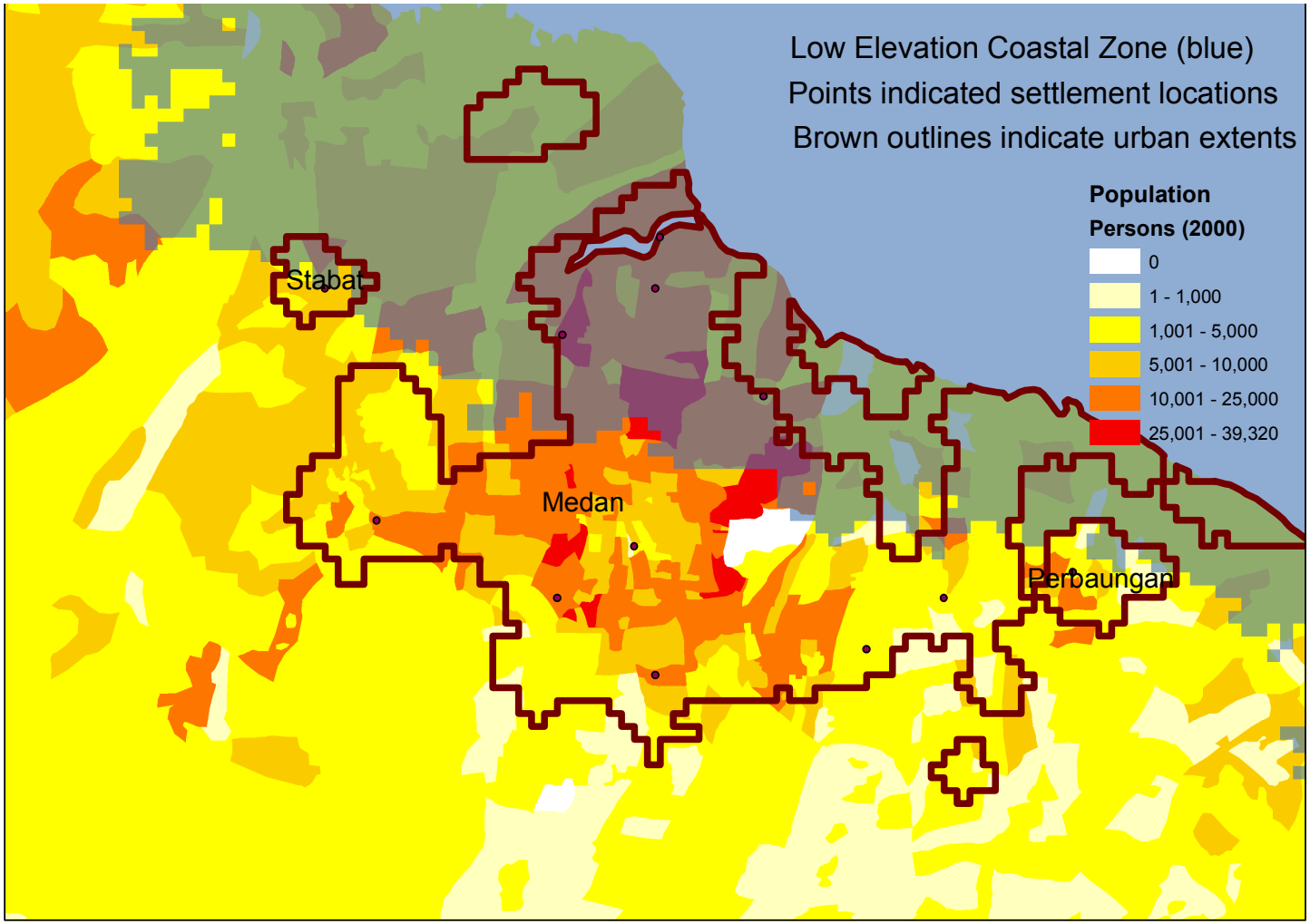
India	Dryland		LECZ	
City Size	Population	Land Area	Population	Land Area
Less Than 100,000 persons	67.1%	67.9%	3.7%	3.3%
100,000 - 500,000 persons	64.5%	63.6%	7.5%	5.5%
500,000 - 1 million persons	59.1%	50.8%	4.0%	5.1%
1 million persons +	54.2%	58.3%	23.2%	10.3%

China	Dryland		LECZ	
City Size	Population	Land Area	Population	Land Area
Less Than 100,000 persons	29.3%	32.7%	8.0%	6.6%
100,000 - 500,000 persons	28.5%	37.5%	10.8%	8.3%
500,000 - 1 million persons	23.2%	32.3%	14.9%	10.7%
1 million persons +	27.2%	33.1%	26.6%	23.8%

Asia except China and India	Dryland		LECZ	
City Size	Population	Land Area	Population	Land Area
Less Than 100,000 persons	49.0%	52.9%	13.1%	8.5%
100,000 - 500,000 persons	43.1%	53.2%	17.1%	11.3%
500,000 - 1 million persons	49.1%	57.9%	14.1%	9.4%
1 million persons +	26.8%	37.6%	22.9%	17.7%

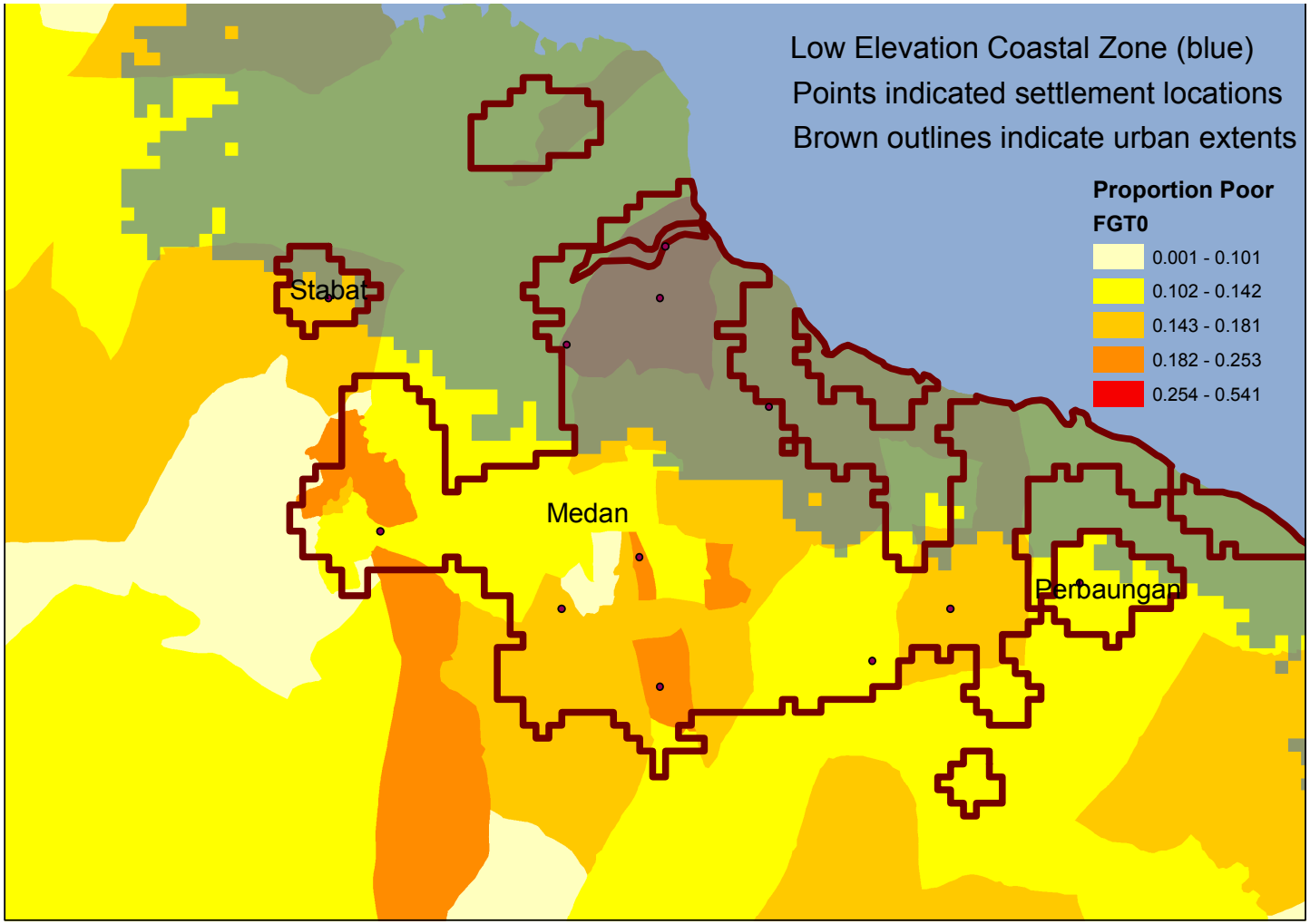
Population Exposed in the LECZ: Medan, Indonesia

Columbia University's Global Rural–Urban Mapping Project



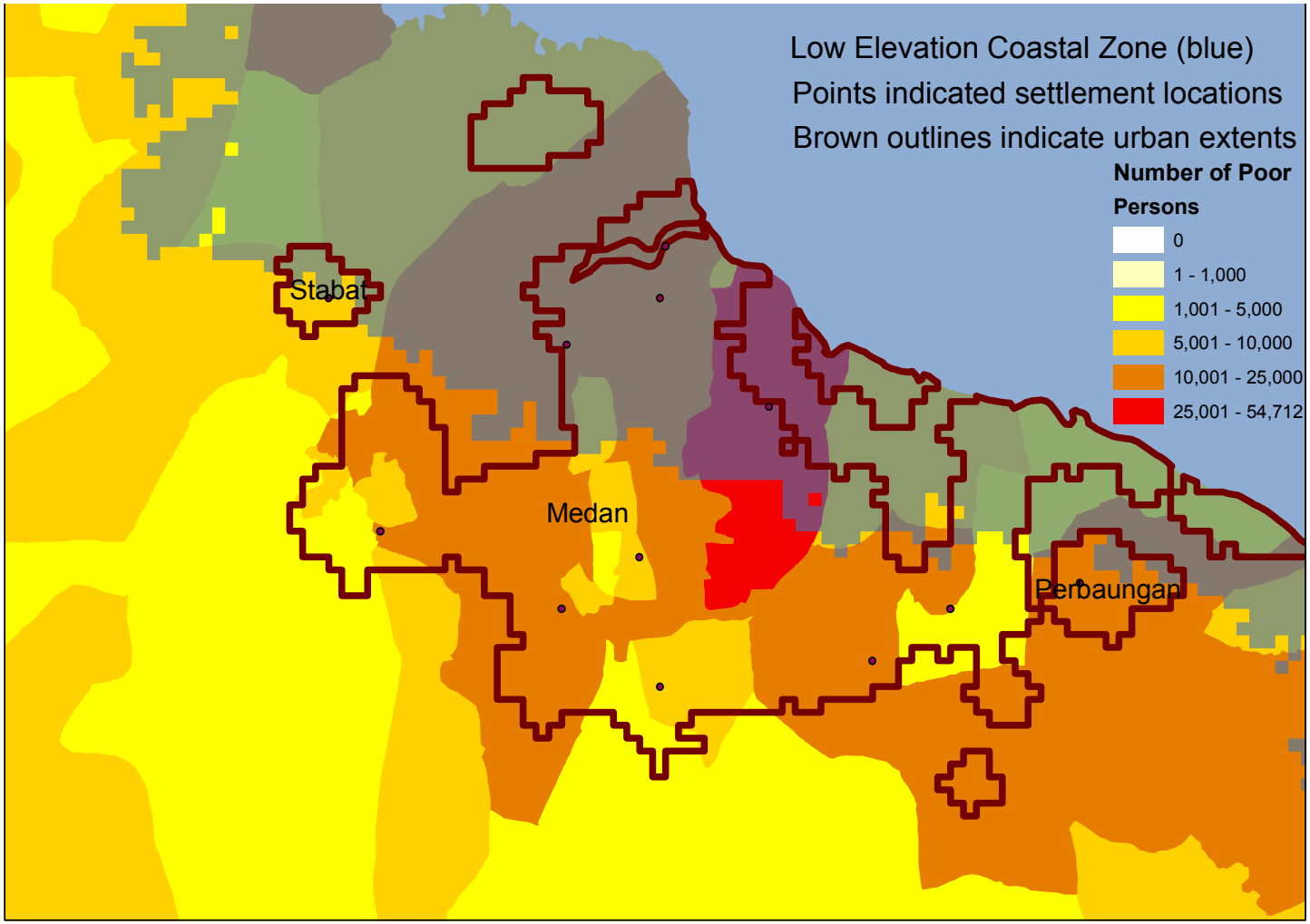
Vulnerability and the LECZ: Proportion Poor

World Bank's Small-Area Poverty Mapping Project



Vulnerability and the LECZ: Number of Poor

Small-Area Poverty Mapping



Estimates of Exposed Urban Poor, Selected Countries

	Percentage Poor			Number of Poor		
	Cities Outside LECZ	Cities Fully or Partly in LECZ		Cities Outside LECZ	Cities Fully or Partly in LECZ	
Country	All Residents	LECZ Residents	Others	All Residents	LECZ Residents	Others
Cambodia	31.36%	36.67%	33.50%	128,347	29,540	107,999
Ecuador	55.57%	50.44%	50.06%	1,277,348	291,947	361,388
Honduras	78.29%	70.21%	70.02%	642,154	28,859	41,404
Indonesia	23.23%	21.96%	22.01%	4,810,857	3,240,764	4,535,325
Panama	46.53%	46.20%	45.01%	41,516	38,420	283,851
South Africa	45.19%	17.16%	18.65%	2,555,721	59,730	1,037,184
Viet Nam	27.60%	27.97%	20.32%	342,030	2,112,987	413,623

Forecasting City Population Growth

- Longitudinal models should include urban total fertility rates—a very important determinant of city growth—and mortality rates, whether estimated nationally or for the urban populations of the city's region, as well as city-specific ecosystem and other geocoded variables.
- In contrast to deterministic forecasts, those based on models can be expressed in probabilistic terms, with confidence bands placed on city growth forecasts. The models can be explicitly Bayesian.
- Linkages among cities: Spatial econometric models of spatial error correlation and city network dependence.

Simple City Growth Regression Models

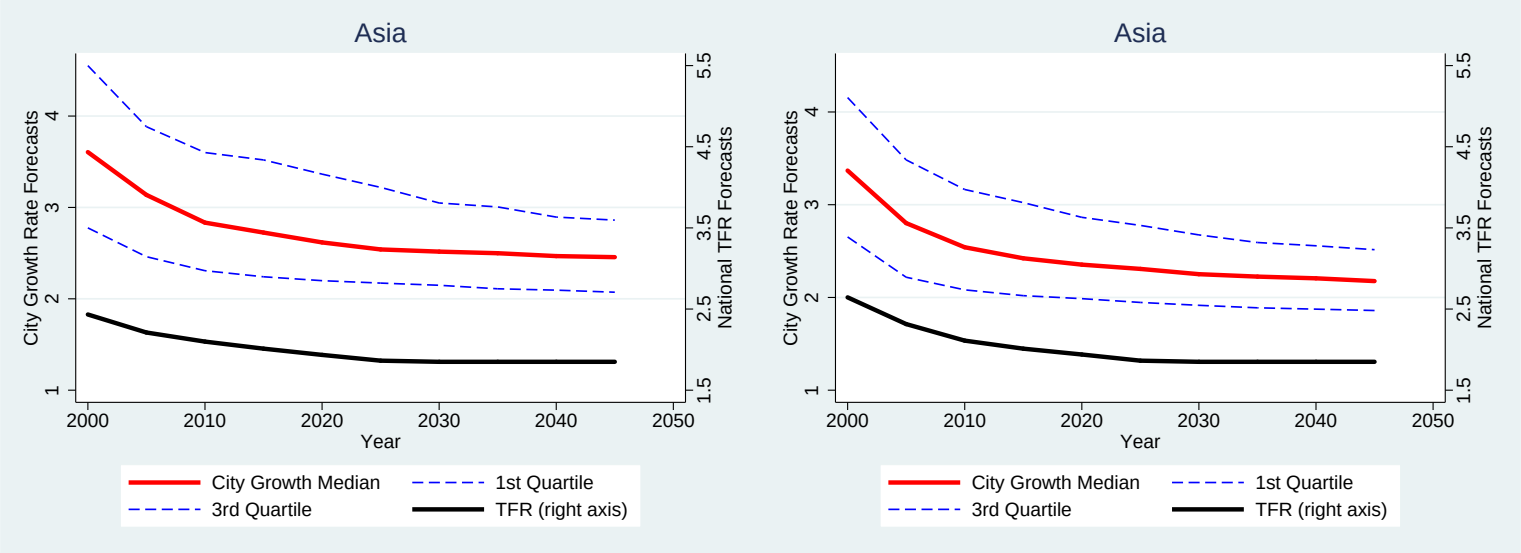
A simple city growth model takes the form

$$g_{i,t} = \alpha + \beta \mathrm{TFR}_{i,t} + \delta q_{i,t} + X'_{i,t}\gamma + v_{i,t}$$

with the i subscript representing city and t representing time. Here $g_{i,t}$ is the city population growth rate, $\mathrm{TFR}_{i,t}$ is the urban total fertility rate in the sub-national region of city i and $q_{i,t}$ the urban child mortality rate (migration rates should also be included, even if poorly measured), $X_{i,t}$ represents spatially coded eco-zone and geographic variables, and $v_{i,t}$ is an error-components disturbance term.

City Population Growth Forecasts for Asia

Regressions using DHS/WFS, UN Population Division Cities Database and GRUMP



LECZ growth forecasts in the left panel, and non-LECZ forecasts on right. Total fertility rate (TFR) in black.

How Ambitious Should Forecasts Be?

Twenty-nine years ago, in *Patterns of Rural and Urban Population Growth*, the United Nations warned,

> *Projection of city populations is fraught with hazards. . . . There are more than 1,600 cities in the data set, and it is obviously impossible to predict precisely the demographic future of most of them. . . . In most cases, national and local planners will have access to more detailed information about a particular place and could supply more reliable information about its prospects.*

Referring to Mexico City, whose population was to rise to 31 million by the turn of the century according to the 1980 projection, the United Nations cautioned,

> *Whether such size can actually be attained is, of course, questionable. It has been noted, for example, that population growth at Mexico City threatens to destroy tree cover that is necessary to prevent erosion and flooding. Water-supply also appears to be a potentially constraining factor in this case. Natural or social limits to growth could be encountered well before a size of 31 million is reached, or of 26 million for São Paulo, and so on down the line.*

All Good Points—and Yet:

An Outpouring of New Data

To an extent that probably could not have been foreseen in the early 1980s, several streams of new data—on demographic behavior as well as land cover, water supply, and environment—have emerged into the public domain over the past decades. If these new materials are joined together in a spatial framework, they may well support more informed and credible city population estimates and forecasts than the experts of the time could have envisioned.

Do Local Planners Have Access to the Detail?

- In some poor countries, they do, of course.
- But in most—especially in the smaller cities of these countries where the technical sophistication and resources of the national capitals are lacking—national and local planners operate with the most rudimentary population and socioeconomic data, which often have little to no useful spatial content. Here there is an urgent need for information that can be addressed (initially, at least) through internationally-assembled but spatially-specific datasets.
- SEDAC, anyone?