The Demography of 'Natural' Disasters

What Can We Learn from DesInventar?

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Outline

The Hyogo Framework for Action, 2005–2015

This international initiative aims to:

- Fully integrate disaster planning, early warning, preparedness, and vulnerability reduction into economic development strategies
- Ensure that multiple levels and units of government are well coordinated and linked with NGOs, community-based organizations, and civil society
- Repeatedly emphasizes integration at the level of the community, need to understand risk perceptions and constraints on responses at the level of families and neighborhoods
- But what data will support an evidence-based approach?
- United Nations (2009) *Global Assessment Report on Disaster Risk Reduction: Risk and Poverty in a Changing Climate* an excellent overview; other GARs have followed.

Looming Extreme-Event Threats

- Sudden-onset extreme weather events: typhoons, heavy precipitation, coastal and interior flooding, landslides—these disasters believed to disproportionately harm women and children and there may be important differences in exposure, vulnerability, and resilience by education as well.
- Gradual-onset conditions: Less is known about droughts and in arid regions, increasing water scarcity. Implications for rural and urban dwellers (especially the poor) and for rural-urban migration.

Adaptation to Extreme Events and Climate Change

- National, regional, and municipal governments in poor countries will need adaptation strategies that are spatially-specific and evidence-based, focusing on individual cities and neighborhoods within them.
- Exposure to climate-related risks is being studied systematically by bio-geophysical scientists at the level of world regions and sub-regions.
- But exposure varies greatly sub-nationally and across cities and their neighborhoods—these smaller-scale differences are not being systematically examined by social scientists.

The Urban Dimension

National climate adaptation and risk-reduction plans often ignore city dwellers

- Poor countries are approaching urban majorities
- Some extreme-weather events (e.g., floods) repeatedly strike city-dwellers, harming lives and damaging assets and livelihoods
- Apart from national censuses, demographers collect little or no *city-specific* data
- Majority of urban residents live in small- and intermediate-size cities, where officials have limited abilities to anticipate risks and guide local development.
- Substantial mobility and both rural-to-urban and urban-to-urban migration: changes of neighborhood and locale generate a sequence of place-specific exposures.

What Role for Demographers?

How Do We Link Our Socoeconomic Data to Hazard Exposure?

This is the major challenge facing demographers. We have much to contribute, but we must organize our data to join the adaptation and risk-reduction conversations. Population censuses can make a vital contribution—but only if they are fully disaggregated. Longitudinal surveys—if properly designed (or retrofitted) with spatial detail—can address issues about short-term and longer-run consequences.

Mapping Demographic Data

1. Measures of built-up area (structures) from Martino Pesaresi's GHSL rasters, from 1975 to the present using LandSat and other sensors. (Time-series!)
2. Measures of large-city population size and growth rates (UN Population Division) and increasing coverage of smaller cities and towns. (Time-series!)
3. High resolution population density rasters, from Andy Tatem's *WorldPop* team, see `http://www.worldpop.org.uk/`
4. Economic activity and city spatial extents: Night-time lights from NOAA, both OLS (Time-series!) and the newer VIIRS.
5. Sub-national census and survey (IPUMS, DHS, MICS) data on population numbers and composition (Time-series at admin level)
6. DHS sampling cluster coordinates: fairly precise spatially (Not exactly a time-series, but multiple points in time)

Themes and Fundamental Issues

- Selectivity biases in disaster reporting. What kinds of extreme events go under-reported? What are the spatial and social differentials in reporting?
- When is spatial specificity not enough? Droughts versus floods.
- Characteristics of those exposed to risk and those actually harmed

Where, Exactly, Have Disasters Struck?

Improving the Empirical Record

Surprisingly, the spatial locations of disasters have not been recorded very specifically.

- *EM-DAT*: The OFDA/CRED International Disaster Database. National-level disaster reports are available here: `http://www.emdat.be`. In recent years, sub-national units where disasters occurred are listed, but effects not disaggregated.
- Much of the literature on disaster exposure and consequences has employed whole countries as the units of analysis. Poor, less poor, and higher-income countries; High, moderate, and low exposure to risks.
- Helpful, but hardly enough.

Disasters in Guatemala: EM-DAT (2014)

	Disaster	Date	Total Affected
1	Earthquake	4/2/1976	4,993,000
2	Drought	3/1/2009	2,500,000
3	Earthquake	7/11/2012	1,321,742
4	Flood	12/10/2011	528,753
5	Storm	1/10/2005	475,314
6	Storm	28/05/2010	397,962
7	Drought	6/1/2012	266,485
8	Flood	22/10/2008	180,000
9	Drought	9/1/2001	113,596
10	Storm	26/10/1998	105,700

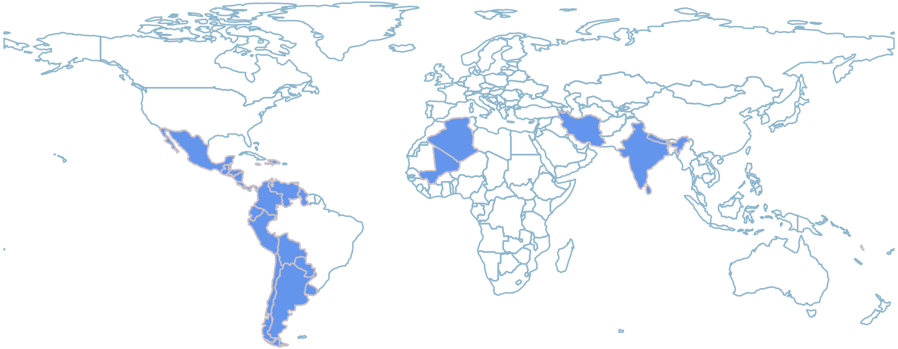
The DesInventar Program

Since the late 1980s in Latin America and a smattering of other countries in Africa and Asia, a coherent system of comprehensive, small-scale disaster reporting has been in place, with protocols, software, and public-domain data: `http://www.desinventar.org`.

Curiously under-exploited by researchers to date, apart from thin summaries in GAR (2013). Not clear whether funding exists to sustain the initiative.

The Core of the DesInventar Program

Other countries (not shown) have tested parts of the protocol: see GAR (2013)



Disasters in Guatemala: DesInventar 1988–2011

Estimates from 5000+ spatially-specific reports

Type of Harm	Flooding	Landslides
Deaths	882	836
Injuries	1,204	808
Otherwise Harmed	1,042,530	26,409
Missing	991	131
Evacuated	507,723	22,255
Relocated	20	779
Indirectly Harmed	1,940,733	1,668,509
Houses Destroyed	26,426	1,823
Houses Damaged	153,180	3,490

The DesInventar Approach

- Event occurs (e.g., storm)
  - No human harm ⇒ No record of event (Design bias)
  - Human harm occurs:
    - But not reported in the media ⇒ No record of harm (Reporting biases)
    - Reported in the media ⇒ Disaster record(s) created via a well-conceived process of:

      Verification by two or more coders

      Spatial pinpointing with a record created for each spatial (administrative) unit affected

      Coding at most disaggregate level possible given the verified data

      Notes on street addresses often included for urban events

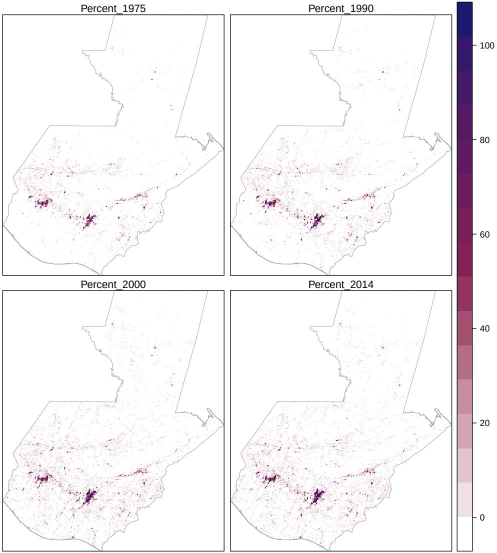
      Multiple types of harm detailed for each unit

Shortcomings

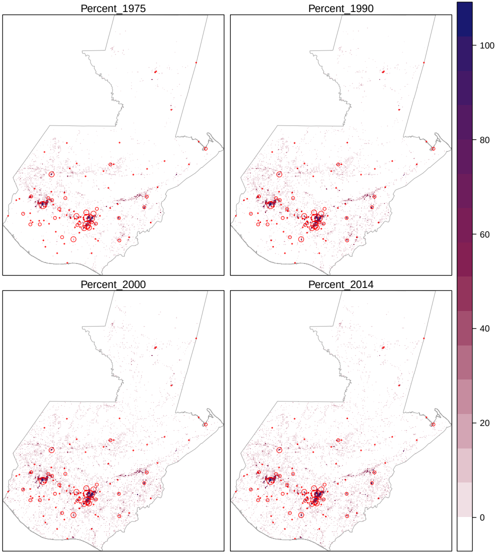
Issues to consider in designing future reporting systems

- What is the reach of the media?
- What events and harms are deemed "newsworthy"?
- As we'll see, improves greatly on the who is exposed to risk analysis, but —
- Does not address the fundamental problem affecting most disaster data: Who is harmed? Sex, age, education, poverty, . . .

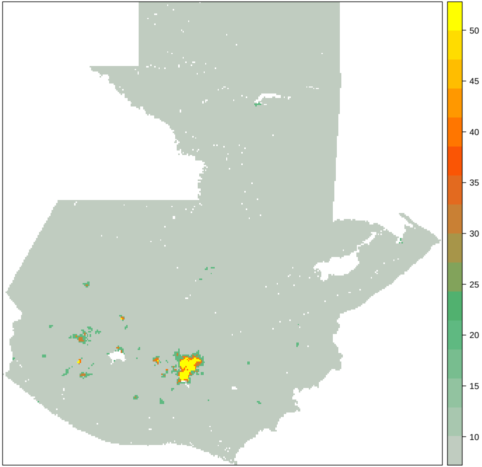
Built-Up Area from GHSL, 300m Resolution



Urban and Rural Structures: GHSL

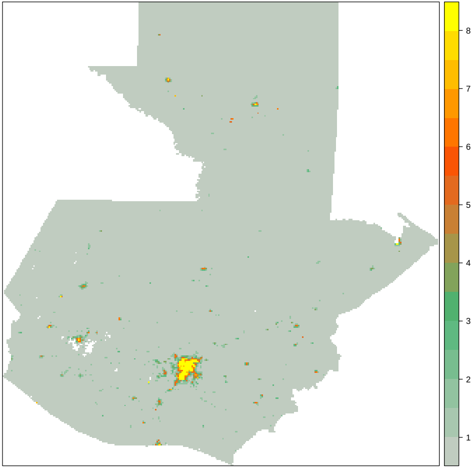


Populations Densities from the WorldPop Raster

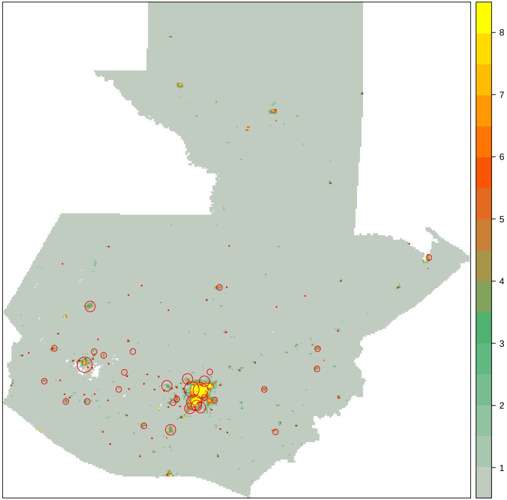


VIIRS High-Resolution Lights

Even more detailed measures of structures will appear in the next 2 years . . .



Guatemalan Cities (population 10,000+) and VIIRS Lights

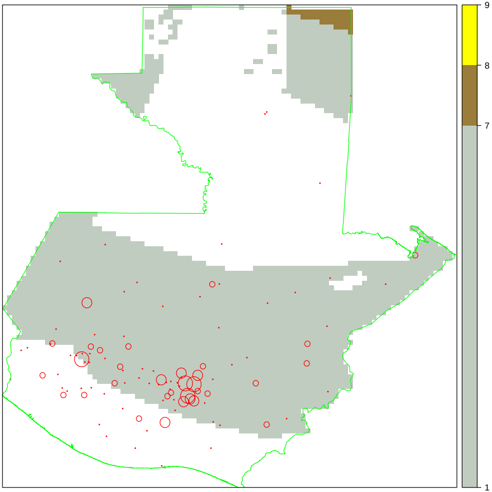


Probabilistic Models of Risk Exposure

- I use the 2005 “Hotspots” measures put into the public domain by the World Bank, CIESIN at Columbia University, and a host of partners. For data and documentation, see `http://sedac.ciesin.columbia.edu/data/collection/ndh`
- Provides model-based estimates for a range of risks; global coverage
- Spatial resolution often coarse, but gives a starting-point for more detailed country-specific research

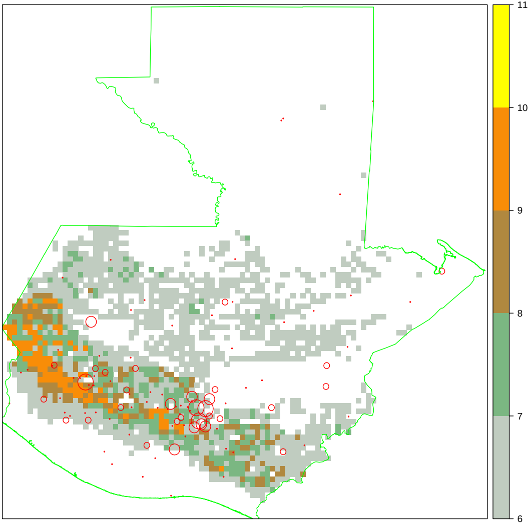
Locating Hazards using Models: Hurricane Risks

From storm tracks; Decile among all exposed areas world-wide



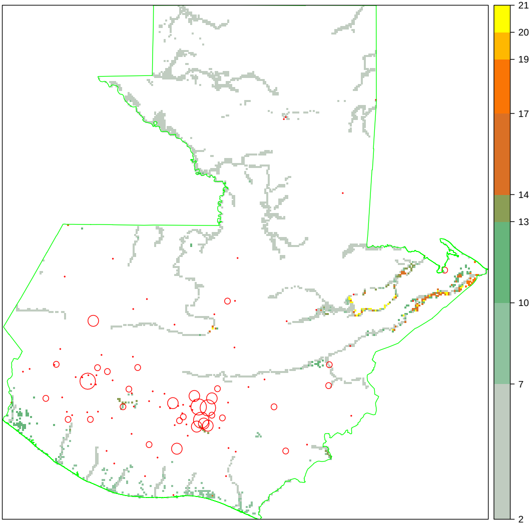
Landslide Risks

Probability models use slope, soil type and moisture

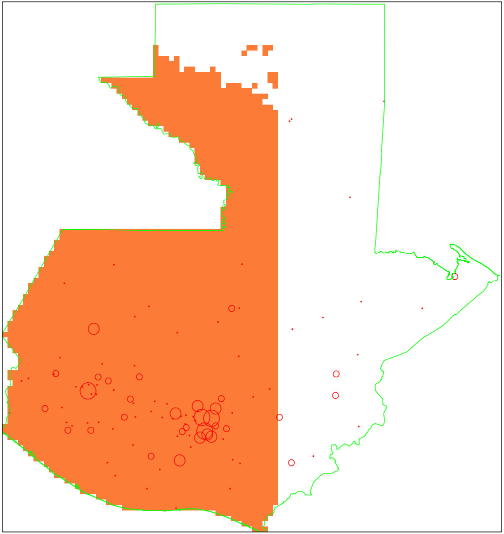


River Flooding Risks

Dartmouth Flood Observatory model



Drought



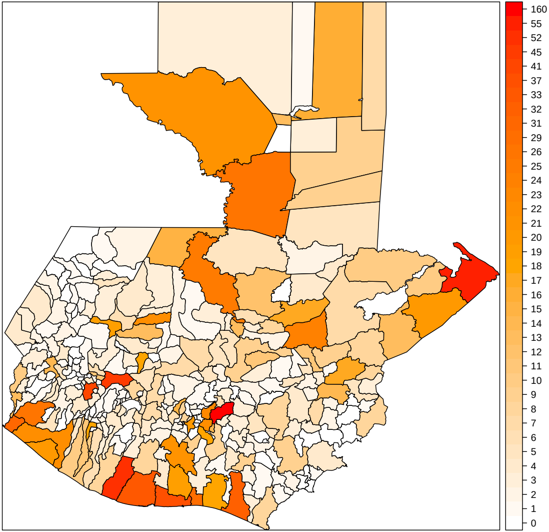
Estimated Population at Risk: Total and Urban

Using WorldPop raster and city-specific populations

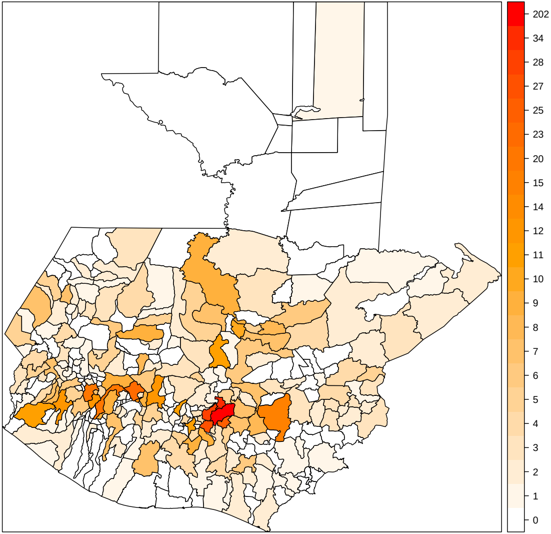
Risk	Total Population	City and Town Population
Hurricanes		
1st decile	10,367,818	3,597,841
7th decile	45,420	10,299
8th decile	2,476	
Landslides		
Category 6	3,716,903	1,418,933
Category 7	1,633,098	214,657
Category 8	1,772,364	257,605
Category 9	823,010	134,055
Category 10	524,186	68,566
Inland Flood Risk		
"Low"	275,702	61,123
"Medium"	79,761	40,274
"High"	2496	
Drought	12,145,434	3,819,705

Flood Events, 1988–2011, Recorded by DesInventar

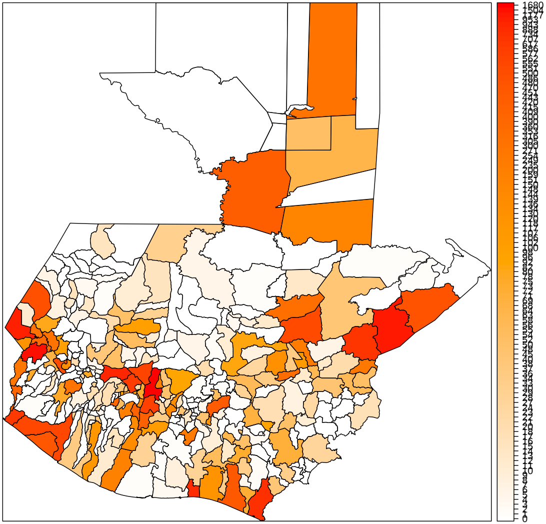
Units are *municipios*



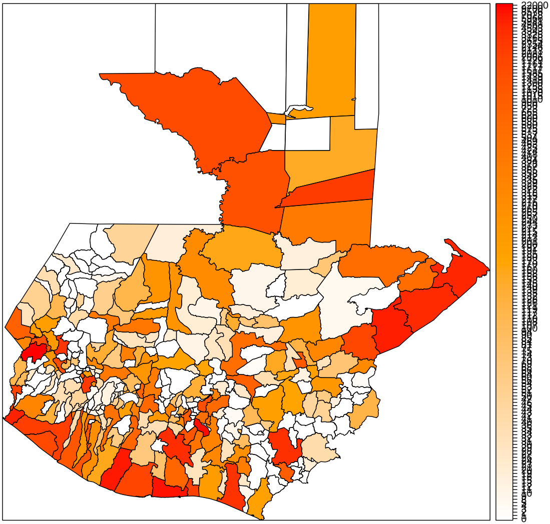
Recorded Landslides



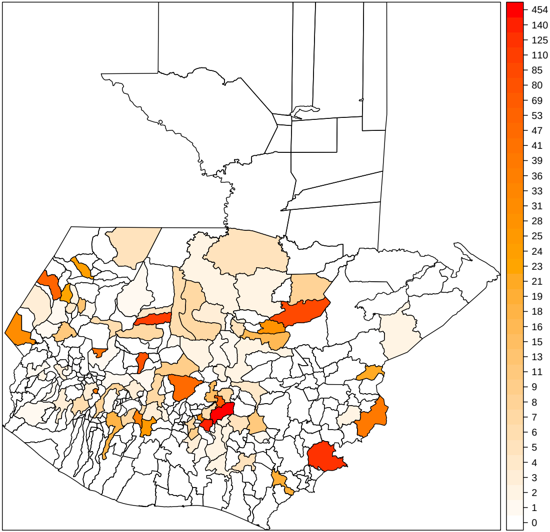
Homes Destroyed by Floods, 1988–2011



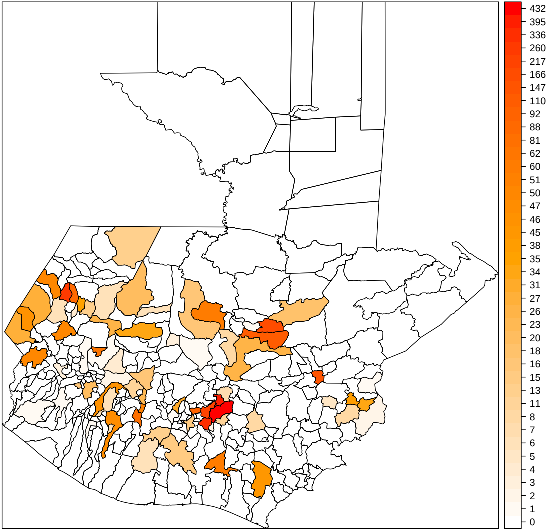
Homes Damaged by Floods



Homes Destroyed by Landslides, 1988–2011

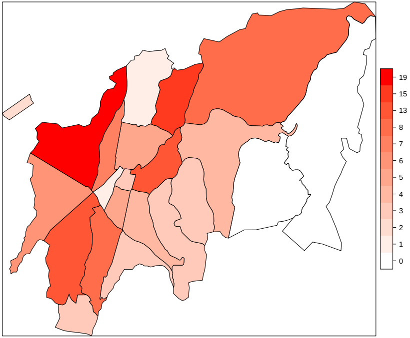


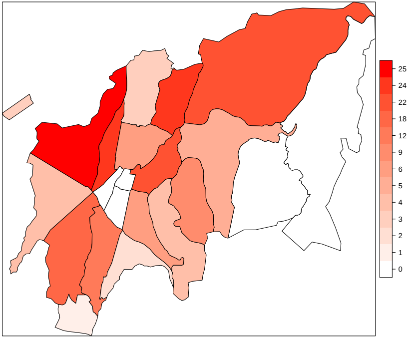
Homes Damaged by Landslides



Flooding and landslides within Guatemala City, 1988–2011

By the *zonas* of the *municipio*

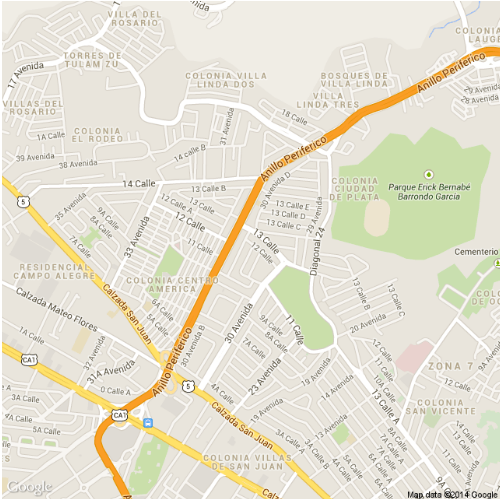




Garbage pickers in a Guatemala City ravine

Pinpointing disasters in Guatemala City by address

Parts of Zone 7 as seen in Google Maps



We've Seen *Where* Risky Events Occur—but *Who* is Exposed to Them?

- Using 2002 Guatemalan Population Census (we have the full micro-records) we can characterize all *municipios* and (eventually, we hope) the *zonas* of Guatemala City by: education, age, sex, proxies for poverty in both urban and rural settings.
- A 2002 small-area poverty map, based on a living standards survey and the census data, also summarizes municipios by mean consumption and indexes of poverty and inequality.
- Problem: Both sources represent Guatemala City as a whole. Neither disaggregates it even by *zonas*—despite the well-known and enormous within-city inequalities! Within-city differentials are commonly overlooked!.

Illustration: Risk Exposure Differentials by Education

- 2002 Population Census provides completed schooling, by levels and grades within level. Examine "no schooling" and "any secondary or tertiary". Census also records *municipio* of residence.
- Linking these records on people to DesInventar records on municipios, and thereby to counts of disasters, we can:
  - Estimate the average number of disasters by schooling level
  - Investigate place-of-residence and environmental risk association: For each schooling level, are people likelier to live in lower-risk municipios, or in higher-risk municipios.

A very simple descriptive analysis follows—it reveals the consequences of naively representing all Guatemala City as one unit, rather than disaggregating this highly unequal city by within-city zone.

Let π_m^s be the proportion of schooling group s living in municipio m. Let T_m be the risk index for municipio m (e.g., total disasters over 1988–2011).

$A^s = \sum_{m=1}^{M} \pi_m^s \cdot T_m$ is the average risk for schooling group s.

We can correlate

$$\begin{bmatrix} T_1 \\ T_2 \\ \vdots \\ T_M \end{bmatrix} \; and \; \begin{bmatrix} \pi_1^s \\ \pi_2^s \\ \vdots \\ \pi_M^s \end{bmatrix}$$

to see whether people with s schooling are likelier to live in lower-risk municipios or higher-risk municipios. Then we'll compare across schooling groups.

All municipios For flooding (and also true for landslides):

$A^{none} = 12.5$ floods over 1988–2011
$A^{secondary+} = 47.5$ floods
Correlation between π_m^{none} and T_m flood risk: 0.54
Correlation between $\pi_m^{secondary+}$ and T_m flood risk: 0.77
Consequence of aggregating the zones of Guatemala City!

All municipios except Guatemala City Again for flooding:

$A^{none} = 8.4$ floods over 1988–2011
$A^{secondary+} = 14.1$ floods
Correlation between π_m^{none} and T_m flood risk: 0.37
Correlation between $\pi_m^{secondary+}$ and T_m flood risk: 0.38

What Does This Illustration Teach Us?

1. The unfortunate tendency to ignore within-city heterogeneity (in SES and in incidence of hazards) can produce highly misleading estimates of SES differentials in risk exposure
2. Had the *zonas* of Guatemala City been identified in the Census, a different risk profile for the educated and uneducated would have emerged
3. But—even with Guatemala City out of the picture—there is suggestive evidence of positive associations of areal risk and individual education.
4. Spatial specificity is not enough. Even if the educated do tend live in riskier areas, they may be able to protect themselves against harm, safeguard their own assets, and rebound more quickly than the less-educated living in the same areas.

Next Steps

- Analysis is underway of all core DesInventar datasets. Not every country supplies micro-level census records, but much can be done to map socioeconomic exposure even without them.
- The low-elevation coastal zone (not very important in Guatemala) will be a significant feature in many of these countries.

Data Issues Needing Attention

- What other countries are maintaining DesInventar-like records of disaster events? What is going on in Asia?
- How successful are any of these efforts in locating gradual-onset conditions and identifying the harm coming from them? I am skeptical about whether DesInventar adequately measures the incidence of droughts. How often is a sustained drought "newsworthy"?
- Census data can describe the neighborhoods in which disasters took place, but not the characteristics of affected individuals and households. Within-neighborhood heterogeneity will remain a challenge even in estimating exposure to risk.

- Not even DesInventar systematically collects records of harm according to sex, age, education of the affected people. Relief and humanitarian agencies evidently unable to fill this data gap. Who can?
- Potential of longitudinal studies to contribute—if they link in spatially detailed hazard event information, and craft questions that identify individuals and households who were harmed (not simply in the vicinity of a hazardous event). Big challenges in dealing with mobility, migration, and mortality.
- Some extreme events—droughts—can do damage at a distance (for instance, by raising food prices thereby harming the urban poor) as well as in the immediate vicinity. Spatial specificity helps, but is not enough.