Global Spatial Population Projections: What Can Be Done Now?

Roosevelt House (New York, NY) **September 20, 2013**

Attendance

Mark Montgomery (SUNY Stony Brook)
Barney Cohen (UN Population Division)
Corrie Griffith (UGEC)
Burak Gunerlap (Texas A&M)
Susana Adamo (Columbia Earth Inst.)
Alex de Sherbinin (Columbia Earth Inst.)
Solly Angel (NYU Stern)
Chris Small (Lamont, Columbia)
Patrick Gerland (UN Population Division)
Danan Gu (UN Population Division)
Deborah Balk (Baruch)
Bryan Jones (NCAR Boulder/Baruch)
Bill Solecki (Hunter/CISC)
Carson Farmer (Hunter)
Peter Marcotullio (Hunter/CISC)
Joy Cytryn (Hunter)
Natsumi Yokura (Hunter/CISC)

Summary

A workshop on *Spatial Population Predictions: What can be done now?* sponsored by CISC and the IHDP-UGEC was convened at the Roosevelt House, Hunter College, NYC on Friday, September 20th from 8:30 am to 6:00 pm. The workshop gathered scholars from the NYC region and a few from out of state, to discuss work on producing human spatial population distributions to the year 2100. After an intensive day of presentations and discussions (see agenda), we convened for a dinner to discuss collaboration and the way forward. The dinner was held at *The Oyster Bar*, Grand Central Station, NYC.

Notes from the discussions

Introduction

(Peter Marcotullio)

Why are we here?
In recognition of the conjecture that it matters how people act, and where they act, there is a need to compare the spatial distribution of human population and biodiversity.

Greatest biodiversity exists around the equator and although population growth began in the 25 – 45 latitude of the northern hemisphere, subsequent spikes have moved south towards the equator. Against this backdrop, recognition of climate change impacts as well as where people live and how they act becomes increasingly more important.

2 questions for the workshop:

1. For population projections, what can be done now?
2. What type of collaborative projects can we generate?

Integrated spatial population models (10:00am-12:00pm)

Moderator: Barney Cohen
Panel: Deborah Balk, Bryan Jones, Mark Montgomery

Deborah Balk: Apples and Oranges
There are land use and population participants attending today.

Are population distribution maps meaningful? How wrong is it? Is it better than nothing? There is a data problem… There is a data problem. It is better now than before. How much can we do with information that is not just that accurate and how we can leverage the best possible efforts?

It matters what kind of land use analyses, and what kind of population data we use – the silos of each discipline have been working together for the past period but we need to think about what we are trying to create and analyze.

Funding is another factor to consider.

Bryan Jones: A gravity-based approach to modeling spatial population scenarios

Use GRUMP for spatial extents:

Gravity-based models are a population potential model. Characterized by gravitational flows in 2 directions and attempts to measure spatial interaction (e.g. function of population and distance between locations). Examples include migration and transportation models. Potential model looks at influence of one location in one direction (Albany and Boston → Hartford, ultimately → New York City).

Spatial choices are informed by accessibility, and population agglomeration is a proxy of certain characteristics, such as jobs and economic growth.

Modified potential-based spatial downscaling model – must assume that there is redistribution of population when looking at population growth (results from not using a geospatial mask).

3 different projects:
Global projections - Need to refine methodologies using historical data.
Fast-track projections - Rural populations decrease while urban population grows.
Grid-cell density population projection - More sprawl in the distribution with higher densities in the northeast.

What is/are the definition of urban/rural definition: What is urban land and who are urban people? The lack of clarity makes it difficult to correlate these two factors.

Future work: continued methodological refinement, investigate and incorporate multi-scale drivers of population change (demo, socio- econ), and add characteristics of the population (age, education, and income)

Mark Montgomery: Where are the Data? Sources and Challenges in the Population-Climate Change Relationship

Most of the world's urban population growth will occur in four countries – many poor countries are approaching urban majorities, and since extreme weather events repeatedly strike city dwellers, we need to think about who is in the pathway of environmental threats, and what can demography inform us of on this question?

Most urban residents live in small and intermediate-sized cities. These cities often lack the resources and information to anticipate and deal with risks and guide urban development.

We need more population information at the **city-level** if we are to make spatial analyses meaningful. The cell approach can tell us a lot, but it doesn't tell you anything about the characteristics of those people in each cell, and thus we don't know who is in the pathway of environmental threats.

- We can only get this information at the national census level, but in poor countries the data is usually not aggregated nor mapped anyway.

The basic formula measuring growth rate is still a good method:

- Population growth rate = birth rate – death rate + in-migration –outmigration
  - Urban fertility is an important factor\
  - 2/3 of growth is attributable to natural increase (birth rate – death rate)
  - Migration is a difficult measure, but achievable in many places.
- But…we don't have the equation components at the city-level.

Also, the equation does not look at changes in the spatial form of cities, thus a hybrid approach is useful. What might go into this hybrid equation?

- Sub-national census and survey data (IPUMS, DHS, MICS)
- Density rasters (Tatem)

    - Shows where people live (not characteristics, but totals)
    - Able to overlay flooding models on density models to understand who is in pathway of disasters
- Sampling clusters (DHS)
    - Sub-national divisions/boundaries (characterized urban fertility, child mortality, and loose migration figures)
- City population size (UN)
    - Current and future urban exposures
    - Small cities (emergence of….)
- City spatial extents (airborne images – LandSat) – and from this, changes in that shape.

The main problem to understanding who is exposed to risk in cities is the need for city-specific growth information that is spatially disaggregated.

- One solution is to overlay a lot of different kinds of information. Another solution is to take demographic rates and insert them into a gravity model.
- Another solution is to work with census bureaus and other agencies to get this kind of data. Most bureaus are willing to provide data, but not in poor countries.

Discussion

- Discussion of data: Types, sources, registers, survey's and census.
- Availability and quality of data.
- Need to agglomerate data of all censuses of countries in digital form.
    - Data-share issues – some nations are very willing to share while others are not (not always a privacy issue, most of the time it's compatibility issues)
- Definition issue: Census and satellite definitions correlate well.
- All cities are growing at the same rate, even though the gravity model depends on its parameters to determine how and which cities grow.
- Clusters can only show where density exists, but it doesn't necessarily show what the 'container' of a city is, or any other characteristic information about those clusters
- Re: Bryan Jones' mapping techniques: Need to sample predictions in the gravity-model projections because you cannot project the future if you do not know it yet; Project at shorter time intervals
- The issue of unpredictability in projecting population:
    - What about policy, unexpected events, conflicts and climate change: maybe something to learn from projections made in 1910 for 2000 (lots of unpredictable things happened in this period, so maybe it's a good indicator)
    - Difficulty in determining the effect of policy on population projects (since policy cannot really be projected, e.g. China)
- 2015 marks the end of Millennium Development Goals program is imminent, and a new agenda to be set. There is a movement towards adopting SDG (sustainable development goals) rather than MDG.

Land use change, population and development models

Moderator: Mark Montgomery

Panel: Solly Angel, Burak Gunerlap, Chris Small

Solly Angel: Urban Land Cover Projections

Definitions:
- Cities = 100,000+
- Urban area = built-up area on impervious surface; everything in that area is urban (includes suburban, core, etc. but does not include open spaces between fingers of growth)

Accra's growth between 1985 and 2000
Urban expansion was happening faster than general population growth – was this true throughout history or in other cities?

Example: Cairo (1800-2000)
Took old maps of built up area, and digitized and georeferenced.
Growth occurred into agricultural area (was not allowed after 1960)

Example: Paris (1800-2000)
Population grew by 20x and land consumption grew 200x
Due to population and income growth, and cheap transportation that influenced growth

Density has declined by 1.5% per year – no matter what kind of density (e.g. Canada vs. Japan) – increased land consumption

Comparison of land covers in different global regions (looked at total urban population, urban land cover in large cities, land cover in small cities (interpolated from the rate of land cover of large cities), then calculated total urban land cover then calculate total urban land cover as percent of total land area).
- The US had the highest area of land cover of all countries.

Factors that increase land cover:
- Gas prices
- Informal land settlement (inverse relationship)
- Amount of arable land (positive relationship)

Fastest growth in population and built up area of cities in coming decades will occur in Sub-Saharan Africa and the Indian Subcontinent (27%)

Decreasing density may not always mean decrease land cover – in most scenarios, there is an inverse relationship, though there are some exceptions.

What growing cities need to do in order to increase resilience of these cities to grow (should plan for mitigation of certain consequences, not for the projected growths themselves):
1. Have realistic projection of how much land you need between now and 2040
2. Determine city limits in correspondence to 1
3. Develop arterial grid for infrastructure to serve projected growth
4. Get the land/right-of-ways for this grid now

Regional/metropolitan governing structures are critical in planning expansions and collect data.

Burak Gunerlap: Probabilistic Forecasts of Global Urban Expansion for 2030

Research questions: 1. How will urban areas continue to grow into 2030; 2. What are the impacts?

Methodology: Use multiple forecasts of urban expansion between 2000 and 2030 (GDP and population); spatial simulation of urban forecast (urban extent, land cover, etc.); spatially explicit forecasts of urban expansion.

Main issues: Uncertainty in forecasts of land change; Indirect impacts of urban expansion (e.g. effect of infrastructure)

Mapping result: Land cover will dramatically become urban by 2030, mostly surrounding existing metropolitan areas.

"Changing Land Use Models, a Report on Opportunities and Research Requirements" provides insights into needs and course of research.

Chris Small: The Color of Cities: Mapping Urban Processes from Space

The Challenges of mapping urban land cover

How is 'urban' defined

Land cover 'type' changes in type (Road? Building? Field?) and over time

What satellites see: spatial, spectral, and temporal resolution

- Optical – too much information sometimes, because it is such high resolution
- The important role of thresholds and assumptions: what is urban, and the estimate itself
- Colors and brightness can help to confirm land use changes

Example: Mapping urban growth in India

- Delhi's physical incorporation of numerous villages in surrounding area

Recommendations

- Understand assumptions and complexity
- Combine methods to double-check results of each

Discussion

Defining urban – how do you separate villages from the city – do you include? In a sense yes because they are part of the economy, etc. Thus, 'urban' loses its meaning.

What are the drivers of land use change? Market? Policy?

It is uncertain whether cities pursue vertical growth or horizontal growth? In places like Africa which are still developing and acquiring resources to grow, this is still uncertain, but obviously affects land cover patterns.

The reality of densification

- Densification is not actually happening in most places. Even in Portland, density is decreasing. The places that are densifying are rare – e.g. Singapore, Johannesburg, etc. But, high density is also present in enclaves throughout basically all cities.
- Cities have simultaneously densified and grown outward. Contrast with cities that are shrinking in population and also retracting its land cover.

Land cover patterns of differing densities and different sized settlements is not unique to Delhi – you can see it in a lot of cities (e.g. Nile Delta)

Spatial population and migration models (3:00-5:00pm)

Moderator: Deborah Balk
Panel: Susana Adamo and Alex de Sherbinin, Carson Farmer, Barney Cohen (Patrick Gerland)

Susana Adamo and Alex de Sherbinin: CIESIN Experience in Spatial Population Projection and Modeling Net Migration

Susan Adamo:

Methods:

- Extrapolation of past trends using growth rates
- Inputs: matched subnational population data and boundaries at two points in time – alternative: growth rates from other sources.
- Exponential growth
- Adjustment and capping

Data:

- Comparing GRUMP (high resolution) vs. GPW v4 (population characteristics using recent data)
- Result: Populations are in the right place, but densities are inconsistent.

Very simple methodology as you only need to look at population size, but it is limited to 10-15 years, and you must deal with varying spatial resolution of input data, and negotiate differing time-space aspects of data.

Alex de Sherbinin:

Try to estimate migration to 1km grid

- Start with 1km GRUMP population grid for 2000 and project using HYDE rates to obtain population grid for key years.
- Figure out natural increase at subnational division then use population density grids to spatially allocate differential rates of natural increase
- Map migration patterns – can also overlay on ecosystems.

Effects of migration – single cities have mostly remained single cities, while many became agglomerations by incorporating surrounding settlements.

- More extreme cases of transnational agglomeration (Delhi-Lahore)
- Cities tending towards less compact forms

Carson Farmer: Cities as Agents of Growth: Agent Models for Population Projections

Why agent-based modeling/framework?

- People live in cities, not grid cells, so the city should be the unit of analysis
- Need to generate probability distribution (historically constituted/validated)
- Cities change over time
- Able to capture emergent phenomena, described in a natural, direct way, and is flexible (you can keep adding elements to the framework)
    - Inter-city interactions during growth
    - Applicability of models in a historical context, global context, etc.
    - Policy implications
        - Cannot predict policy changes, but we can predict that they will occur.

Patrick Gerland (UN) (World Urbanization Prospects: The 2011 Revision

World Urbanization Prospects (WUP)

Provide basic indicators of urbanization for all countries (for 1950-2011)

Need to look at all countries alike – China to Monaco for these projections

- Need to bring down threshold for published city populations from 750,000 to 300,000 so that there can be more data points

Also need to look at observations over time (with consistency) Look at earlier data and use it to make predictions against what has actually occurred.

Definition difficulties

- Relies on differing national definitions of urban areas/location
    - Currently three broad definitions (city proper, urban agglomeration, metropolitan areas)
- Too much focus on the largest agglomerations, which neglects the most dynamic part of urbanization.
    - Cannot make provision for the 'birth' of new cities

Consider also changing life expectancies when doing population projections

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Summary

We should start thinking about how population growth will be organized.

- Seemingly, no matter what work is done, the products will be wrong, especially over time. But, the topic and need for the work is important, in terms of policy-making.

So, how do we continue this work?

- Meet again and discuss what can be done and how – mapping out a forward path
- Identify funding sources (Interested agencies – World Bank, NASA, etc.)