

Thailand

Cambodia

Vietnam

Mapping progress towards the Sustainable Development Goals

world
pop



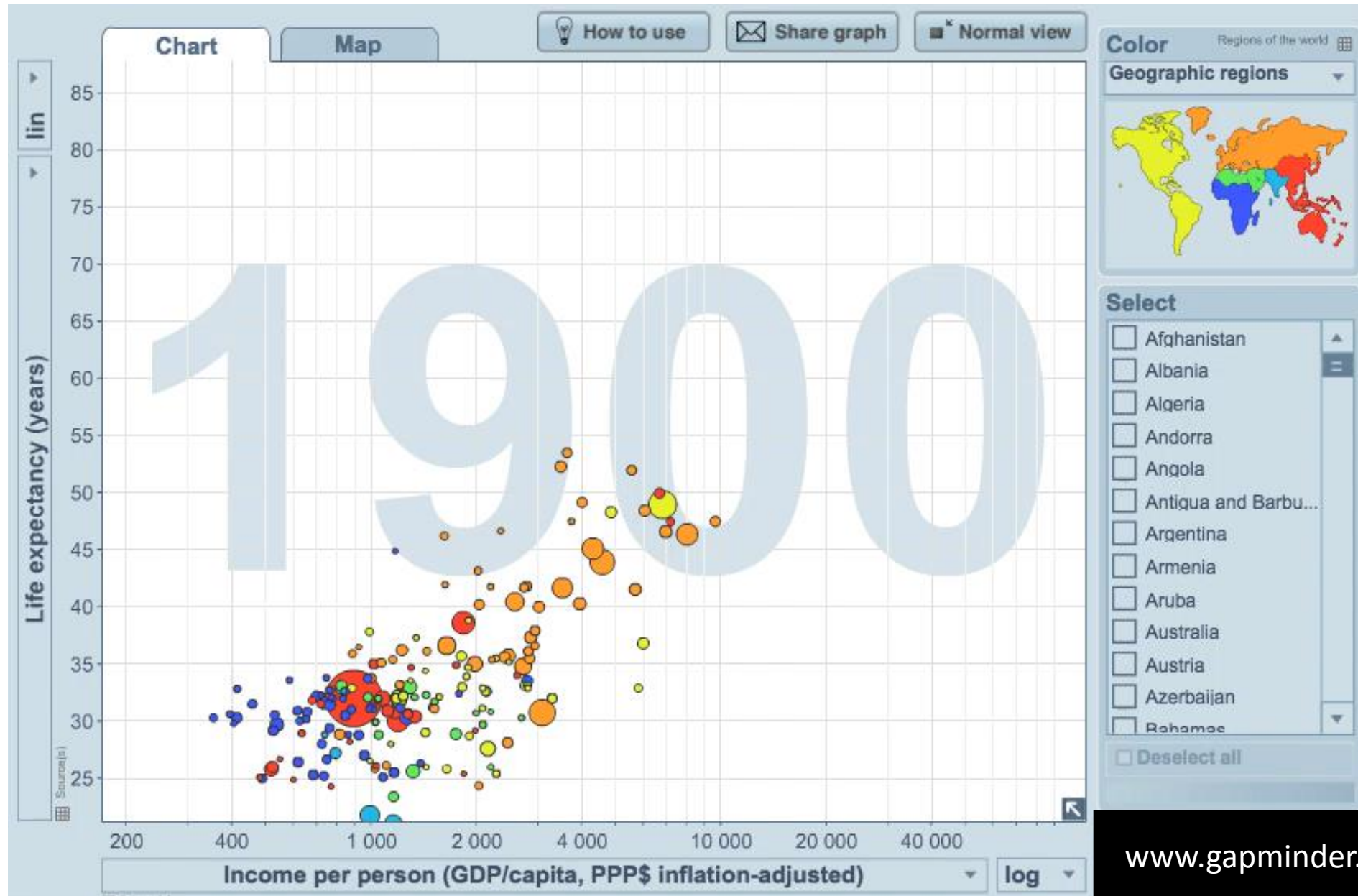
FLOWMINDER.ORG

Professor Andy Tatem

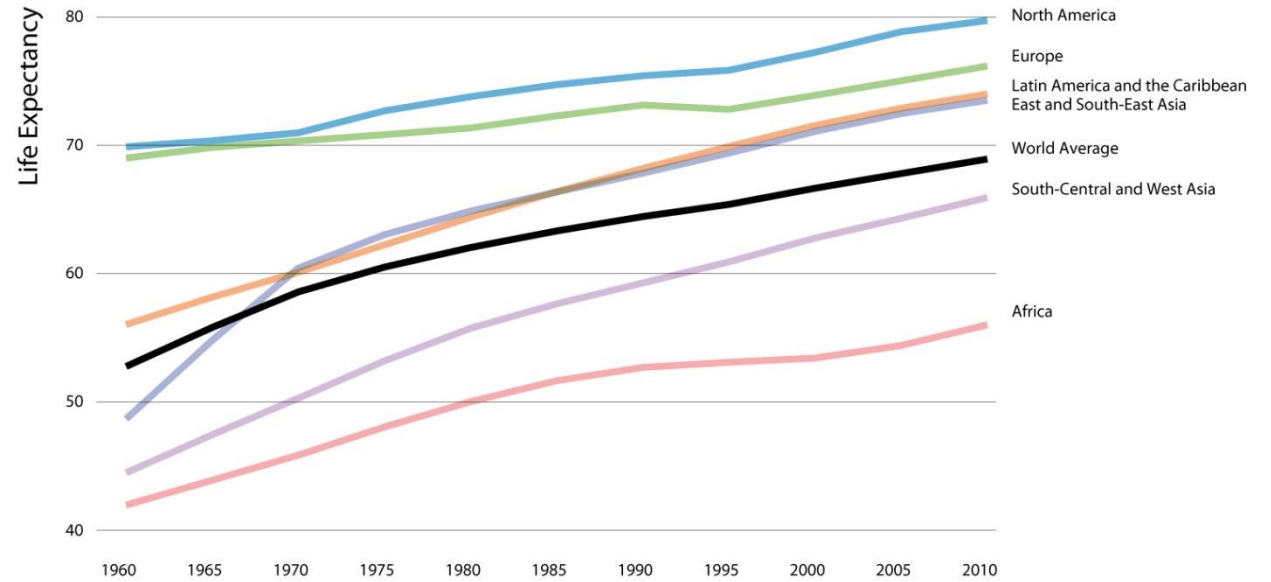
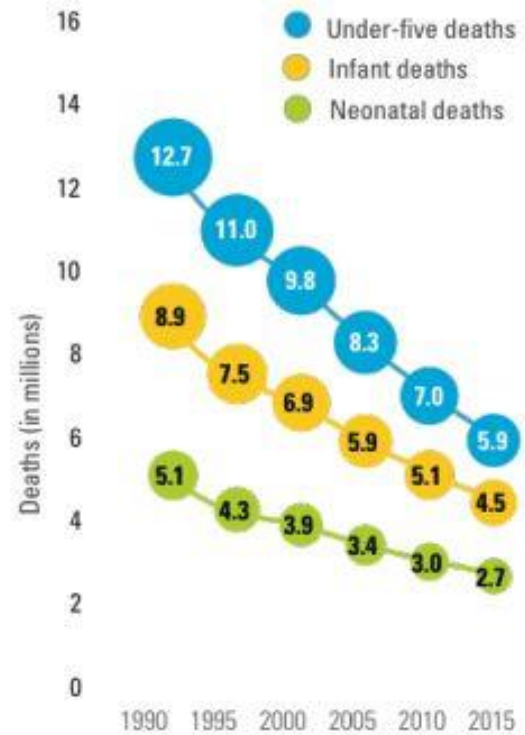
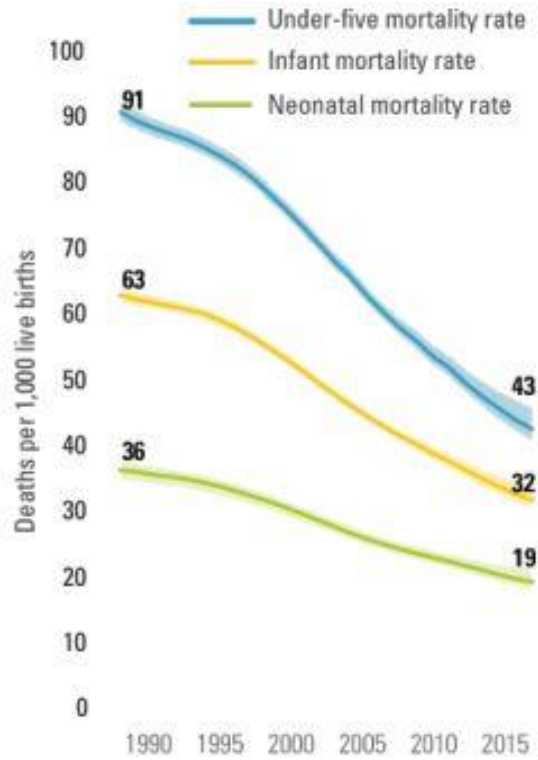
Here is the news....



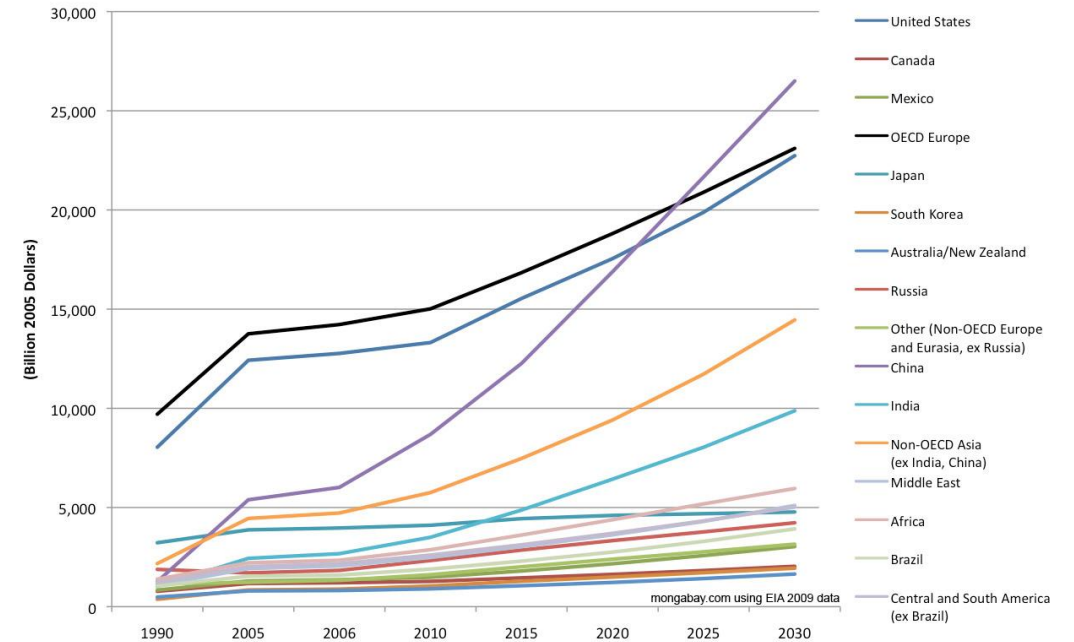
Are things really so bad and getting worse?



It's not so bad after all...



World Gross Domestic Product (GDP) by Region Expressed in Purchasing Power Parity, Reference Case, 1990-2030





Develop a global
partnership for
development



Eradicate extreme
poverty and hunger



Achieve universal
primary education



Ensure environmental
sustainability

2015

MILLENNIUM DEVELOPMENT GOALS



Promote gender
equality and
empower women



Combat HIV/Aids,
malaria and other
diseases

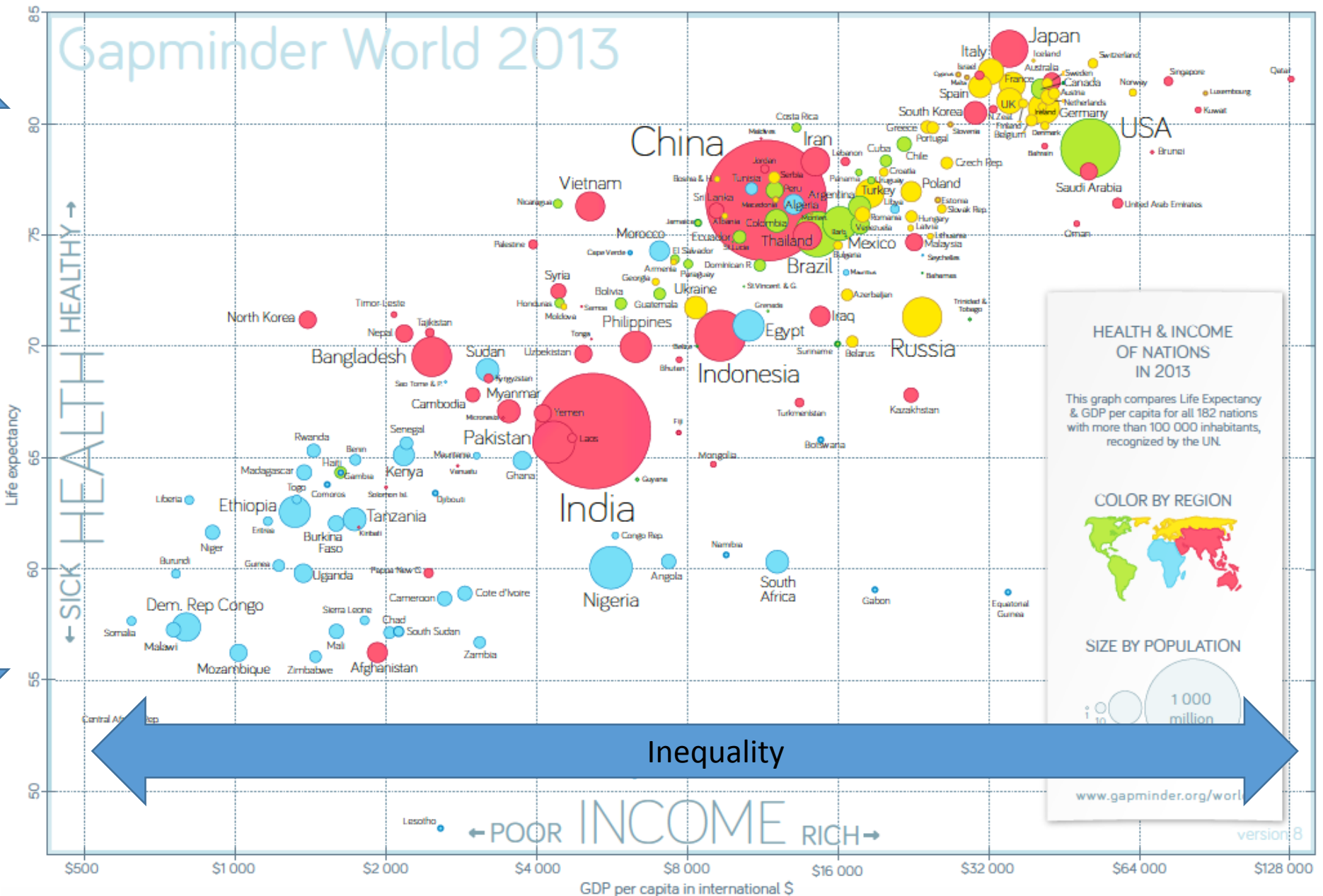
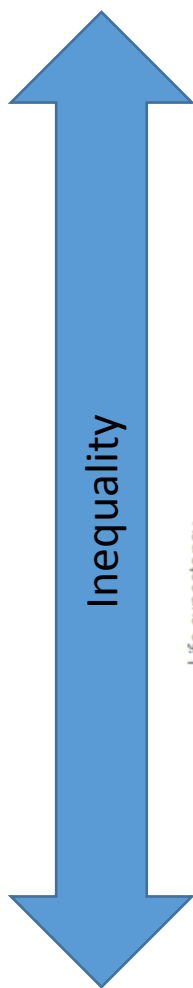


Improve maternal
health



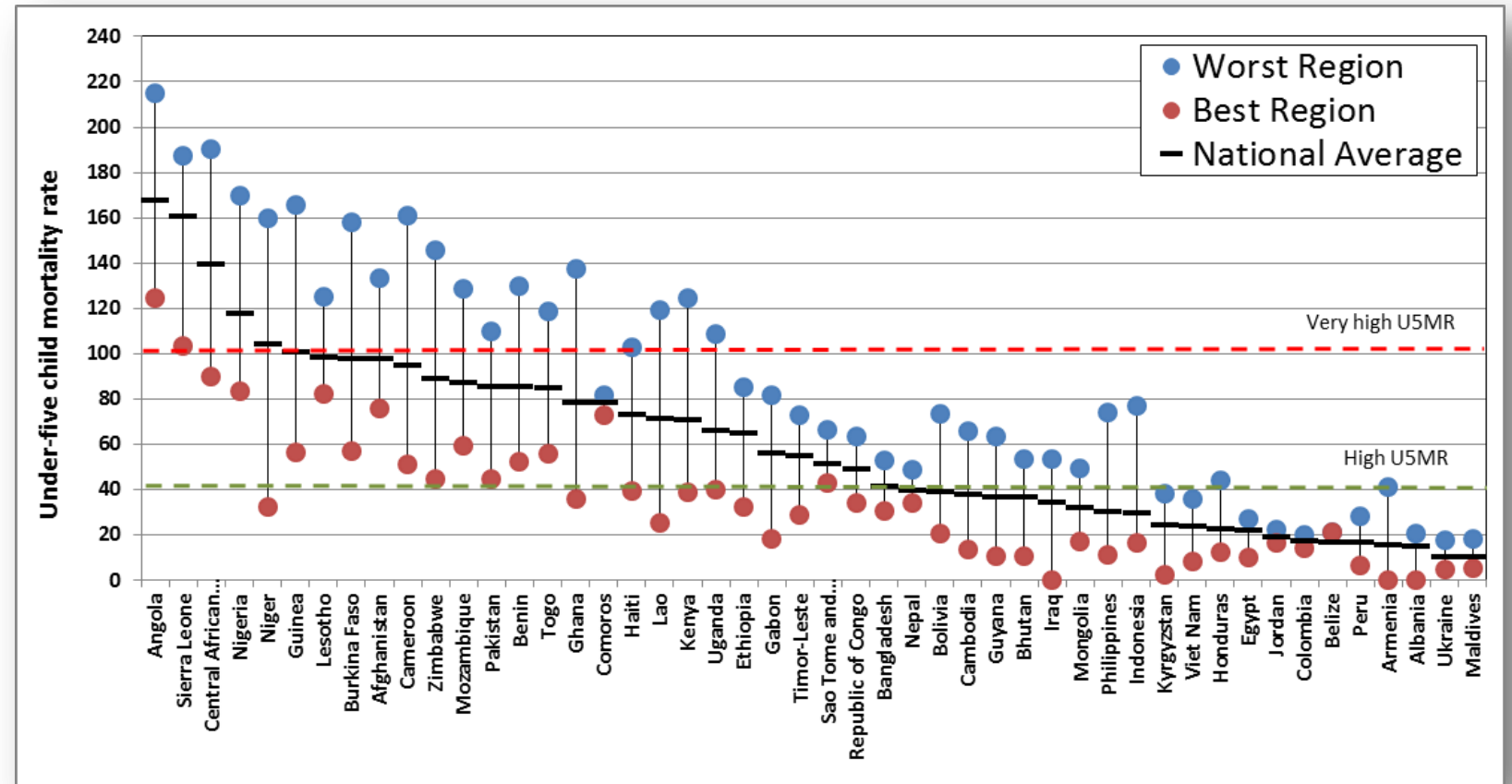
Reduce child mortality

Global inequalities still exist



MDG achievement – but inequalities within countries remain

- Around one third of developing countries reduced child mortality by 75%
- Another 74 cut it by half
- But huge subnational inequalities remain





SUSTAINABLE DEVELOPMENT GOALS



GOAL 1 TARGETS

1.1

By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.25 a day

1.2

By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions

1.3

Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable

1.4

By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance

1.5

By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

1.a

Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions

1.b

Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions



SUSTAINABLE DEVELOPMENT GOALS



2015-2030: 17 goals, 169 targets

Key differences compared to MDGs

- Leave no-one behind: no goal should be met unless it is met for *everyone*
- A focus on achieving x,y,z *everywhere* = geography is important

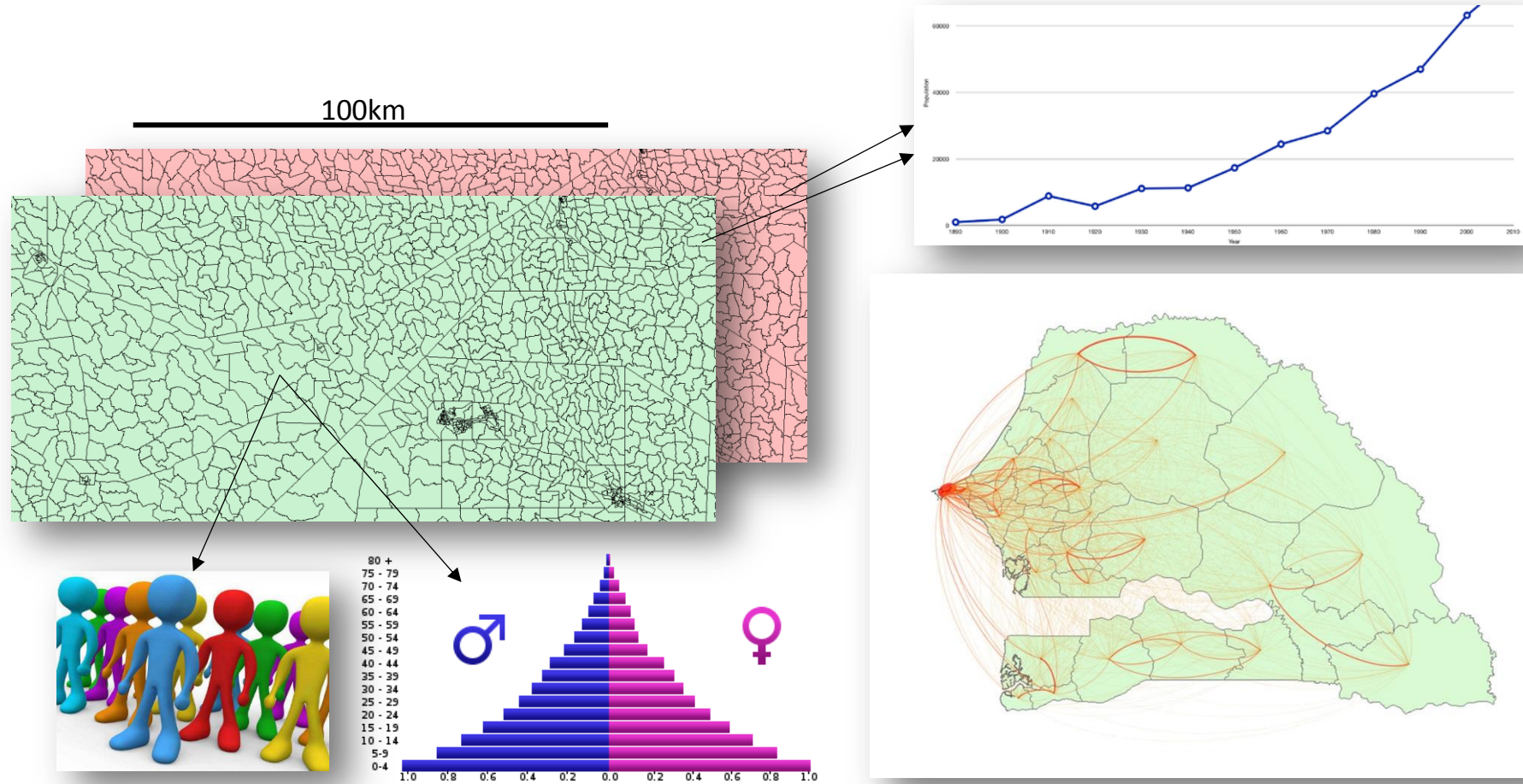


SDGs: Key data

- All SDGs are based on ensuring a certain percentage of the population has access to specific services or resources, or achieves a certain level of social, economic, or physical health.
- Improved understanding of *sub-national geographic variation and inequity* in health status, wealth, and access to resources within countries is increasingly recognized as central to meeting development goals.
- Requires a consistent, comparable and regularly updated understanding of not only how many people live in a country, but where the people are, and who they are.

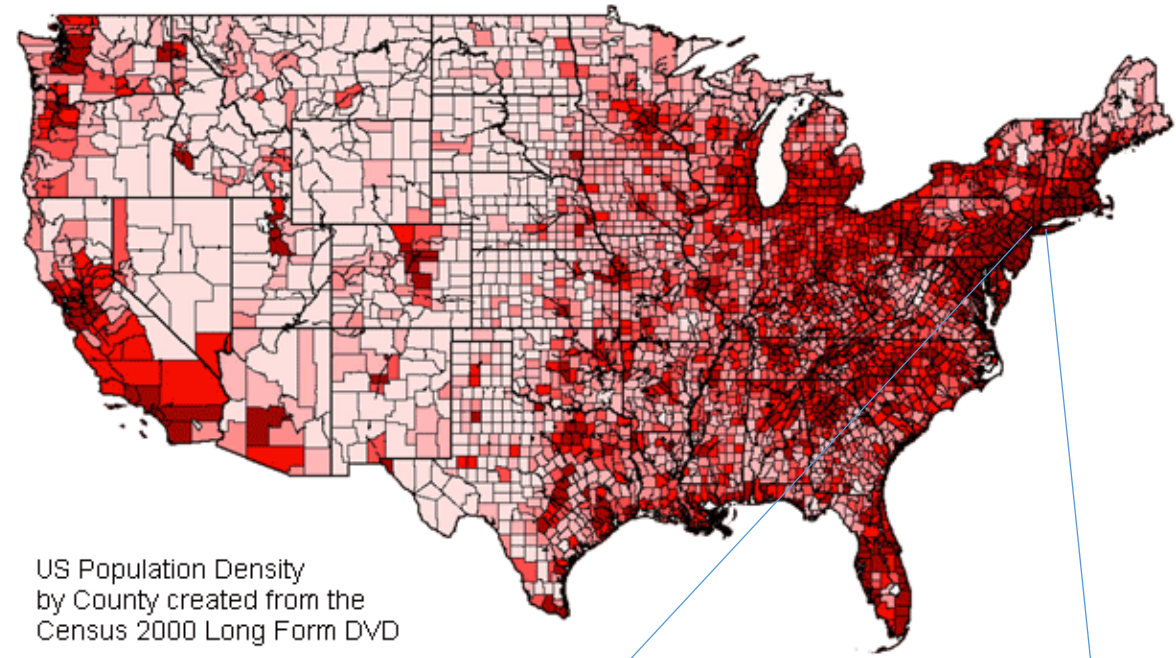


Census data: answers



High income countries

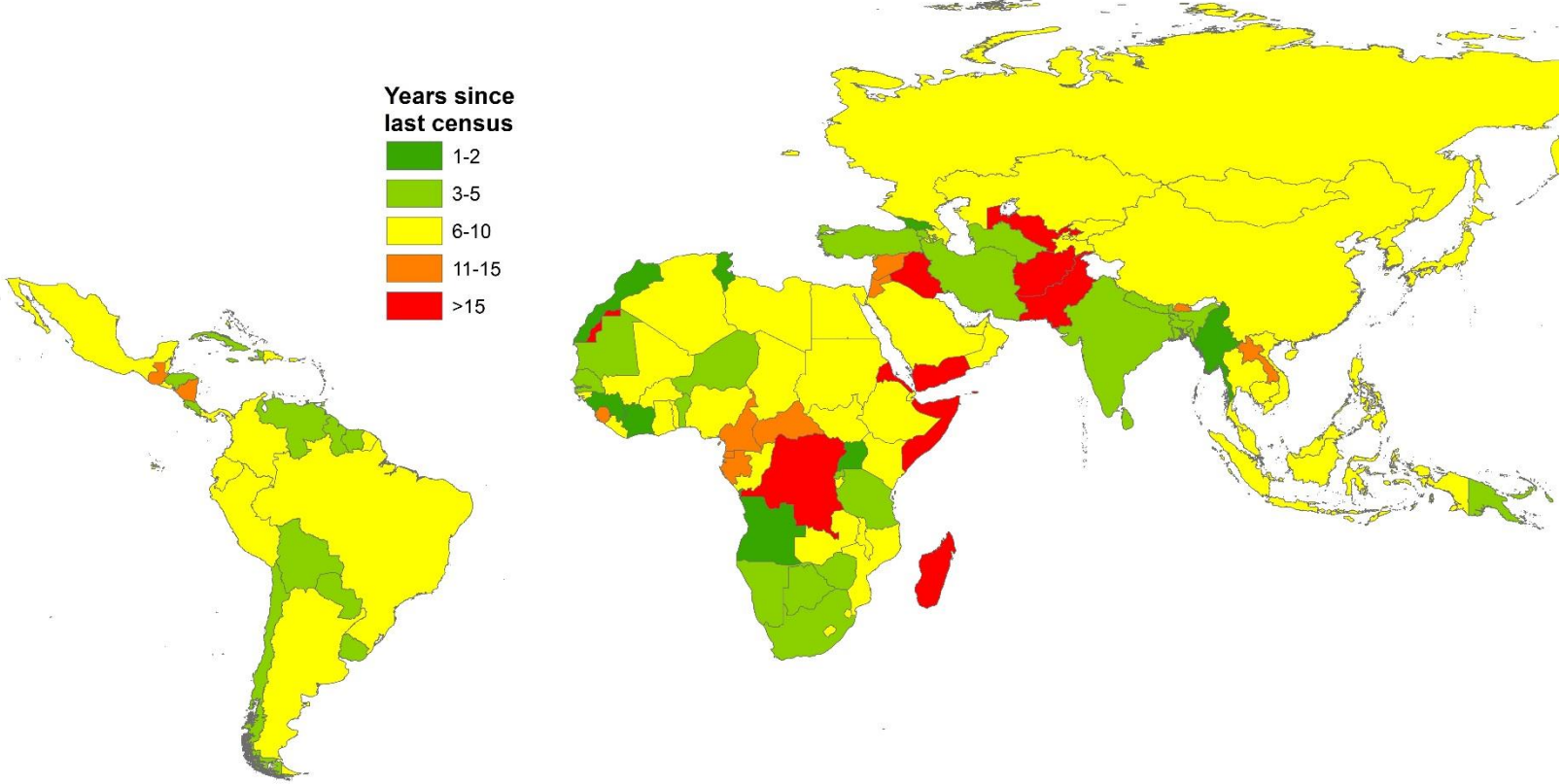
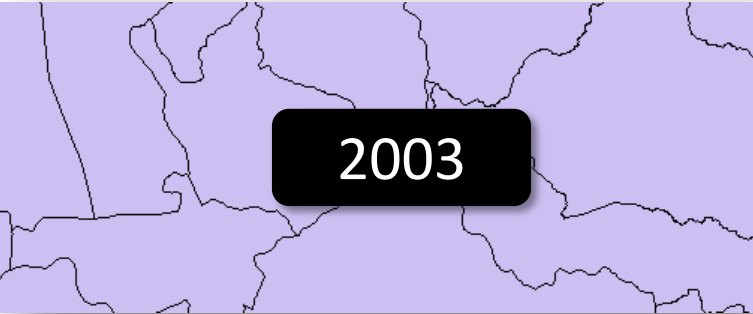
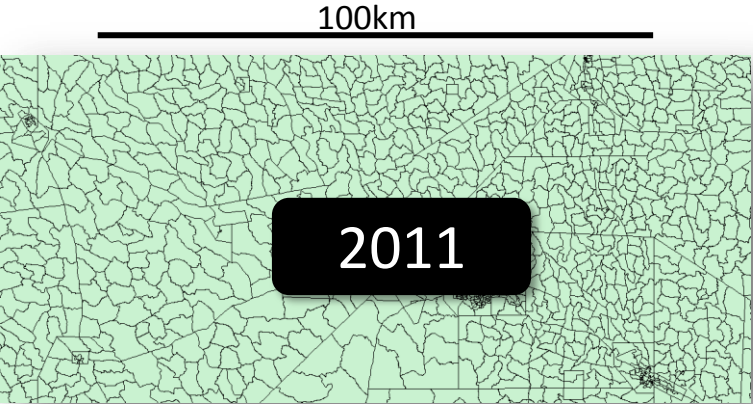
- Regular, reliable censuses with strong mapping components
- Strong and comprehensive civil registration and vital statistics (CRVS) systems
- Multiple other sources of registrations, surveys, statistics



US Population Density
by County created from the
Census 2000 Long Form DVD

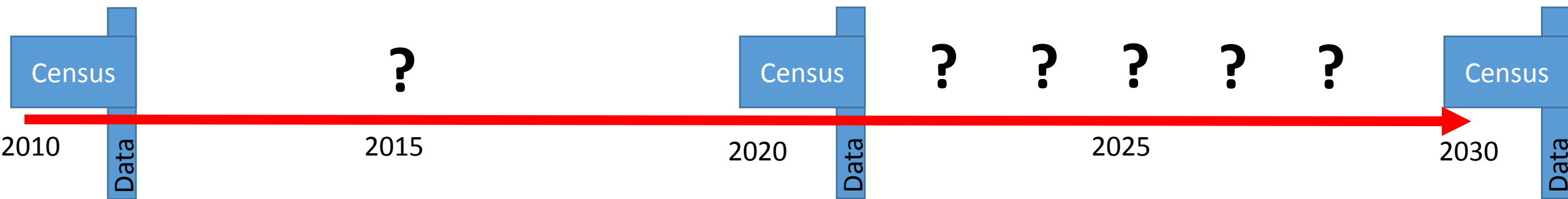
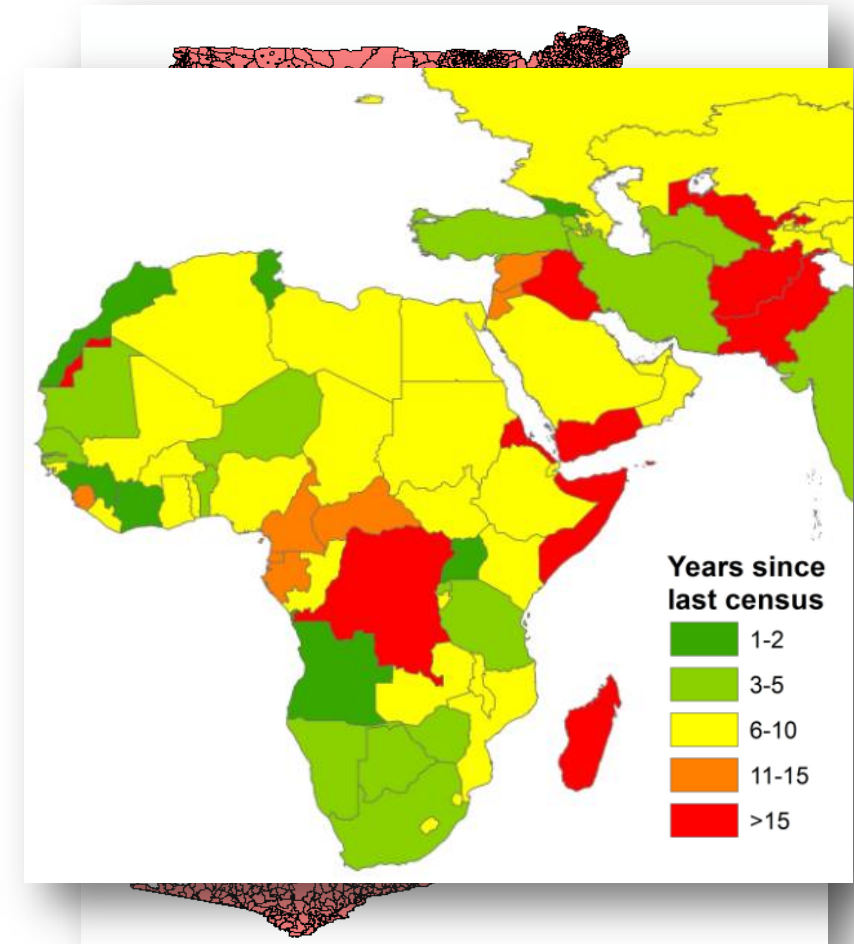


Census data: problems

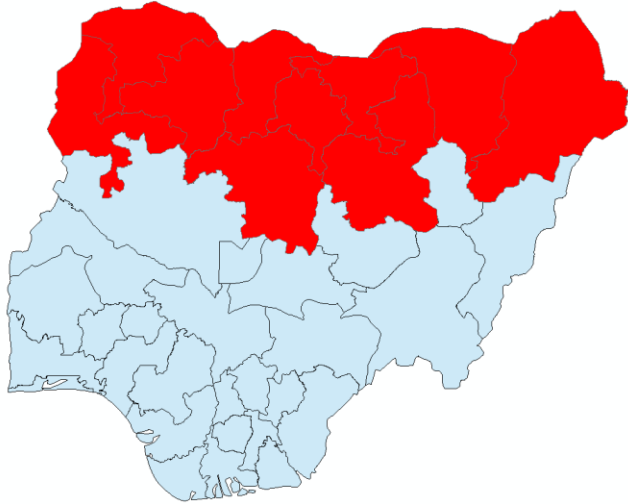


The challenge: low/middle income countries

- National census data will continue to be our most important datasource
- Provides denominators and numerators for all SDGs, and requisite subnational detail
- But, the 2015-2030 SDG period typically includes just one census datapoint
- And in some of the highest burden settings the situation is more challenging



Example application: Vaccination planning needs



Polio elimination: Vaccinate as close to 100% of under 5s as possible

-Ensure correct amount of vaccine is available

Need to know how many under 5s there are

-Plan local vaccine needs

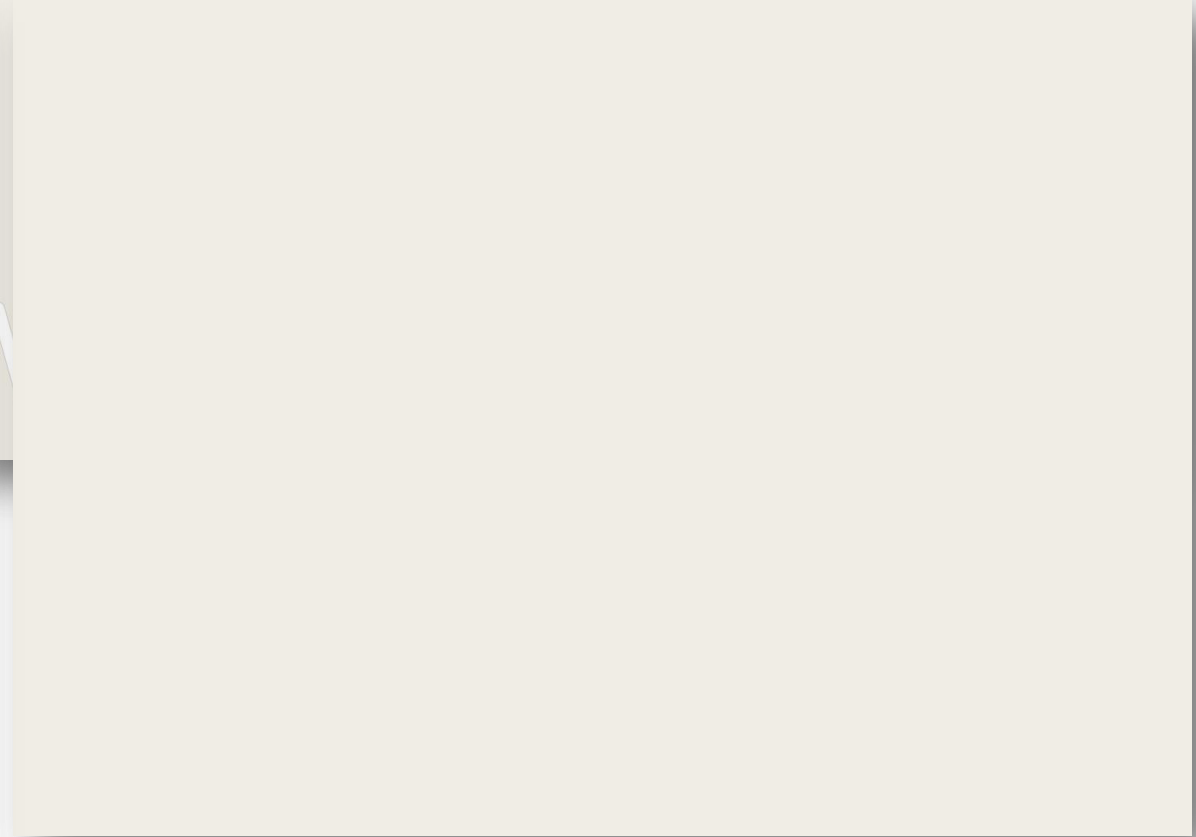
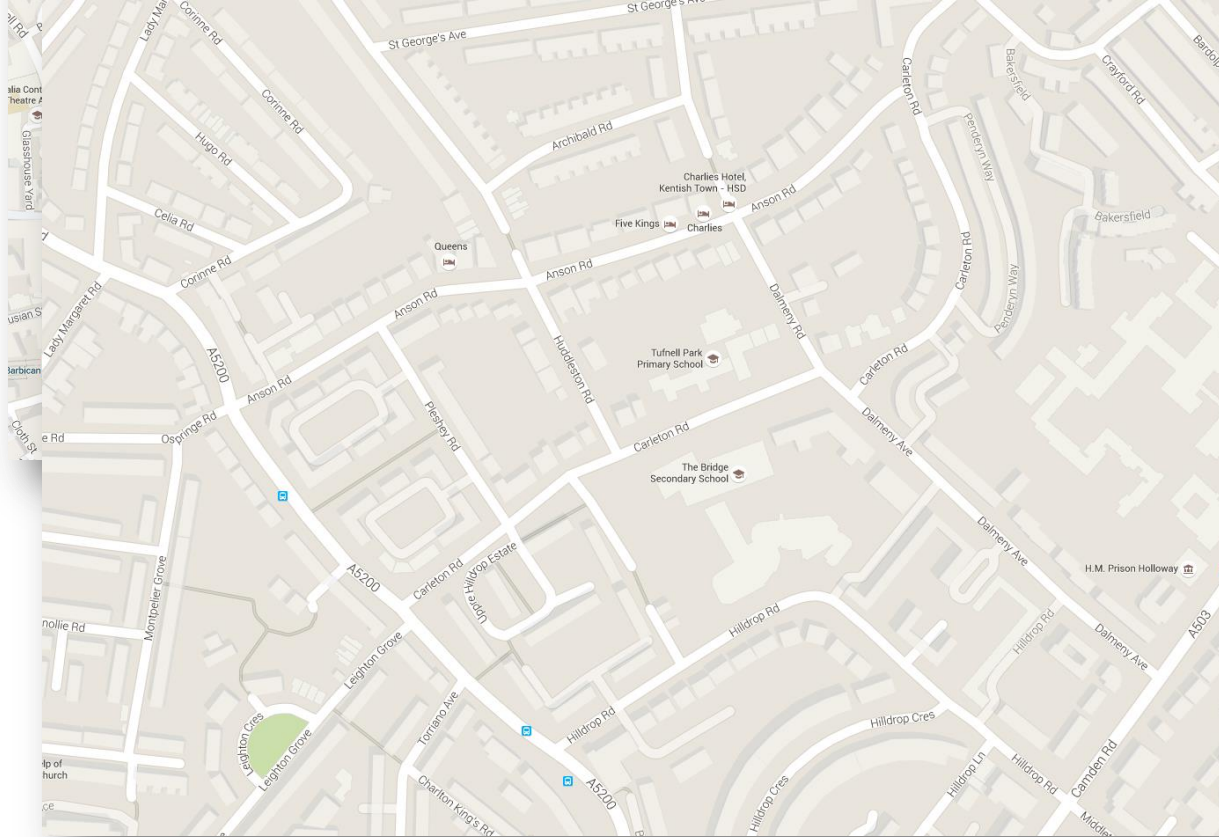
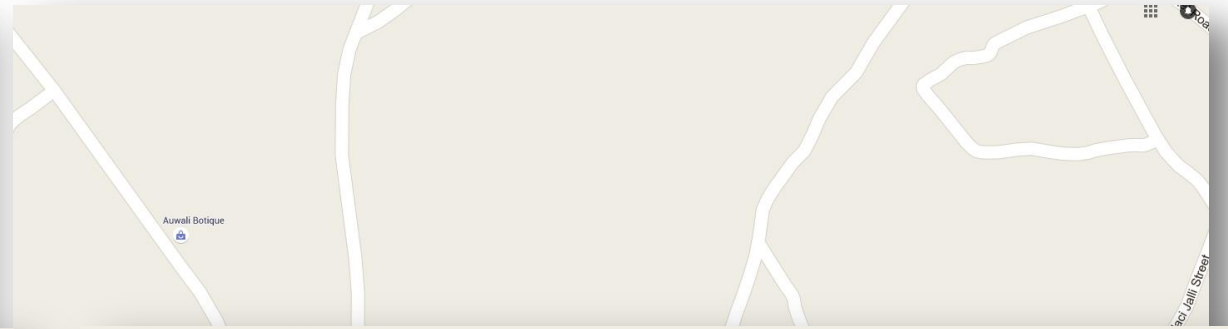
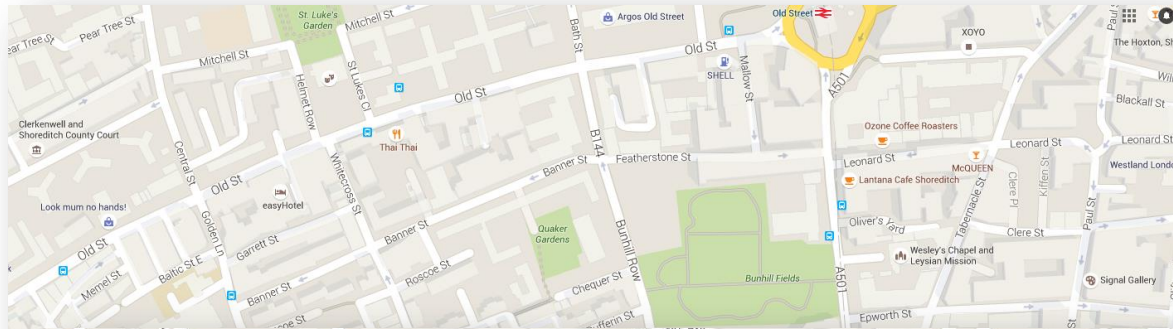
Need to know how numbers change

-Plan vaccinator logistics and routes

Need detailed maps of the region



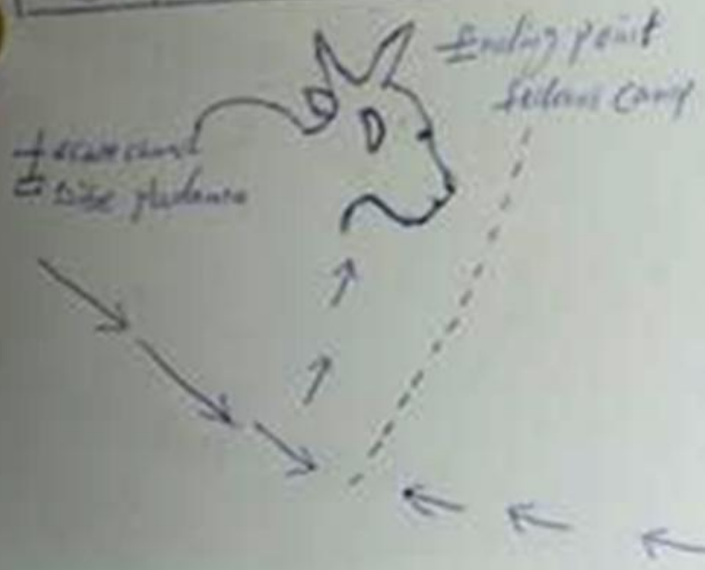
The challenge: subnational data



Day 3

The padama

Special Team
Daily implementation route map



agico church
The padama



play ground

Starting point

TP 38

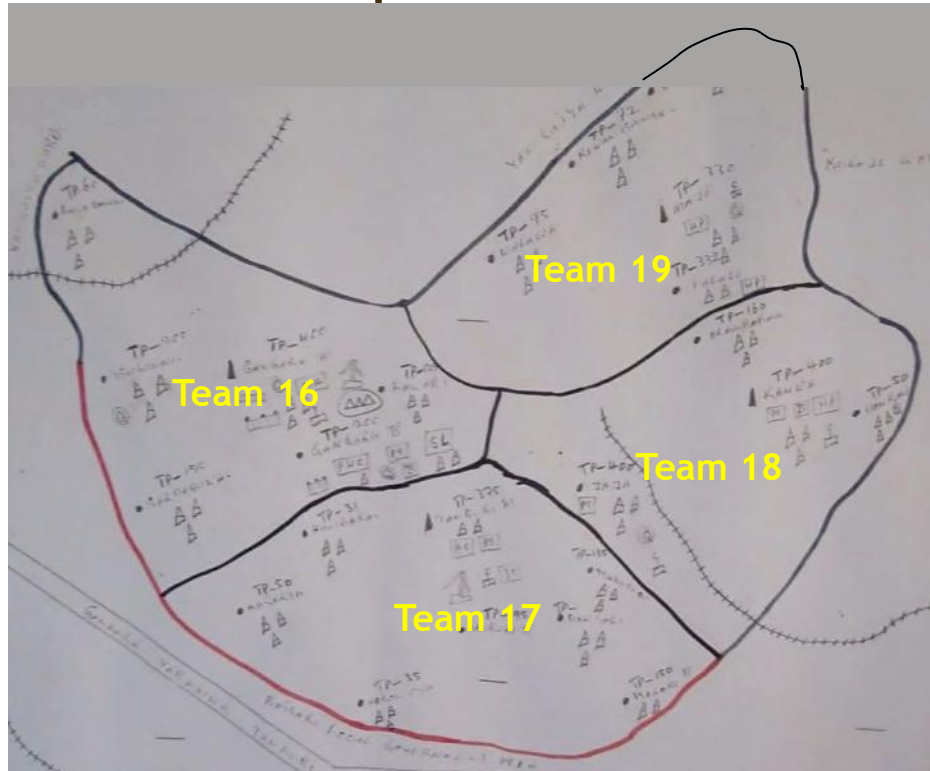
	Fulani Camp
古	Church
	play ground

2011/4/14 1:23

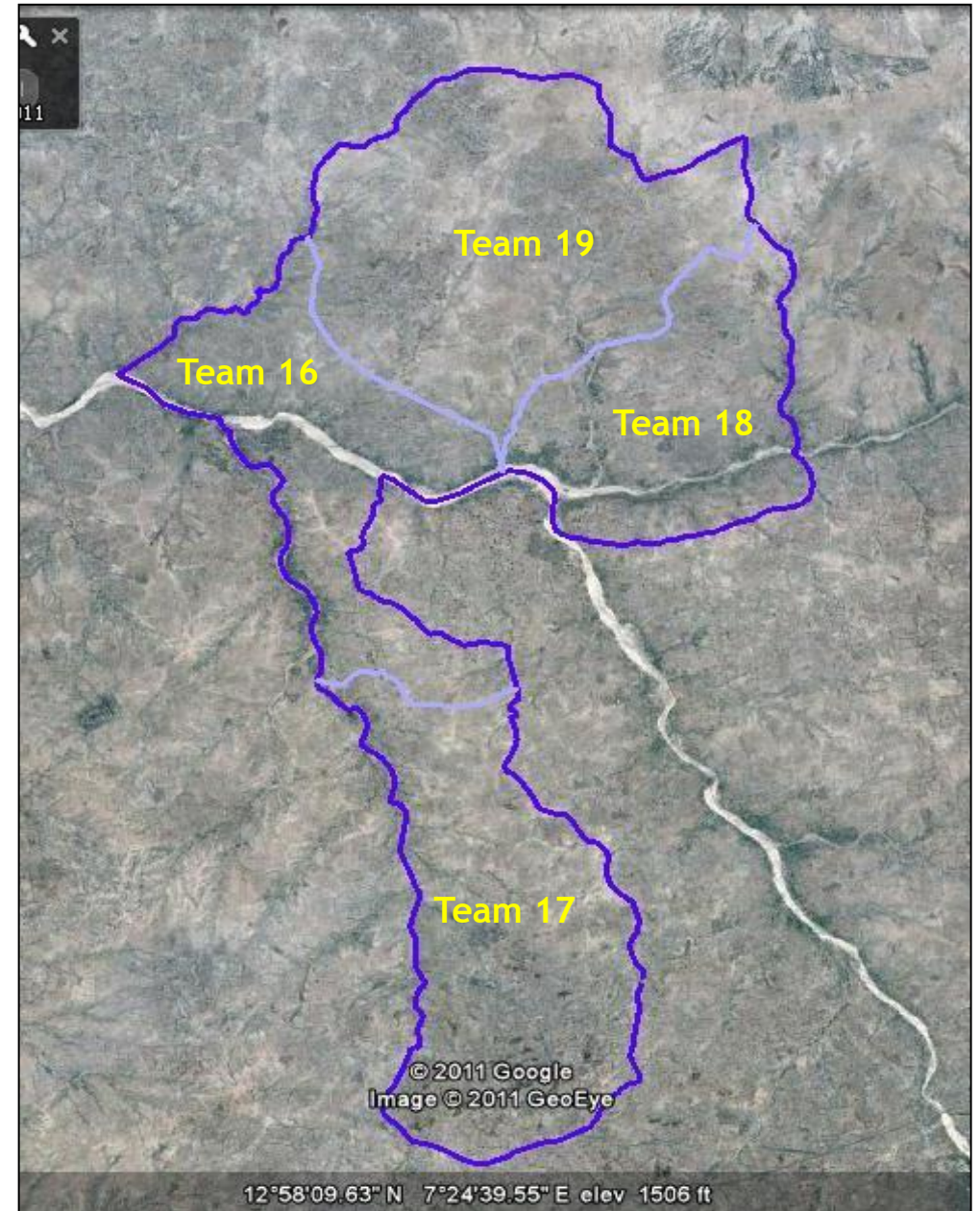
Hand-drawn maps for vaccination planning

Gangara Ward, Jibia LGA, Katsina State

Hand-Drawn Map



Satellite Map →



Inflated Census Populations?

Census-derived estimate = 375

Census-derived estimate = 2675



36 compounds



32 compounds

What do we have to help us?



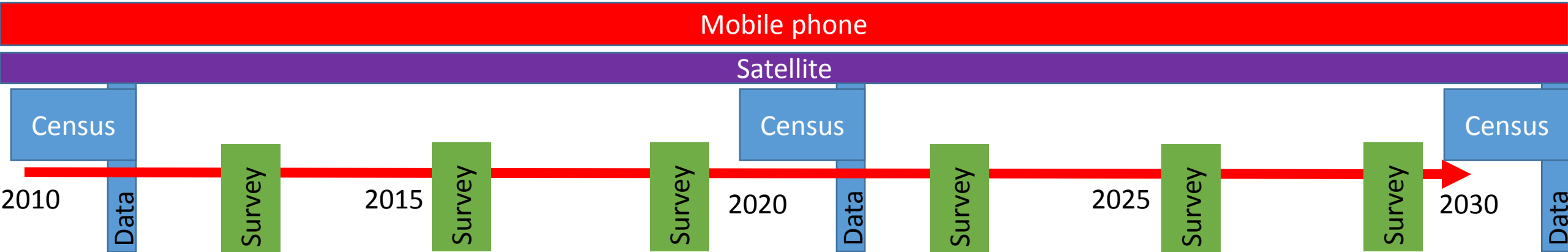
Geolocated household surveys



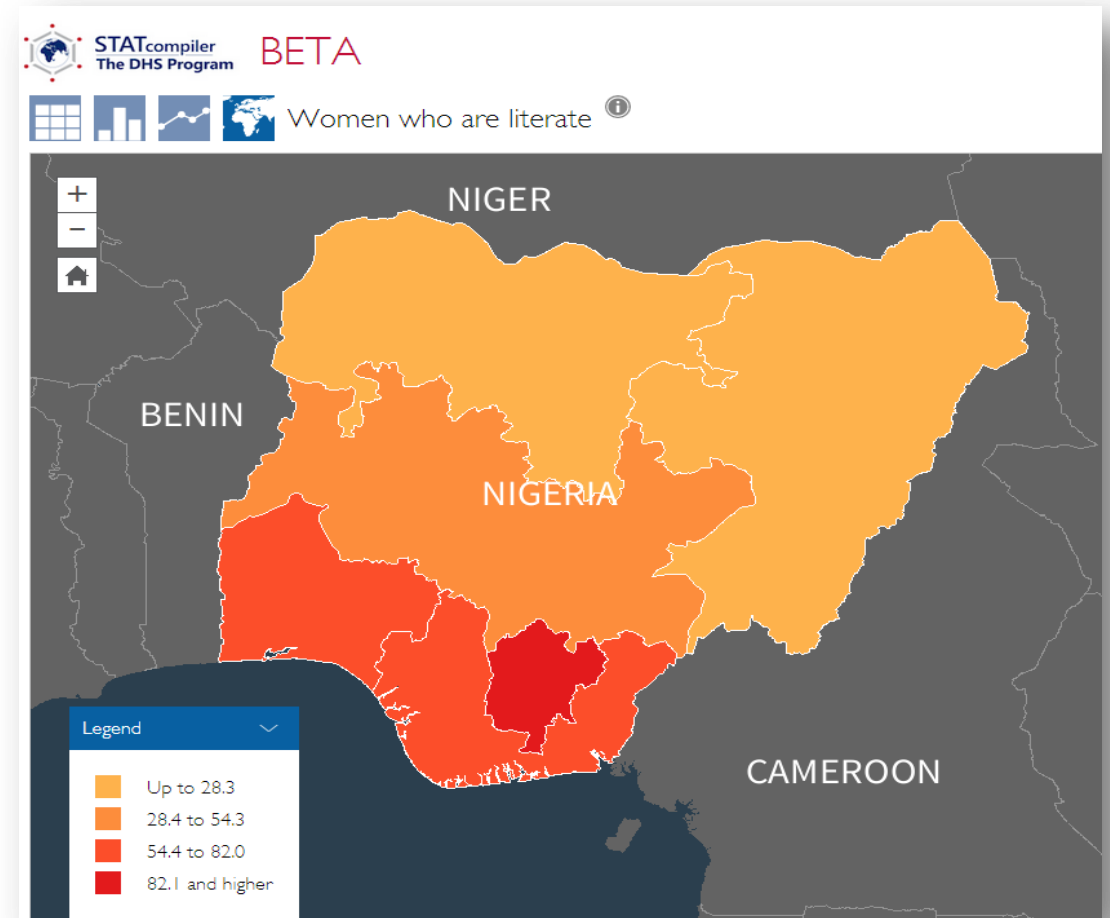
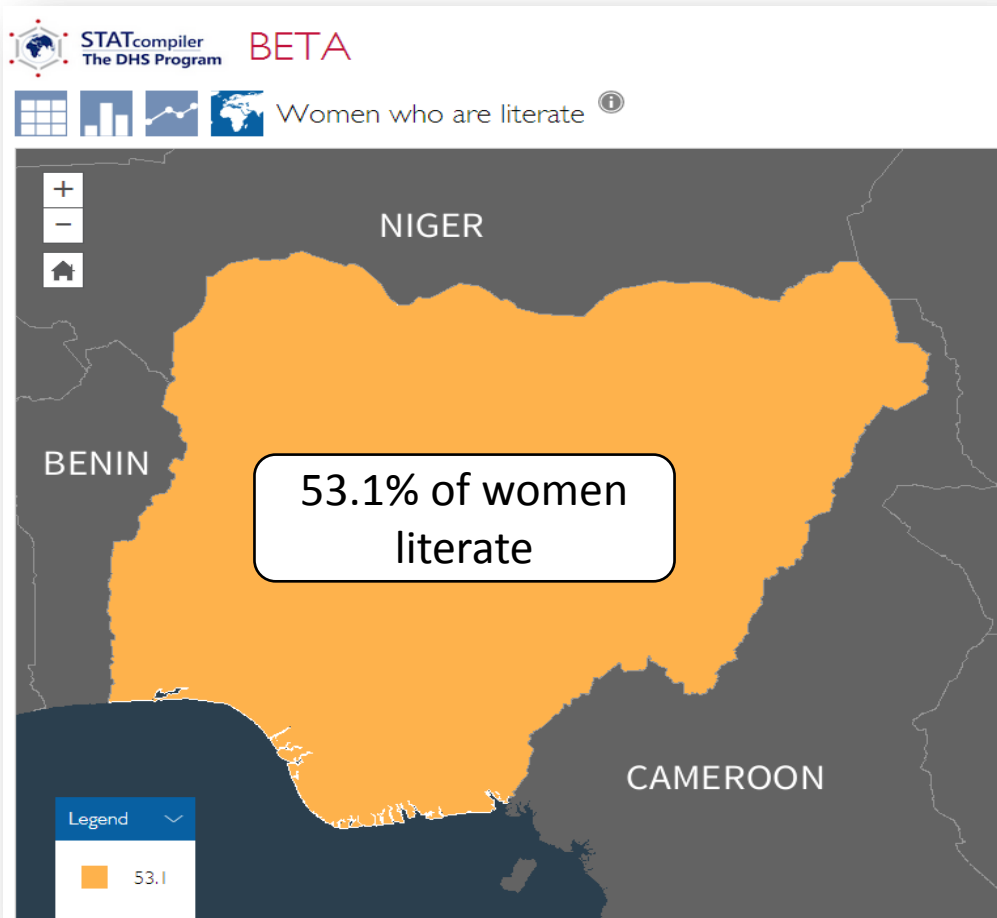
Satellite and GIS data



Mobile phone data



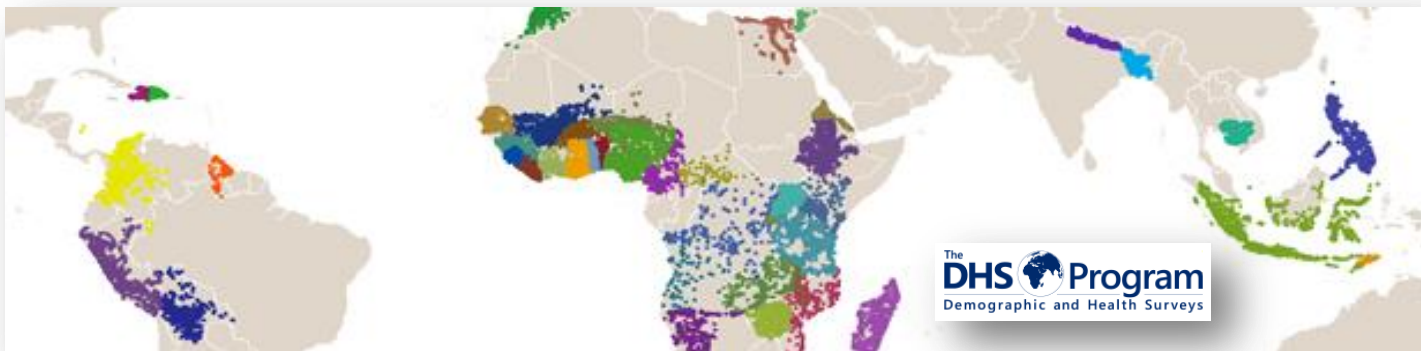
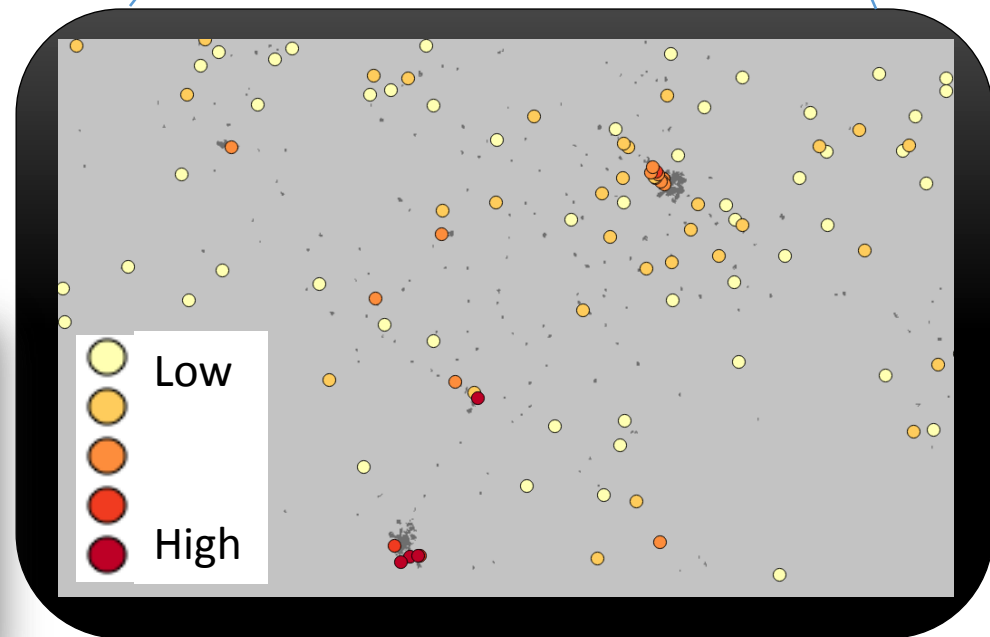
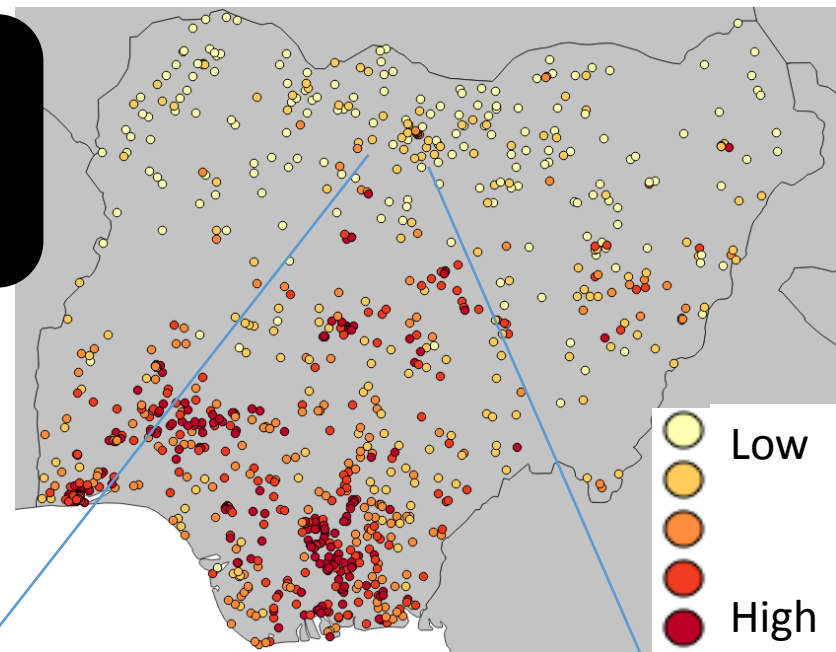
Household Surveys



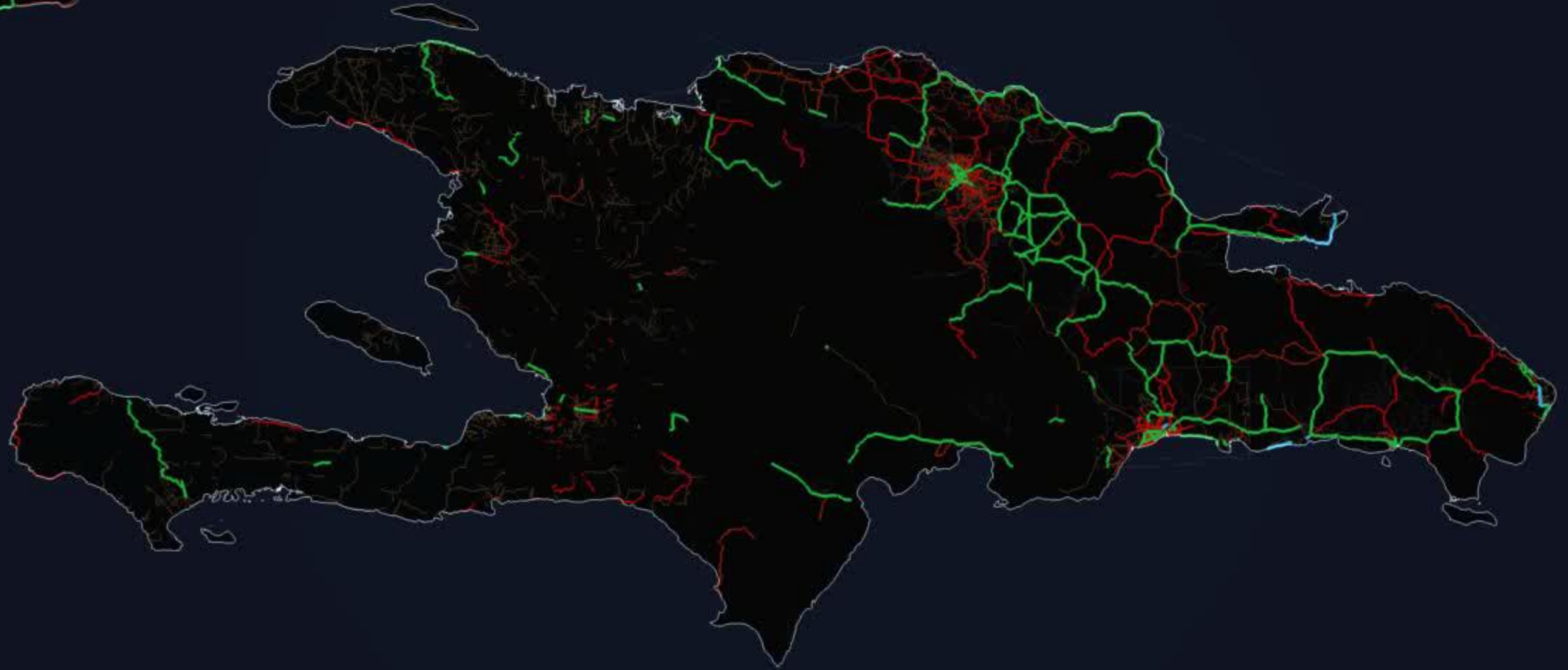
GPS: Geolocated surveys



Proportion of women who are literate



Geographic Information System (GIS) Data



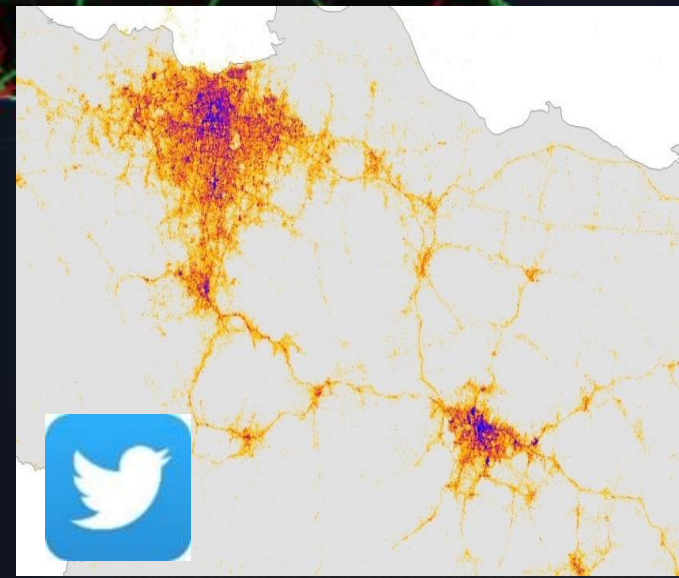
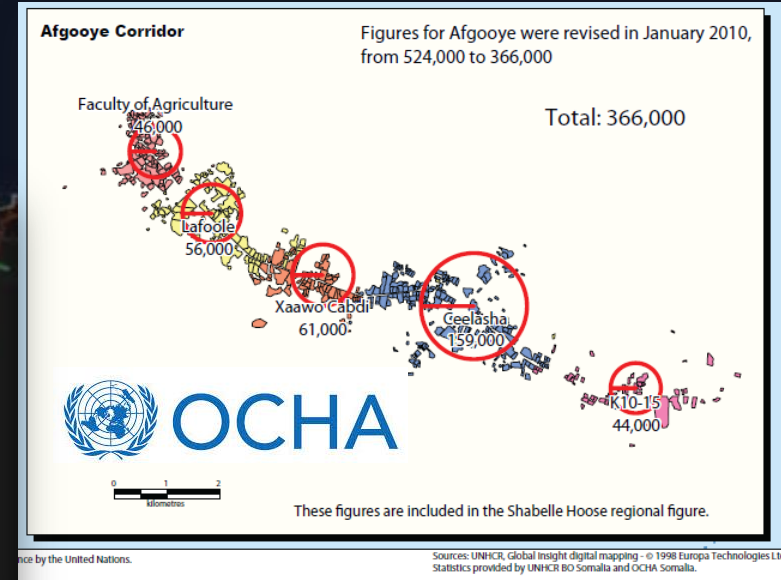
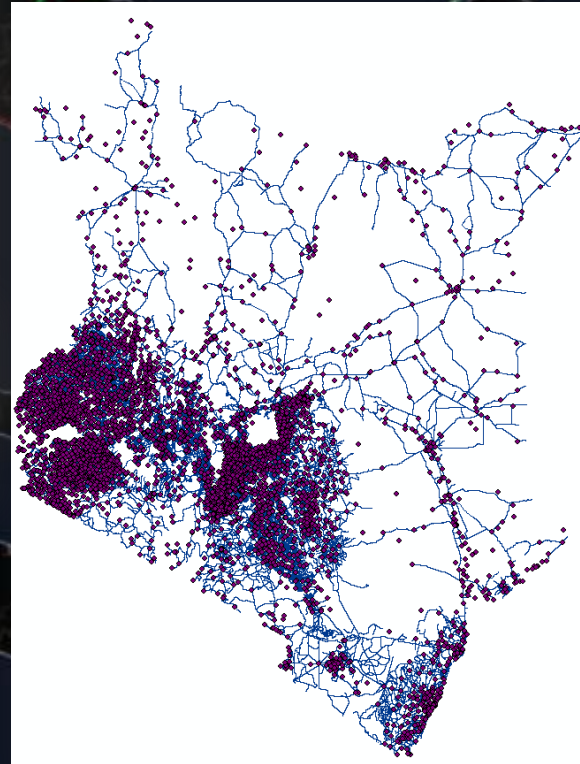
9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 January 2010

OpenStreetMap

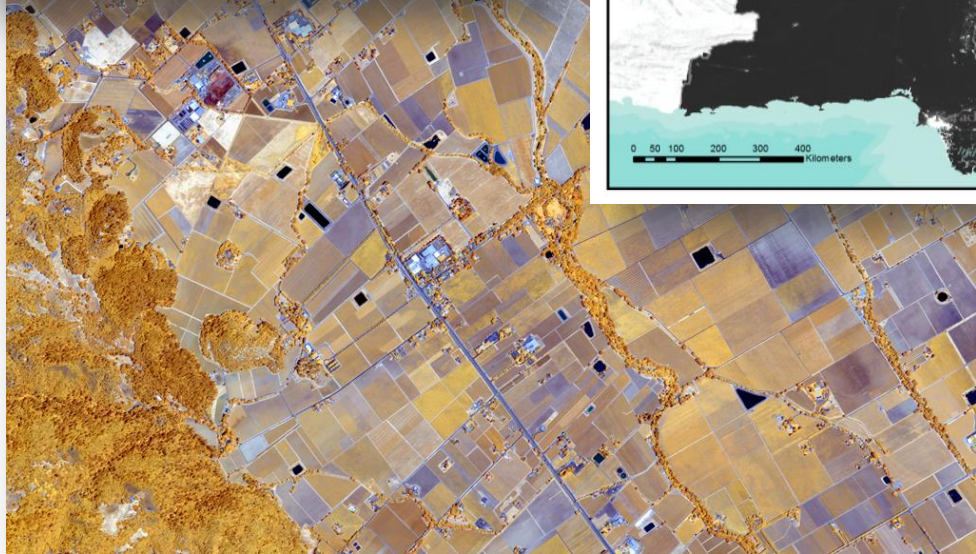
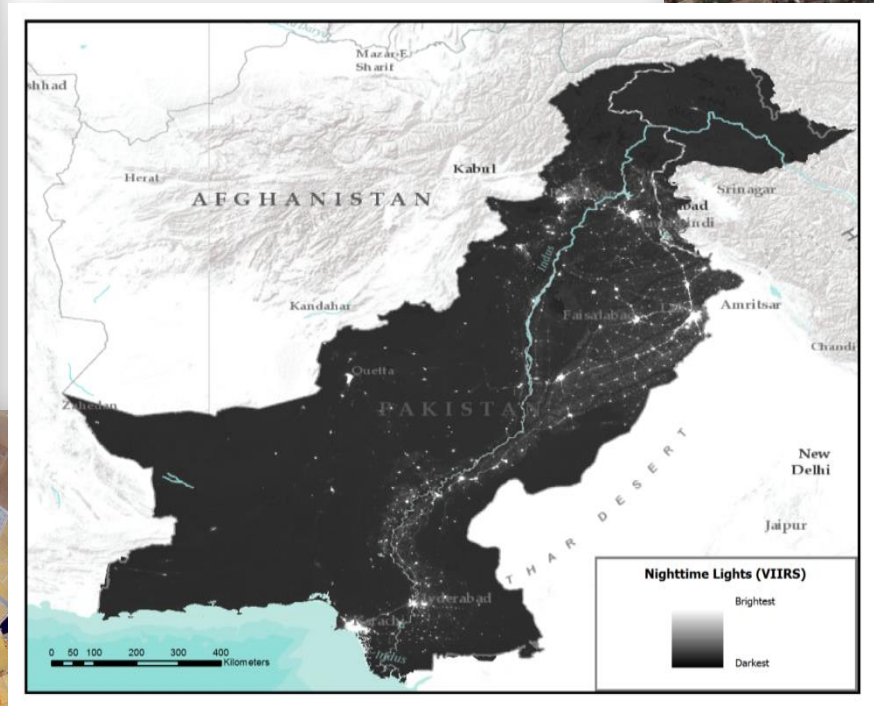
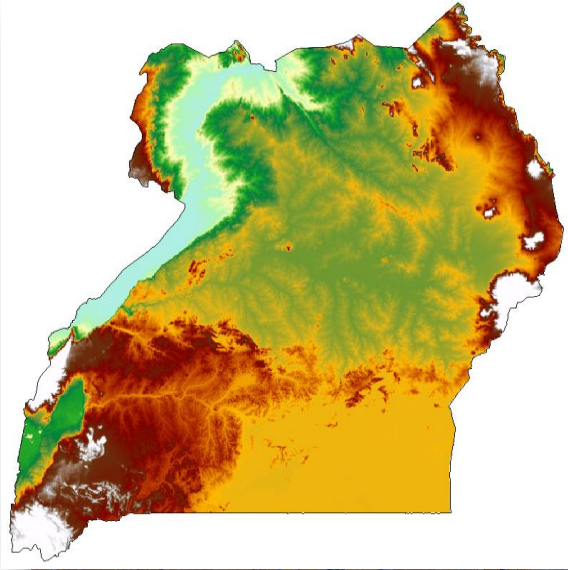
CC-by-SA www.itoworld.com

Map data www.openstreetmap.org 31 Jan 2010

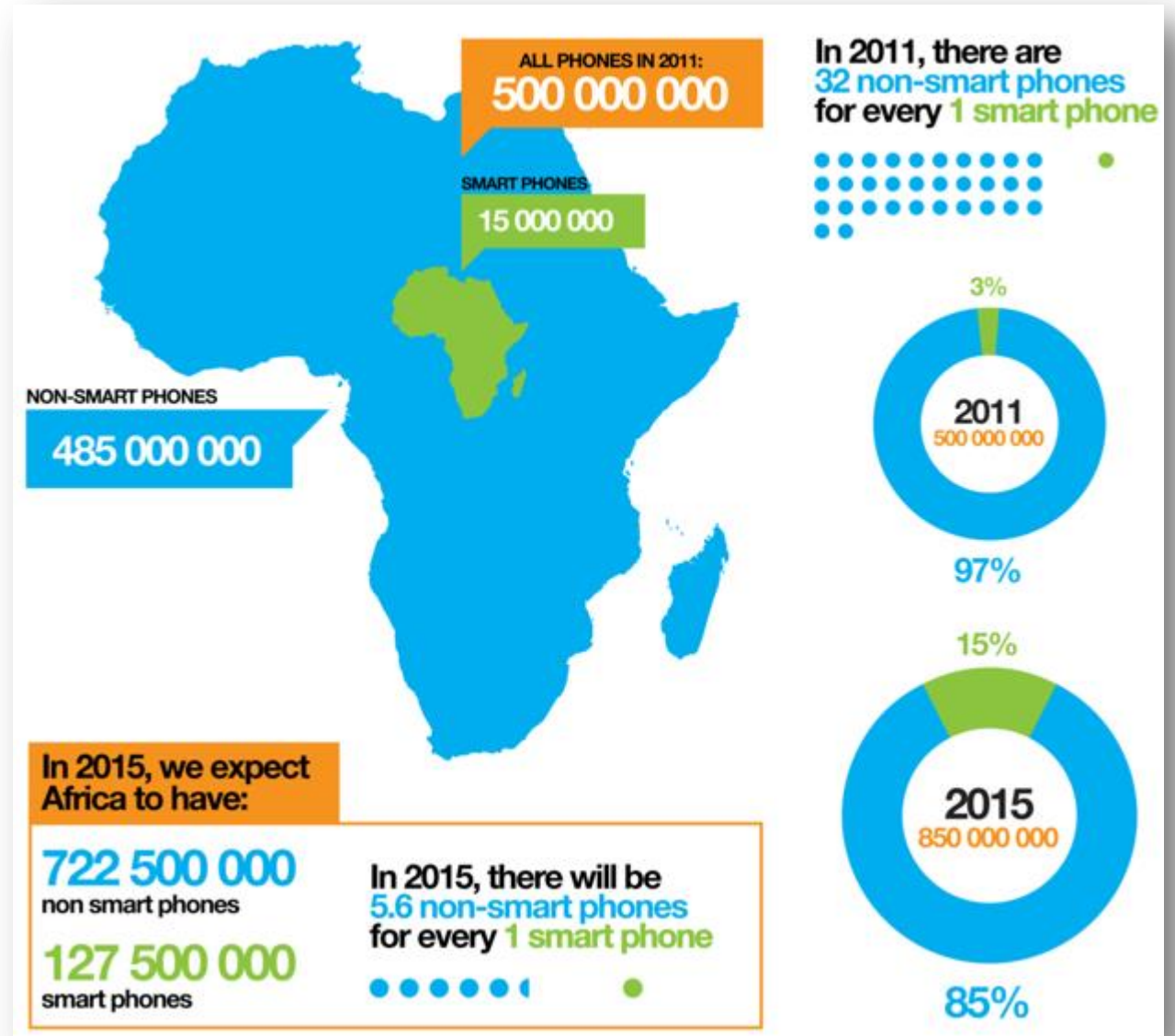
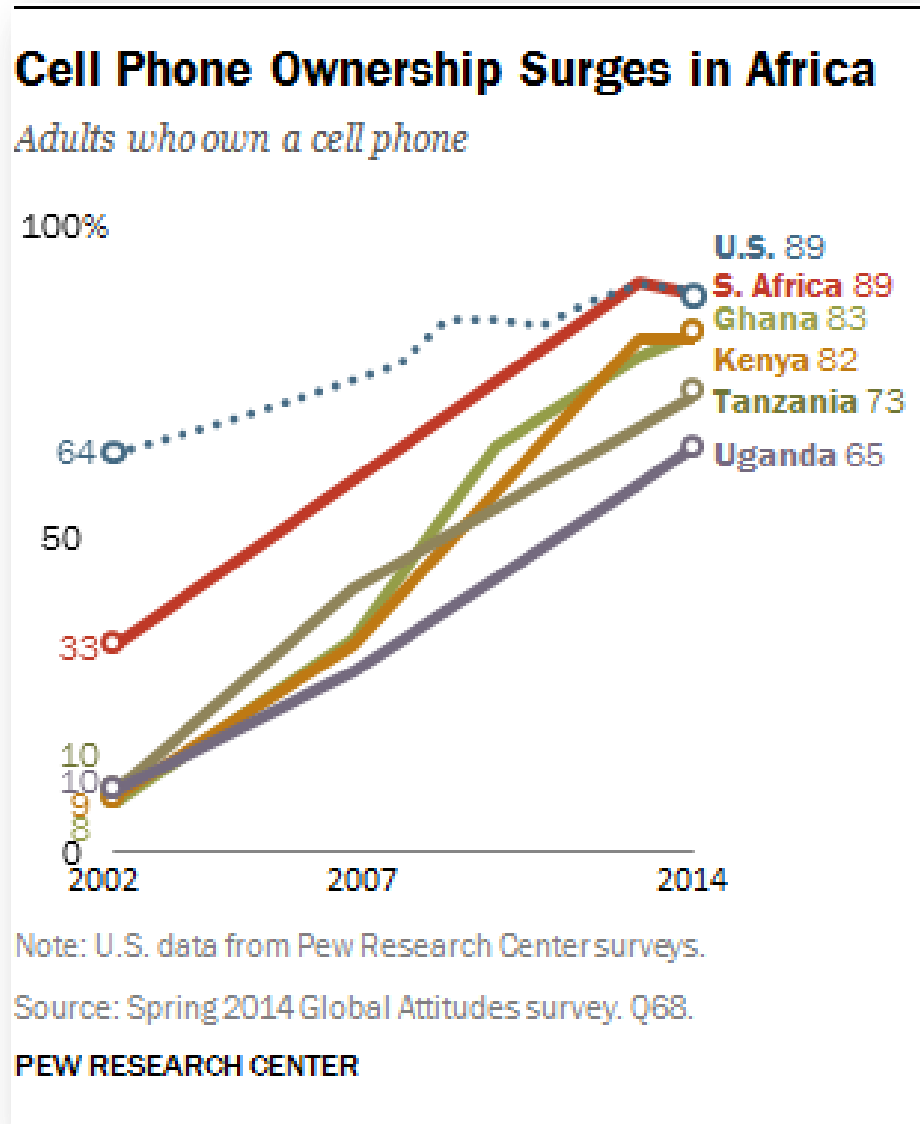
Geographic Information System (GIS) Data



Satellite imagery



Mobile phone call detail records (CDRs)



Mobile phone call detail records (CDRs)



User makes a call from location X



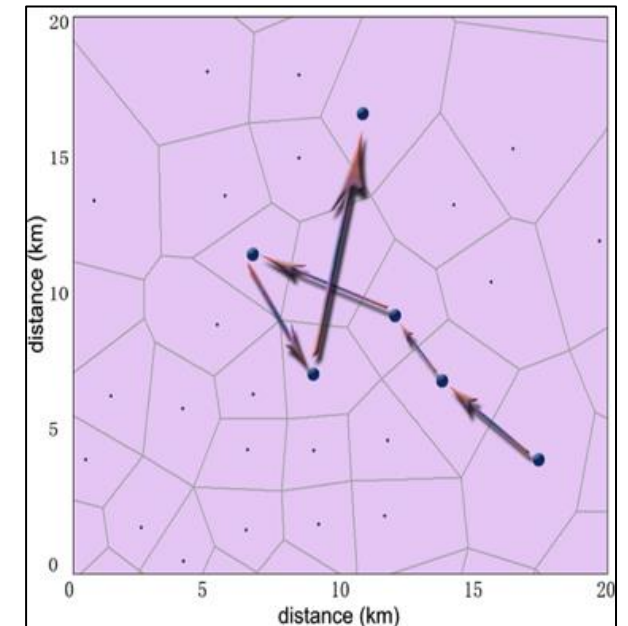
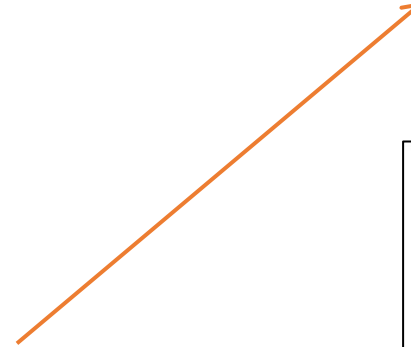
Call routed through nearest tower

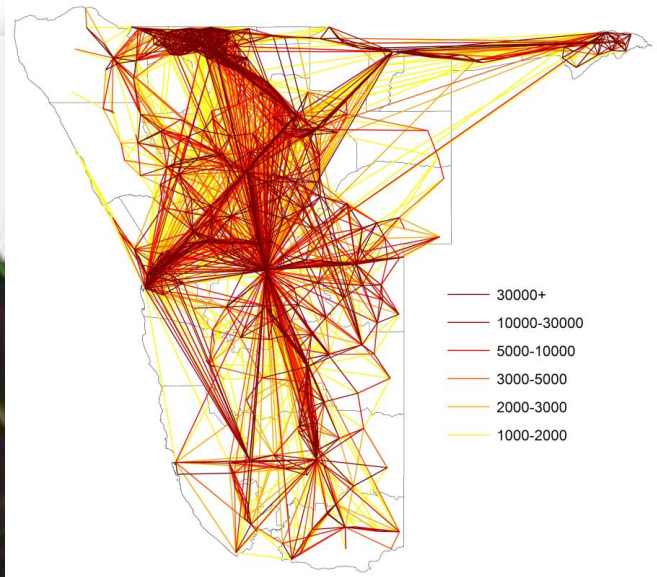
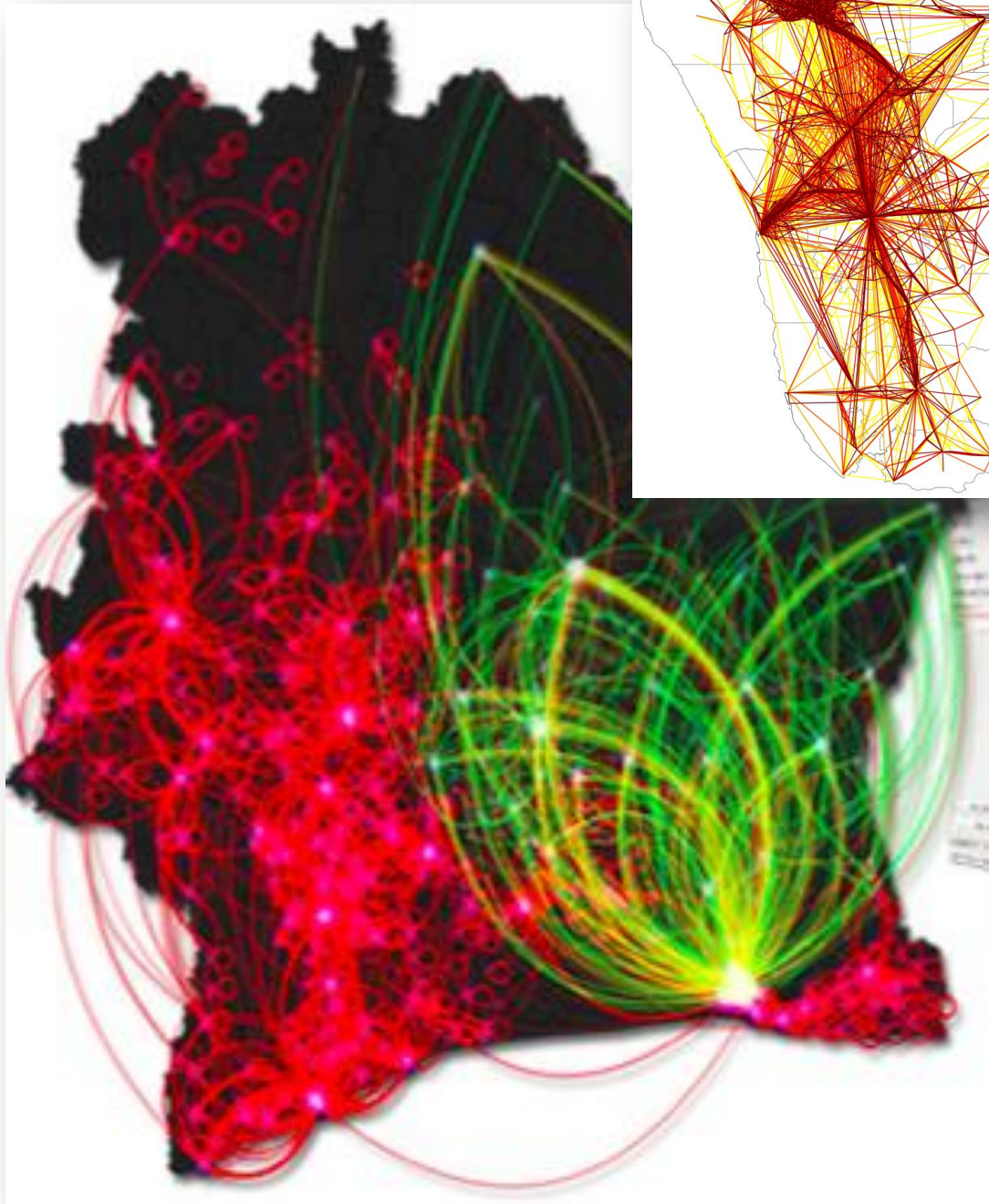


Network operator records time and tower of call for billing



User travels to Y and makes a call





Mobility: Changing densities, flows, seasonal/permanent migration

Social networks: Number of contacts, calling patterns

Consumption: Credit purchase frequencies, top-up amounts

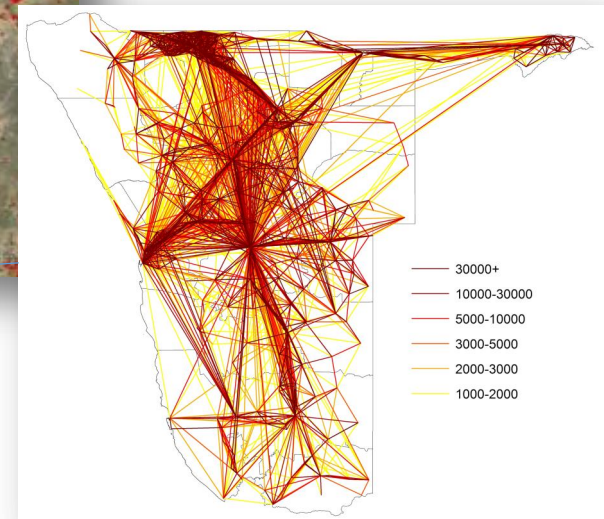
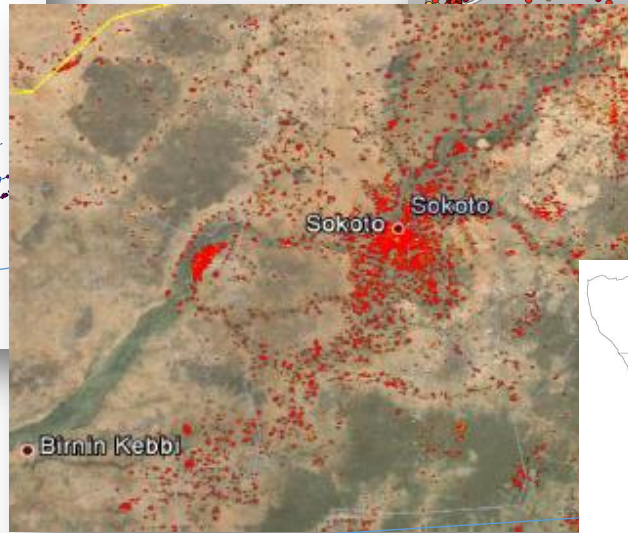
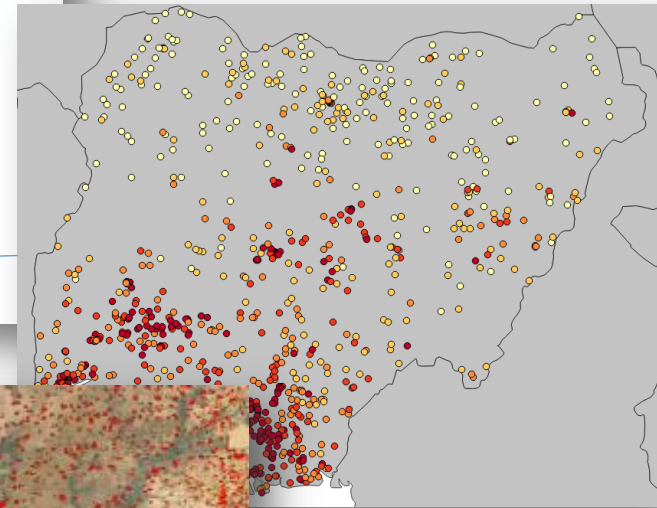
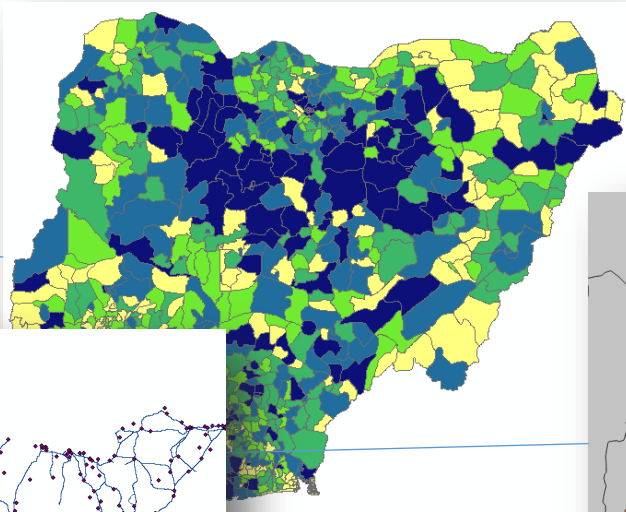
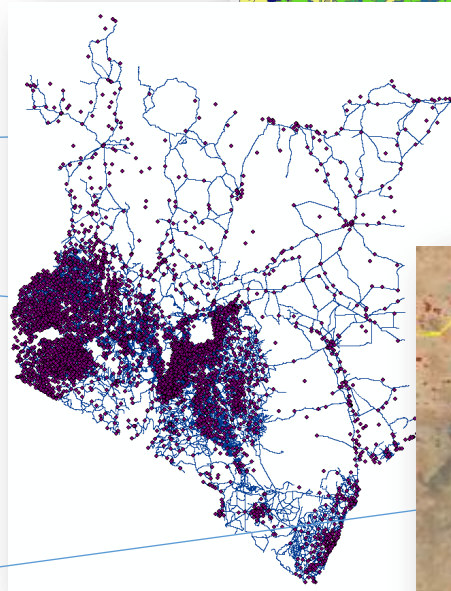
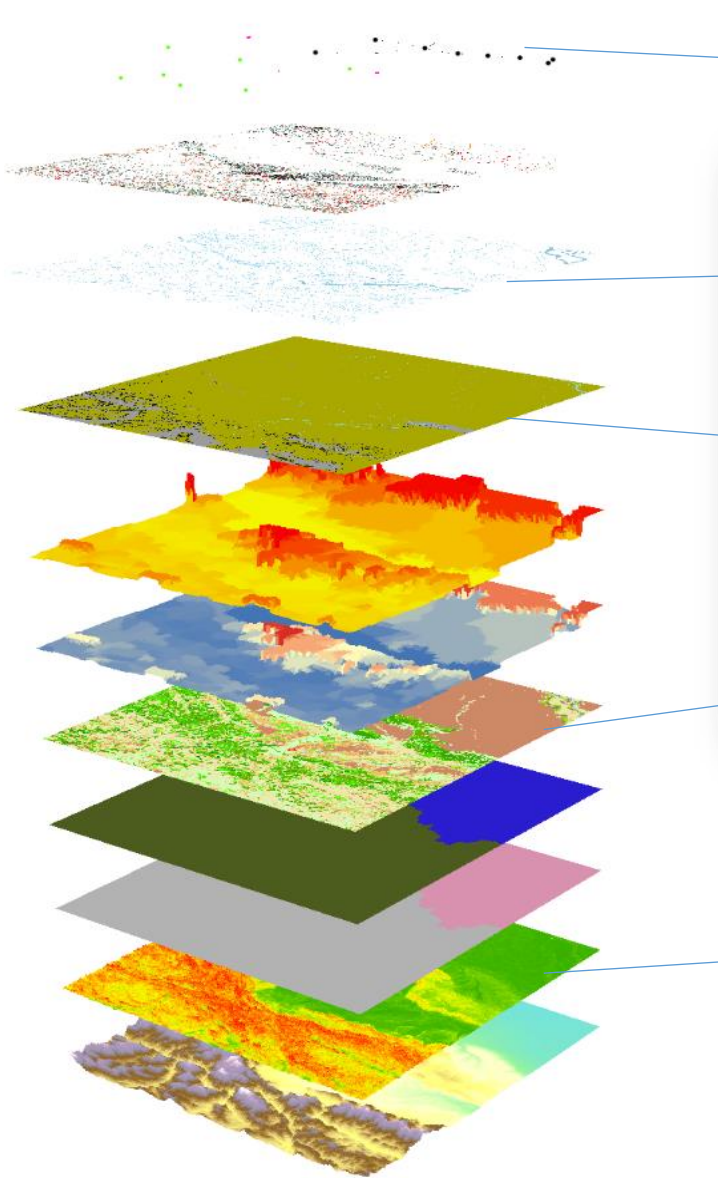
Protecting confidentiality

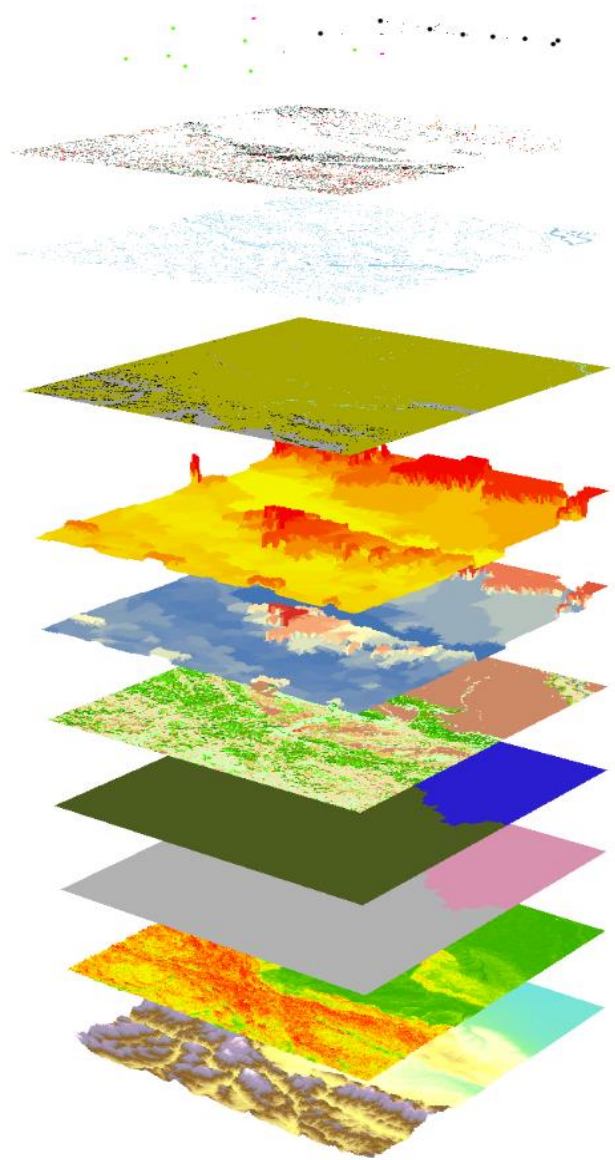
- Aggregate summaries
- Regulator approval
- Raw data never leaves operator

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Data integration

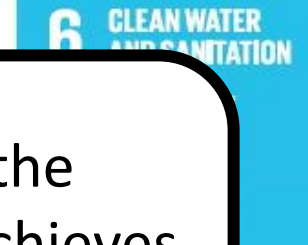
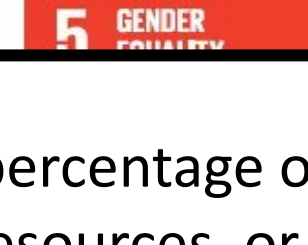
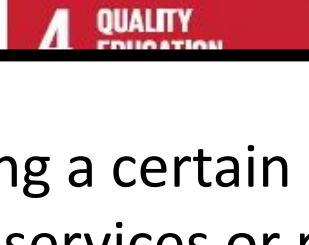
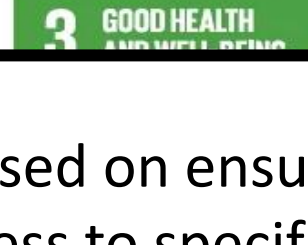
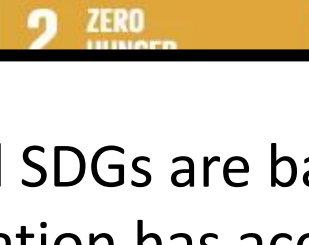





How are all these data useful?



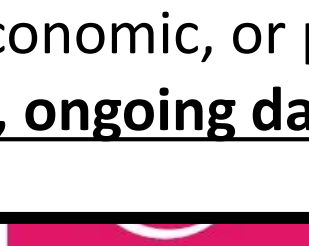
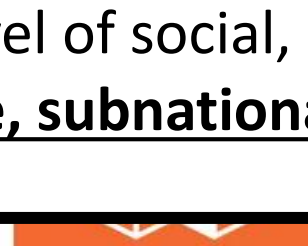
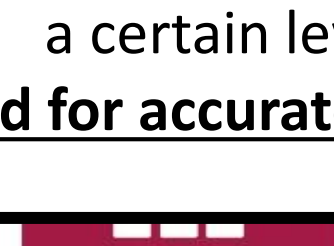



SUSTAINABLE DEVELOPMENT GOALS



All SDGs are based on ensuring a certain percentage of the population has access to specific services or resources, or achieves a certain level of social, economic, or physical health

Need for accurate, subnational, ongoing data on denominators

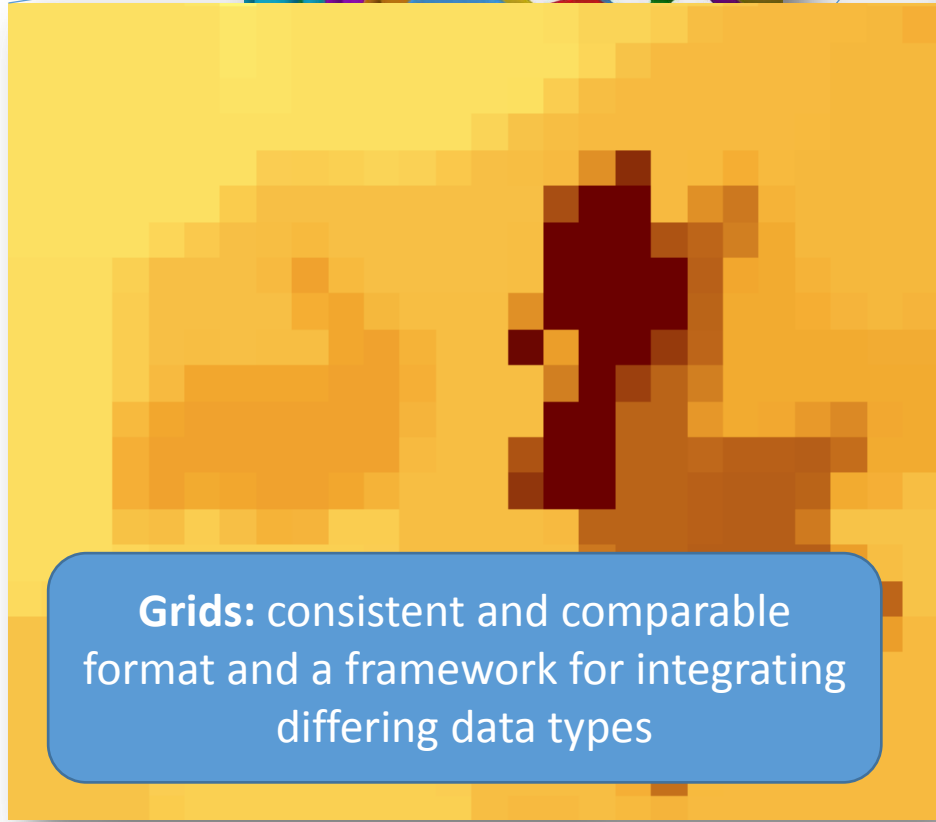
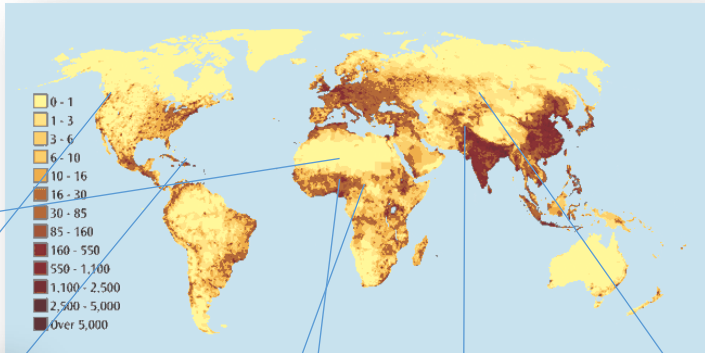


How can we get there with census data plus these newer datasets?



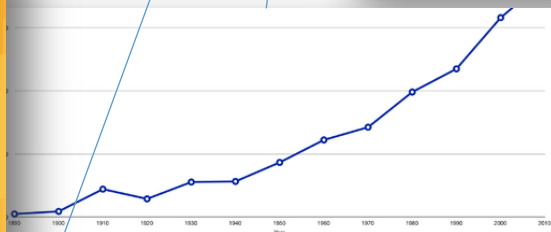
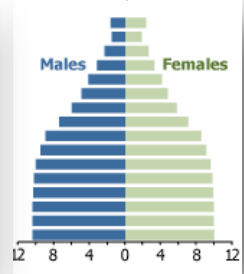
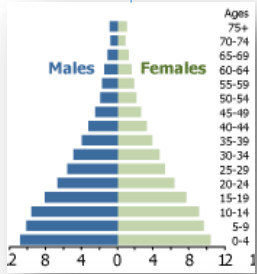
Spatial Demography

- Where is everybody?



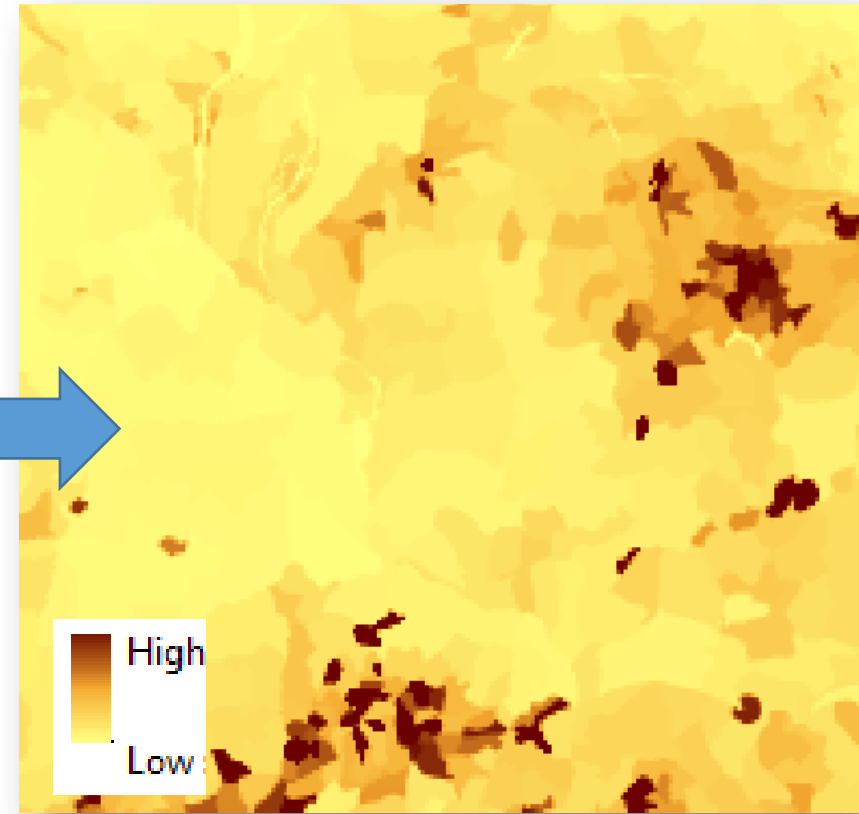
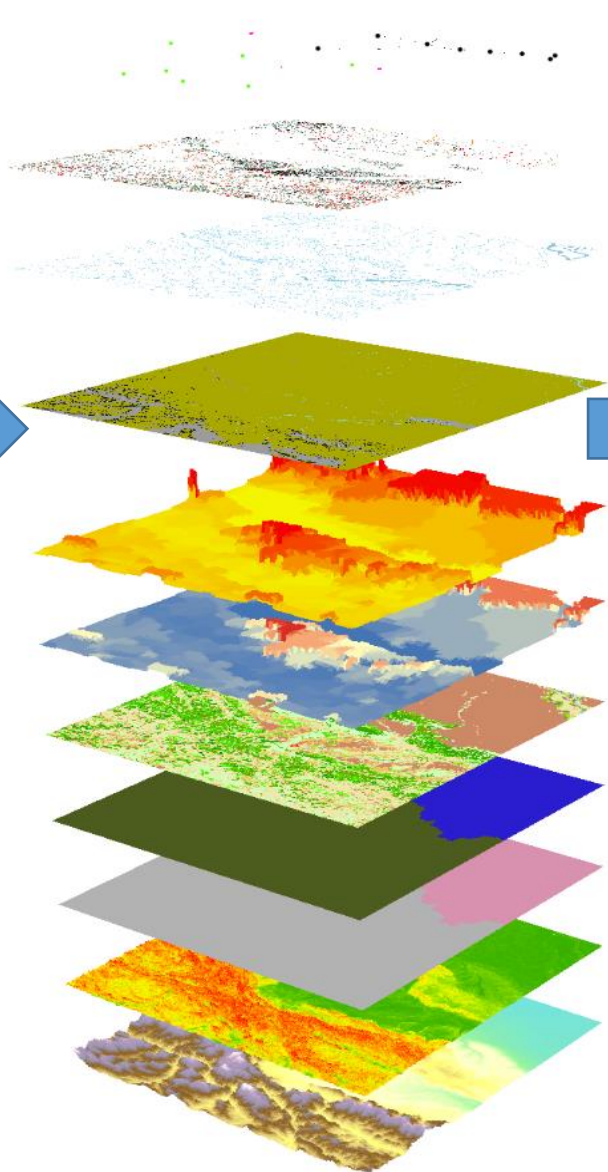
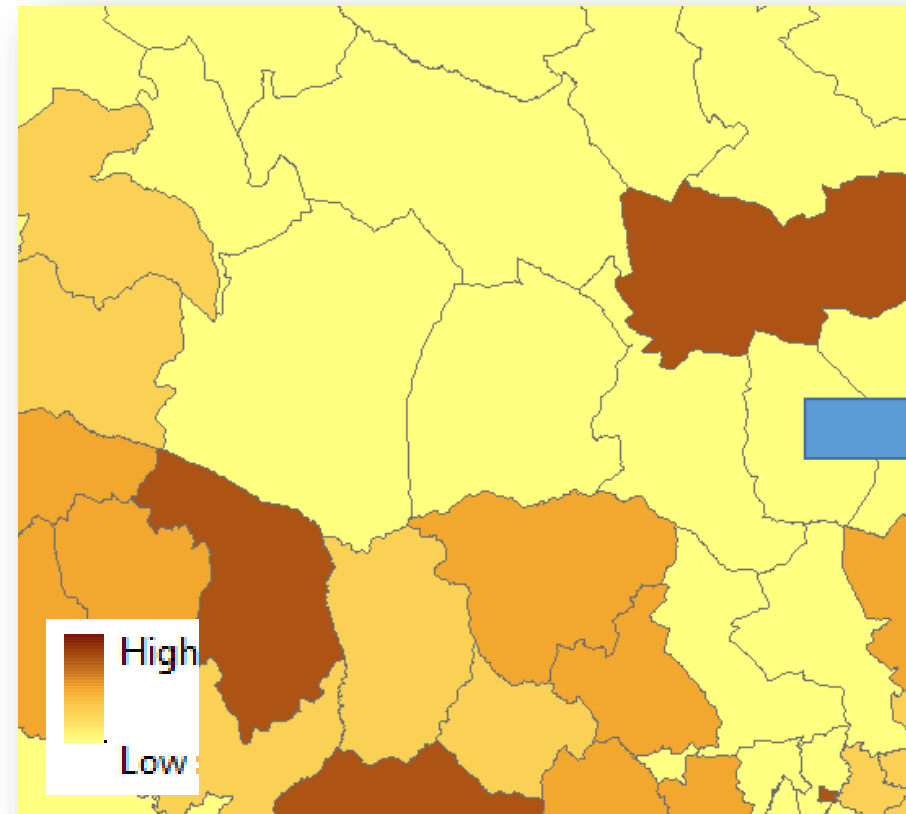
Grids: consistent and comparable format and a framework for integrating differing data types

- Who is there?



mobile is the population?

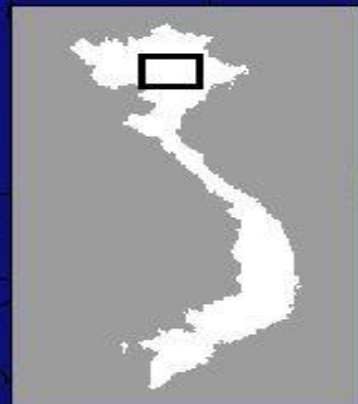
Census data disaggregation



Census counts generally aggregated at coarse, irregular administrative unit level, making integration and comparisons with other data challenging

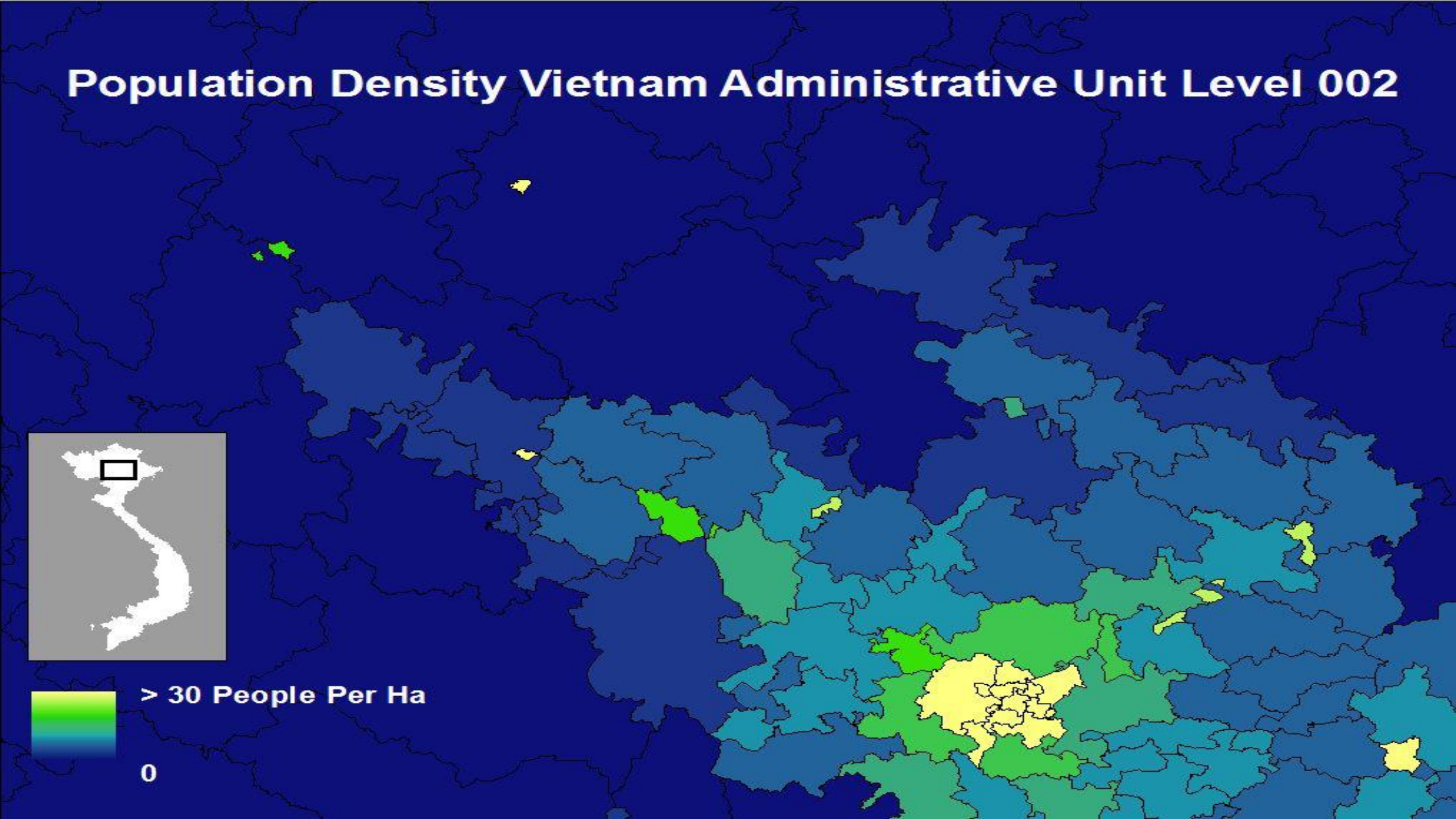
Integration with satellite/GIS data related to human population distribution patterns to disaggregate counts to regular grids using machine learning

Population Density Vietnam Administrative Unit Level 002

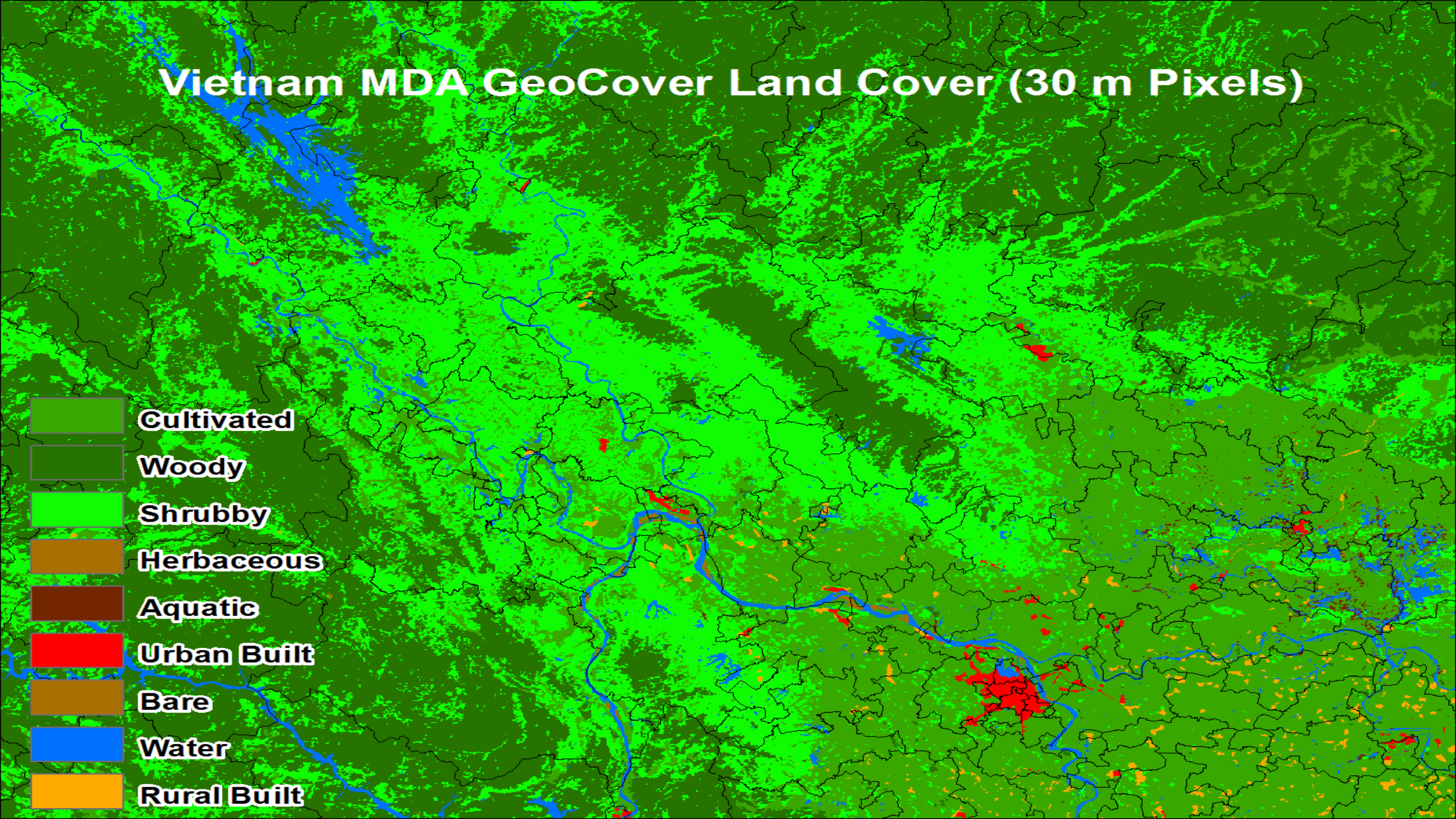
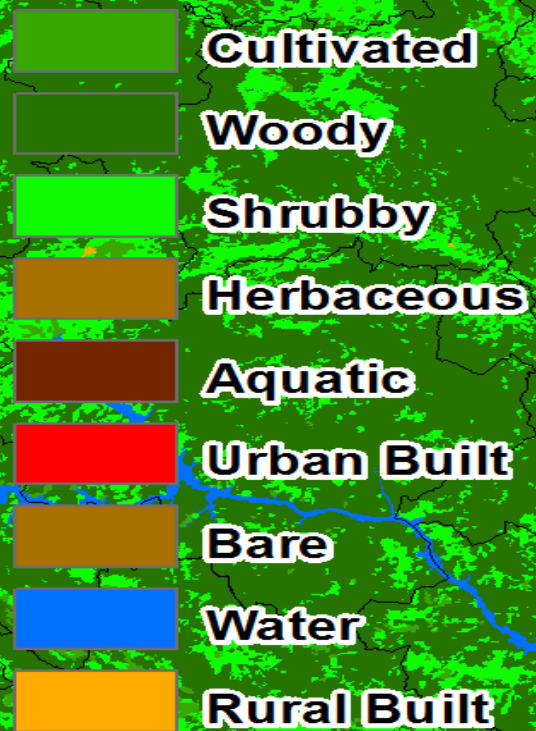


> 30 People Per Ha

0



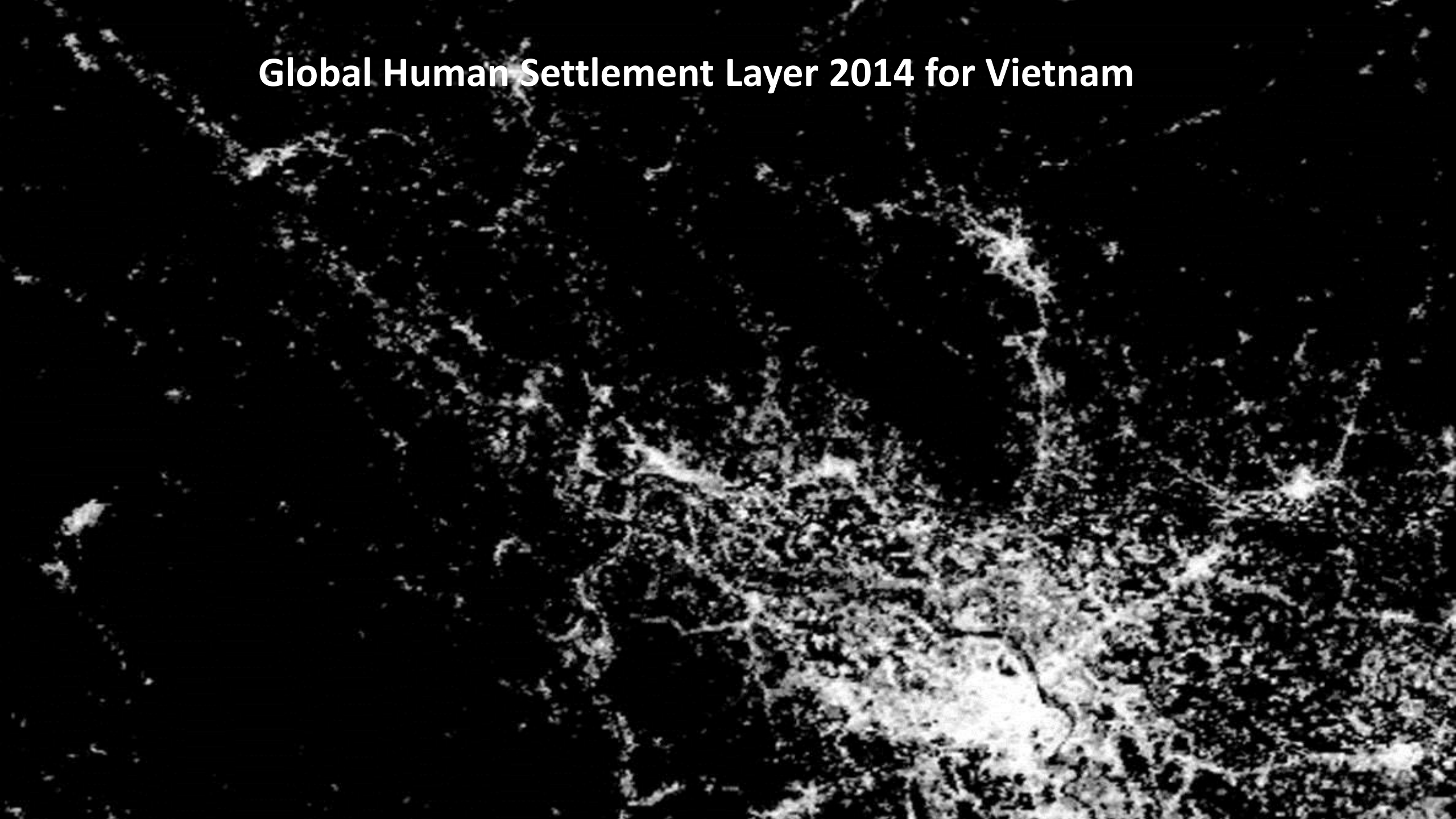
Vietnam MDA GeoCover Land Cover (30 m Pixels)



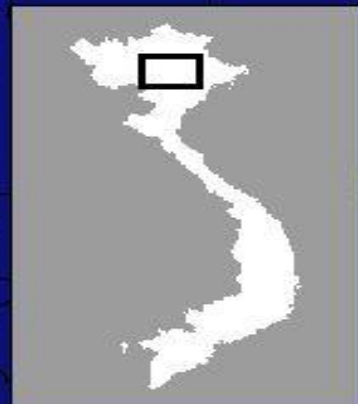
NOAA Suomi VIIRS-derived Lights at Night 2012 for Vietnam



Global Human Settlement Layer 2014 for Vietnam

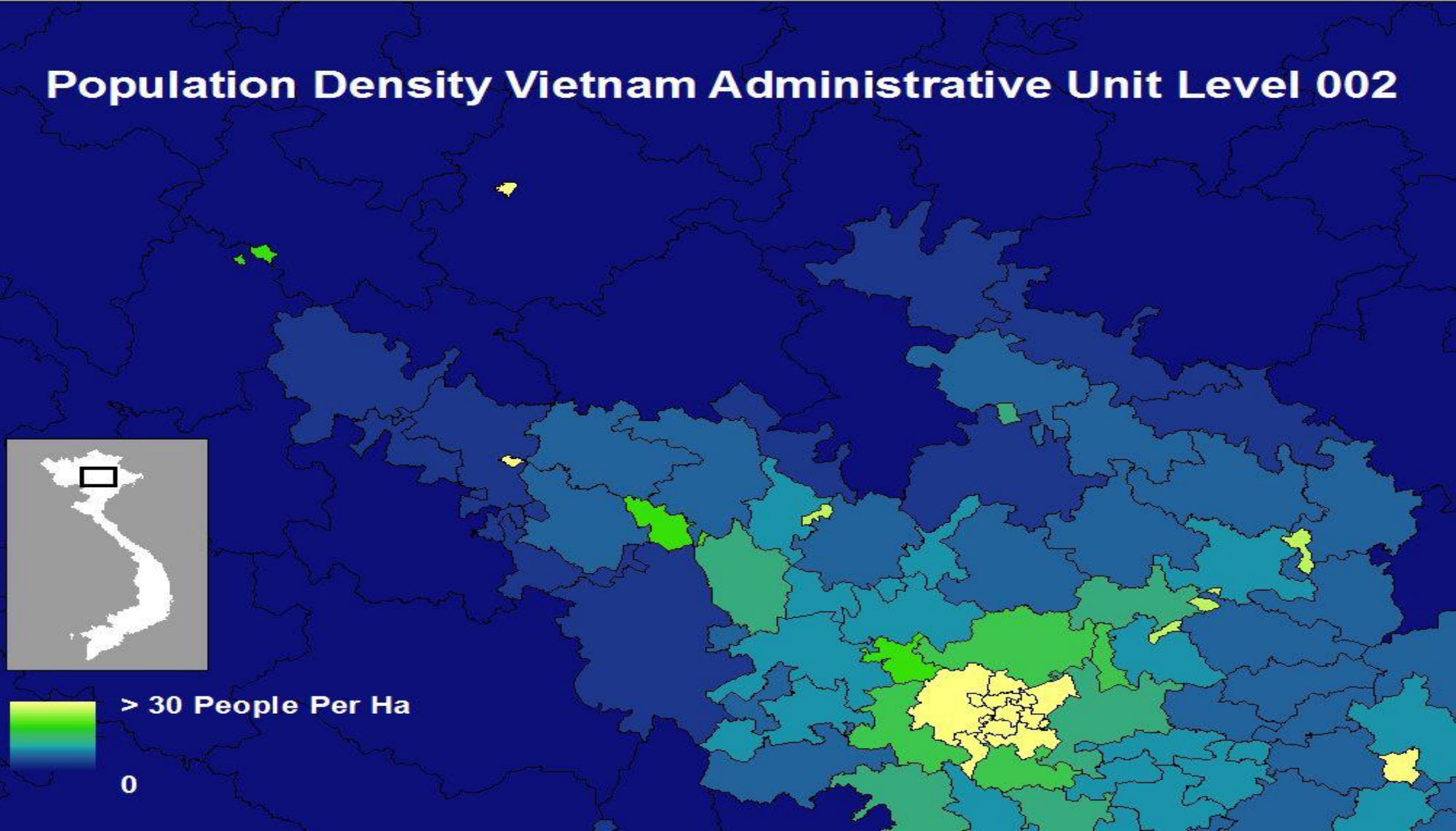


Population Density Vietnam Administrative Unit Level 002



> 30 People Per Ha

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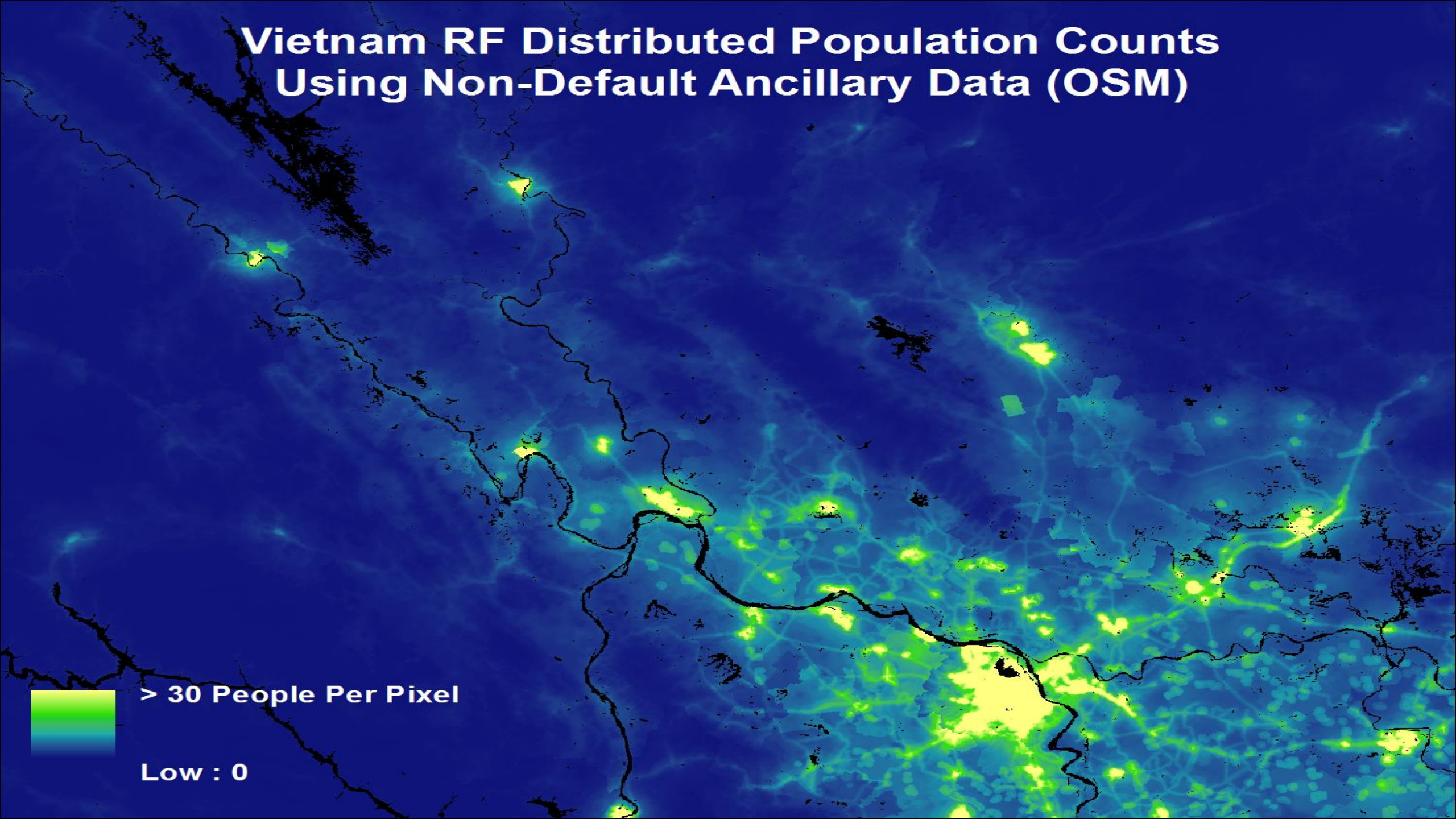


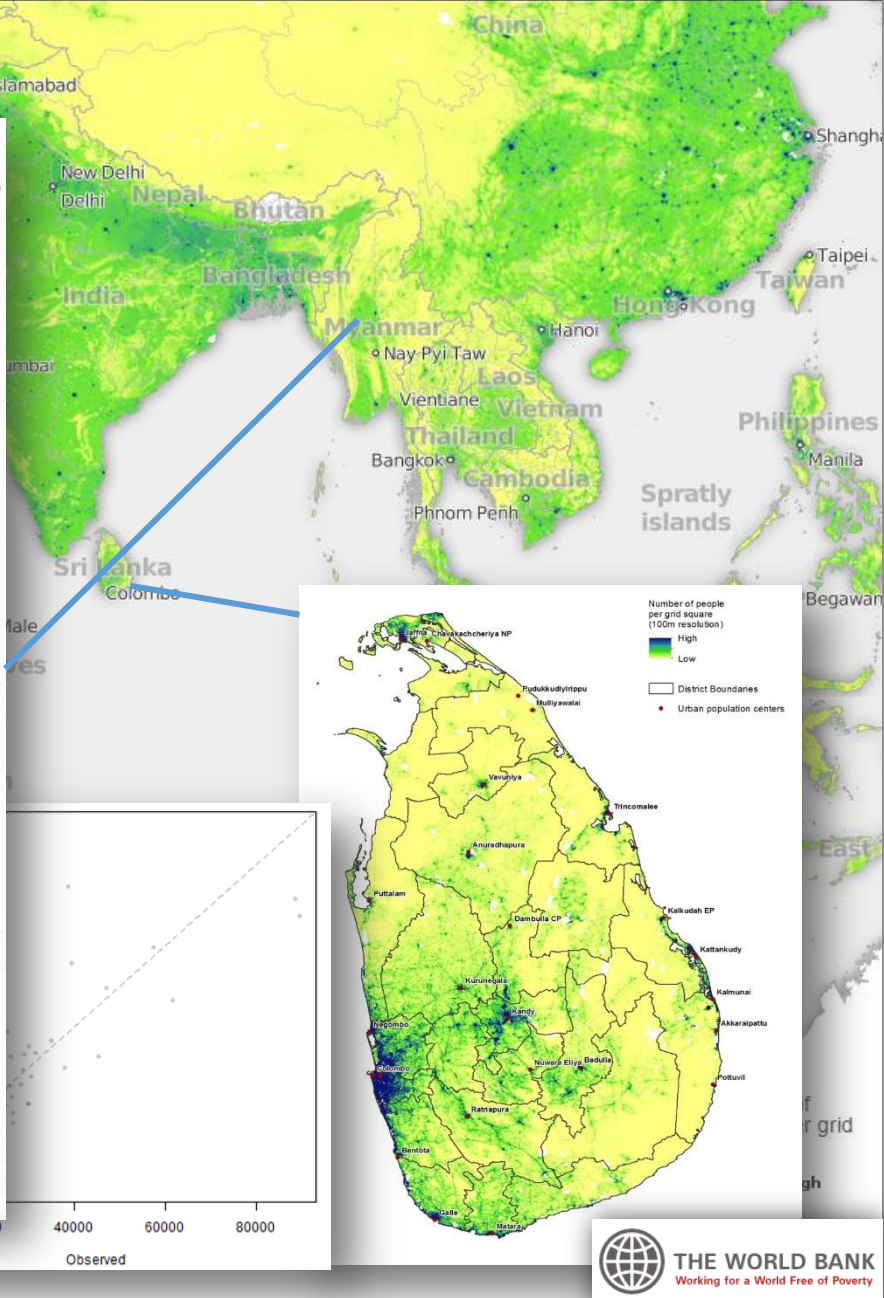
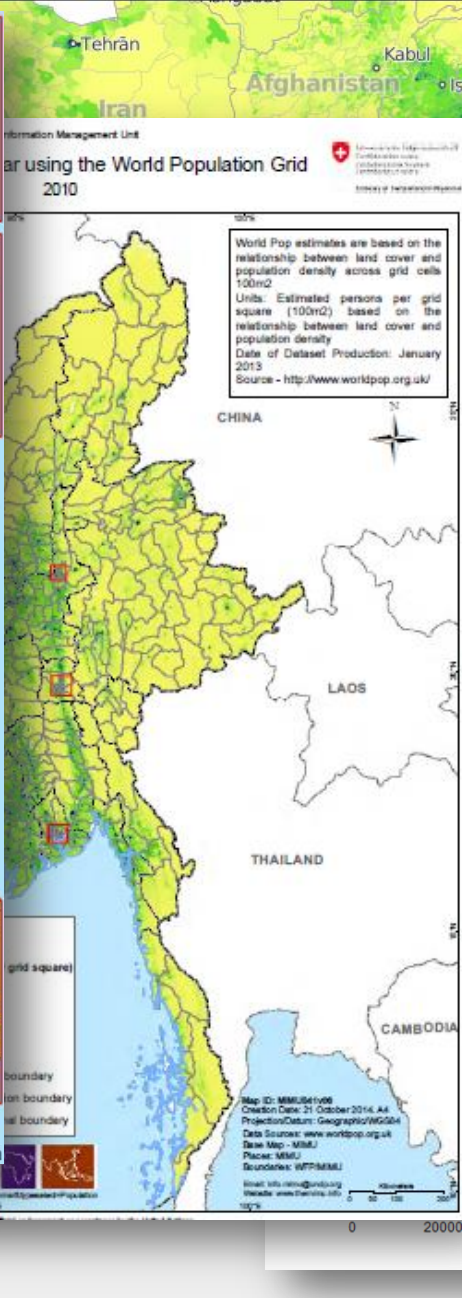
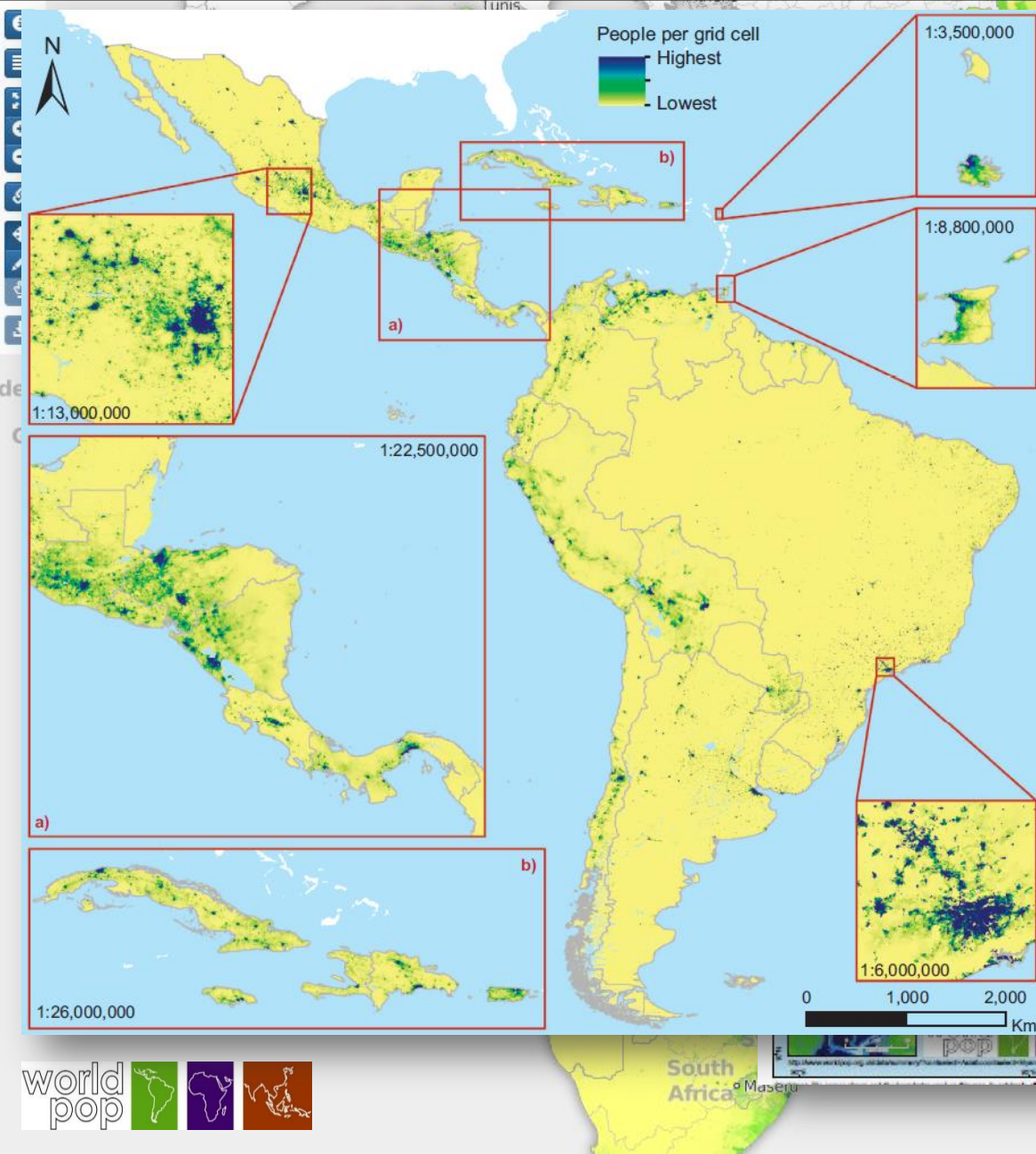
Vietnam RF Distributed Population Counts Using Non-Default Ancillary Data (OSM)



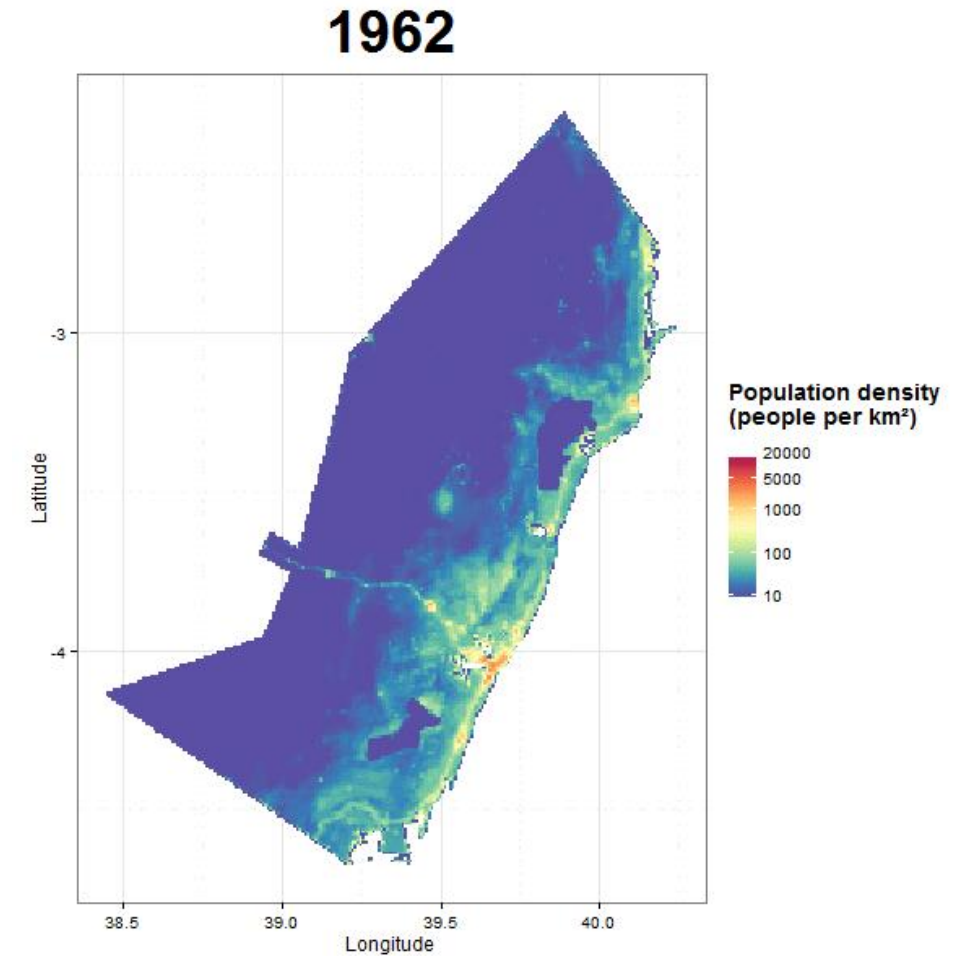
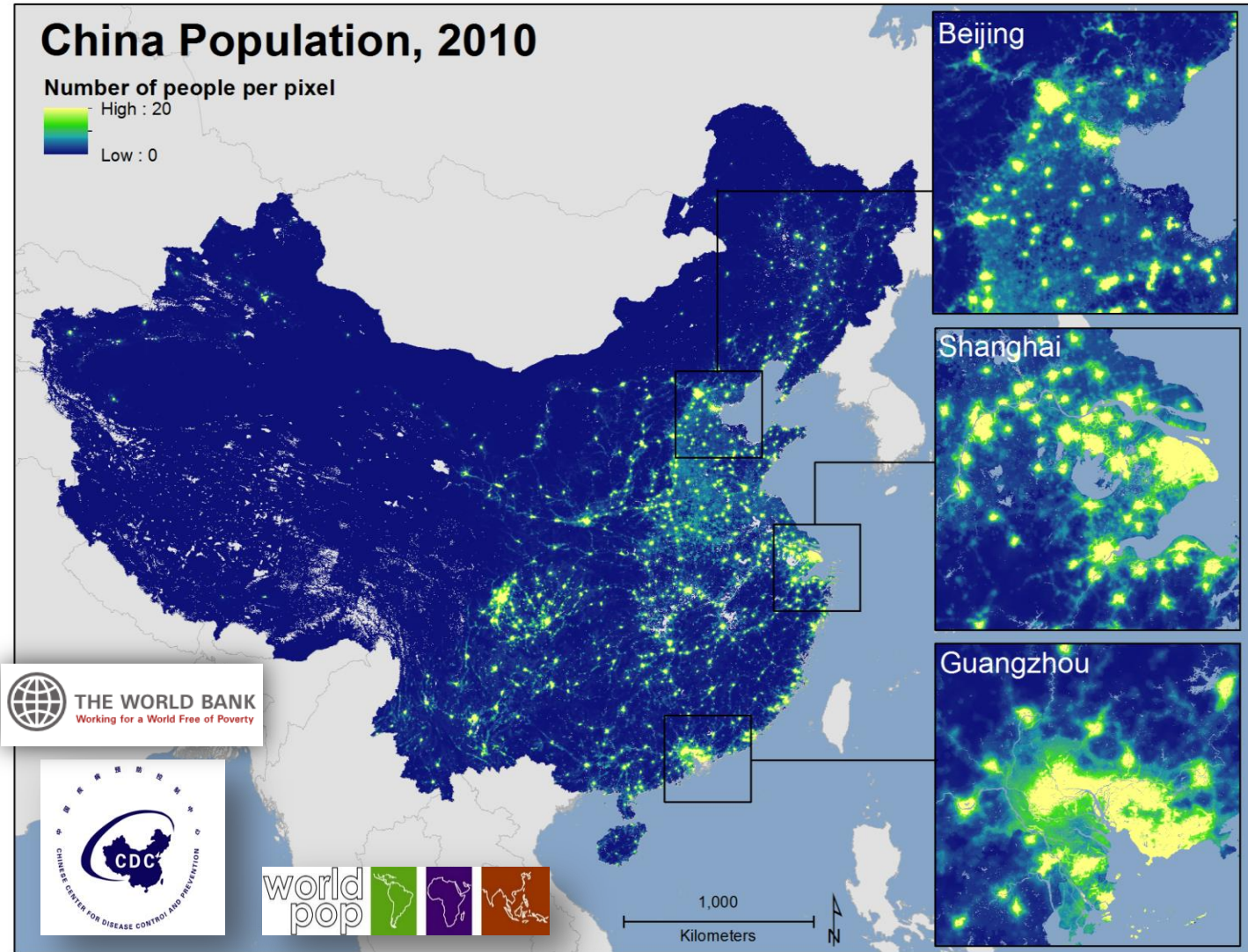
> 30 People Per Pixel

Low : 0

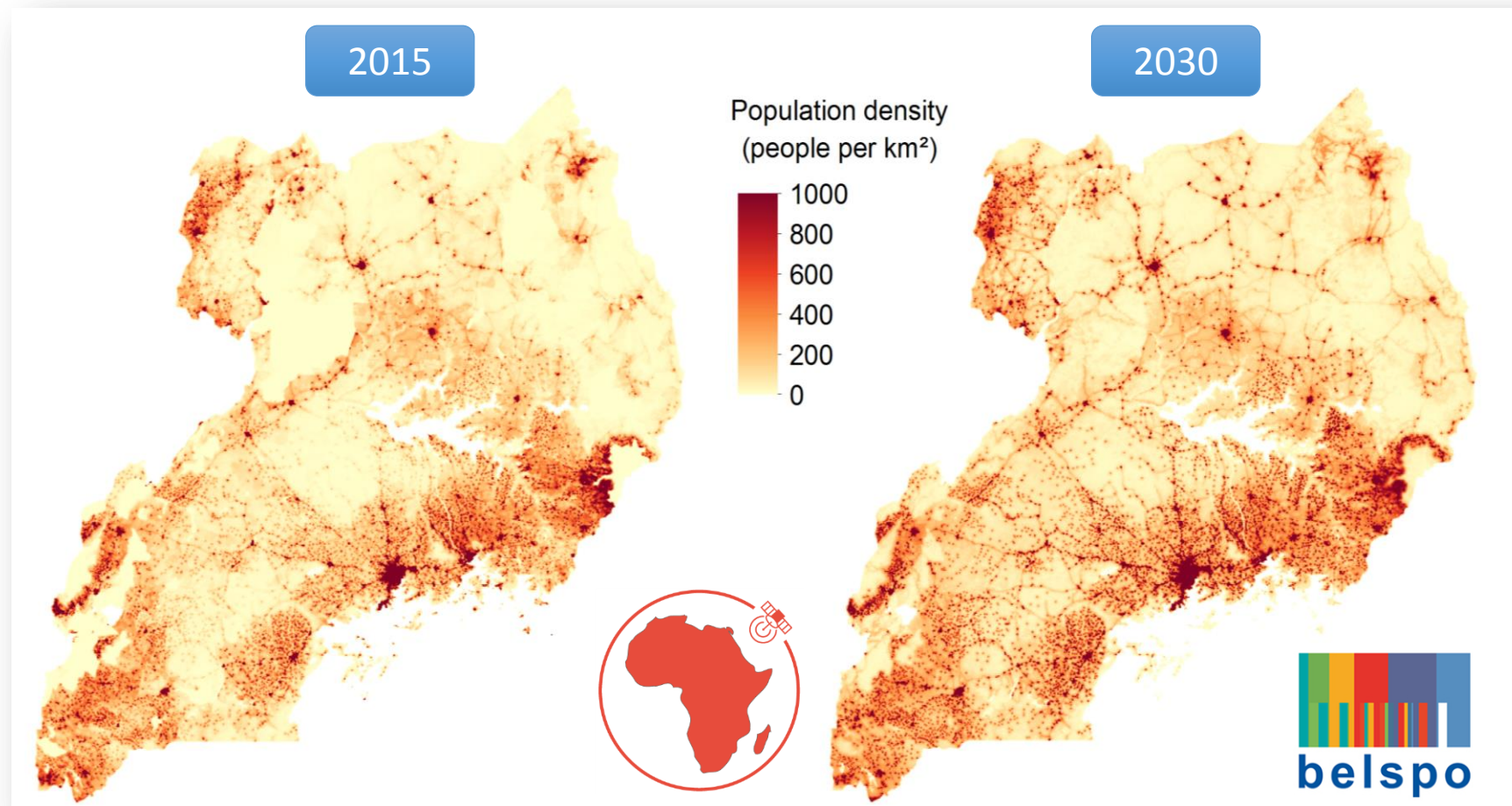
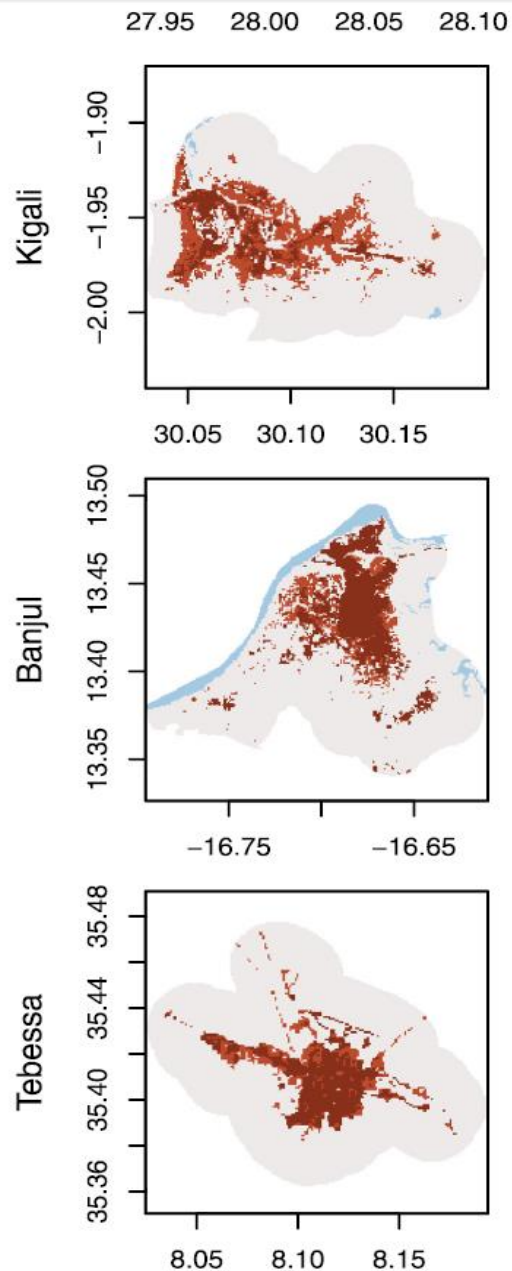




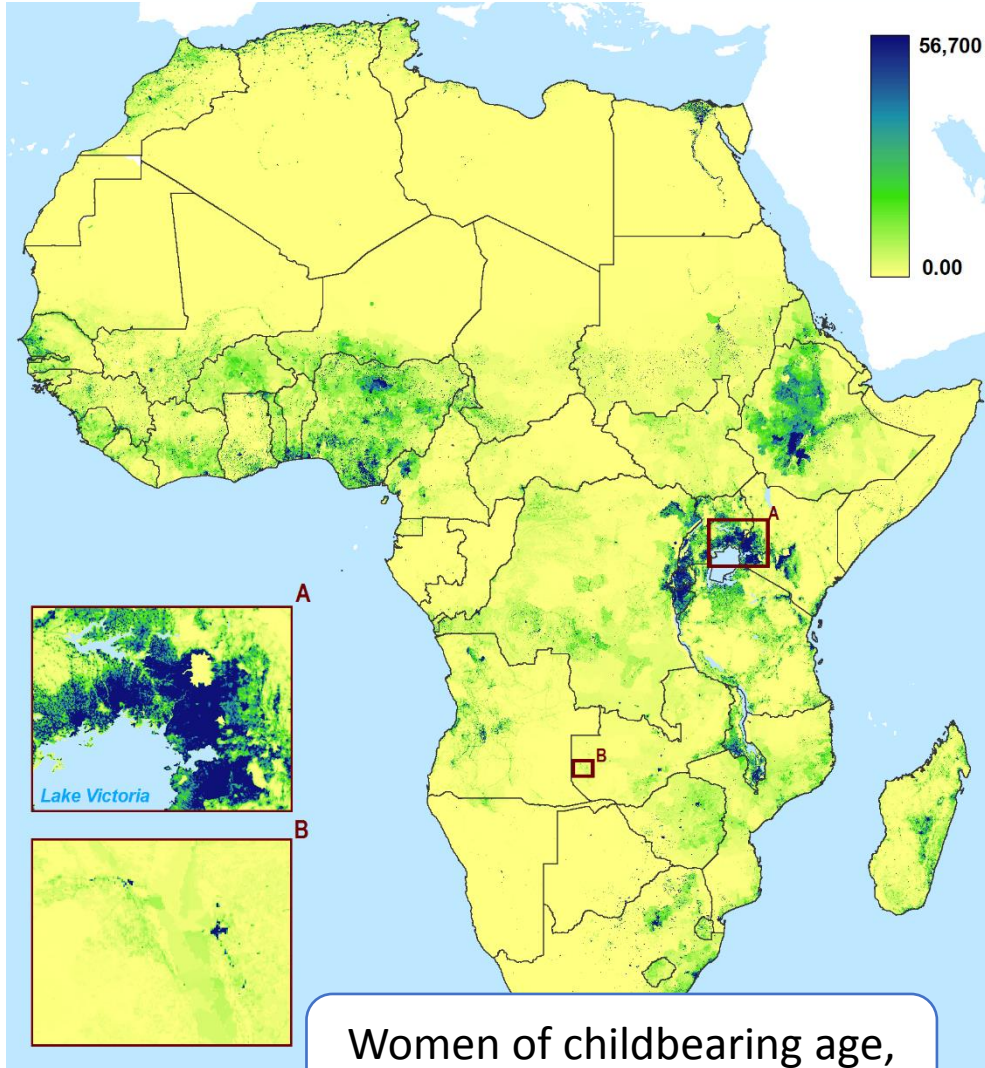
Mapping population change



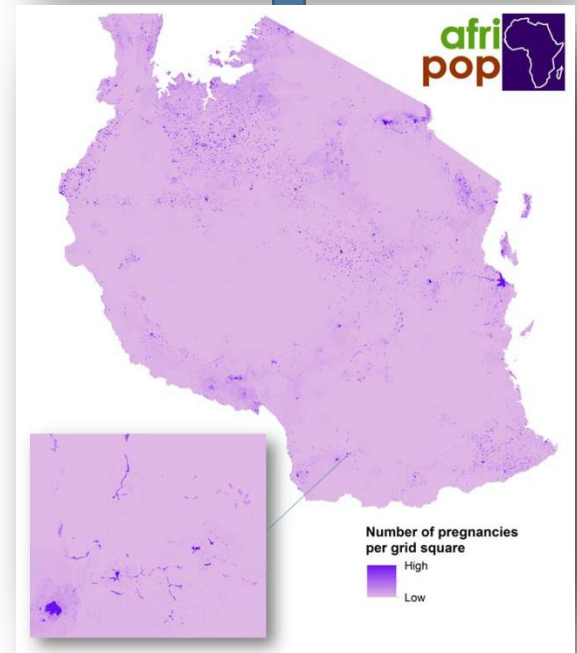
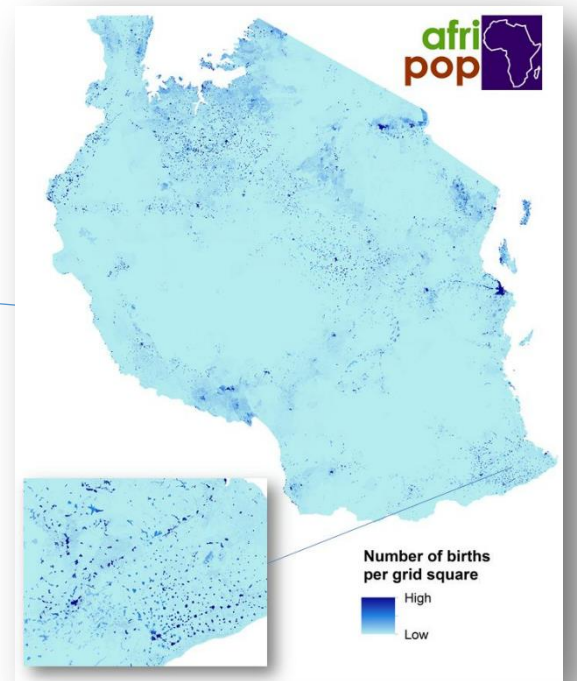
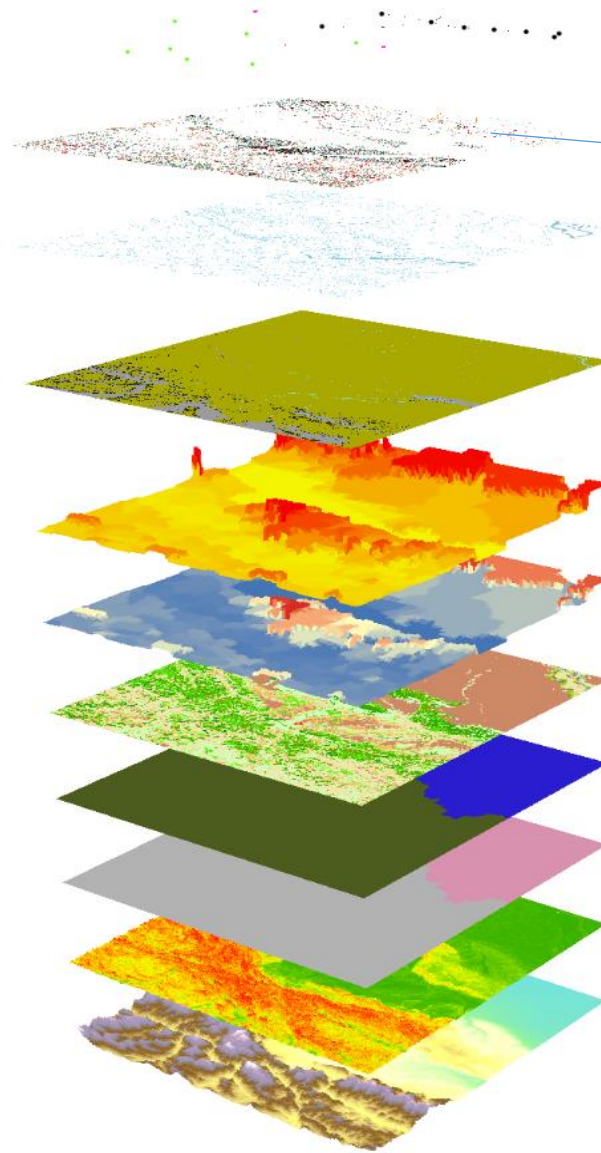
Future scenarios



Mapping demographics

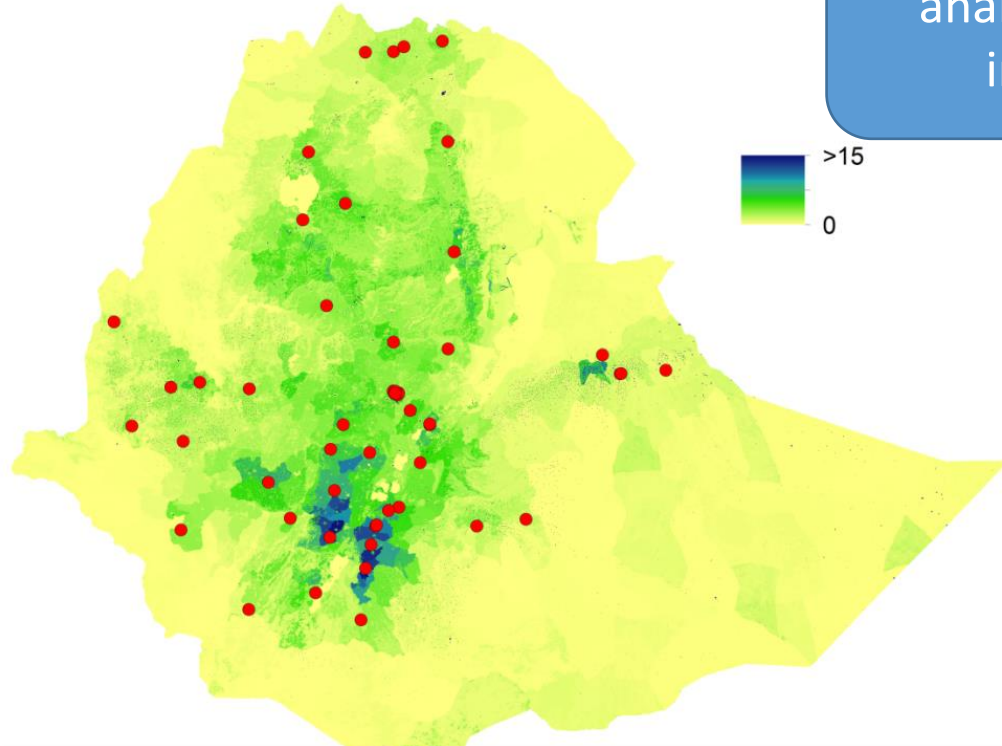


Women of childbearing age,
2010

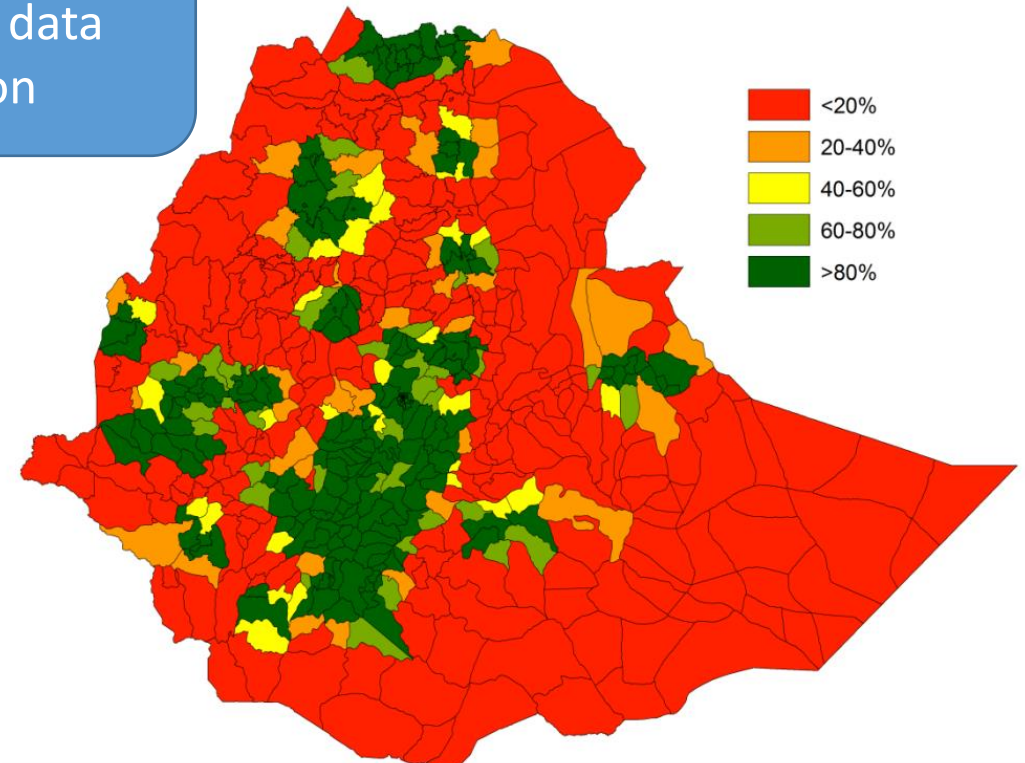


Benefits of 'gridded' demographic data

Grids: flexibility in analysis and data integration



Comprehensive Emergency Obstetric and Neonatal Care (CEmONC) Facilities overlaid on grid of women of childbearing age

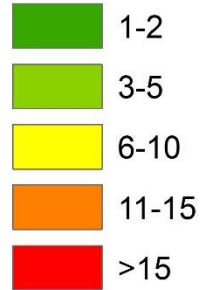


Percentage of women of childbearing age per woreda within 50km of a CEmONC

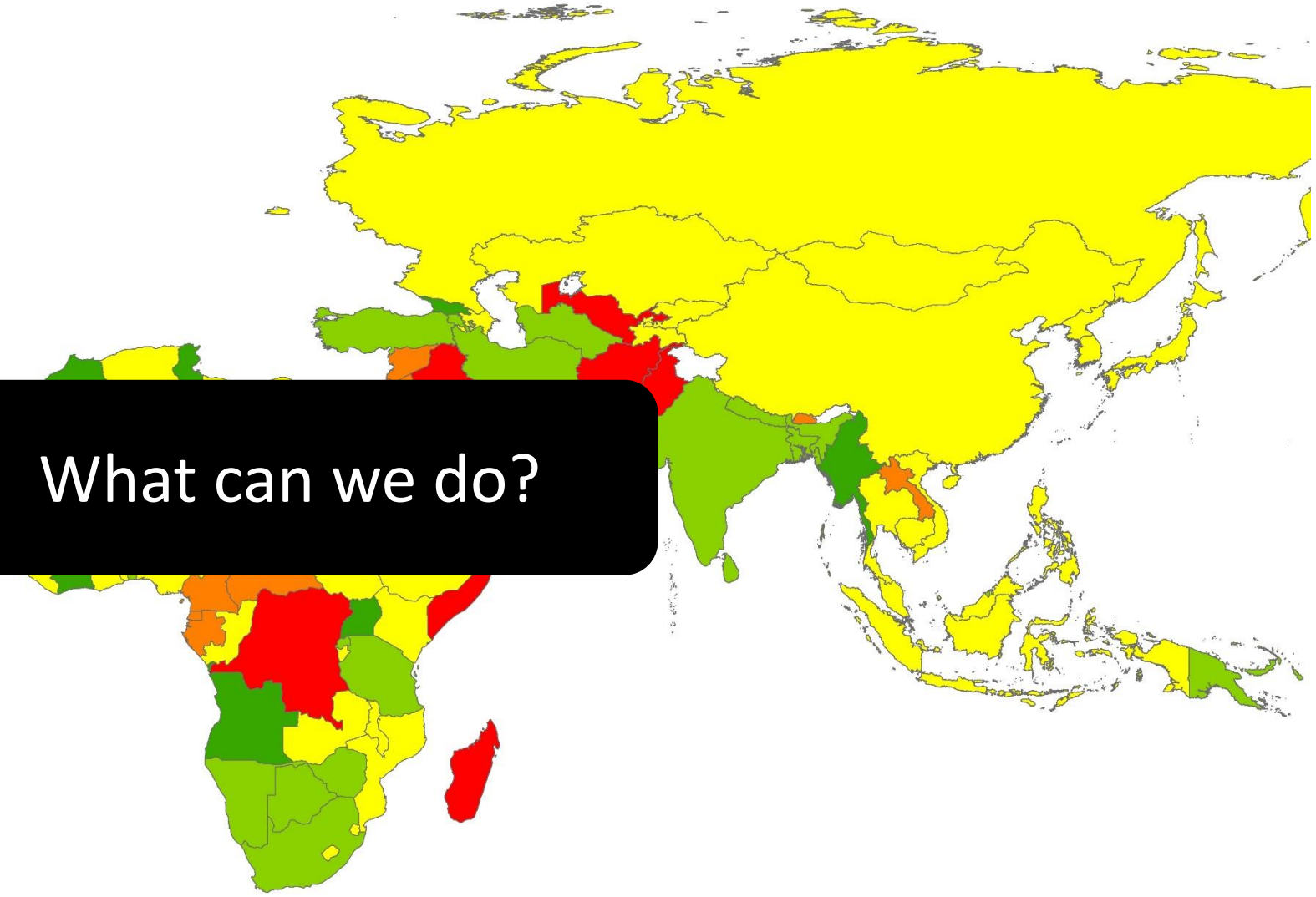
population totals

Census disaggregation can help us create valuable datasets....but.....

Years since last census



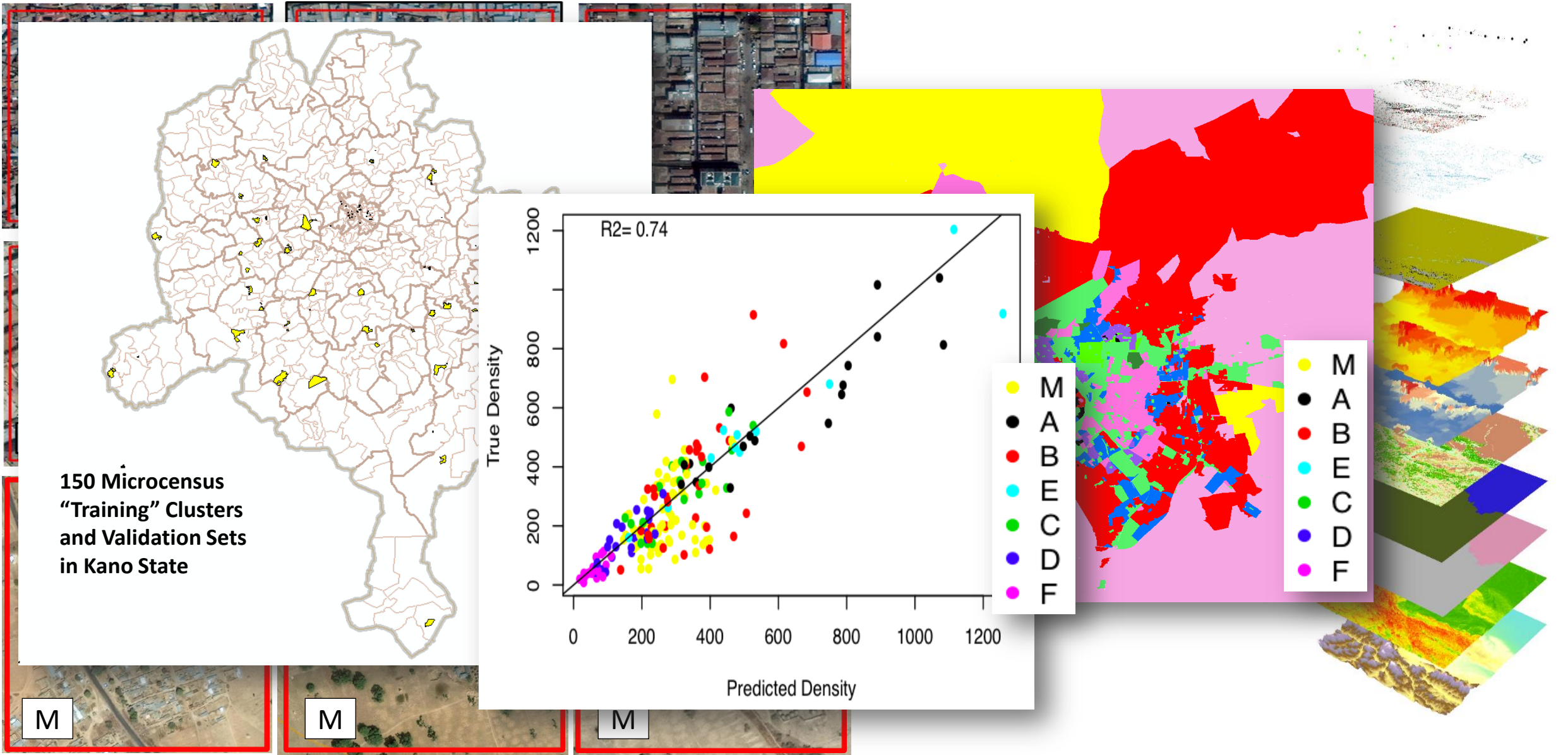
What can we do?



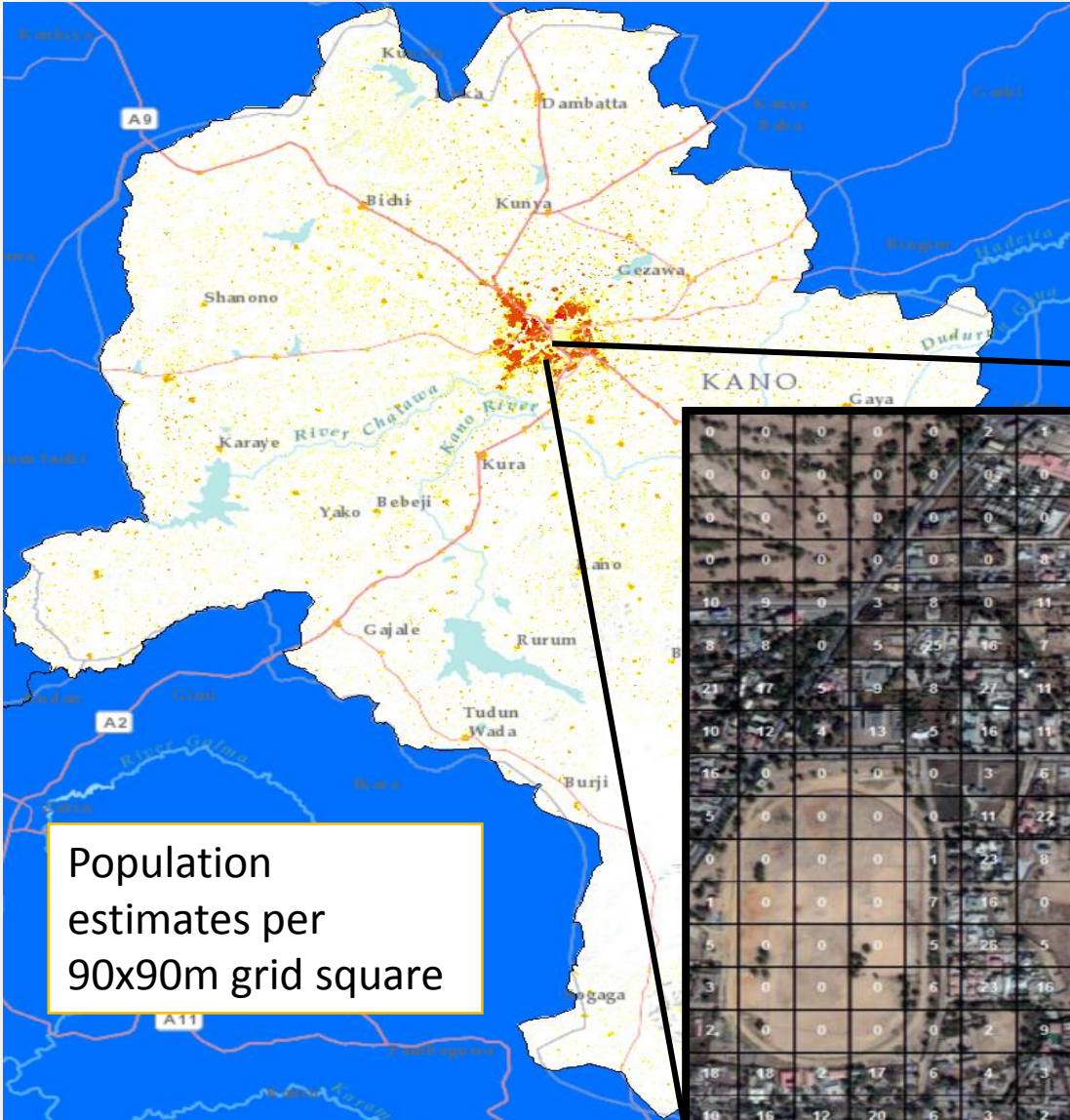
Satellite imagery feature extraction



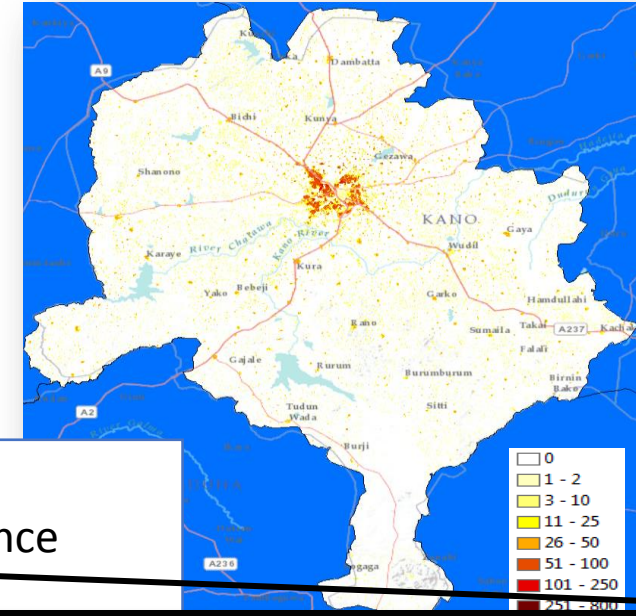
'Bottom-up' population estimation



Kano State, Nigeria



Lower confidence interval



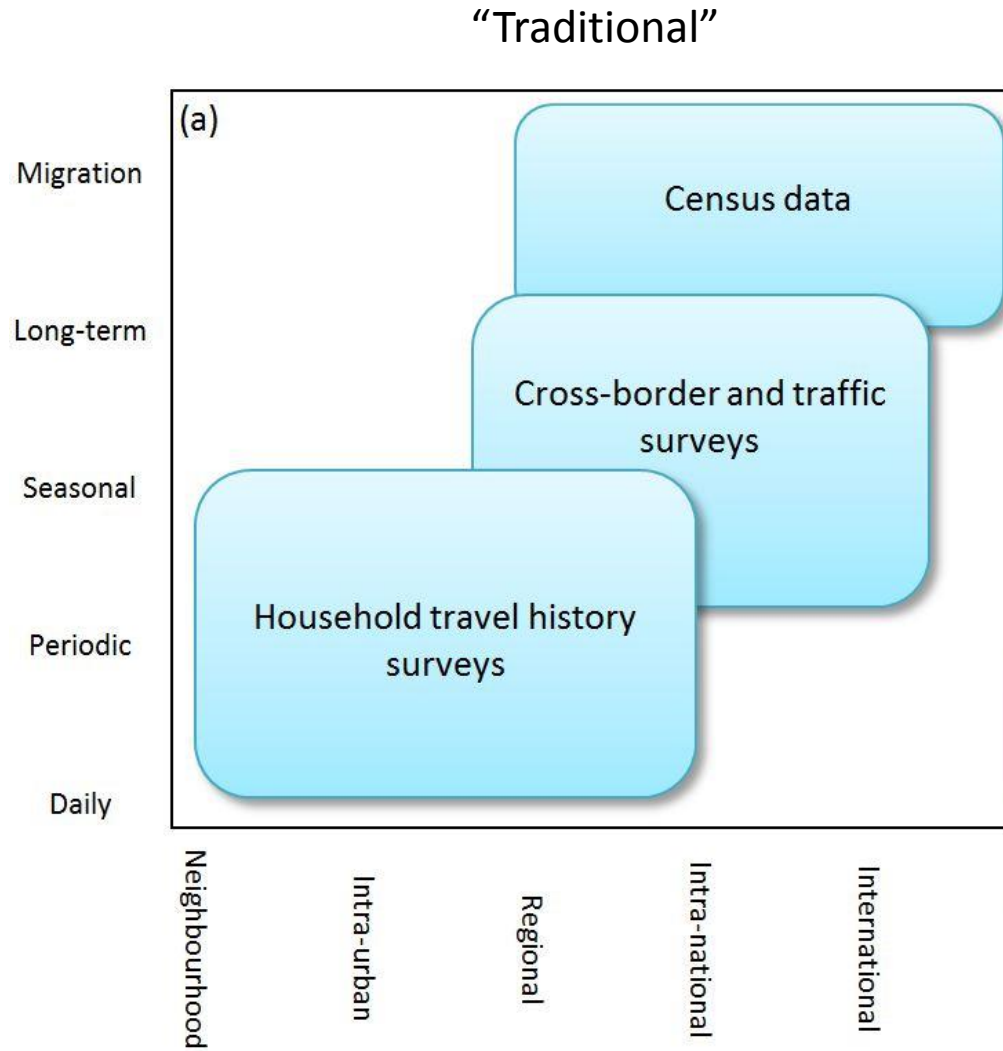
But populations don't stay still.....



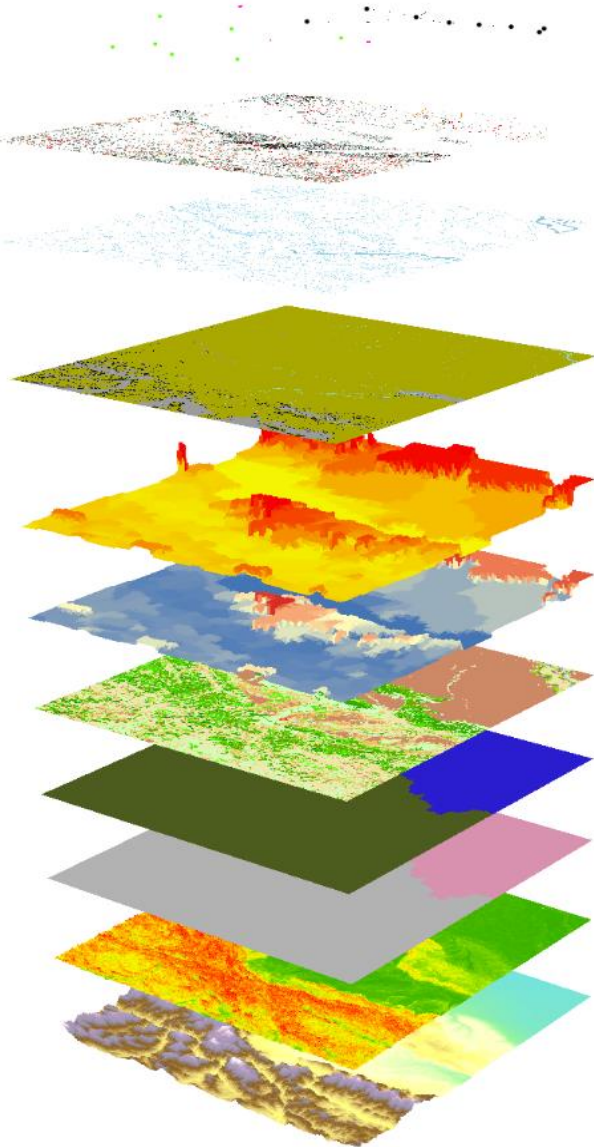
Impacts:

- Denominator estimates
- Health and development metrics
- Service demand, intervention needs
- Identification of vulnerable populations
- Disease dynamics
- Disaster relief

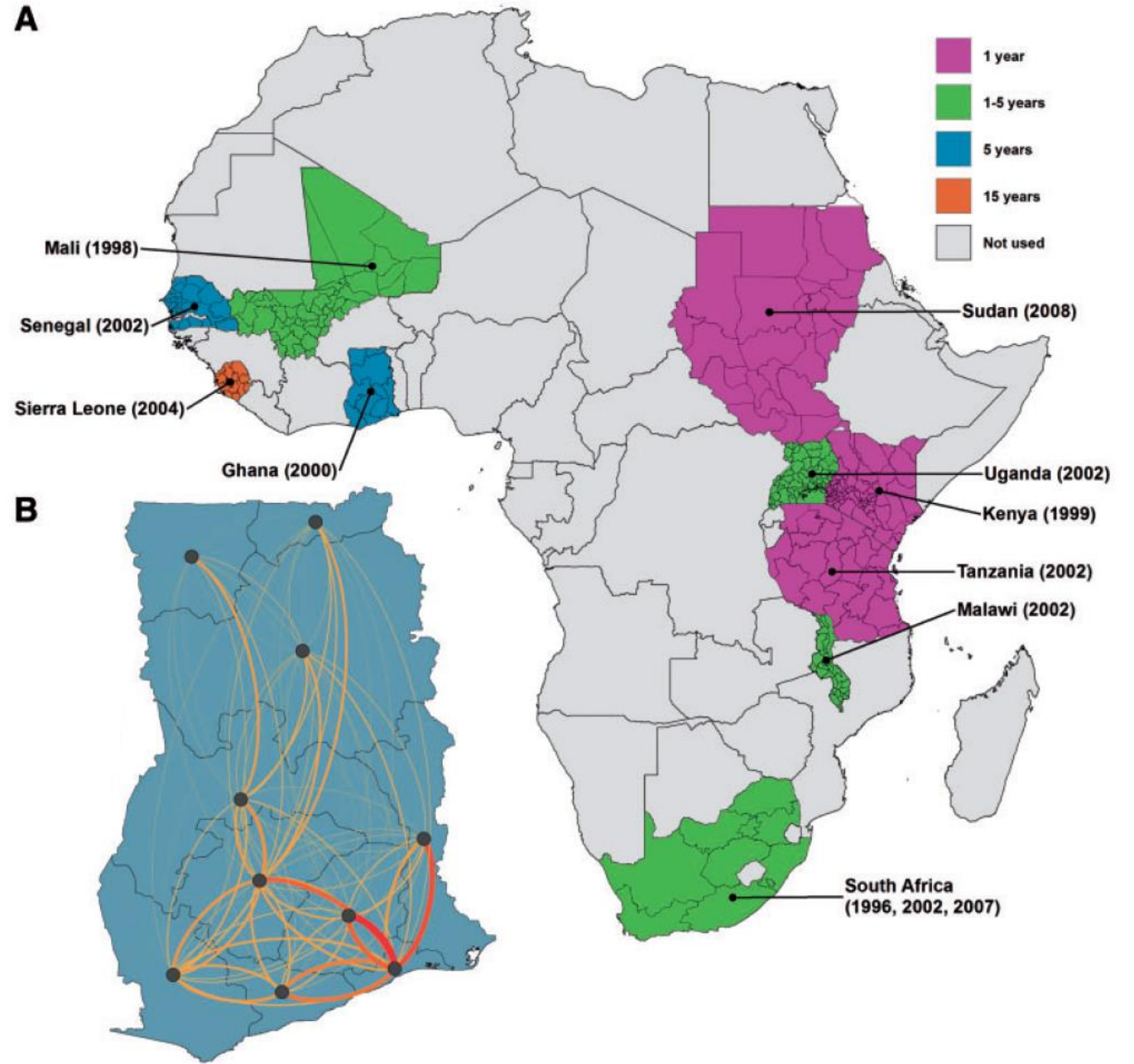
Measuring movements



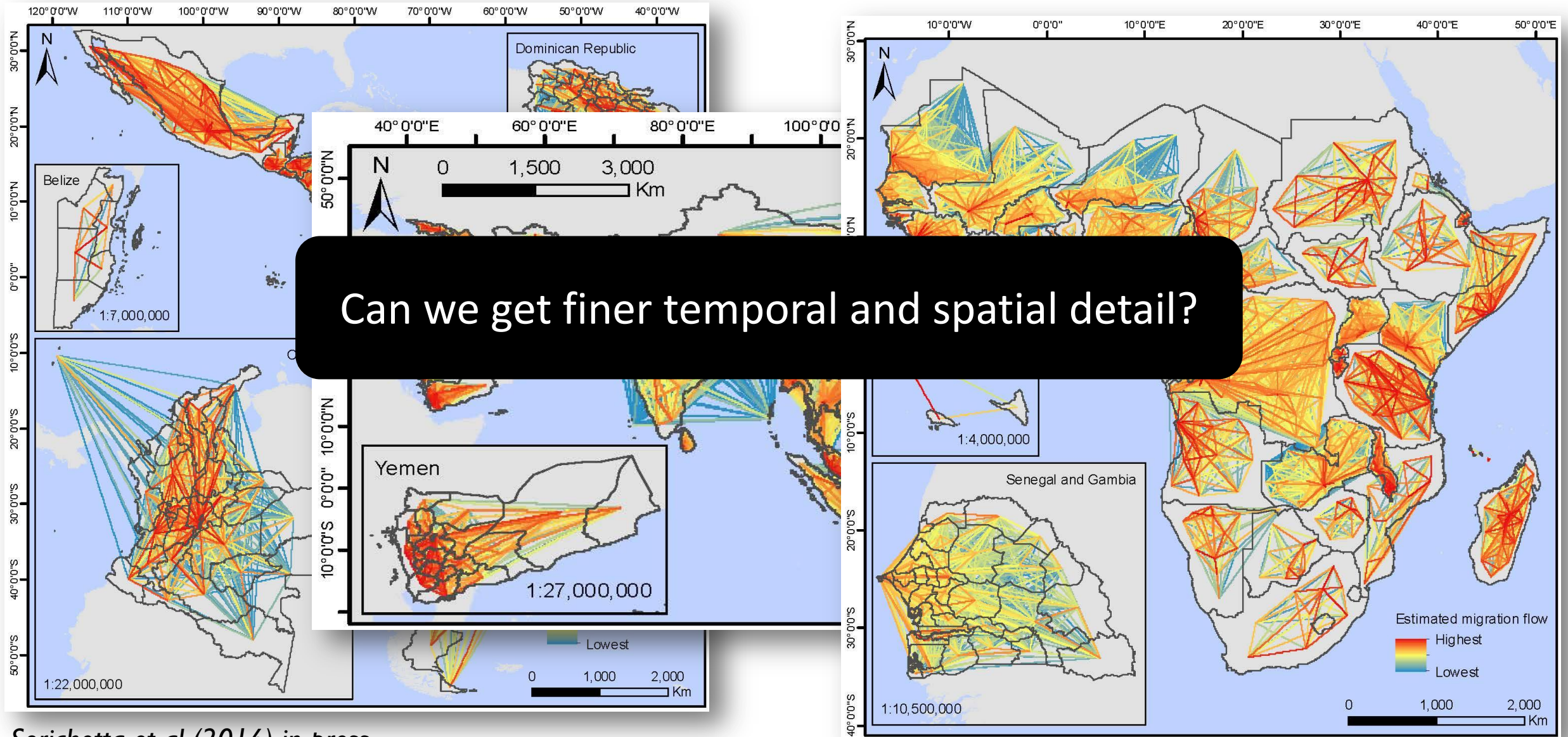
Migration mapping



Gravity-type spatial interaction model built using GIS and satellite imagery-based covariates



Migration mapping



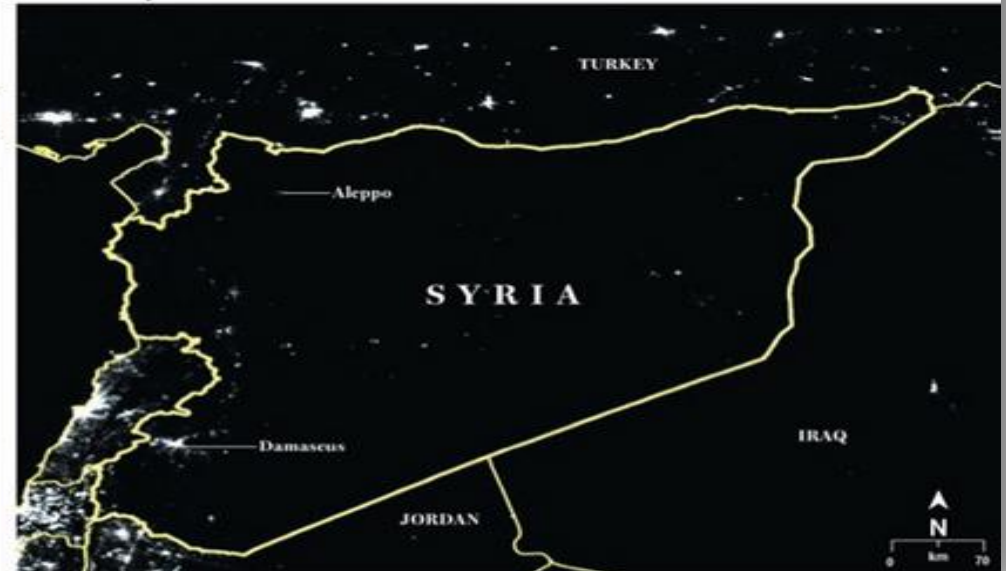


83% OF LIGHTS OUT AFTER FOUR YEARS OF CRISIS

SATELLITE IMAGES SHOWING NIGHT TIME LIGHT LEVELS ACROSS SYRIA
FEBRUARY, 2011

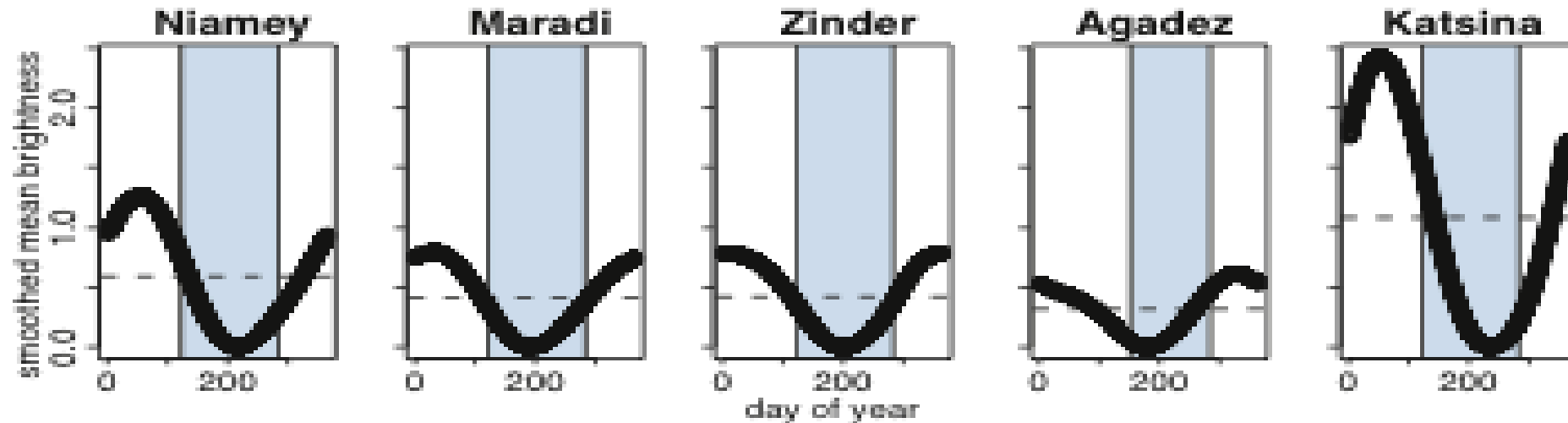


DECEMBER, 2014

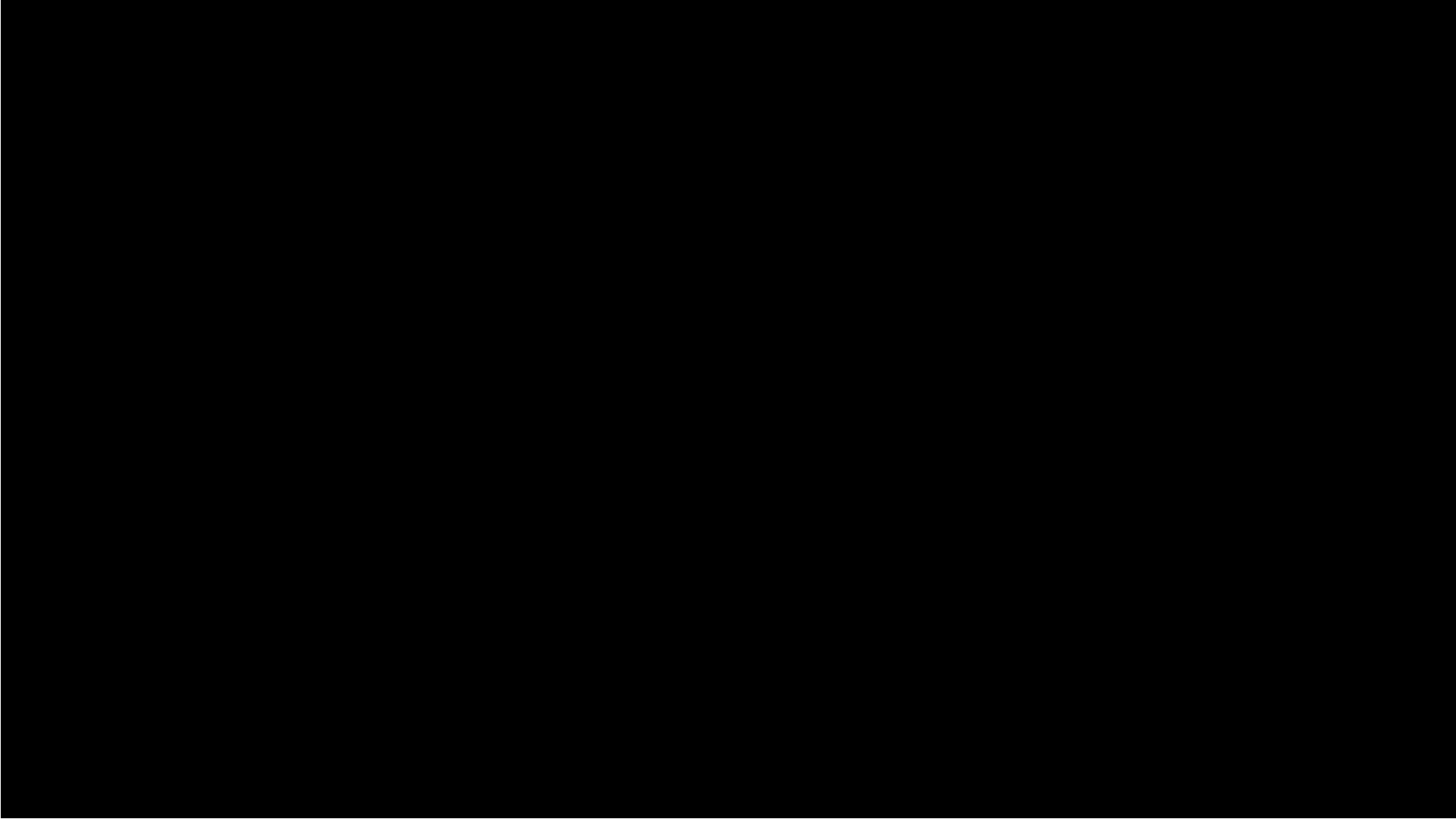


Seasonal movements in Niger

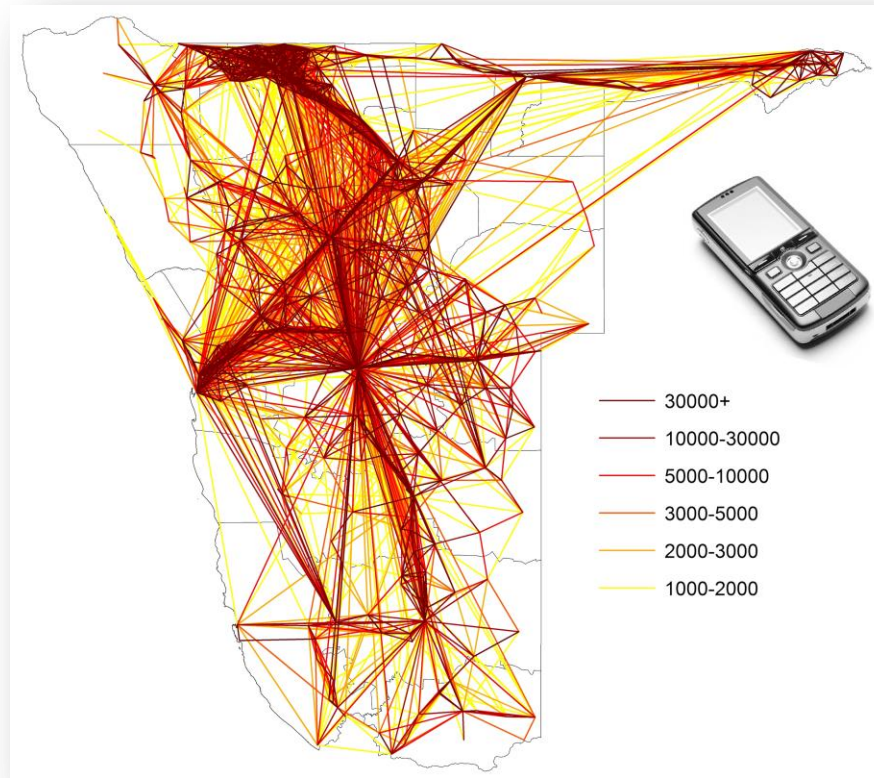
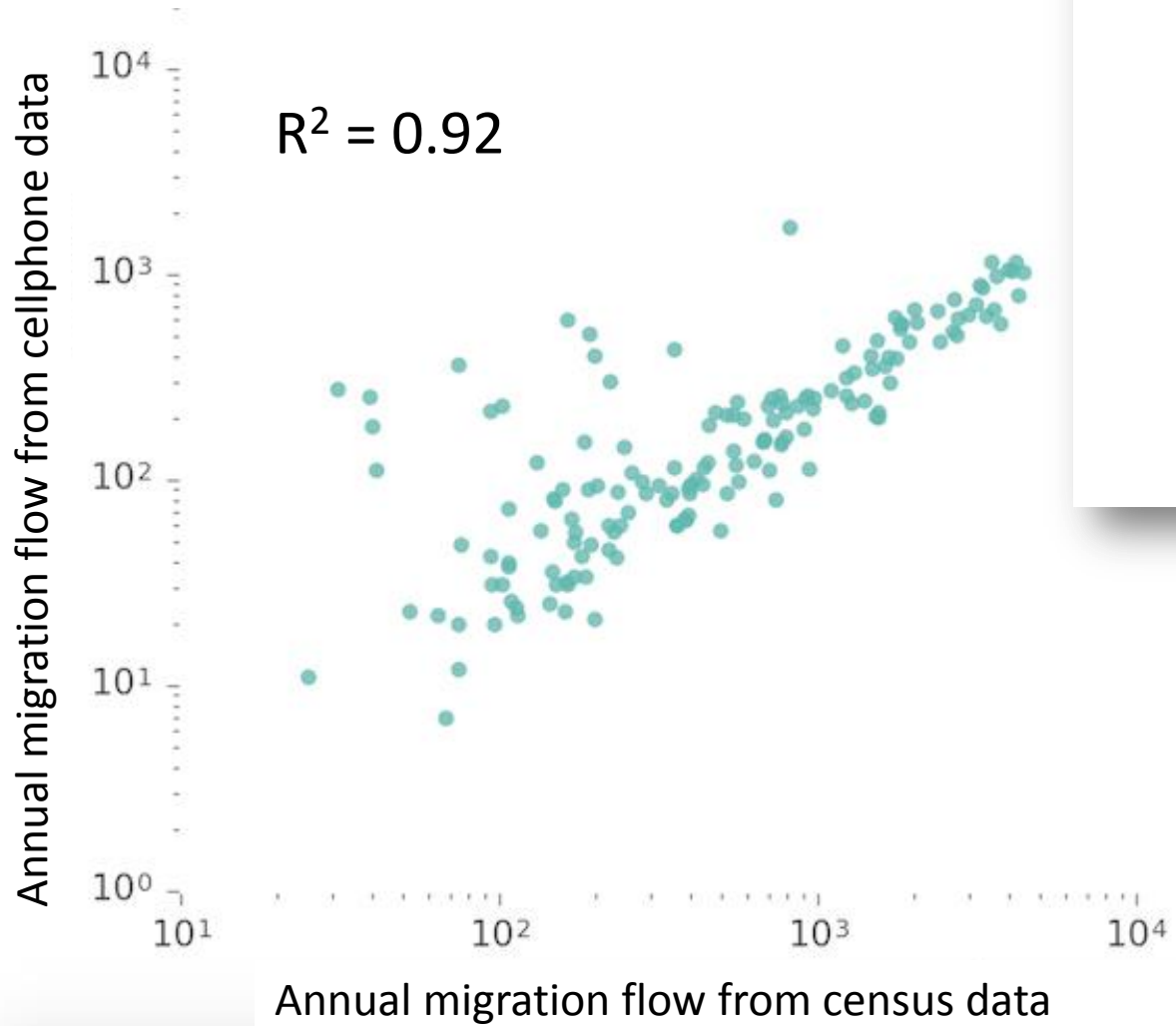
- Substantial agriculturally-driven seasonal migration occurs across the Sahel region
- Can we measure the timing and relative size of the incoming migration using satellite night-lights?

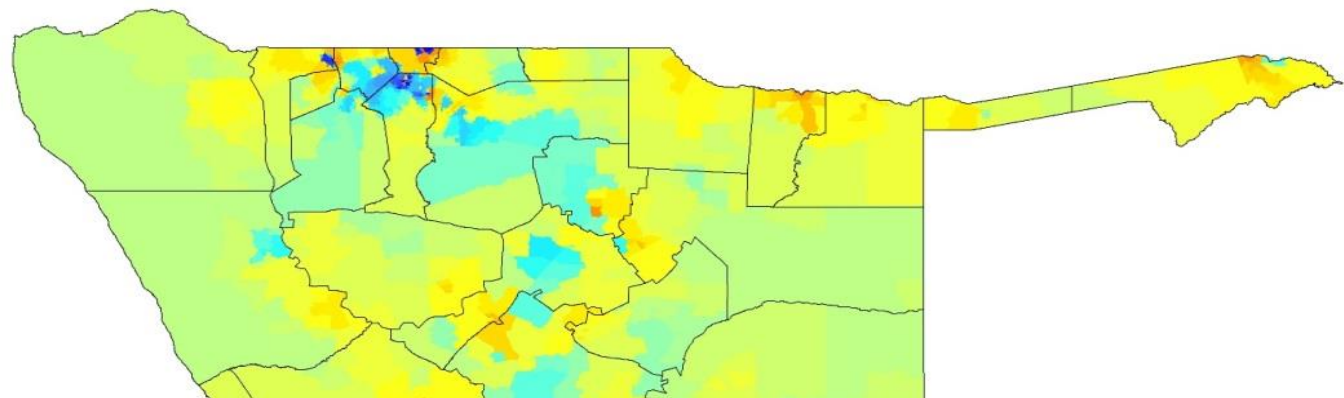
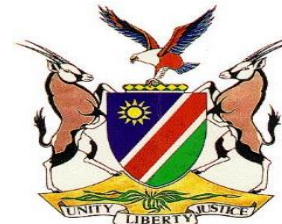


Can we get even finer spatial and temporal detail?



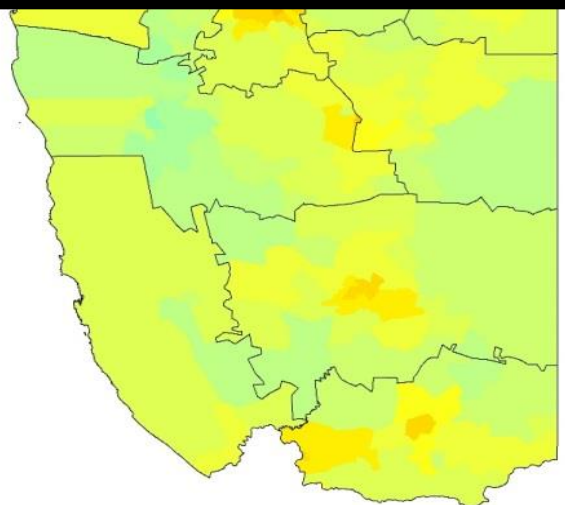
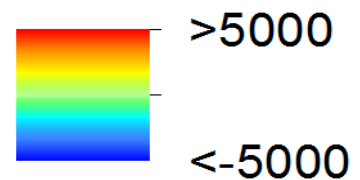
Measuring migration





How is this useful?

Pop density change per square km



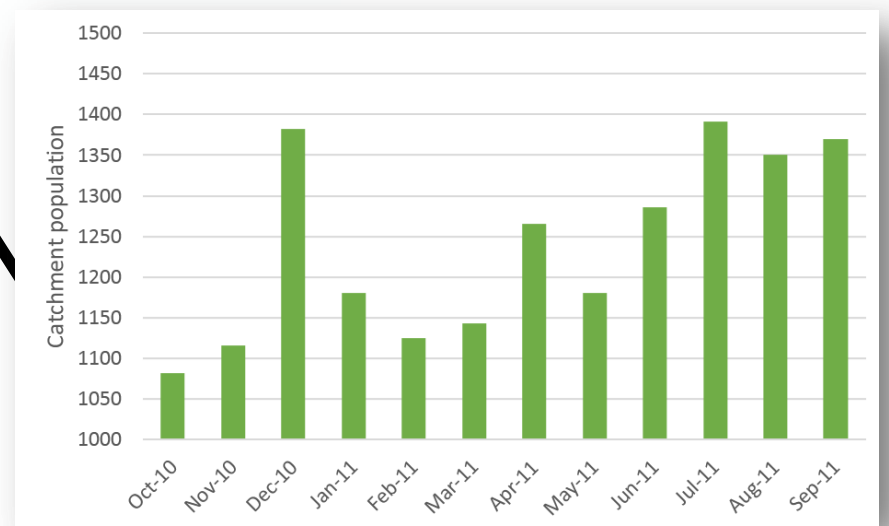
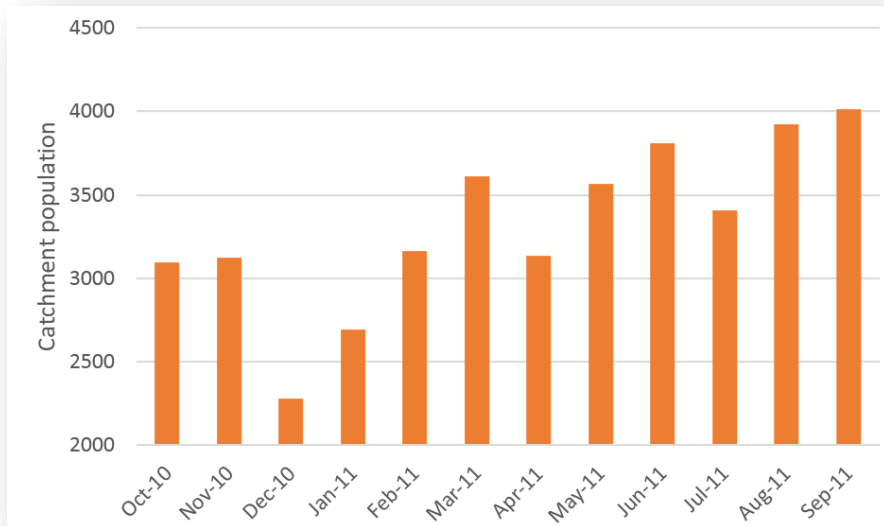
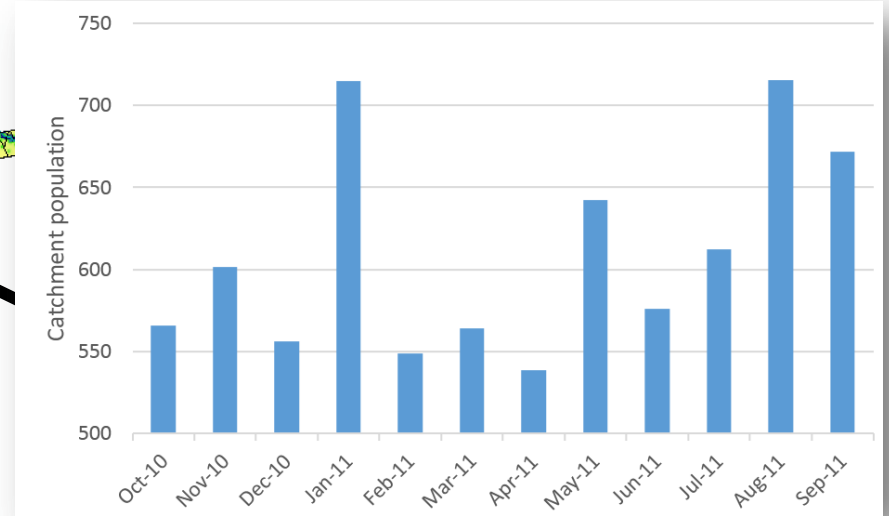
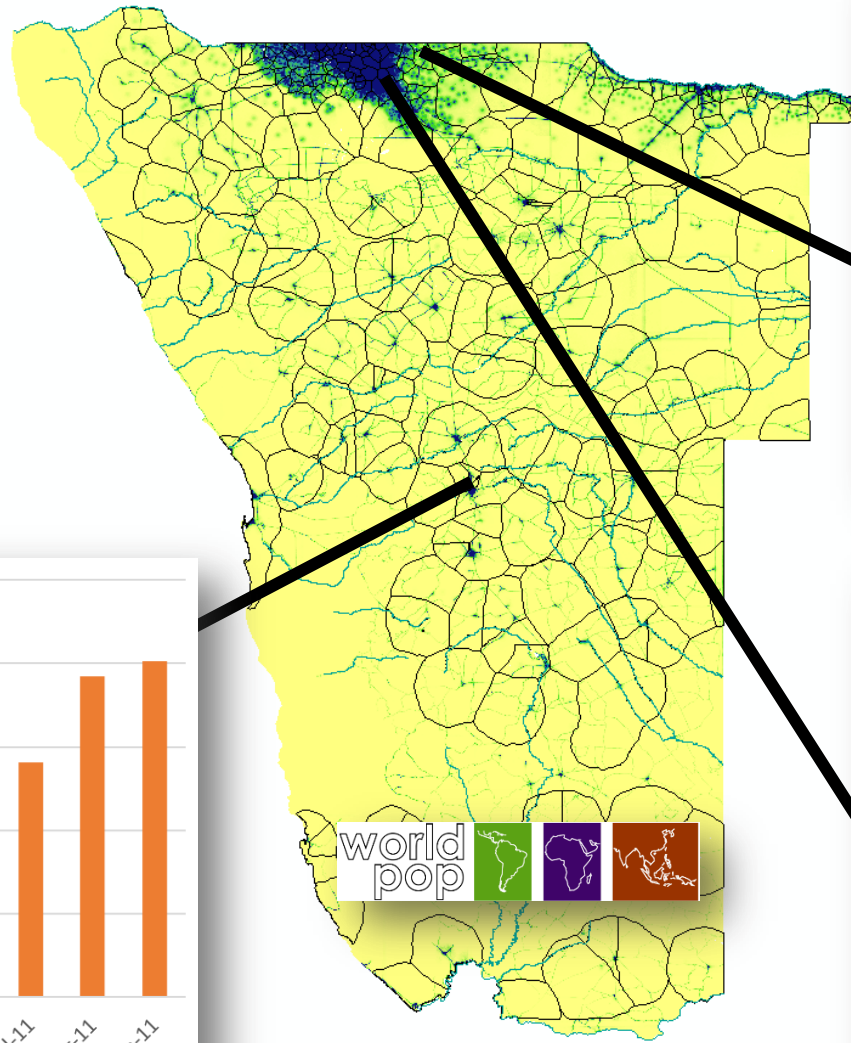
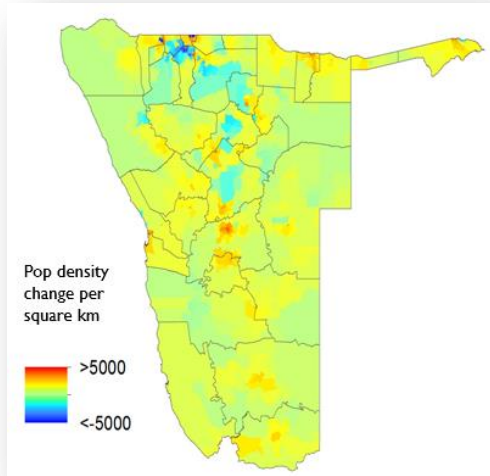
Namibia Pop: 2.3 mill
MTC active subscriptions: 2.1 mill



NOV_12
DEC_12
JAN_13
FEB_13
MAR_13
APR_13
MAY_13
JUN_13
JUL_13
AUG_13
SEP_13



Dynamic facility catchment populations





Denominators



Numerators



Measuring targets: Population characteristics and coverages

SDG targets



- 1.1. Eradicate extreme poverty for all people everywhere -measured as people living on less than \$1.25 a day



- 2.2. End all forms of malnutrition, including the internationally agreed targets on stunting and wasting in children under 5 years of age



- 3.7. Ensure universal access to sexual and reproductive health-care services



- 4.6. Ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy

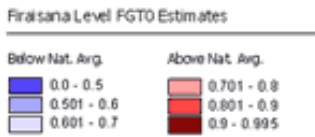
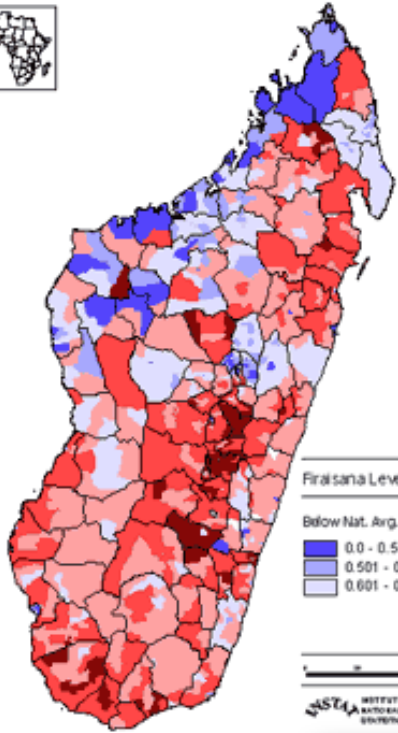
What can we use?



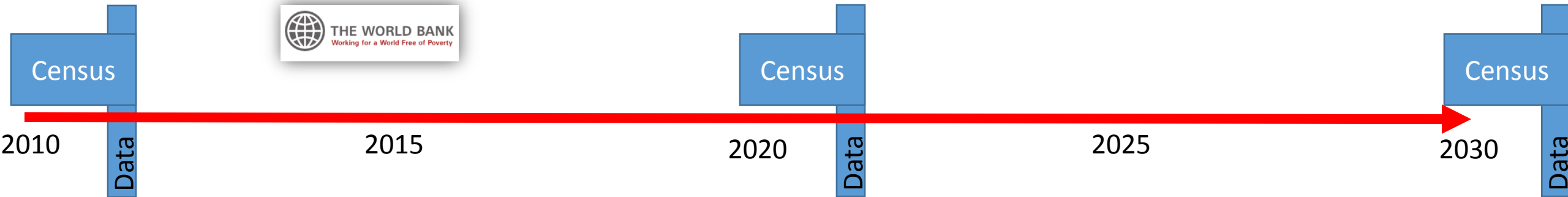
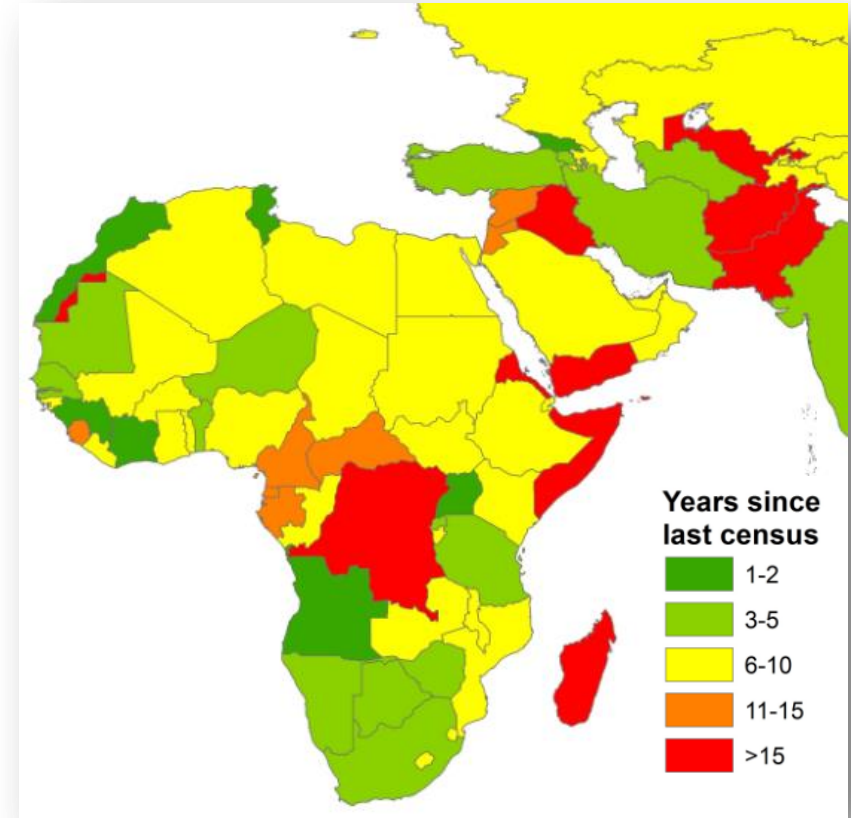


Goal 1 - poverty

Madagascar Poverty Incidence: Commune Level

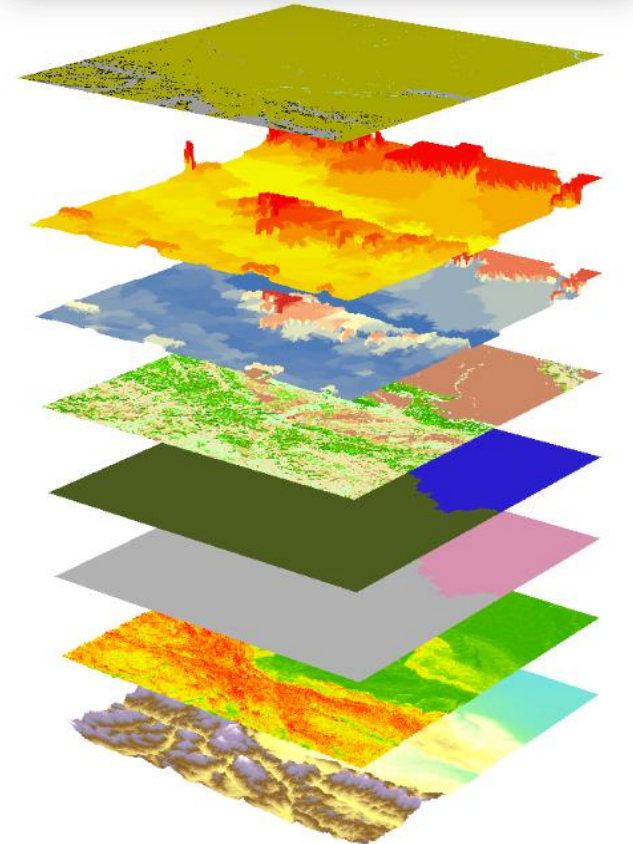
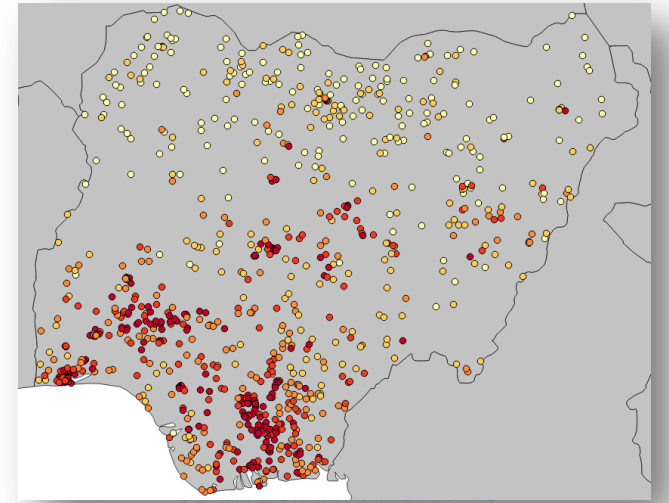


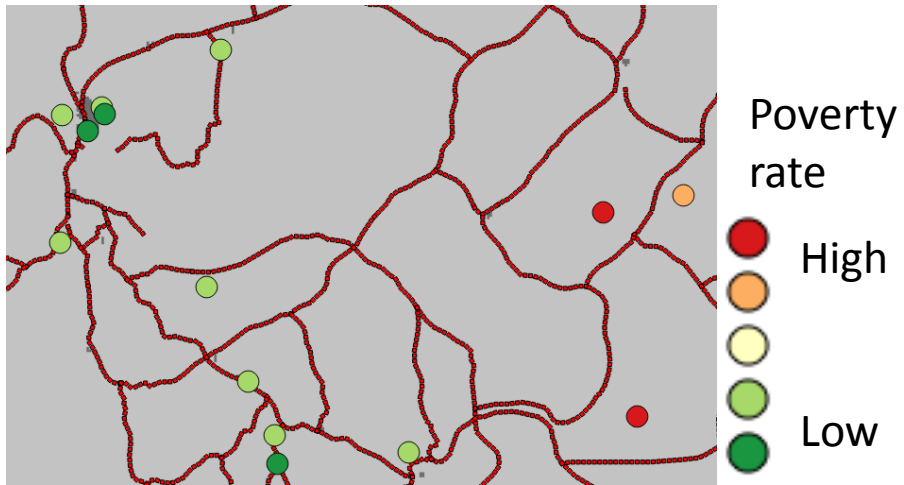
-Poverty mapping is a well-established field
-Small area estimation: integration of survey and census data



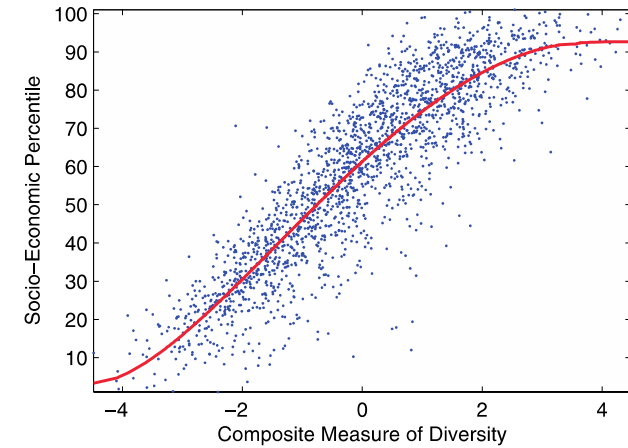
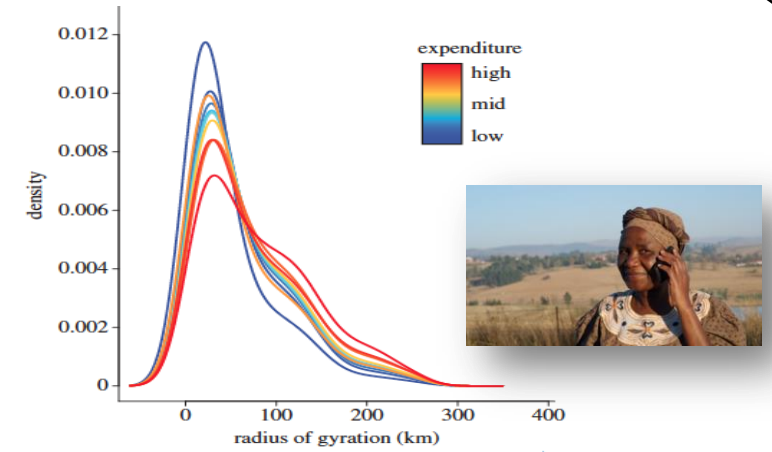
Spatial data integration

- Population characteristics measured in household surveys can be strongly related to features we can measure everywhere
- We can use these relationships to predict characteristics into unsampled locations using metrics from census, satellite and cellphone data to create maps of SDG-relevant indicators
- Importance of validation and the measurement and mapping of uncertainty



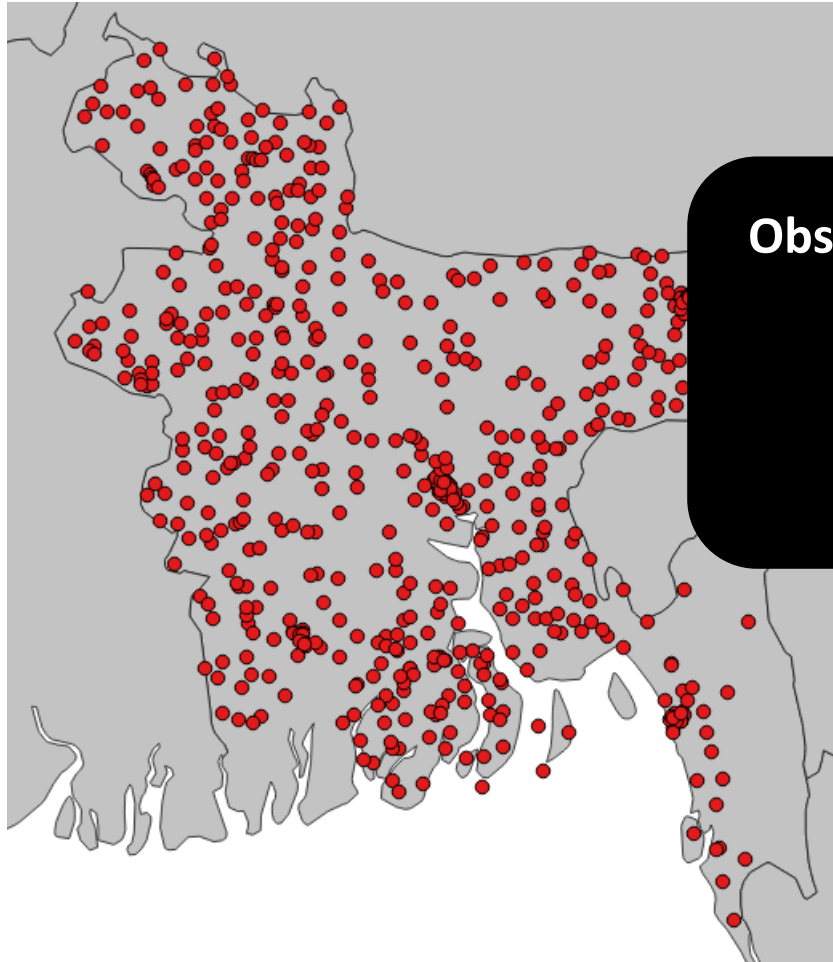


- Increasing distance from major roads = increasing poverty
- Increasing urbanicity = decreasing poverty



- Greater mobility = lower poverty
- Wider social network = lower poverty
- Large, regular credit top up = lower poverty

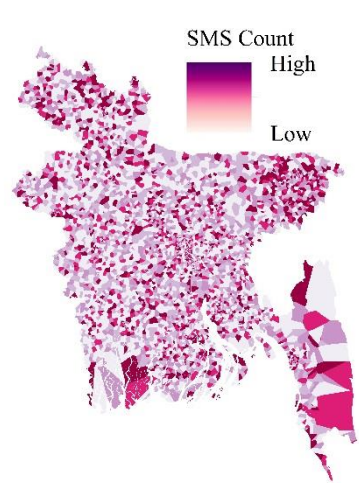
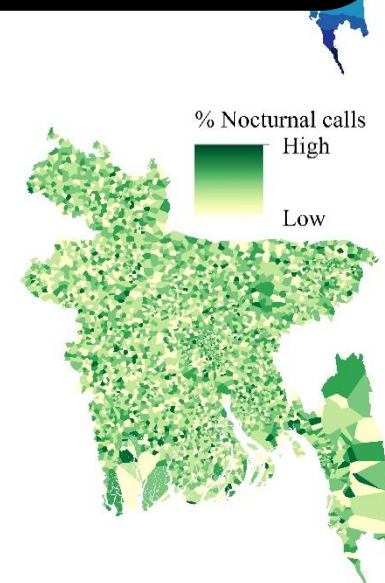
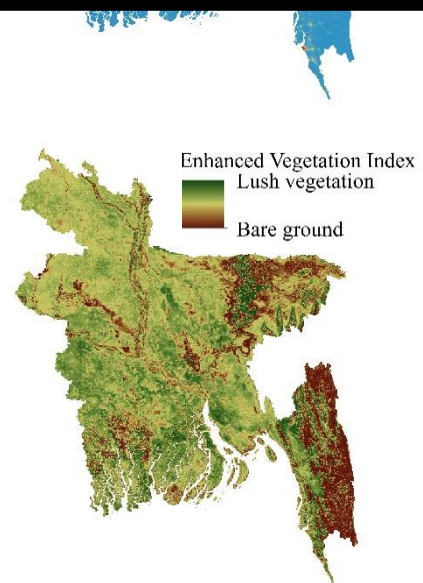
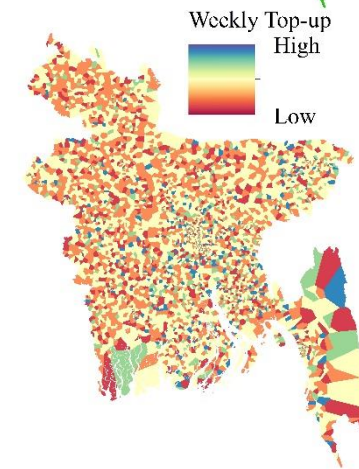
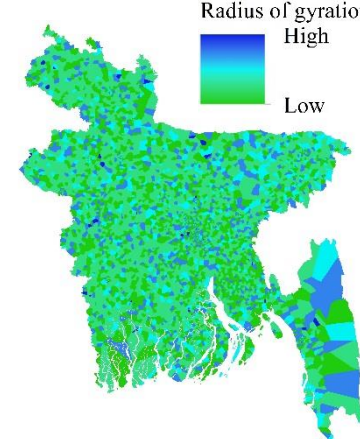
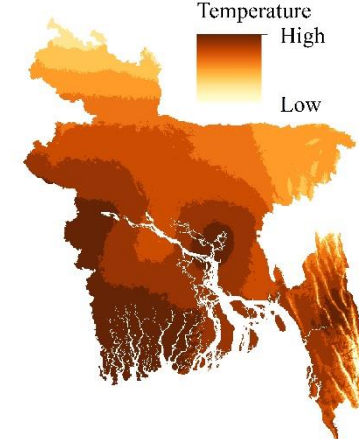
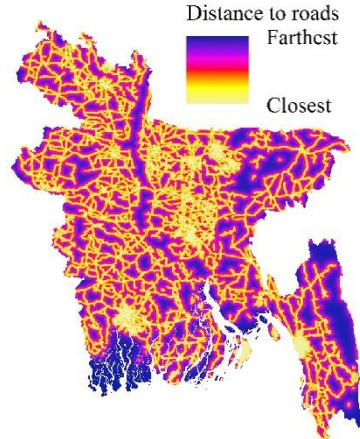
Improving mapping of socioeconomic indicators



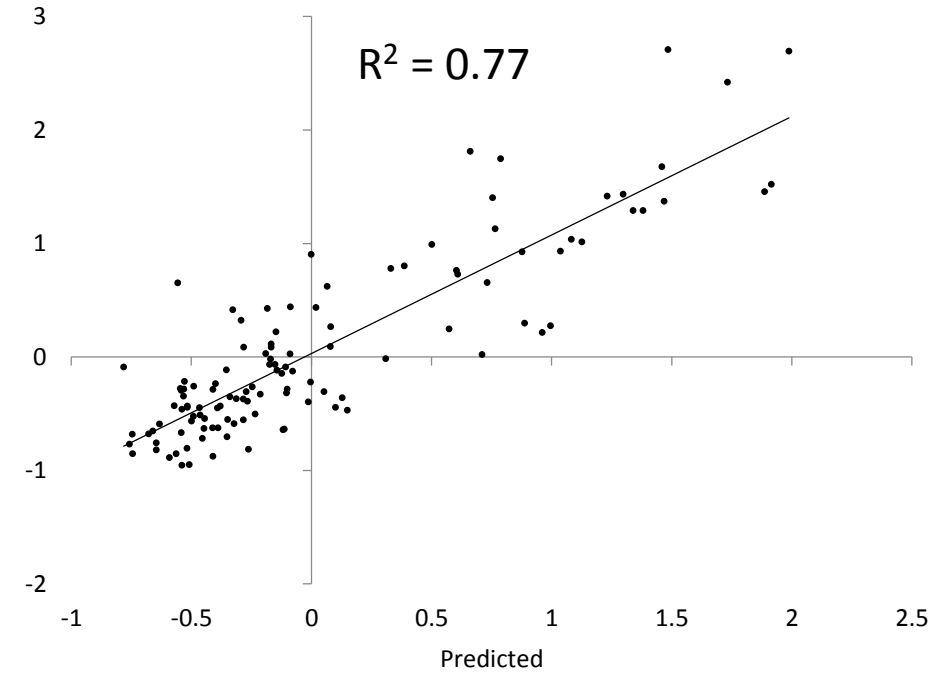
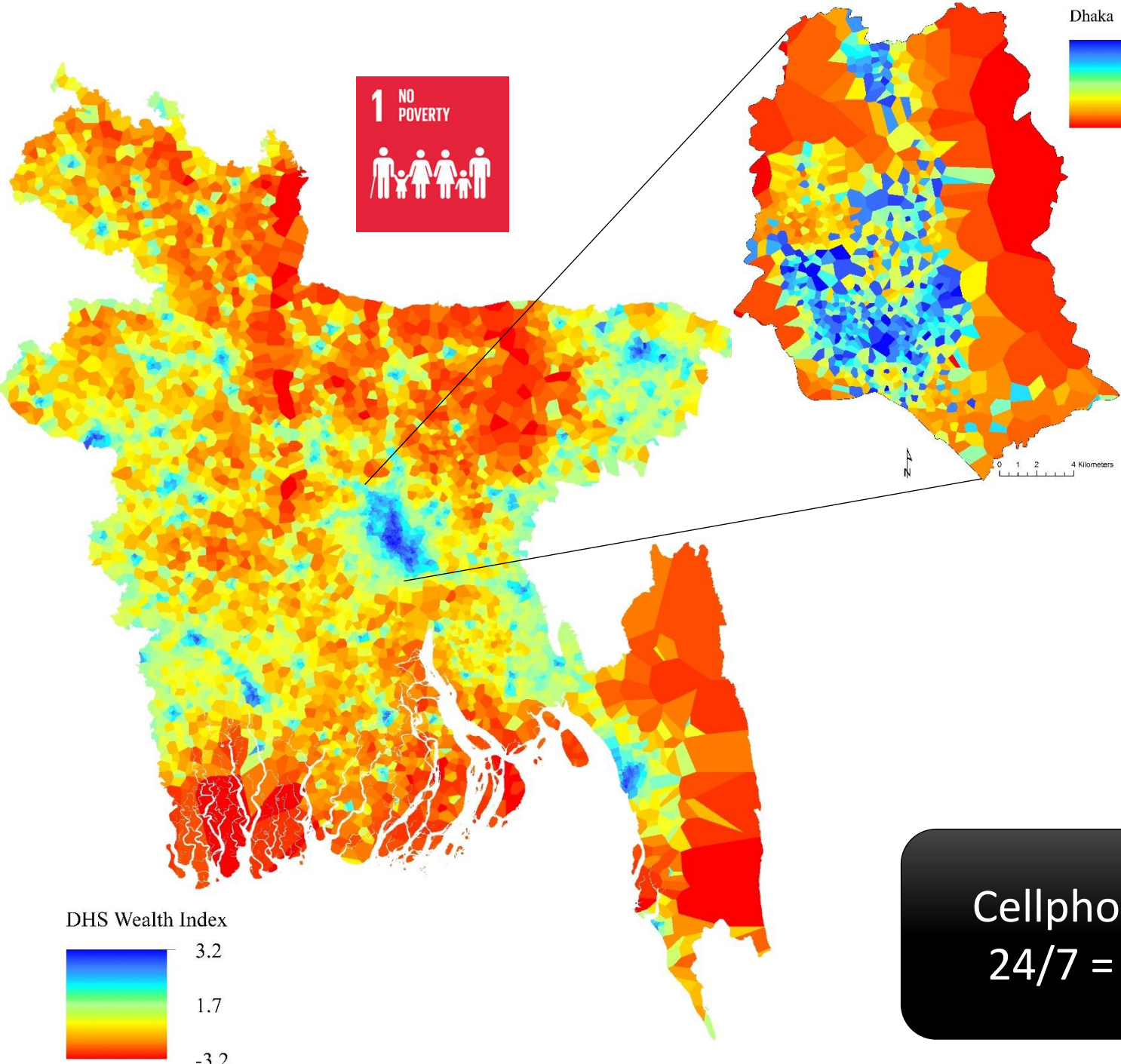
GPS-located survey cluster data

Observed cluster-level variation represented by:

1. Sampling model (e.g. binomial)
2. Geospatial covariates (fixed effects)
3. Spatial covariance (random effects)
4. Gaussian noise term

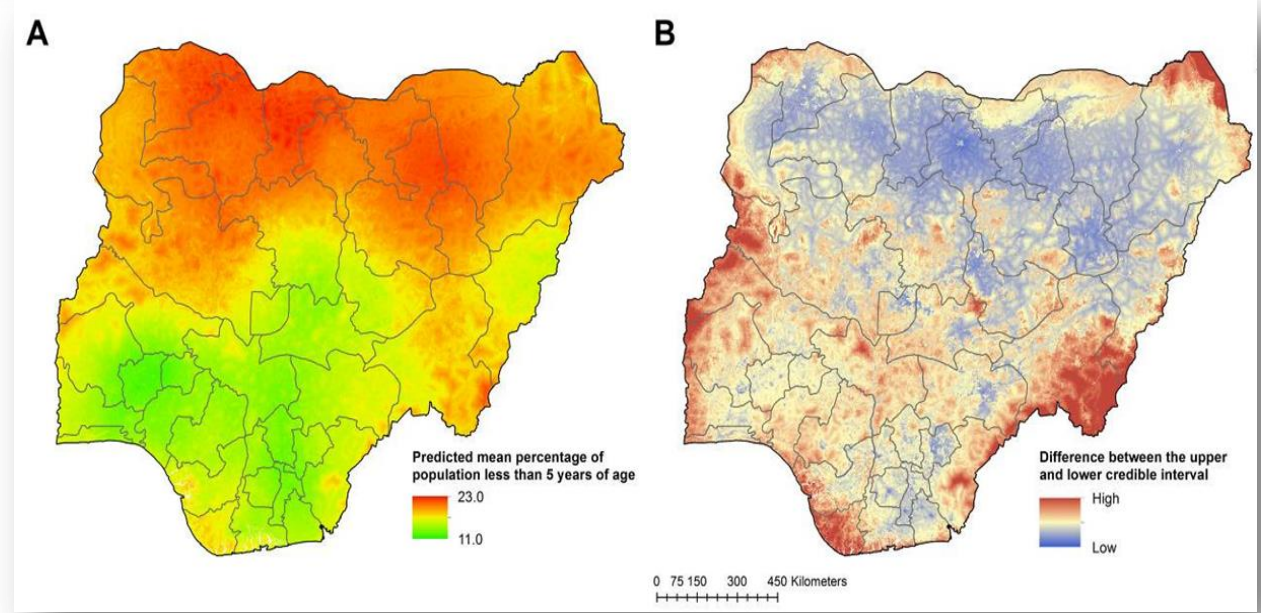
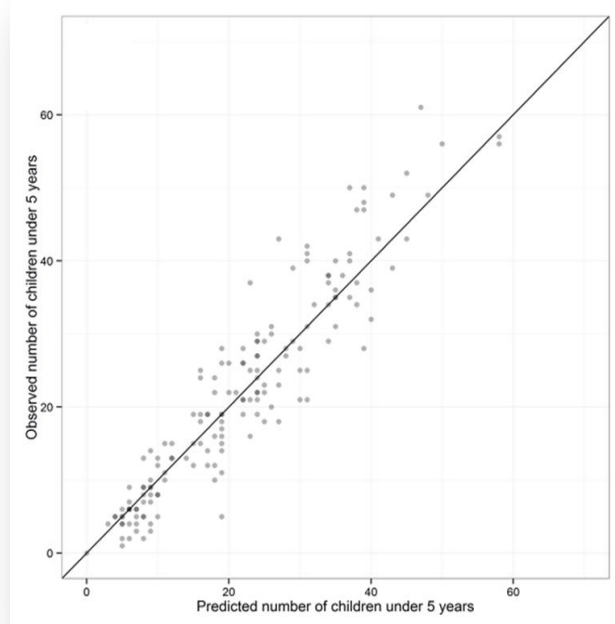
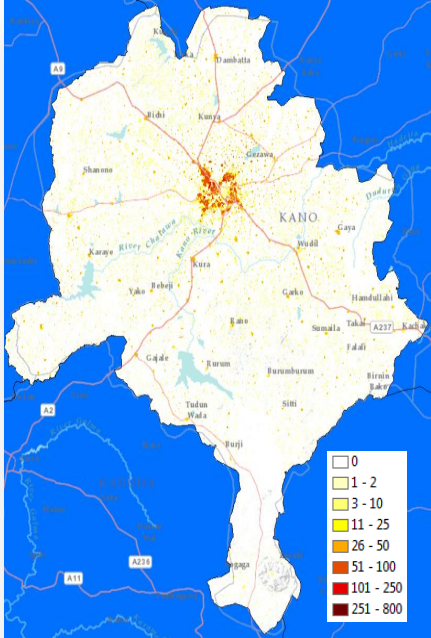
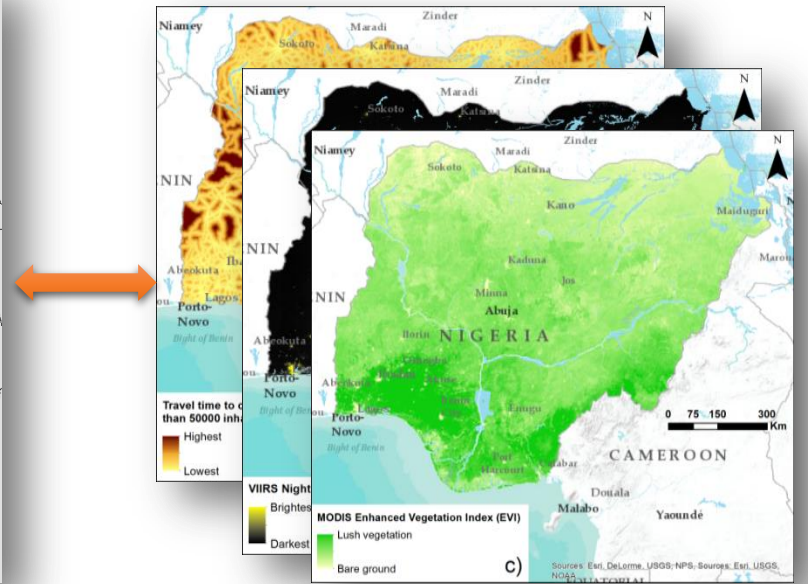
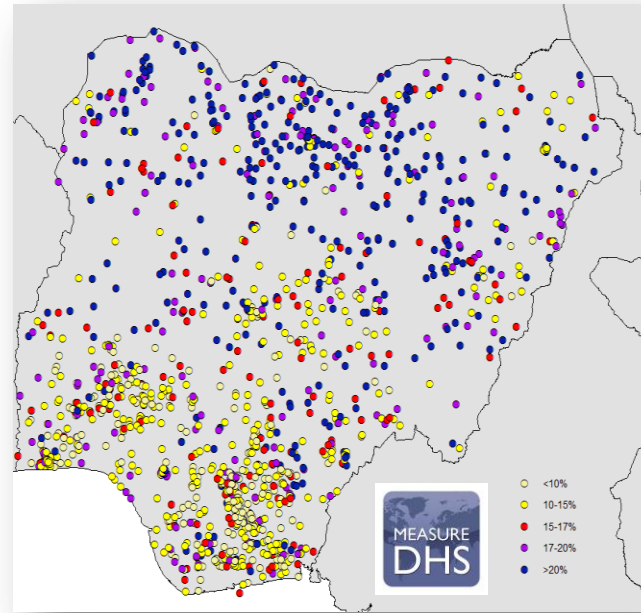


Example output: Bangladesh wealth index

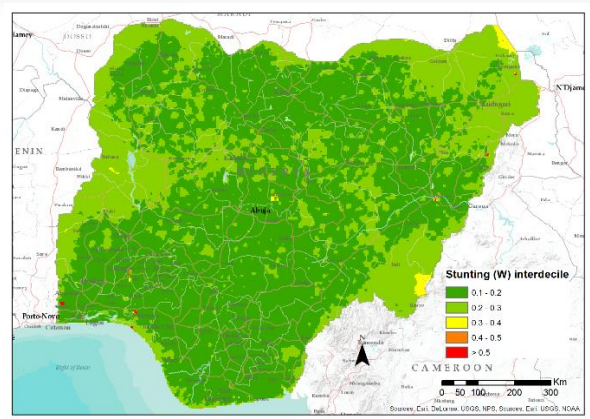
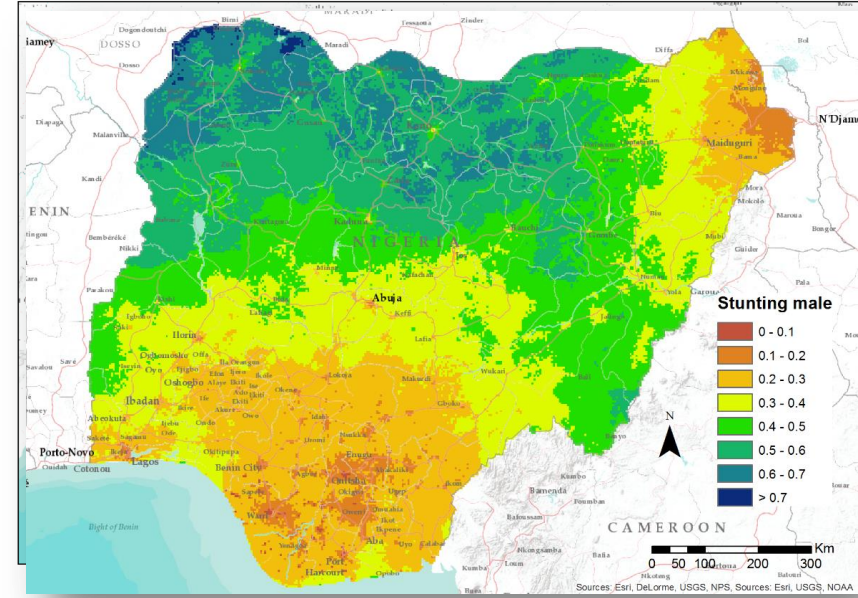
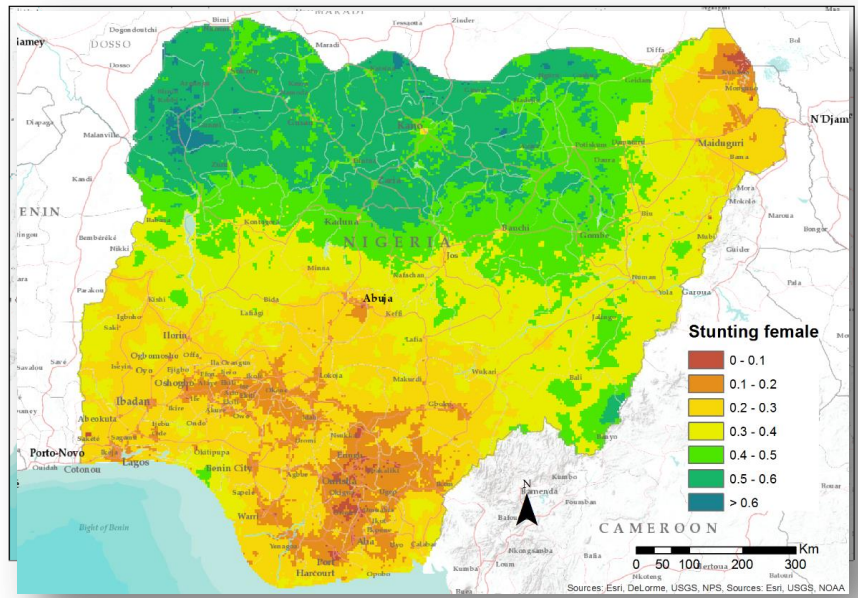


Cellphone and satellite data are collected
24/7 = Potential for ongoing monitoring

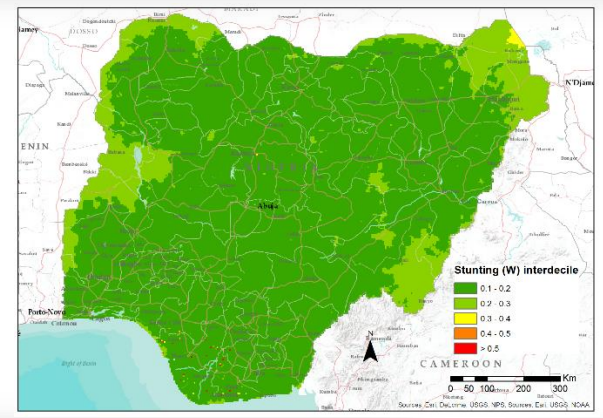
Nigeria age structures



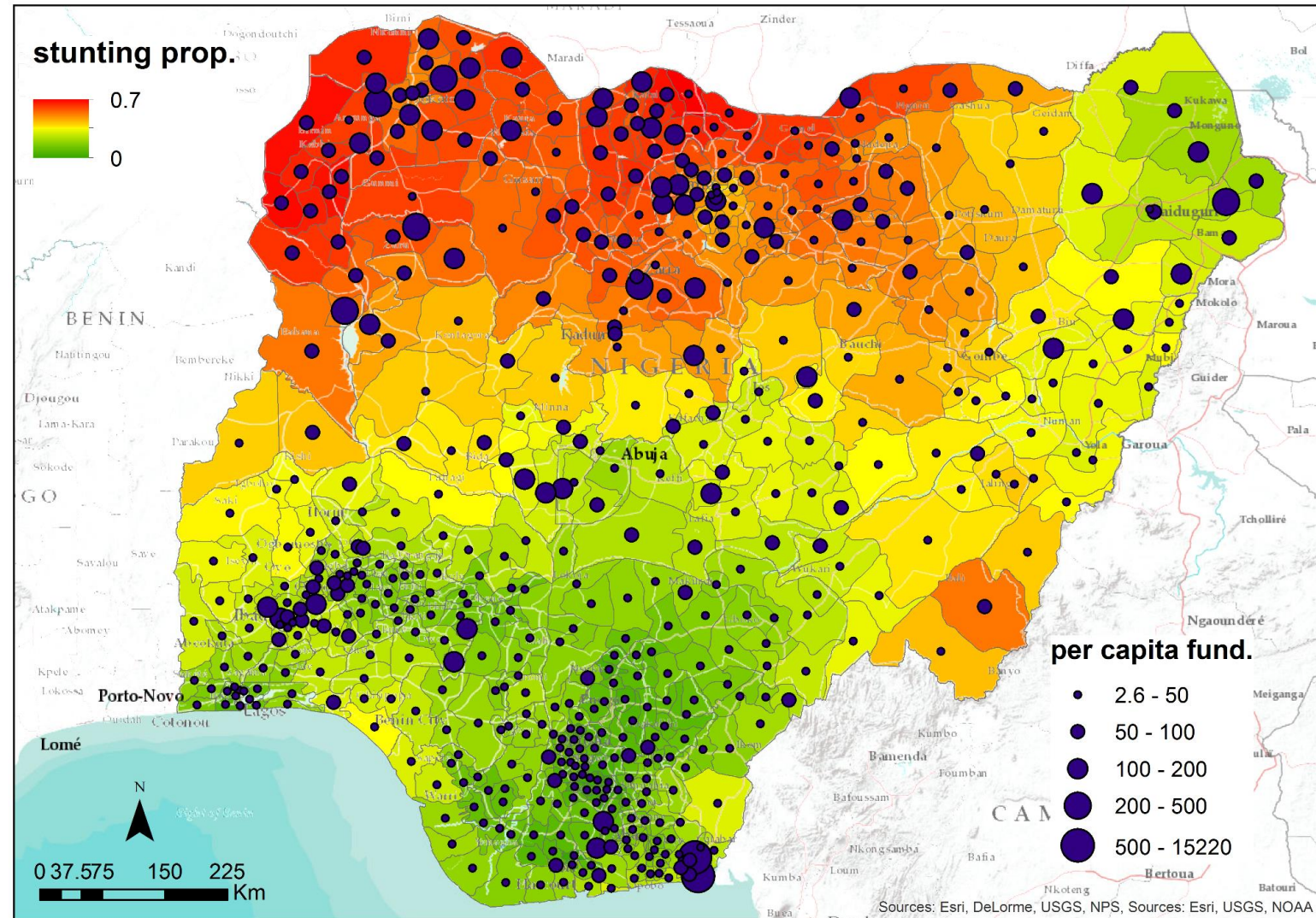
Stunting in girls and boys



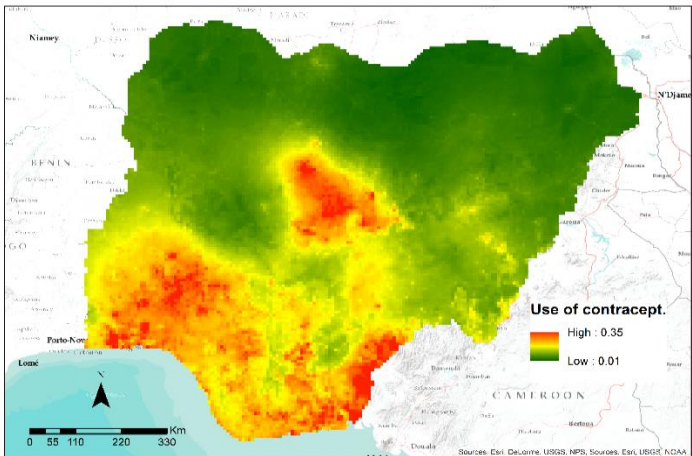
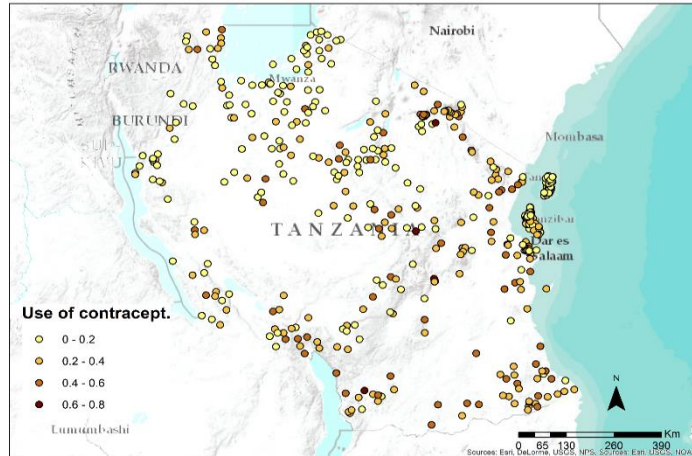
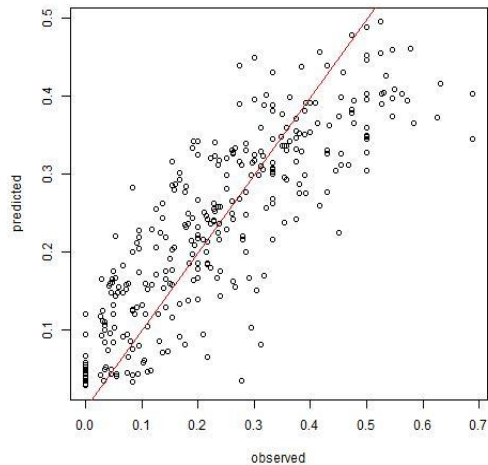
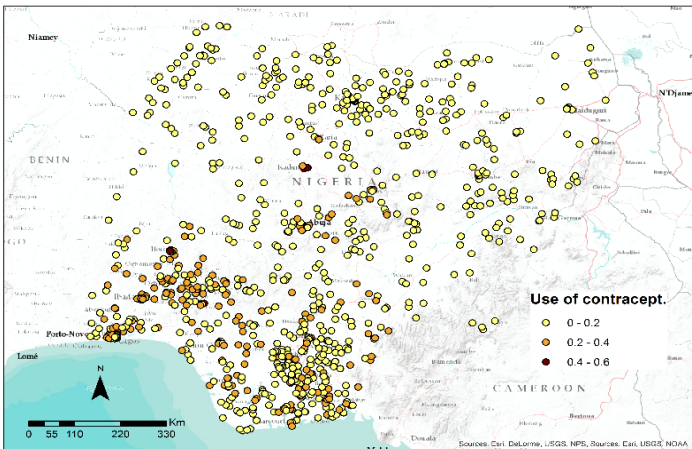
Uncertainty maps: interdecile range



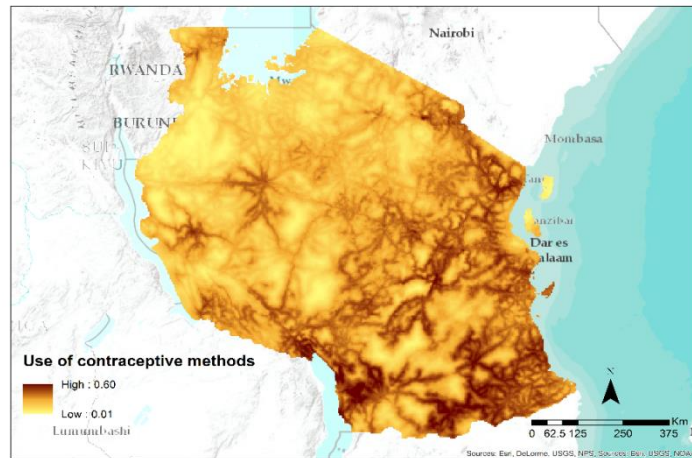
Is aid being equitably distributed according to need?



Sources: Esri, DeLorme, USGS, NPS, Sources: Esri, USGS, NOAA

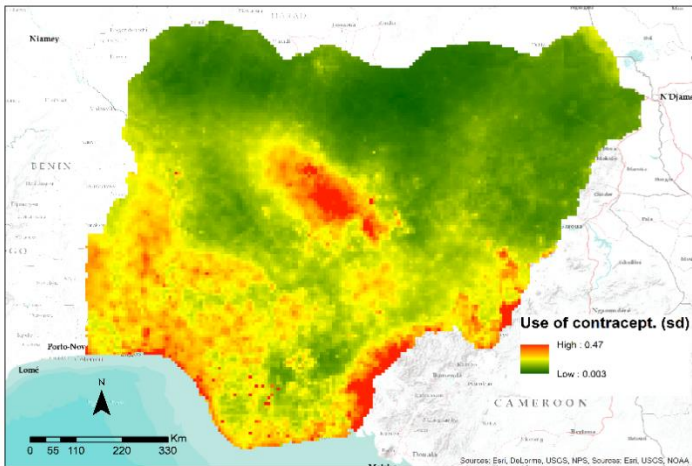


Percentage of women of reproductive age using modern contraceptive methods

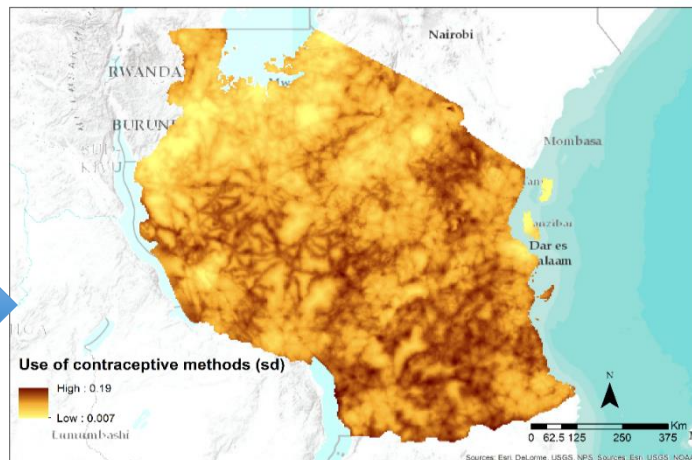


data2x0
partnering for a gender data revolution

UNITED NATIONS FOUNDATION

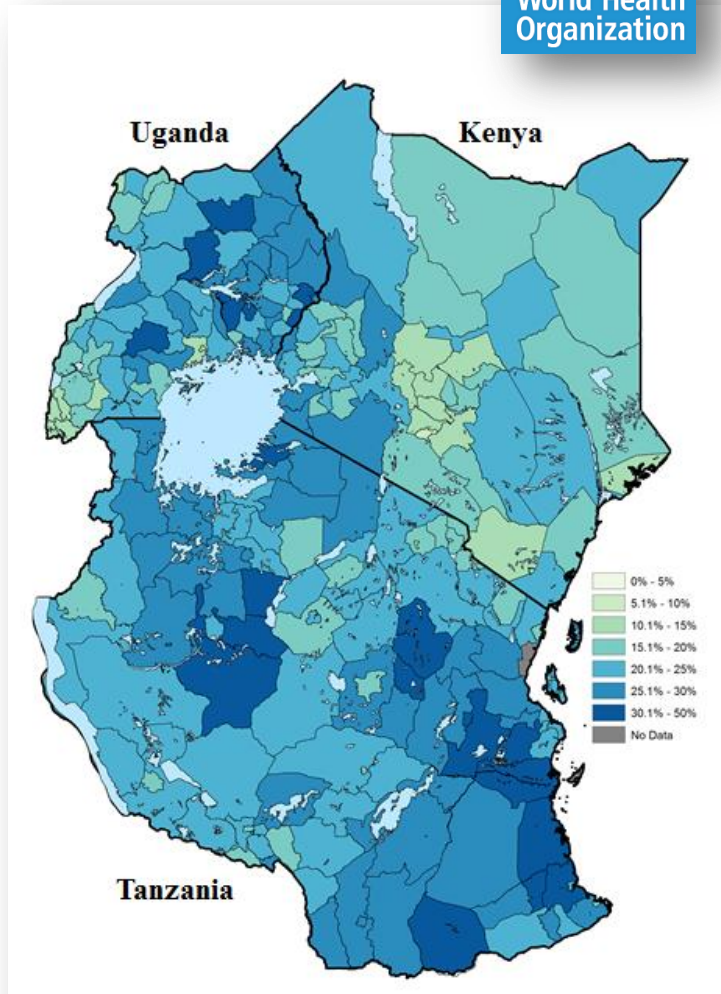
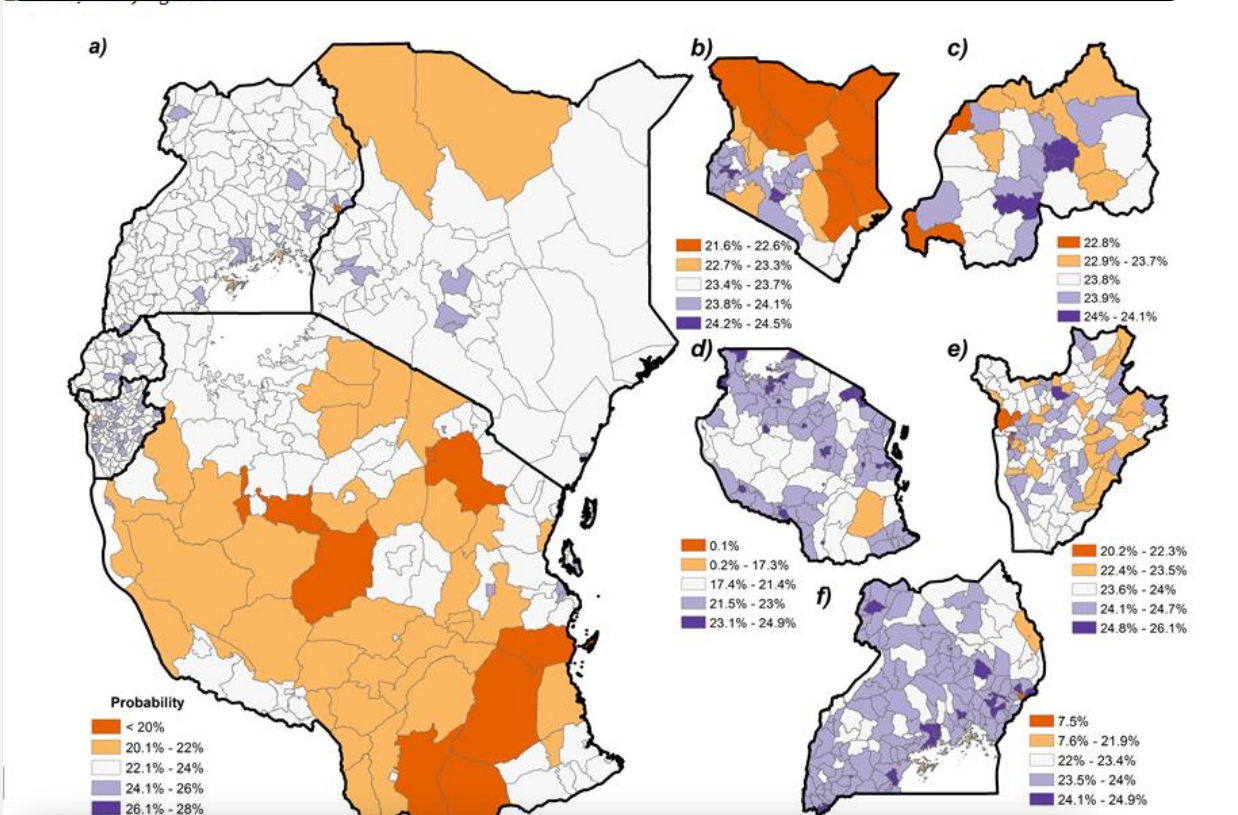


Uncertainty maps: standard deviation



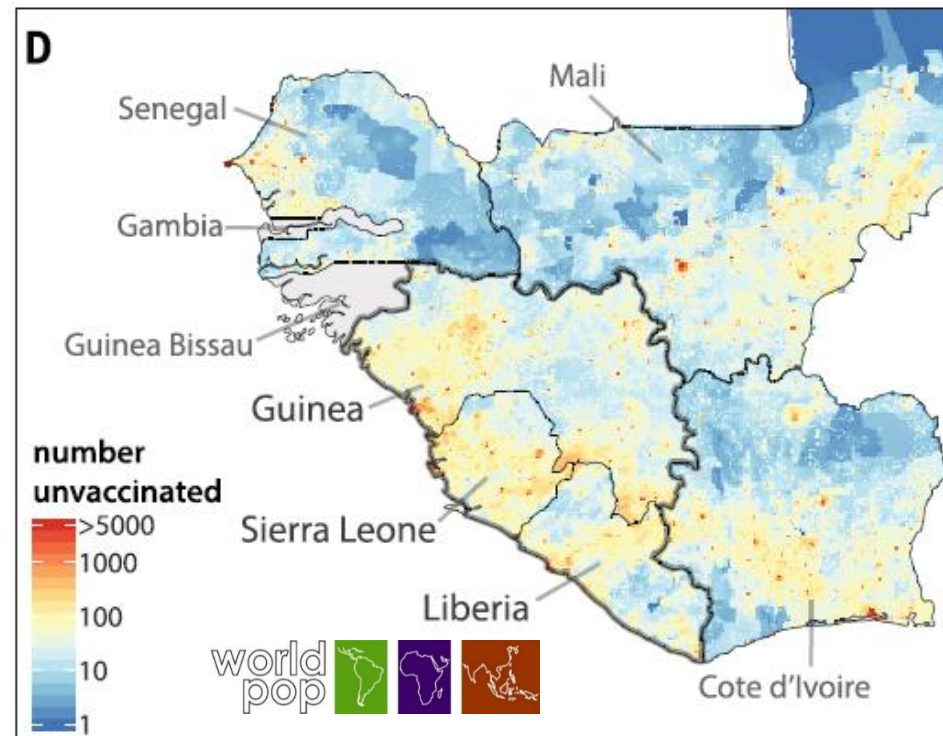
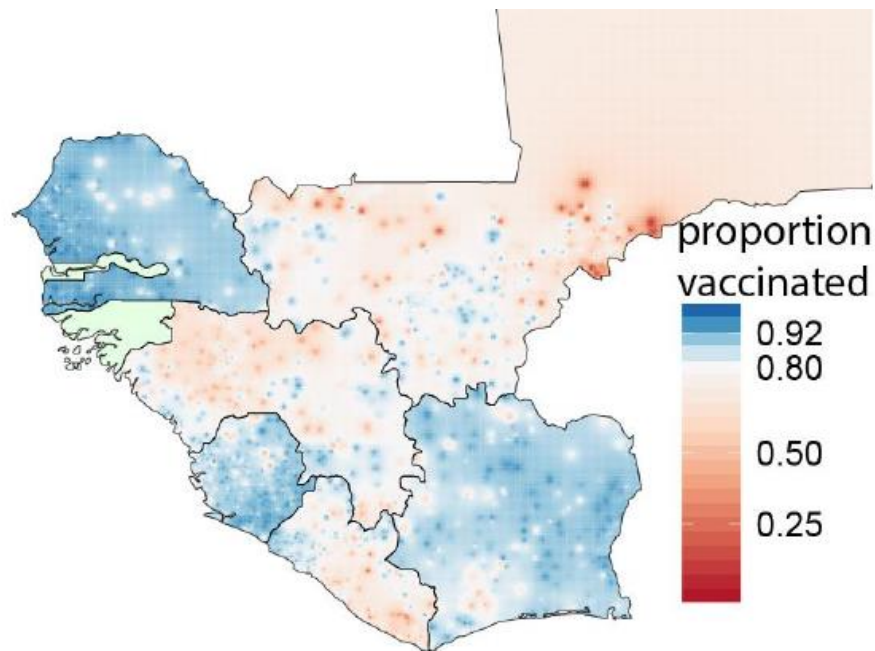
Maternal health

Probability of 4+ antenatal care visits at time of delivery



Proportion of adolescent births to 16-17yr olds

Vaccination coverage mapping: integrating geostatistics and demographic models



EPIDEMIOLOGY

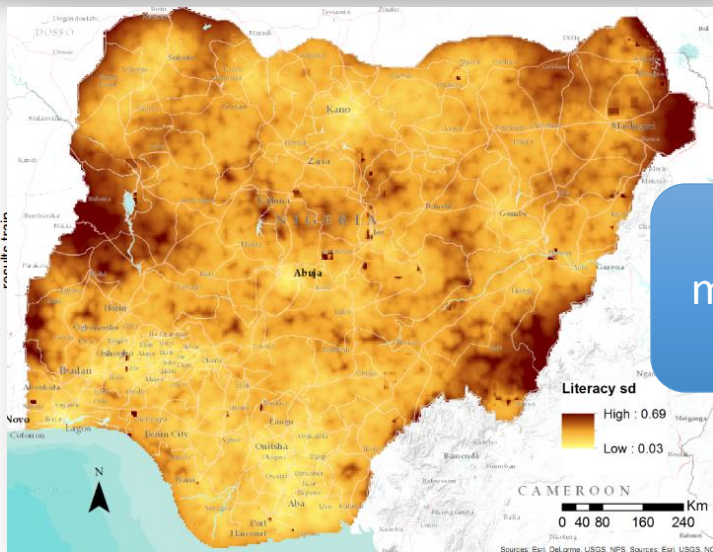
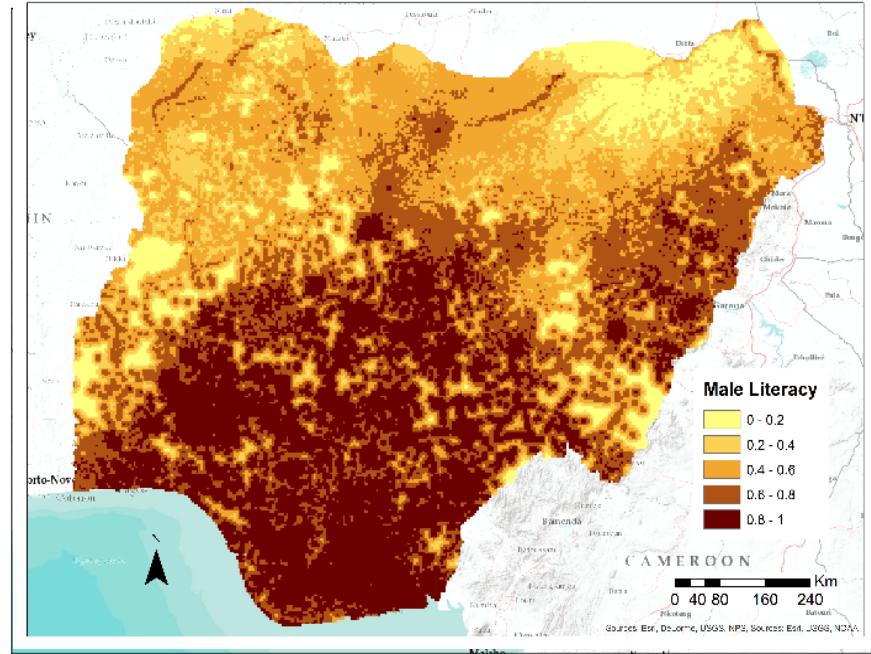
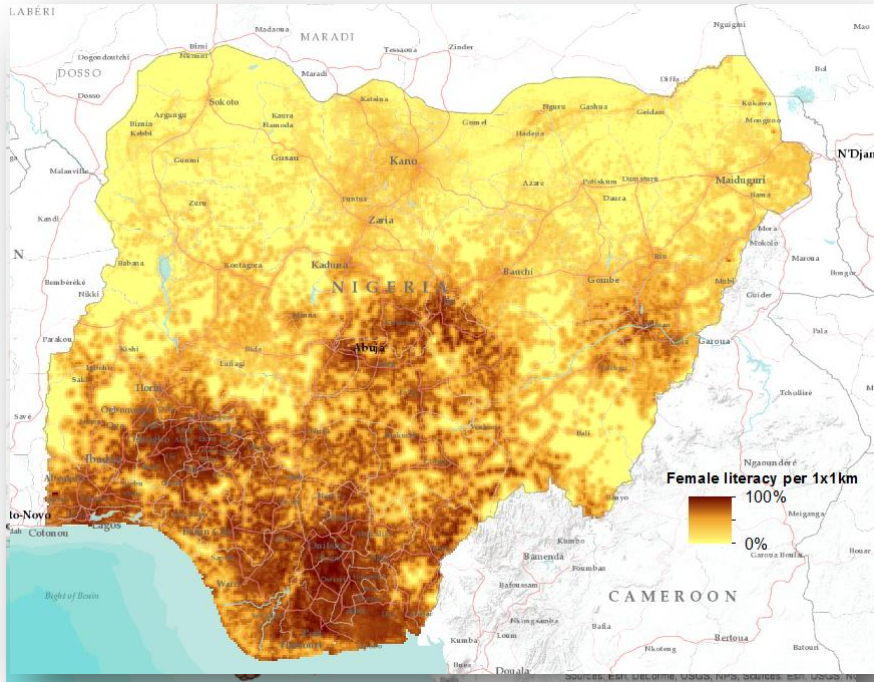
Science
AAAS

Reduced vaccination and the risk of measles and other childhood infections post-Ebola

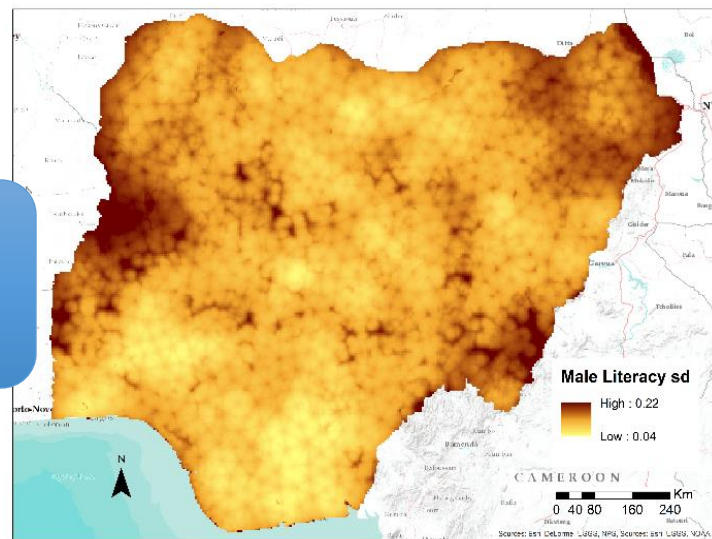
Saki Takahashi,¹ C. Jessica E. Metcalf,^{1,2} Matthew J. Ferrari,³ William J. Moss,⁴ Shaun A. Truelove,⁴ Andrew J. Tatem,^{5,6,7} Bryan T. Grenfell,^{1,6} Justin Lessler^{4*}

Fig. S2. Probability of receiving routine measles vaccination by 2 years of age in the absence of health care disruptions.

Literacy



Uncertainty maps: Standard deviation



Measuring targets: Resilience and risk reduction

SDG targets



- 3.d. Strengthen the capacity for early warning, risk reduction and management of national and global health risks



- 9.a. Facilitate sustainable and resilient infrastructure development in developing countries



- 11.b. Adaptation to climate change, resilience to disasters, holistic disaster risk management at all levels

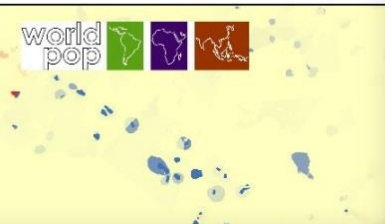


- 13.1. Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

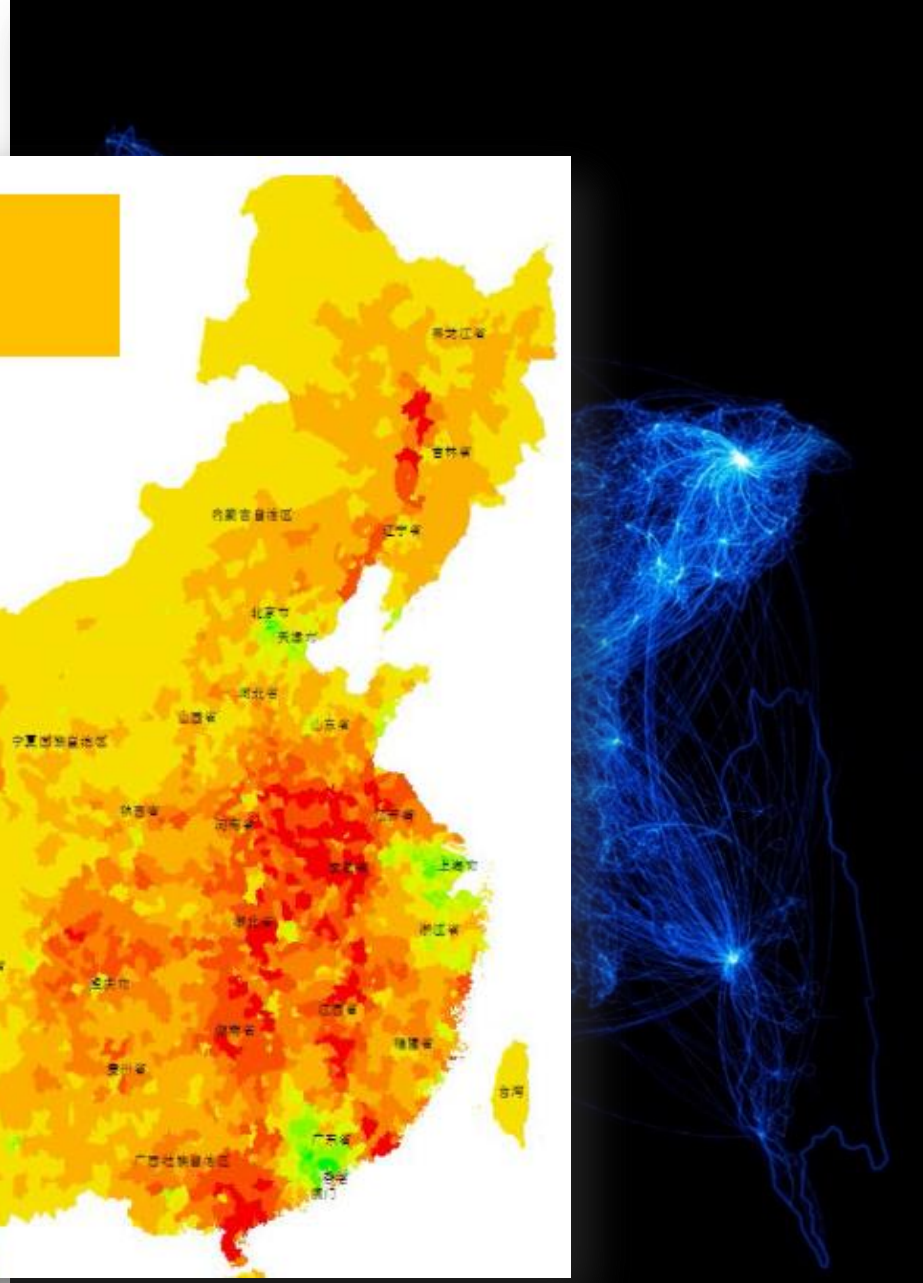
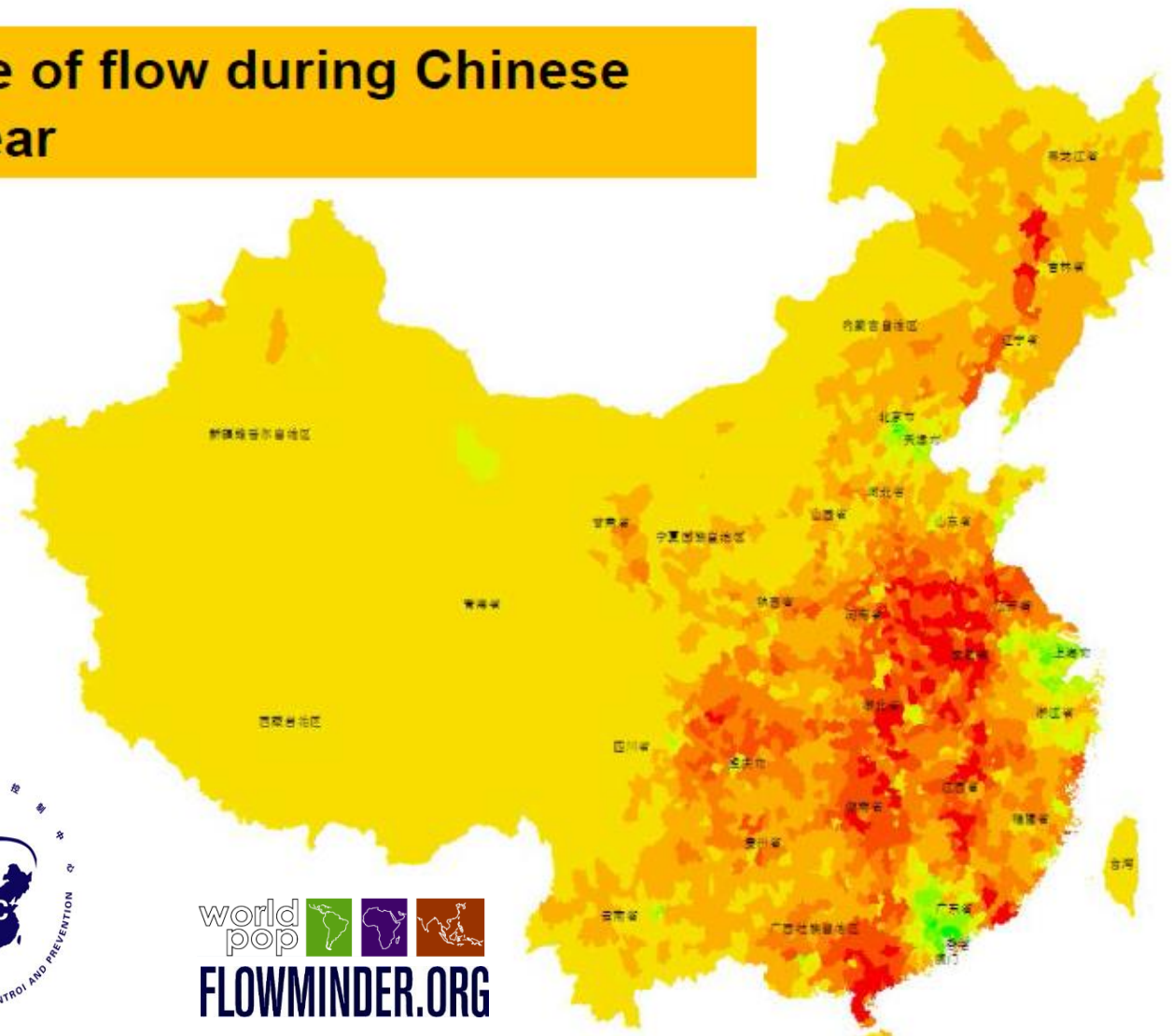
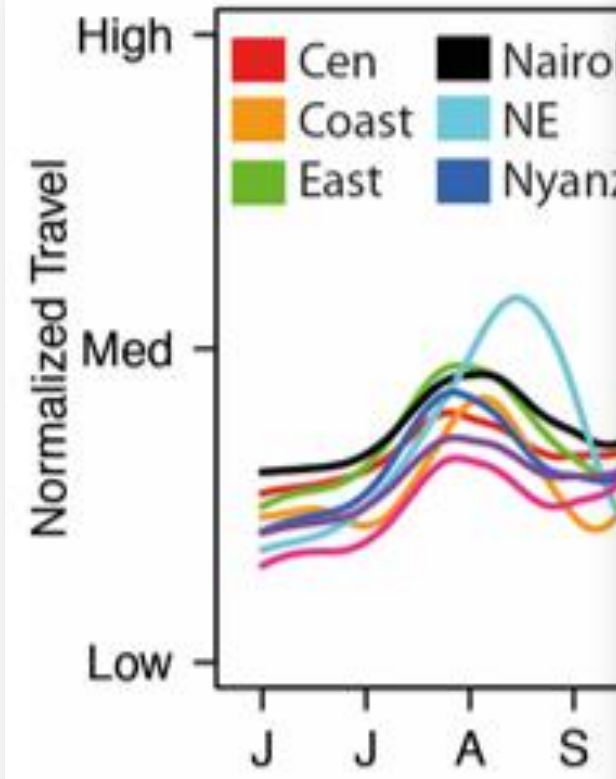
What can we use?



Mapping population movements



Change of flow during Chinese New Year





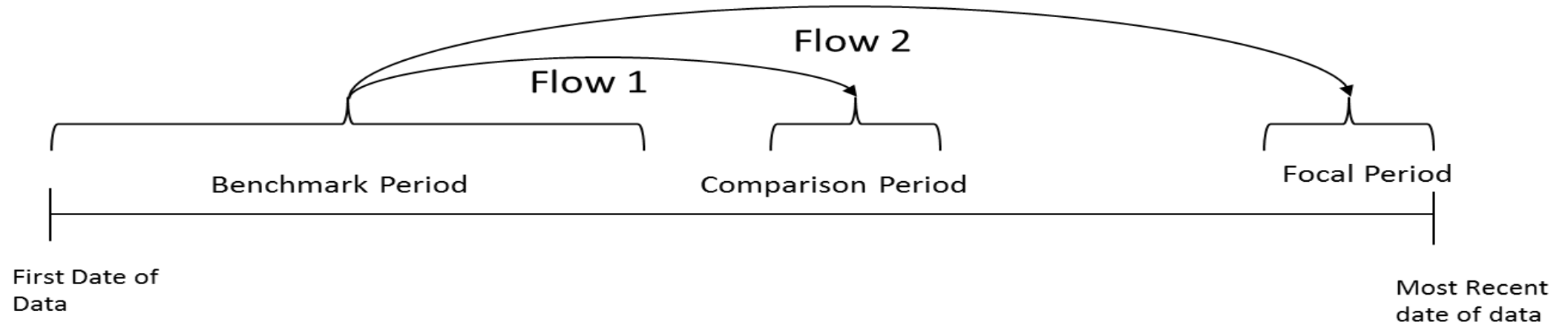
Nepal earthquake 2015

Kathmandu daily exodus may reach 300,000 as residents flee chaos

More than 100,000 have already left the badly damaged capital of Nepal, heading for distant regions to escape the threat of aftershocks, lawlessness and disease

Mapping displacements, building resilience

- Server setup and data-feed within 2 days of initial quake
- Analysis of displacements against pre-quake routines



- First report delivered to response agencies within 10 days of initial quake
- Analyses ongoing



Nepal Population Estimates as of 10th June 2015

Pre-earthquake population

2.8m

Population outflow
(above normal)

+180,000

(110,000 ~ 250,000)

Population inflow
(above normal)

-55,000

(-33,000 ~ -77,000)

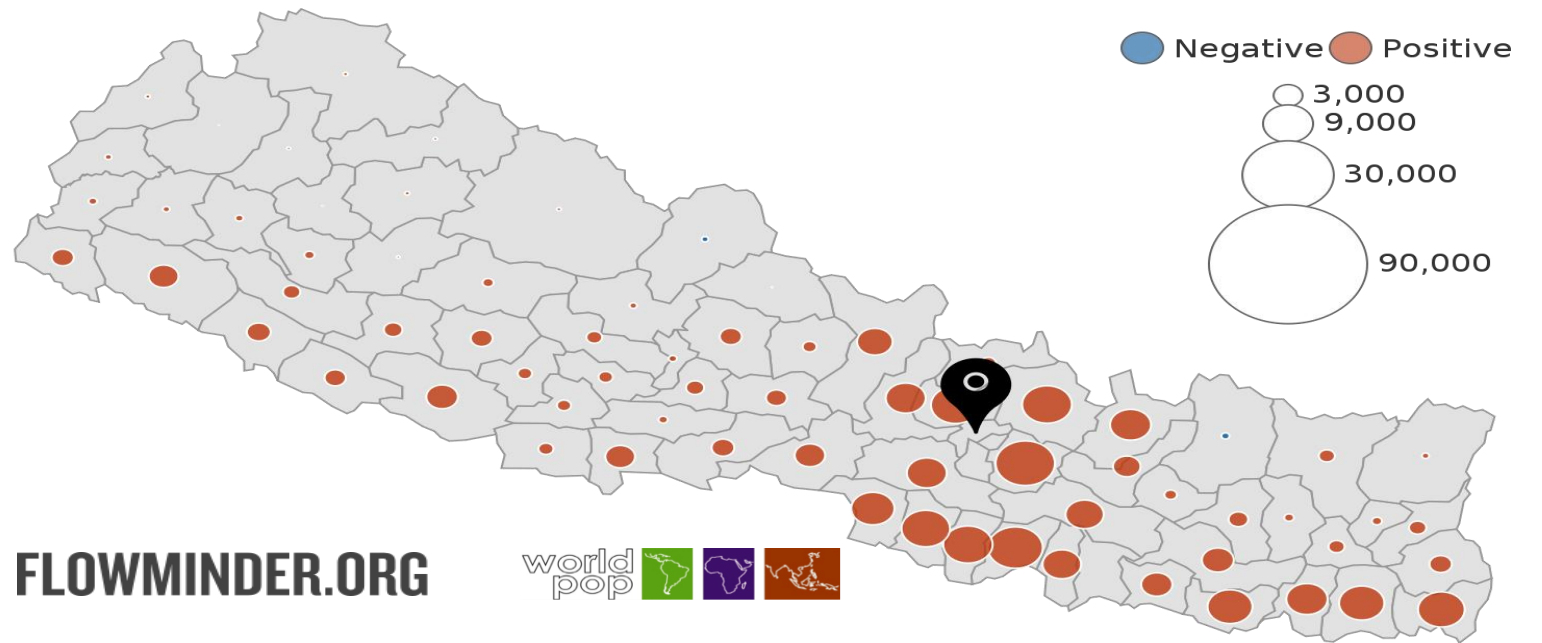
2. Kathmandu Valley

- Kathmandu district is home to 2.8m people under normal conditions [1].

Key findings:

- An estimated 180,000 people more than normal had left Kathmandu - comparing 3rd-10th June with 20th-24th April (ratio to the population 6.7%).
- An estimated 55,000 persons less than normal had come into Kathmandu during the same period (ratio to the population - 2%).
- People leaving Kathmandu Valley went to a large number of areas, notably the populous areas in the south and southeast as well as to the neighbouring districts.

Above normal flows from Kathmandu to other districts



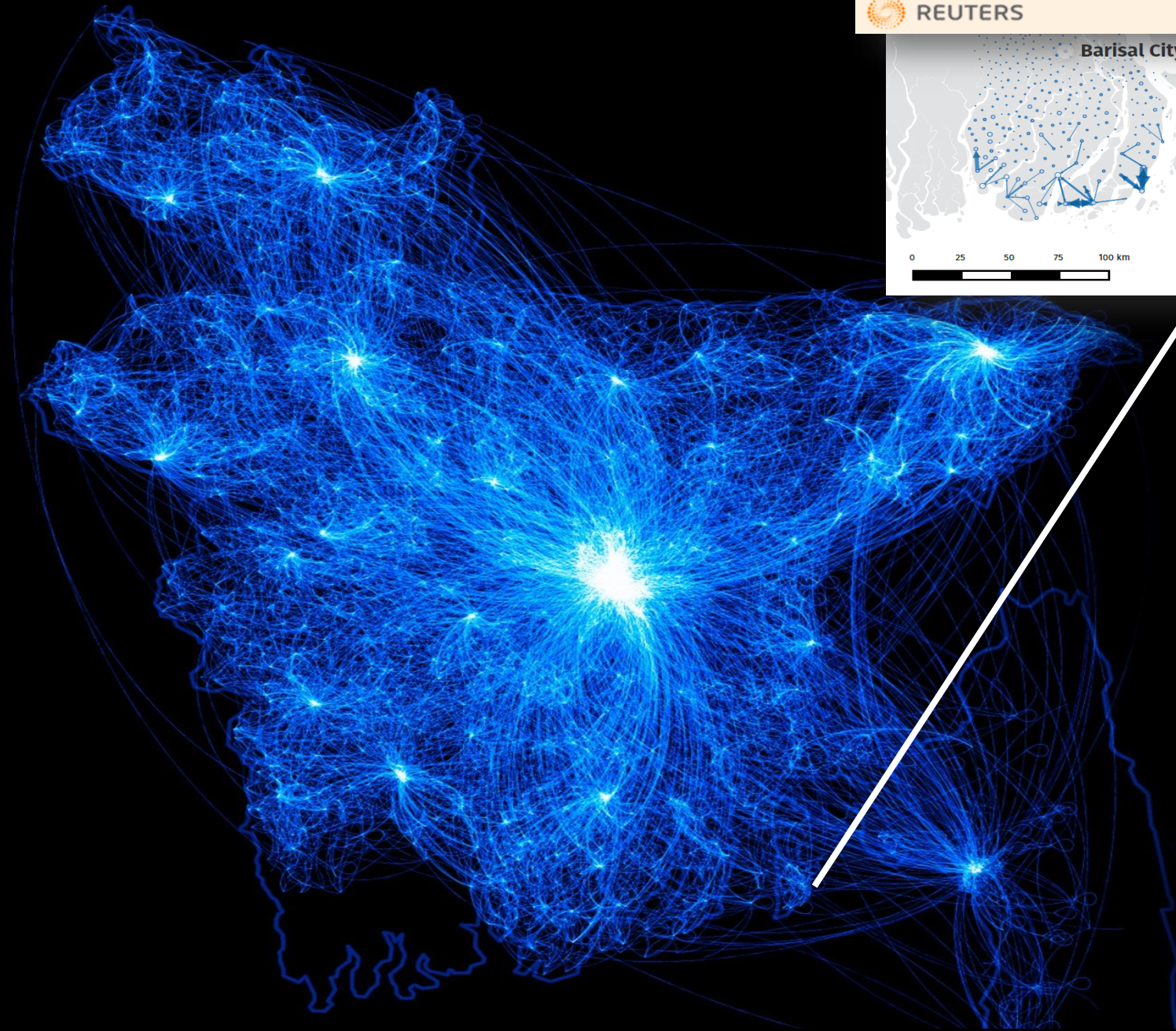
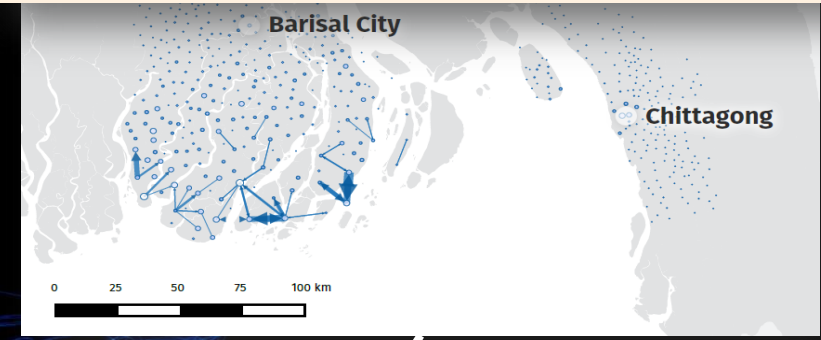
FLOWMINDER.ORG

[1] www.worldpop.org

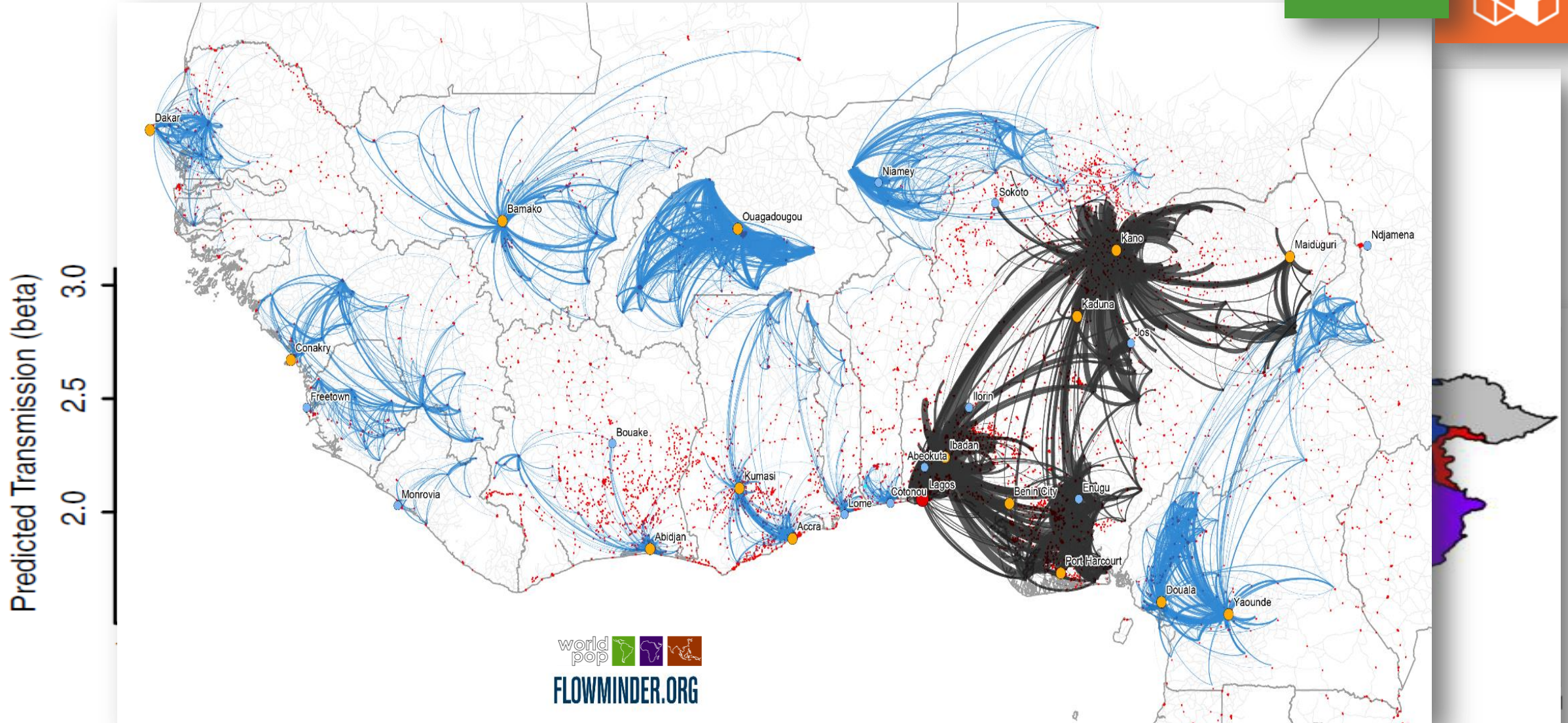
Above normal flows from Kathmandu to other districts (comparing 3rd-10th June and 20th-24th April).

Cyclone Mahasen batters Bangladesh

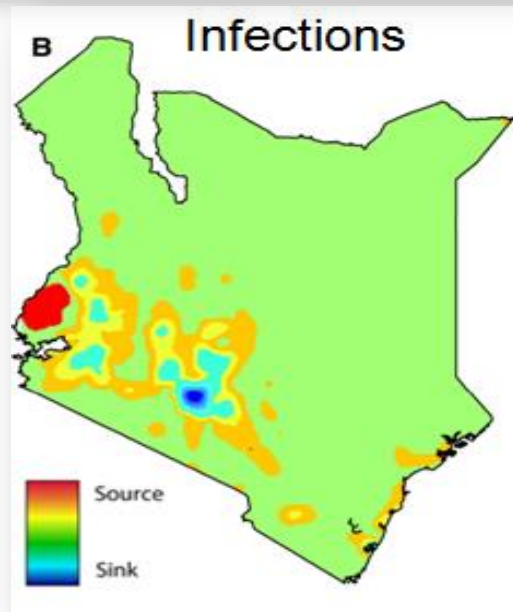
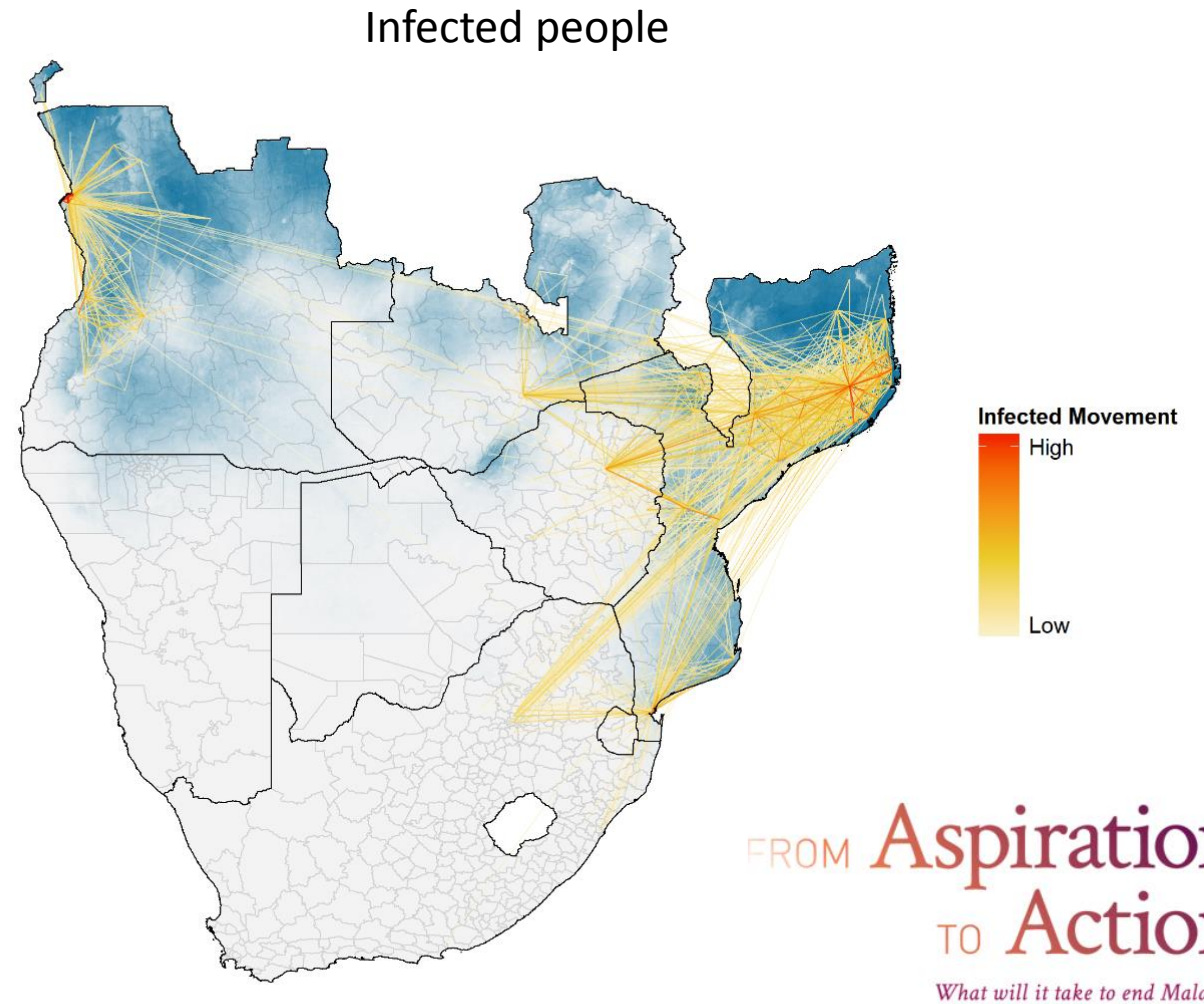
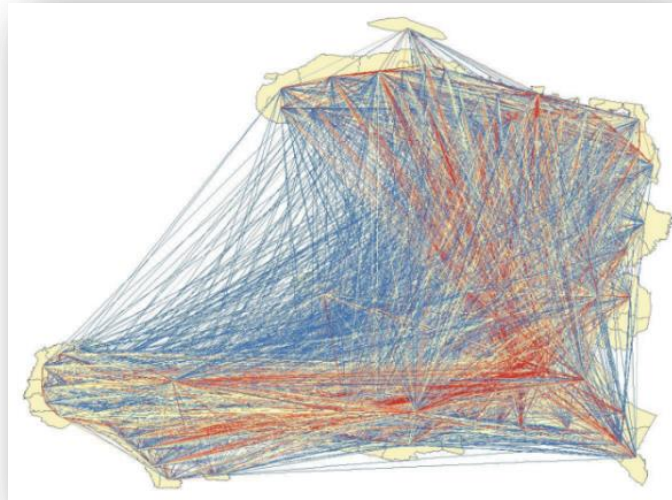
REUTERS



Integrating CDRs improves disease model accuracy



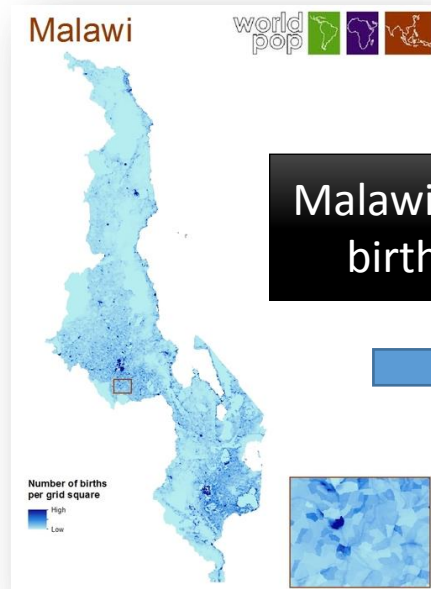
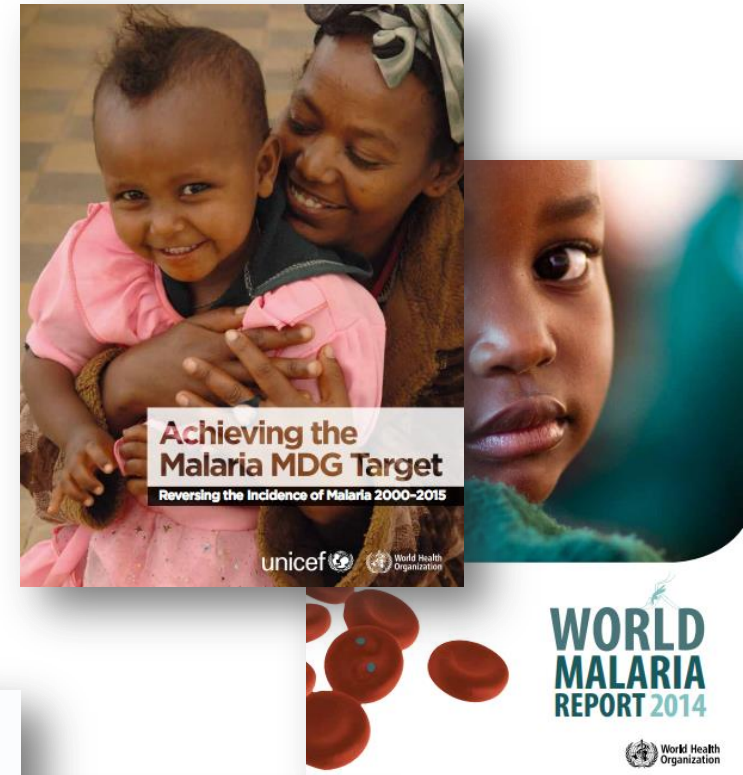
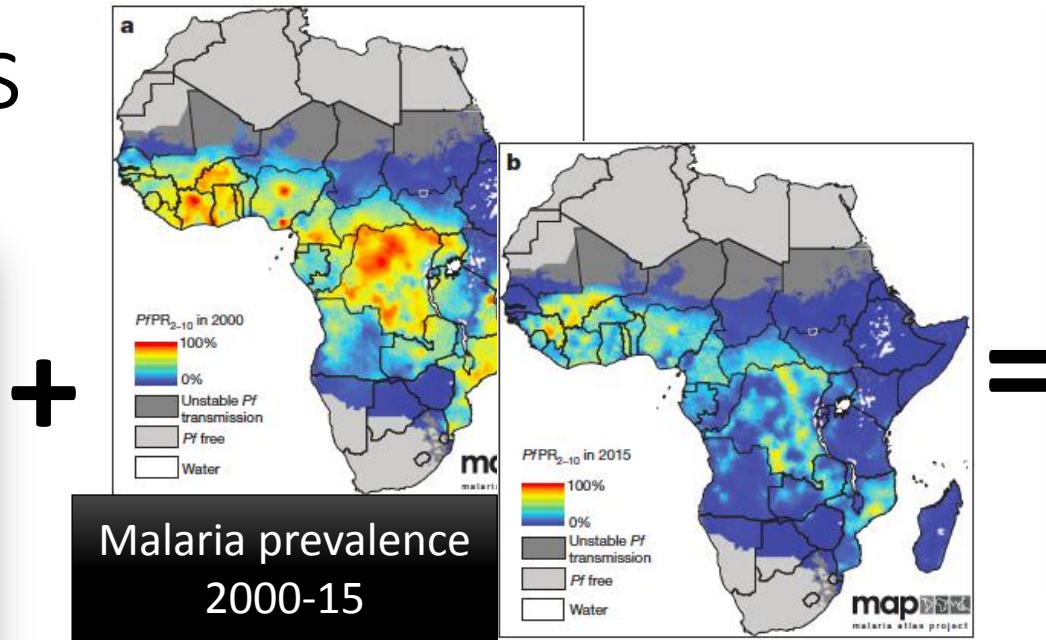
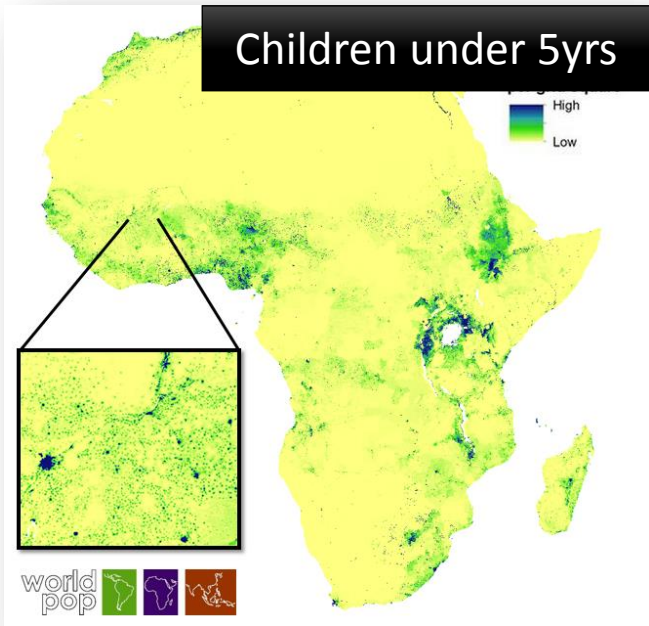
Supporting disease elimination strategy design



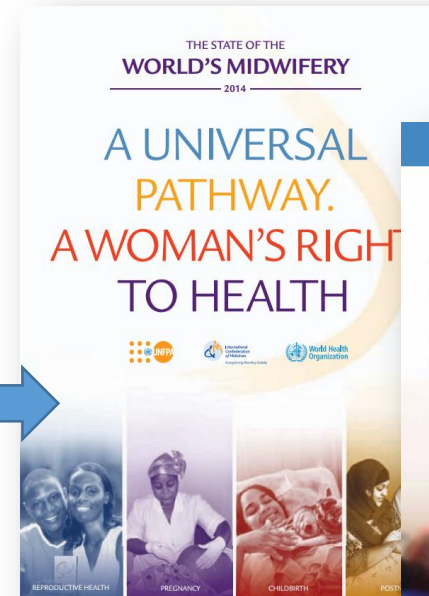
Maybe these are crazy ivory-tower academic ideas that will never find use?



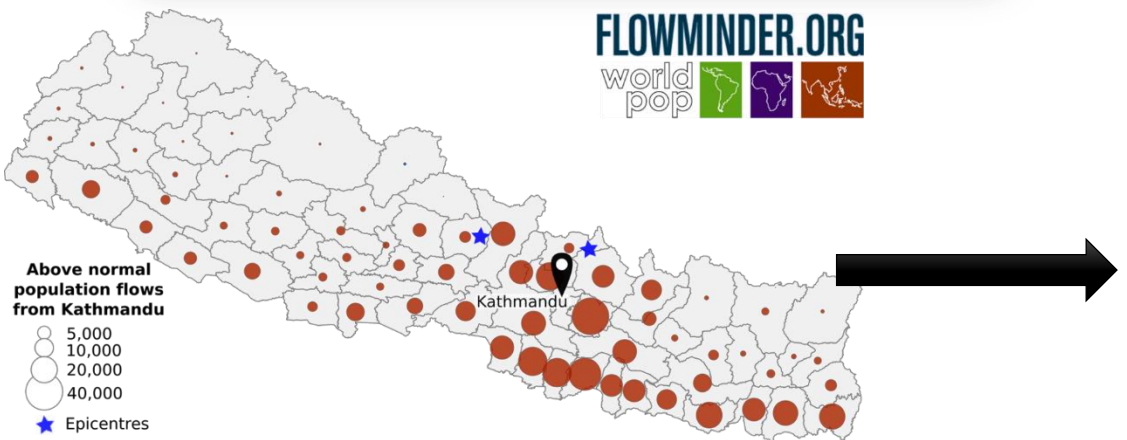
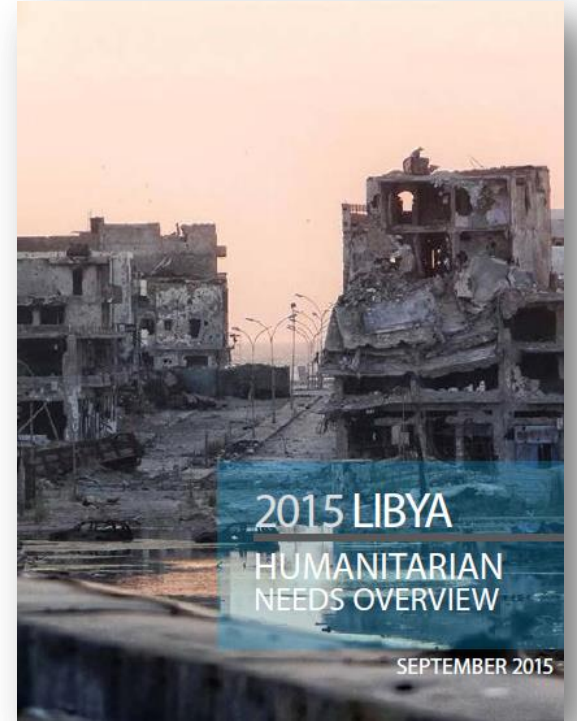
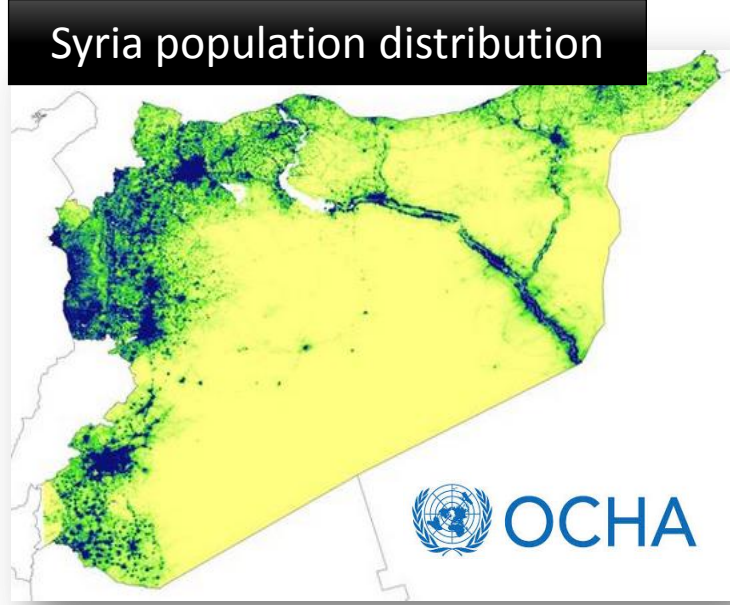
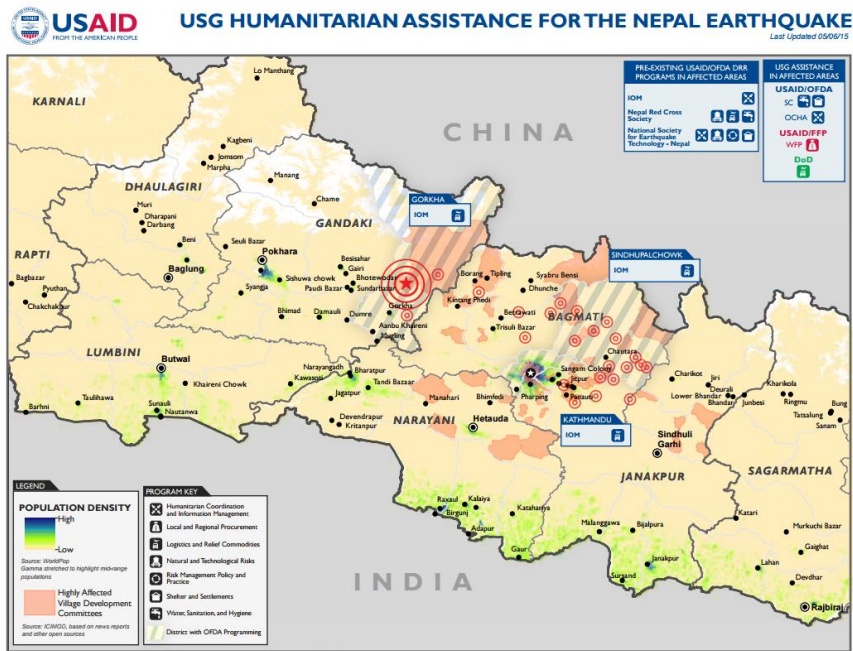
Health metrics



Malawi live births



Disaster response

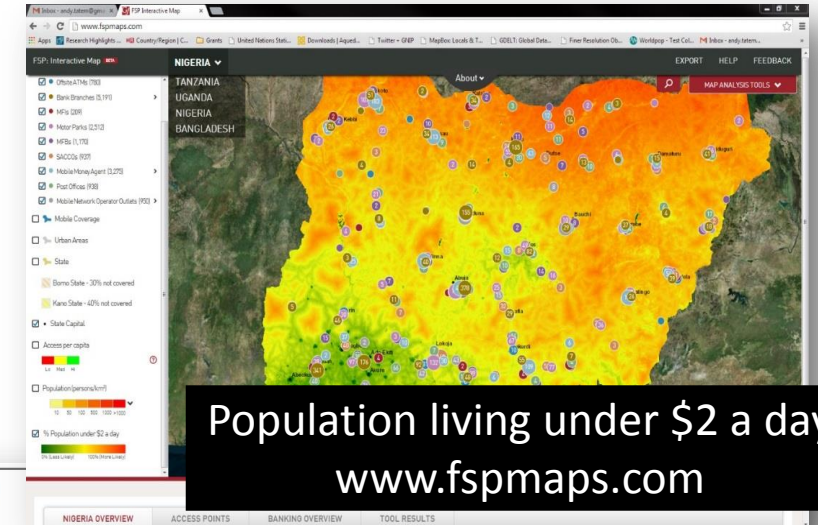
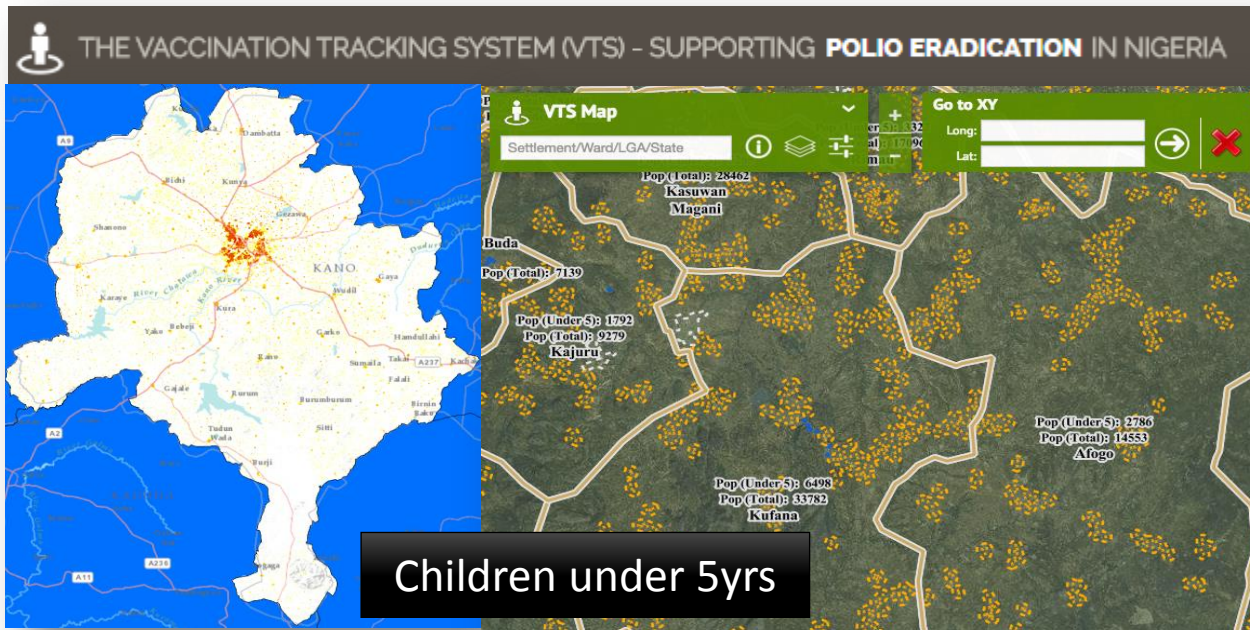


Landslides and displacement in earthquake affected areas
 Bi-weekly update
 27 July 2015

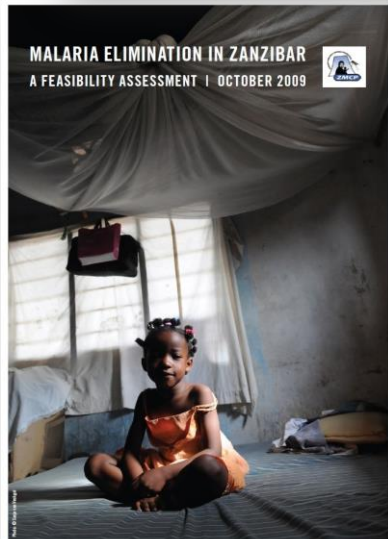
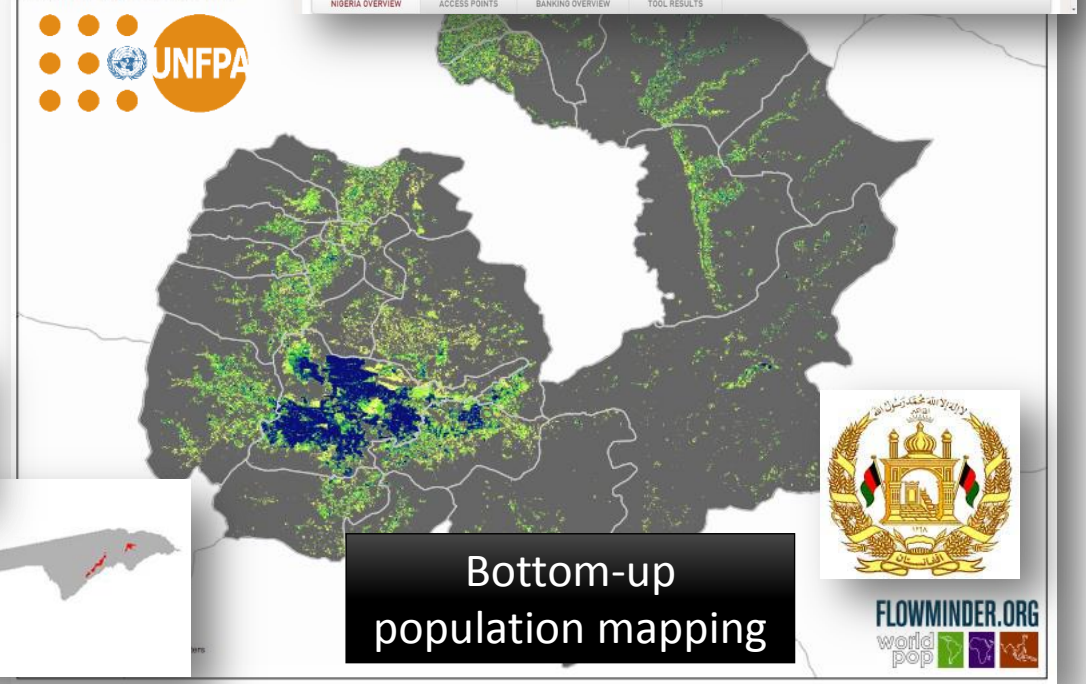
Nepal Earthquake Assessment Unit



Operational support and strategy design



Kapisa and Kabul Provinces Preliminary Draft Output



Malaria intervention strategies



Training, local capacity



- GIS, remote sensing skills and capacity are increasing everywhere
- Open data and software are accelerating uptake
- Making full use of existing traditional data and complimenting it with 'new' dataset integration is more cost-effective than new data collection
- Local ownership and analysis are key to sustainable implementation

Summary

- In producing estimates for different geographical scales and time periods, the integration of multiple types of data to compliment traditional sources is often required
- Novel datasets (e.g. phones, satellite) are prone to biases, but each has advantages over census data in terms of the frequency of measurement and spatial precision
- Methods to account for biases, reporting uncertainties and providing clear metadata/documentation to inform users are all important
- ***Great potential in complimenting traditional sources to build strong and cost-effective demographic databases for measuring progress towards the SDGs***



Acknowledgements



Acknowledgements



Further information



www.worldpop.org

 [@WorldPopProject](https://twitter.com/WorldPopProject)

FLOWMINDER.ORG

www.flowminder.org

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