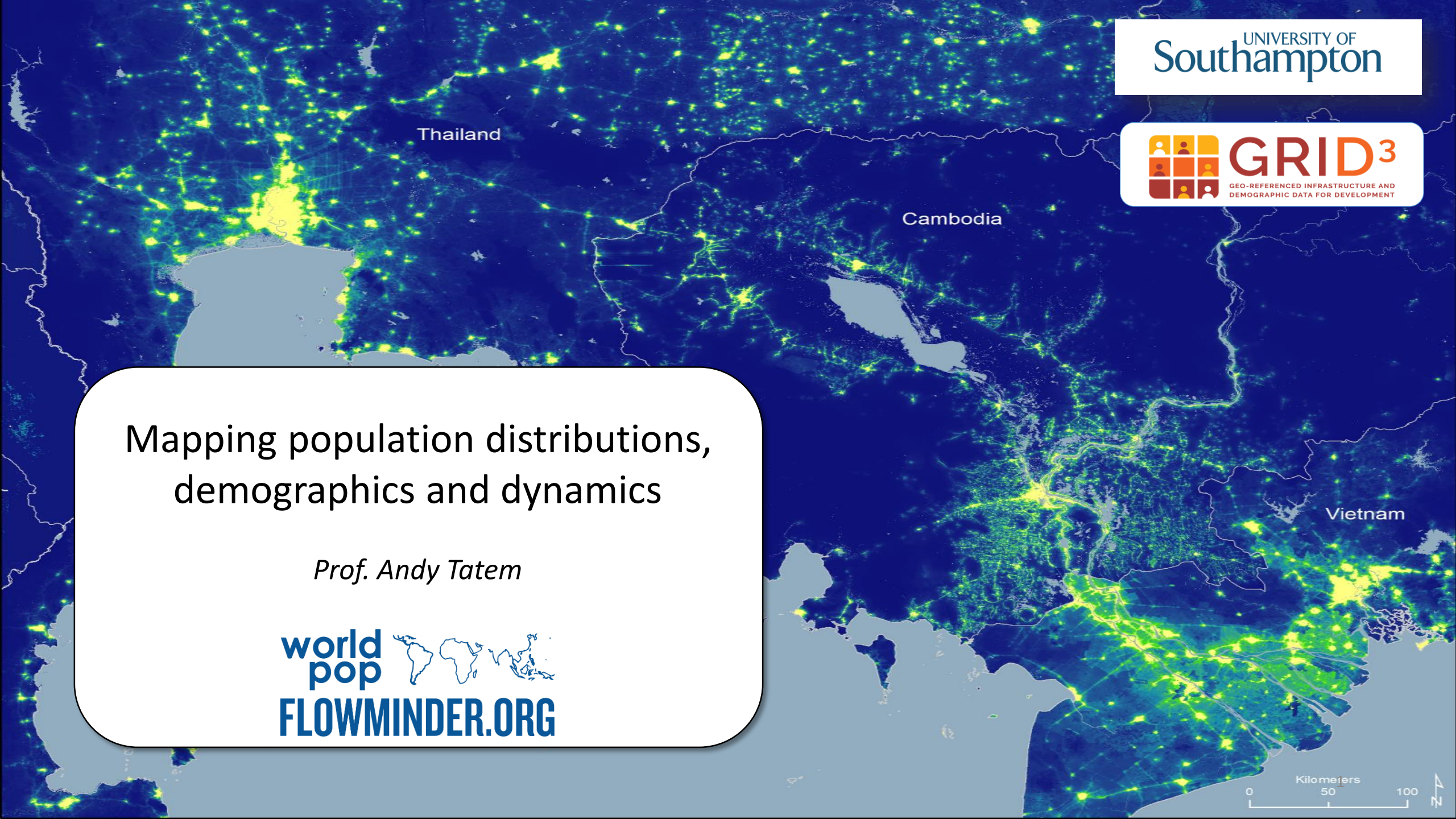


Mapping population distributions, demographics and dynamics

Prof. Andy Tatem

world pop
FLOWMINDER.ORG

UNIVERSITY OF Southampton

GRID3
GEO-REFERENCED INFRASTRUCTURE AND DEMOGRAPHIC DATA FOR DEVELOPMENT

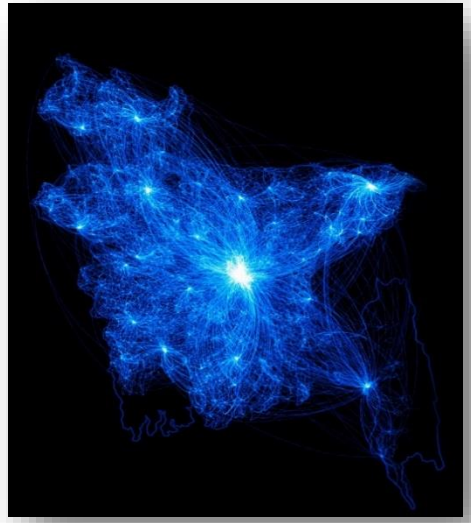
world pop FLOWMINDER.ORG

DATA-POP ALLIANCE

HARVARD HUMANITARIAN INITIATIVE
mit media lab
FLOWMINDER.ORG

UNIVERSITY OF Southampton

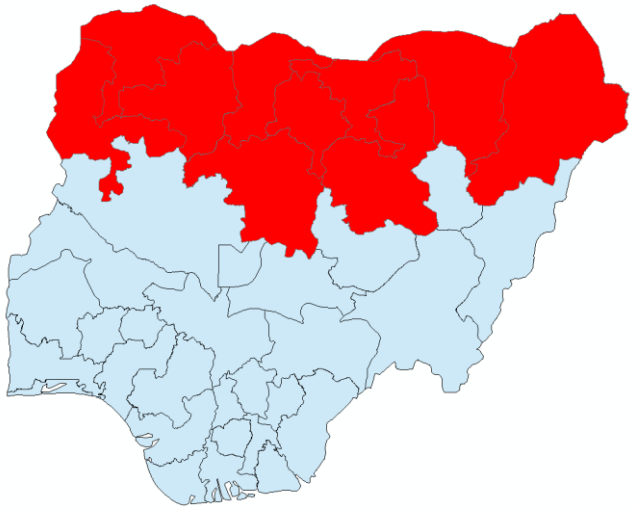
- WorldPop: Research program focused on methods for improving the demographic evidence base in low/middle income countries
- Flowminder: Non-profit foundation working with data providers and international/government agencies to operationalize and scale research in support of vulnerable populations and sustainable development



Key partners and donors

Microsoft Research
wellcome trust
Vodafone Foundation Mobile for Good
CIESIN Columbia University
OCHA
UNFPA
WFP United Nations World Food Programme
MILLICOM
tigo
ERICSSON
International Organization for Migration (IOM)
GeoData Institute
DLR
CLINTON HEALTH ACCESS INITIATIVE
BILL & MELINDA GATES foundation
telenor
WILLIAM + FLORA Hewlett Foundation
UNITED NATIONS FOUNDATION
ADB Asian Development Bank
IDB Inter-American Development Bank
THE WORLD BANK Working for a World Free of Poverty

Example application: Vaccination planning needs



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

-Ensure correct amount of vaccine is available for each area

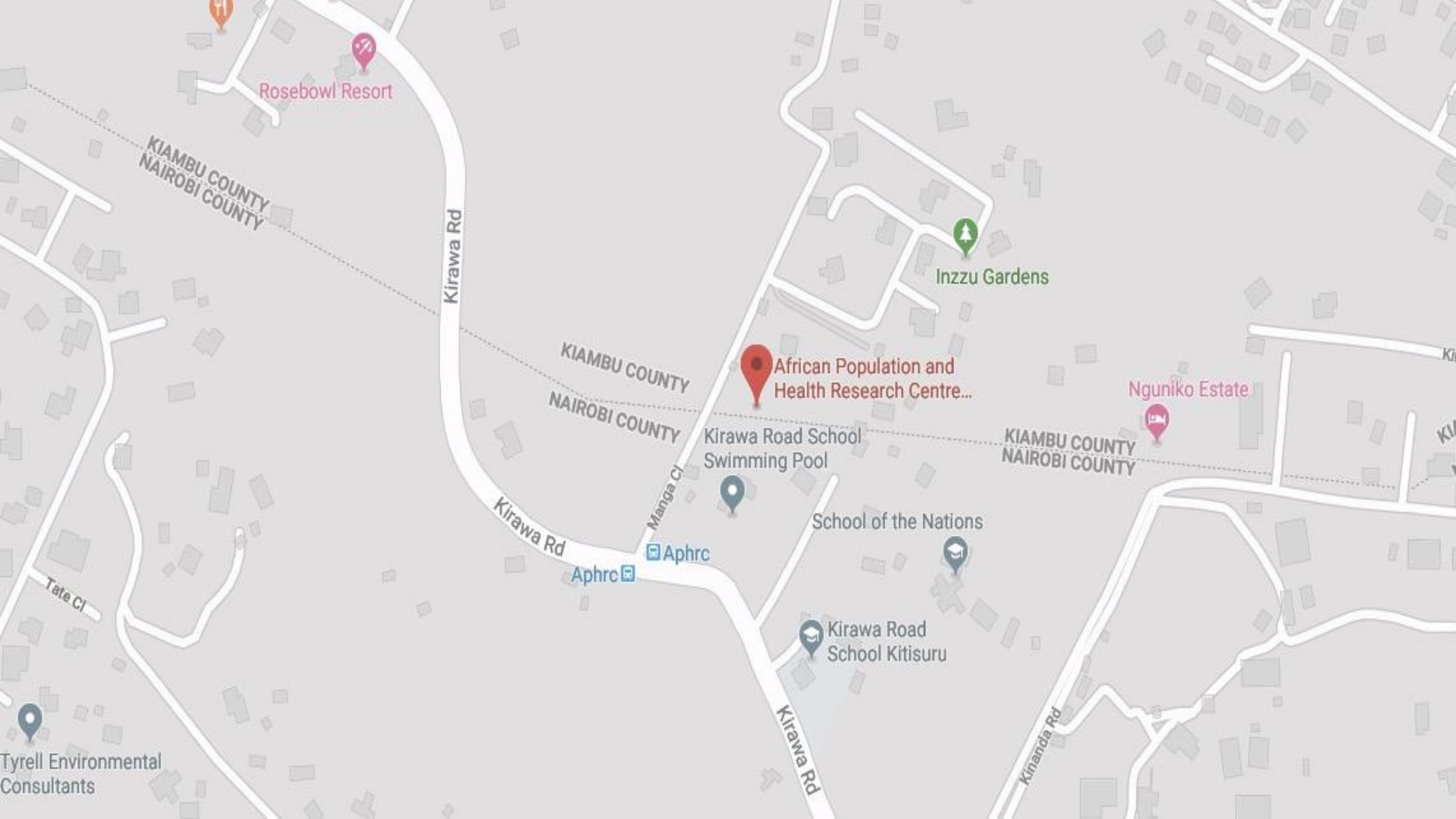
Need to know how many under 5s there are and where they are

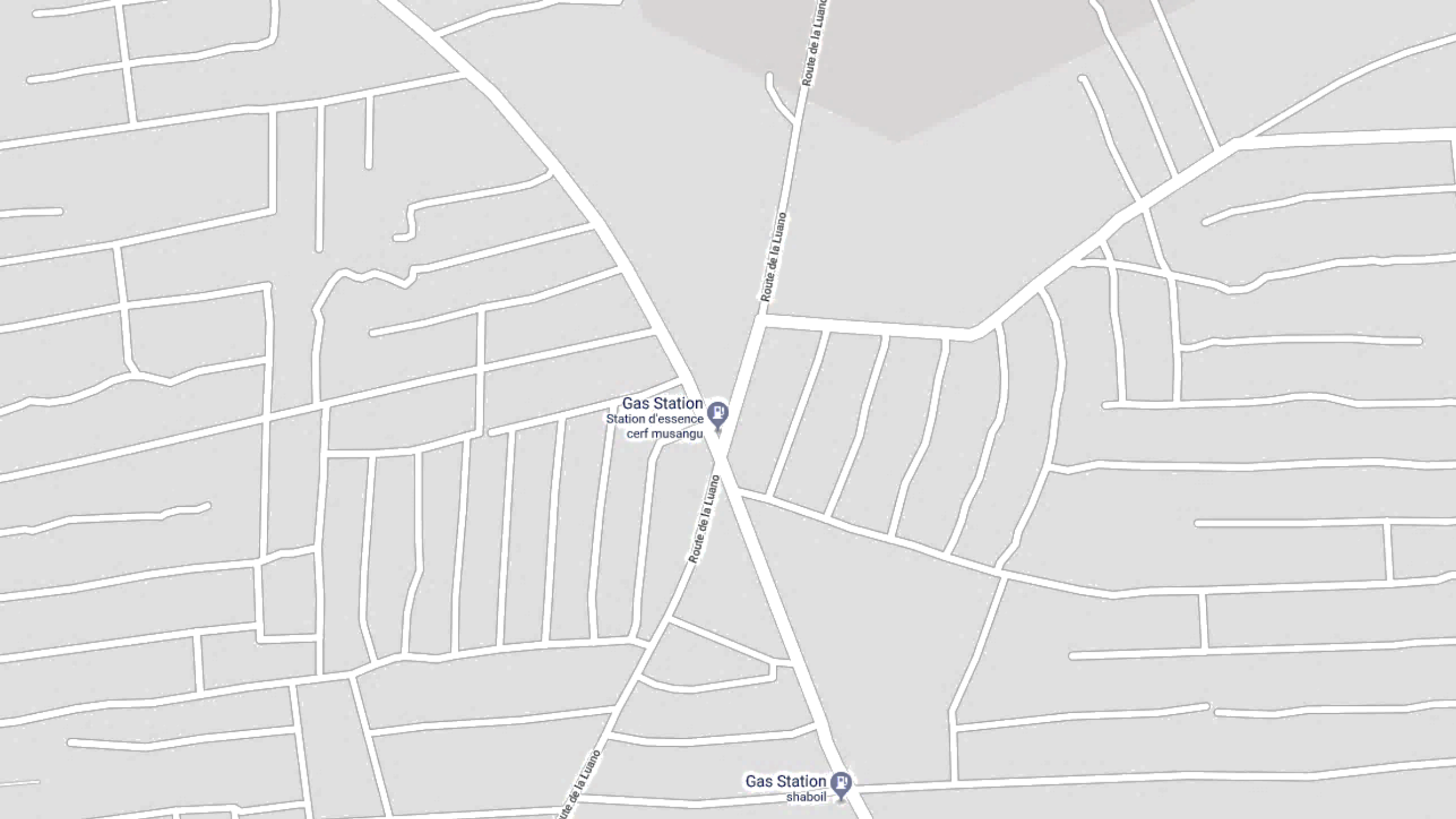
-Plan vaccinator logistics and routes

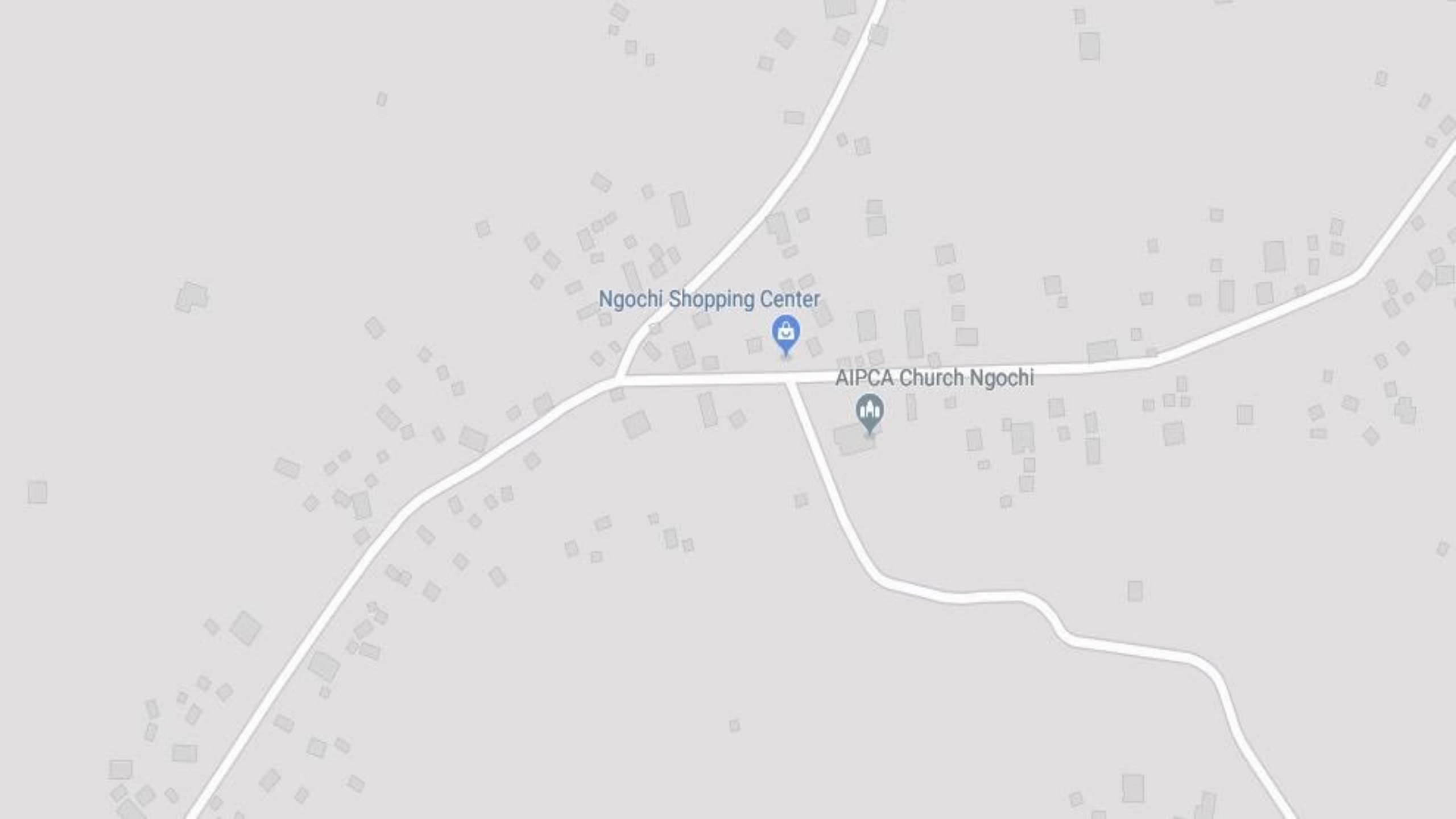
Need detailed maps of the region

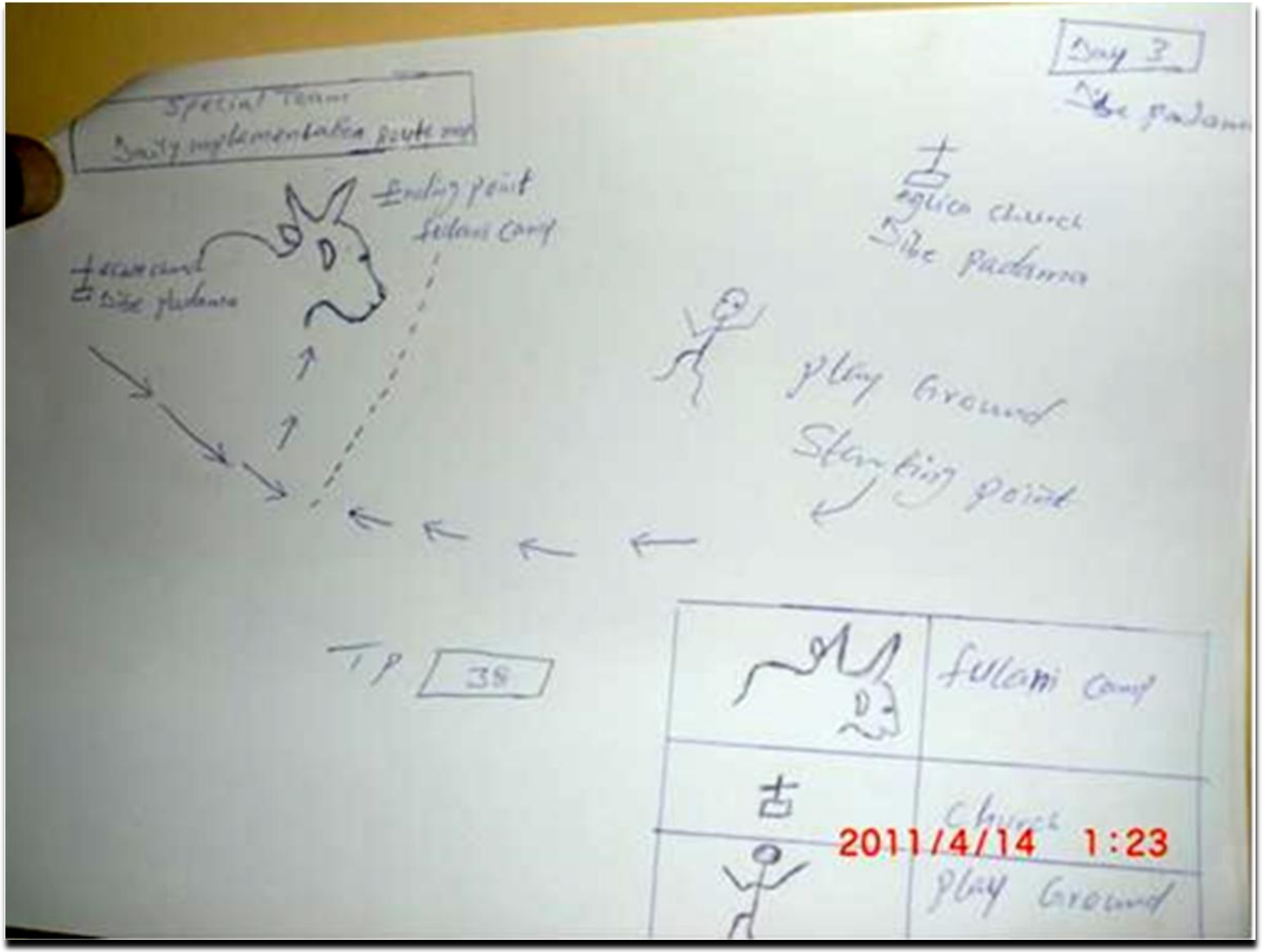
BILL & MELINDA GATES foundation

POLIO GLOBAL ERADICATION INITIATIVE


Rosebowl Resort
KIAMBU COUNTY
NAIROBI COUNTY
Kirawa Rd
Inzzu Gardens
KIAMBU COUNTY
NAIROBI COUNTY
African Population and
Health Research Centre...
Nguniko Estate
Kirawa Road School
Swimming Pool
KIAMBU COUNTY
NAIROBI COUNTY
Manga Cl
Kirawa Rd
Aphrc
Aphrc
School of the Nations
Tate Cl
Kirawa Road
School Kitisuru
Kirawa Rd
Kinanda Rd
Tyrell Environmental
Consultants


Route de la Luano
Route de la Luano
Route de la Luano
Route de la Luano
Gas Station
Station d'essence
cerf musangu
Gas Station
shaboil


Ngochi Shopping Center
AIPCA Church Ngochi



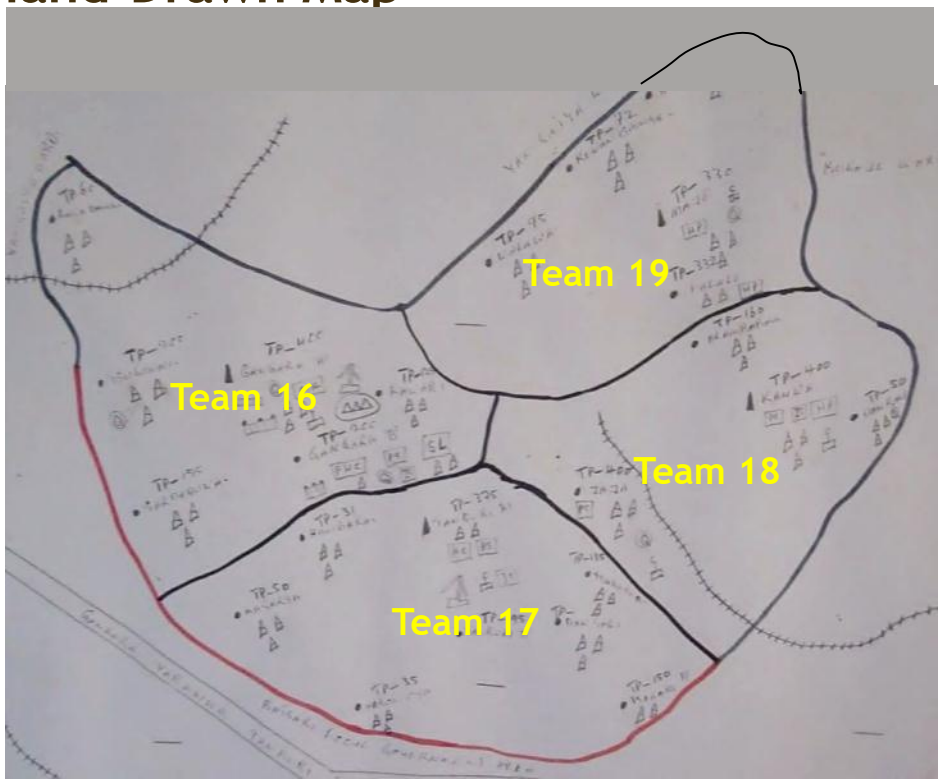
Courtesy of Vince Seaman, Bill and Melinda Gates Foundation

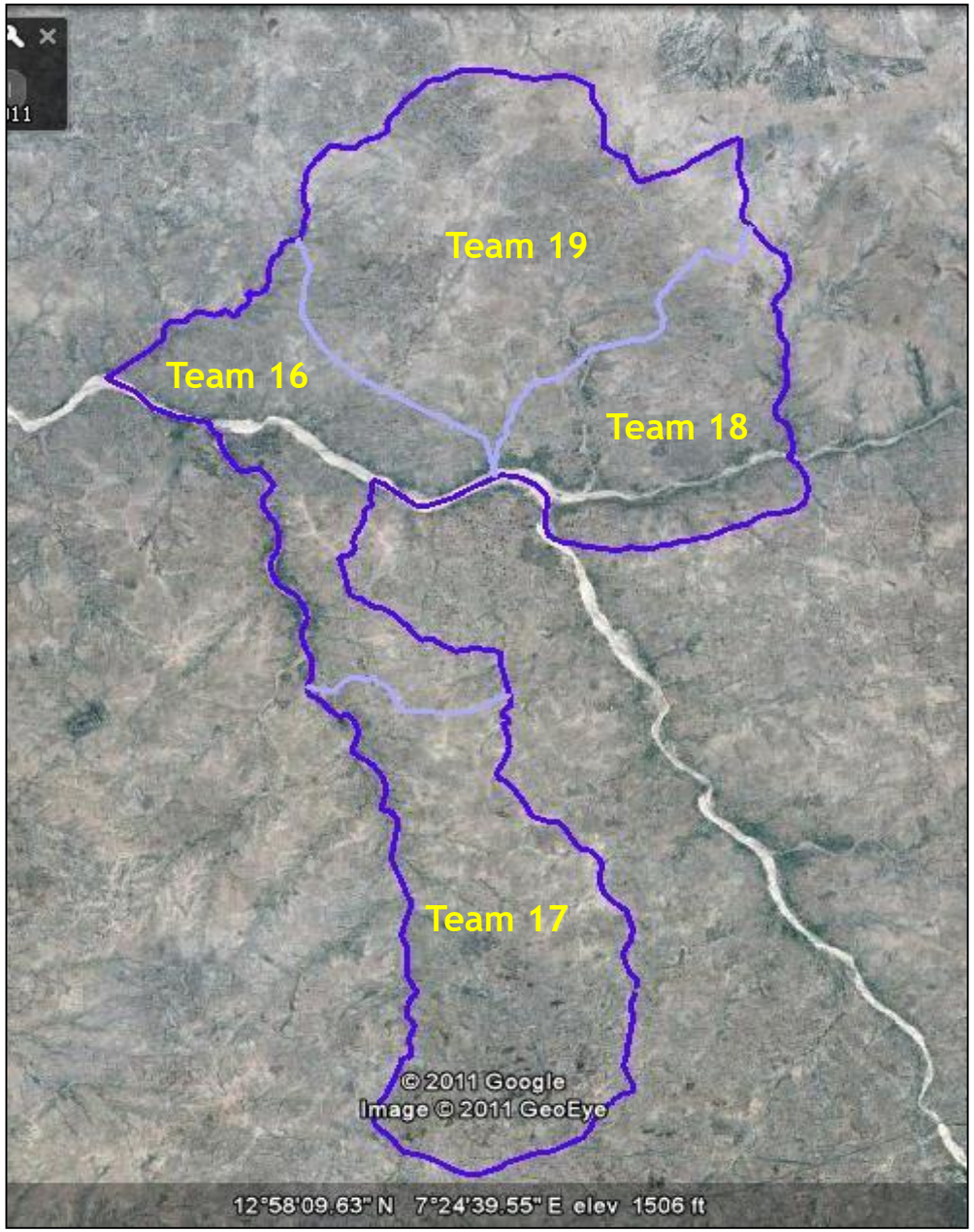
Hand-drawn maps for vaccination planning

Gangara Ward, Jibia LGA, Katsina State

Satellite Map →

Hand-Drawn Map

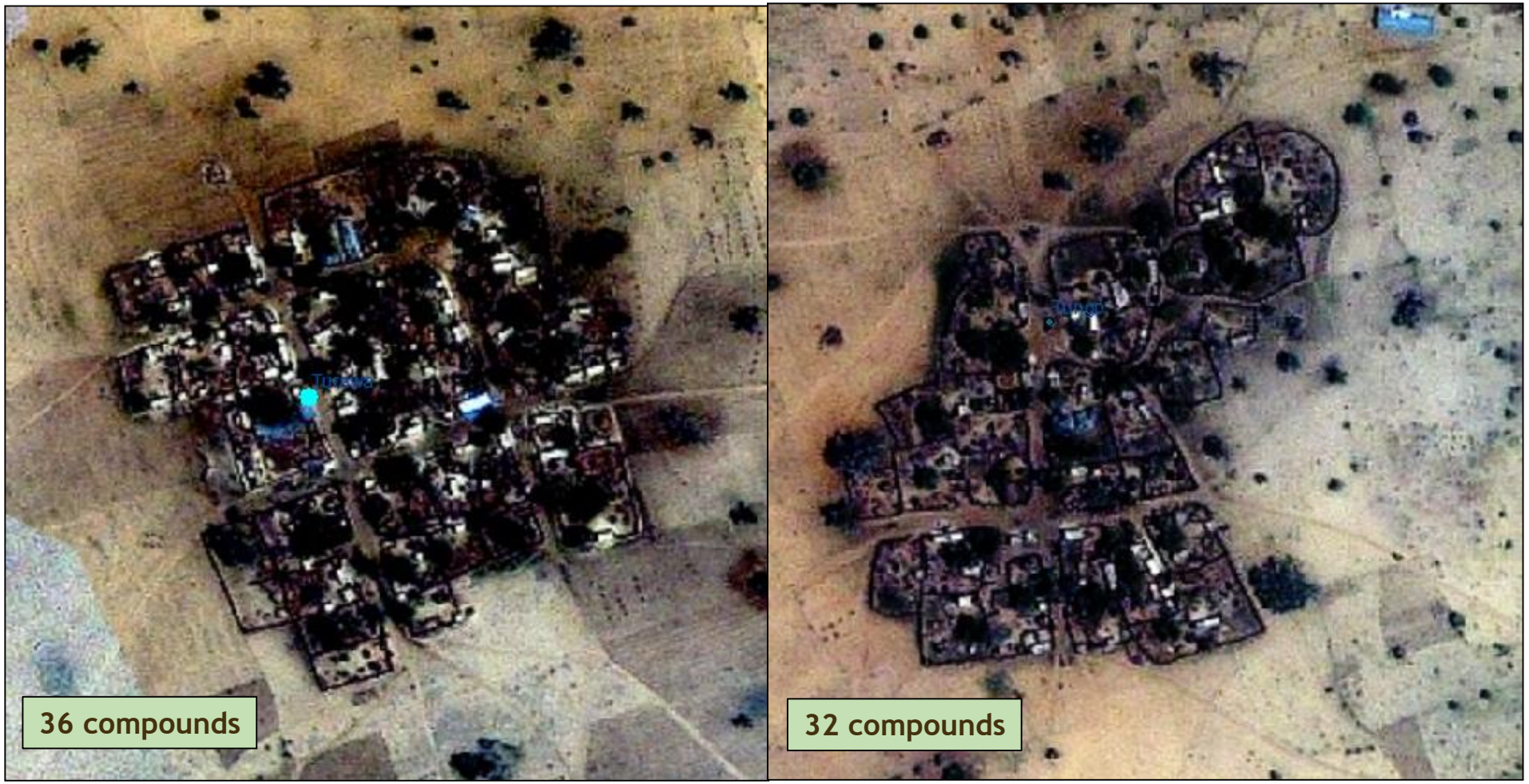




Courtesy of Vince Seaman, Bill and Melinda Gates Foundation

Inflated population estimates?

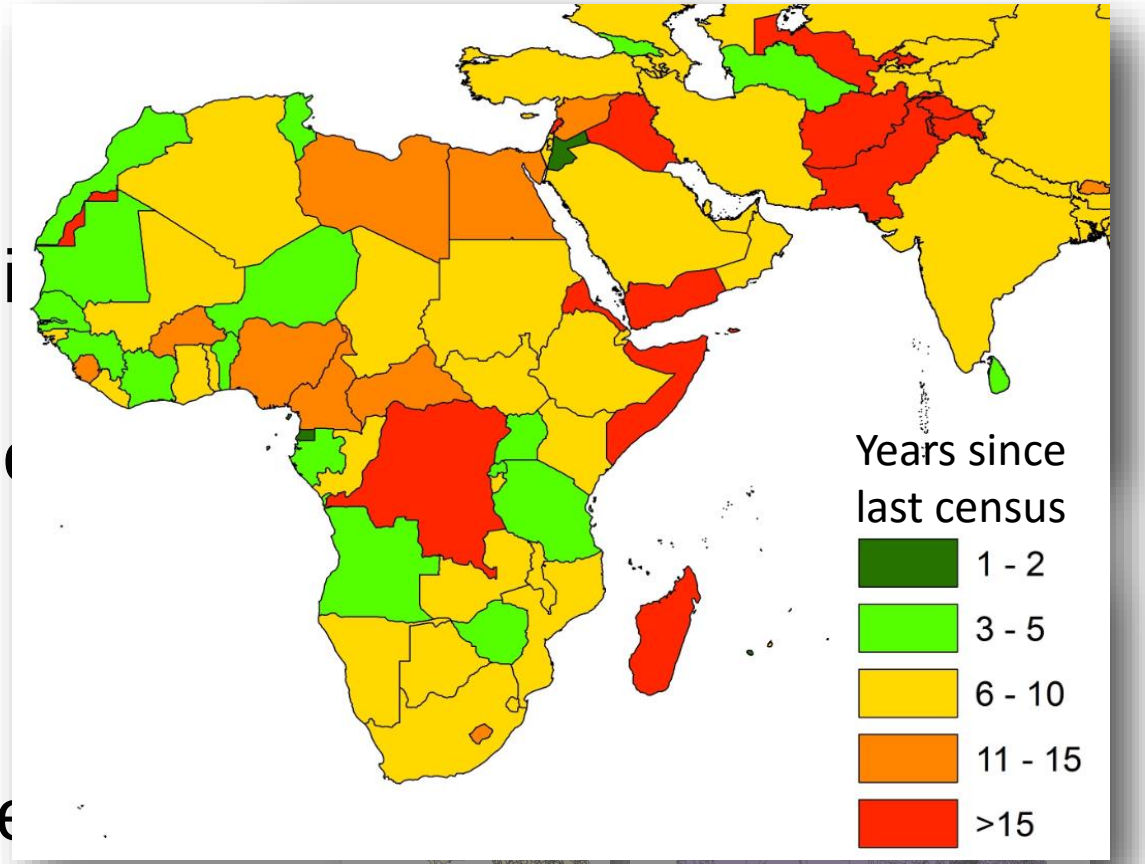
Census-derived estimate = 375	Census-derived estimate = 2675

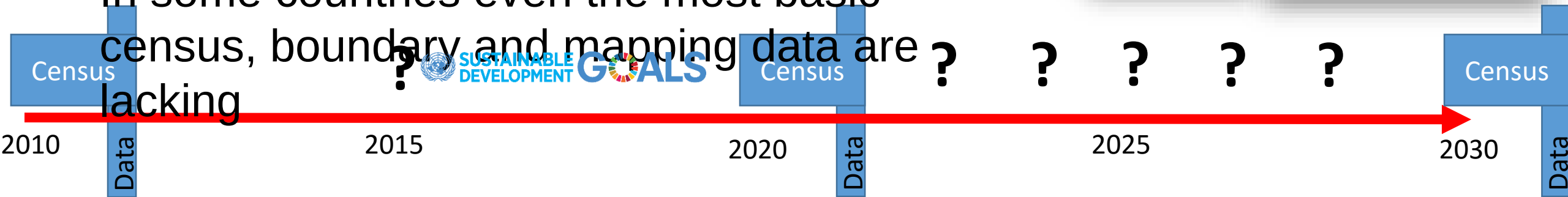


Courtesy of Vince Seaman, Bill and Melinda Gates Foundation

The challenge

- Census data are valuable, but expensi
  collected once a decade
- Increasing need for more timely and d
  data
- Registry, administration data can help
  gaps
- Incomplete/unreliable in low-income se
- Challenge of tracking progress towards
  development goals
- In some countries even the most basic
  census, boundary and mapping data are
  lacking



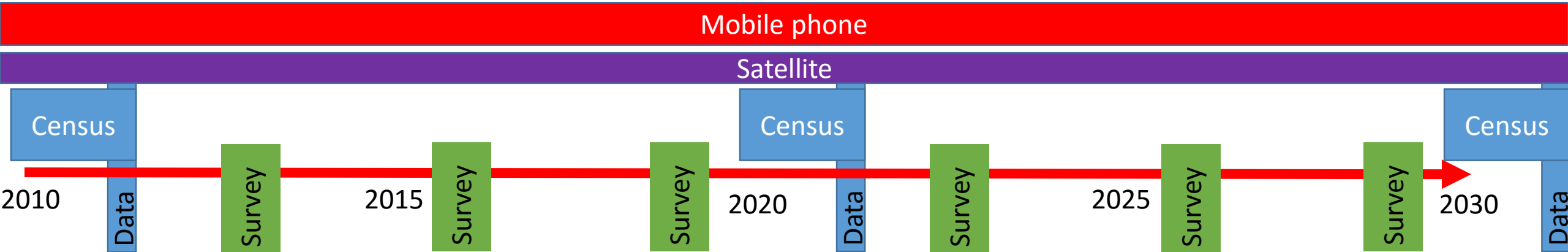


What do we have to help us?

Geolocated household surveys

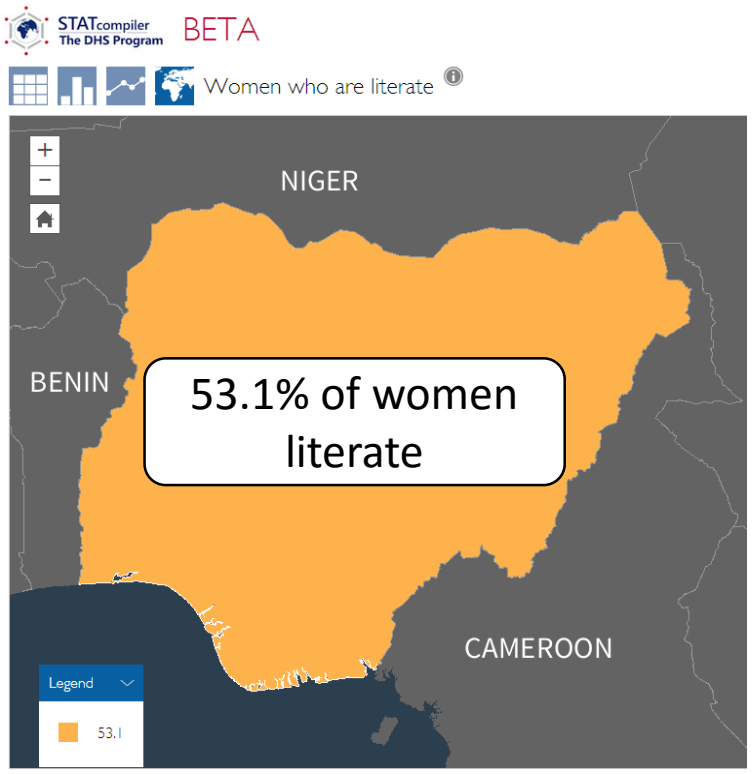
Satellite and GIS data

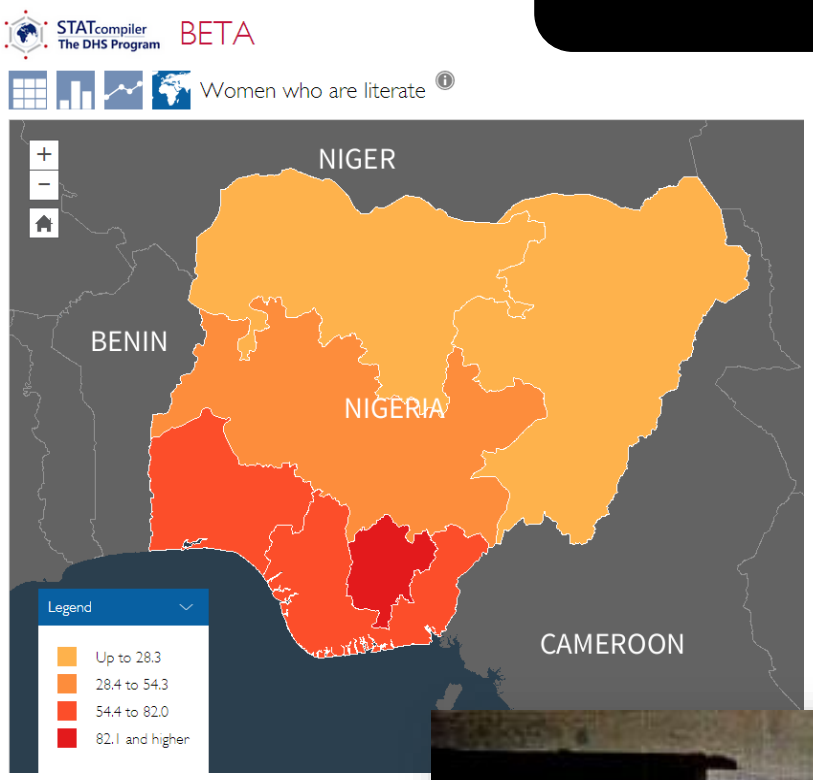
Mobile phone data

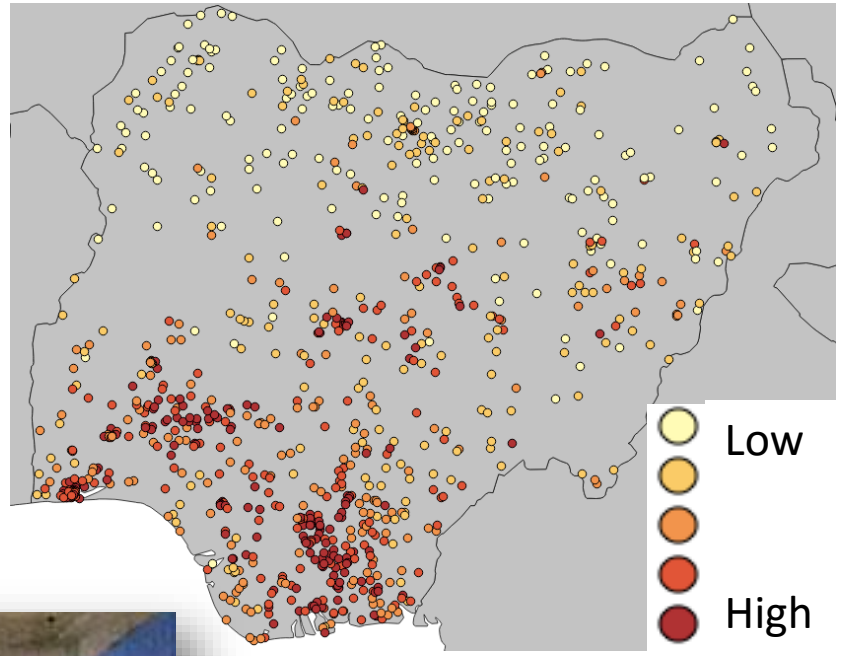


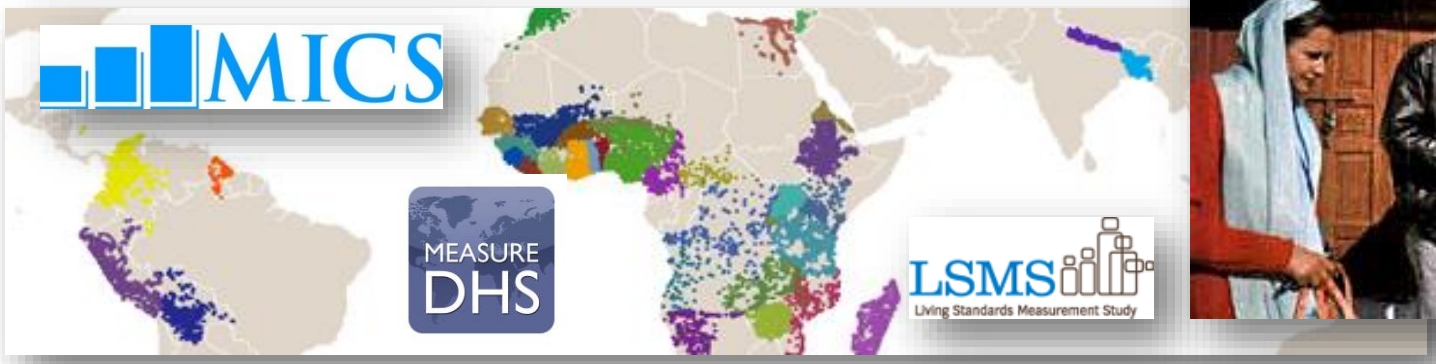
Geolocated Surveys

Proportion of women who are literate

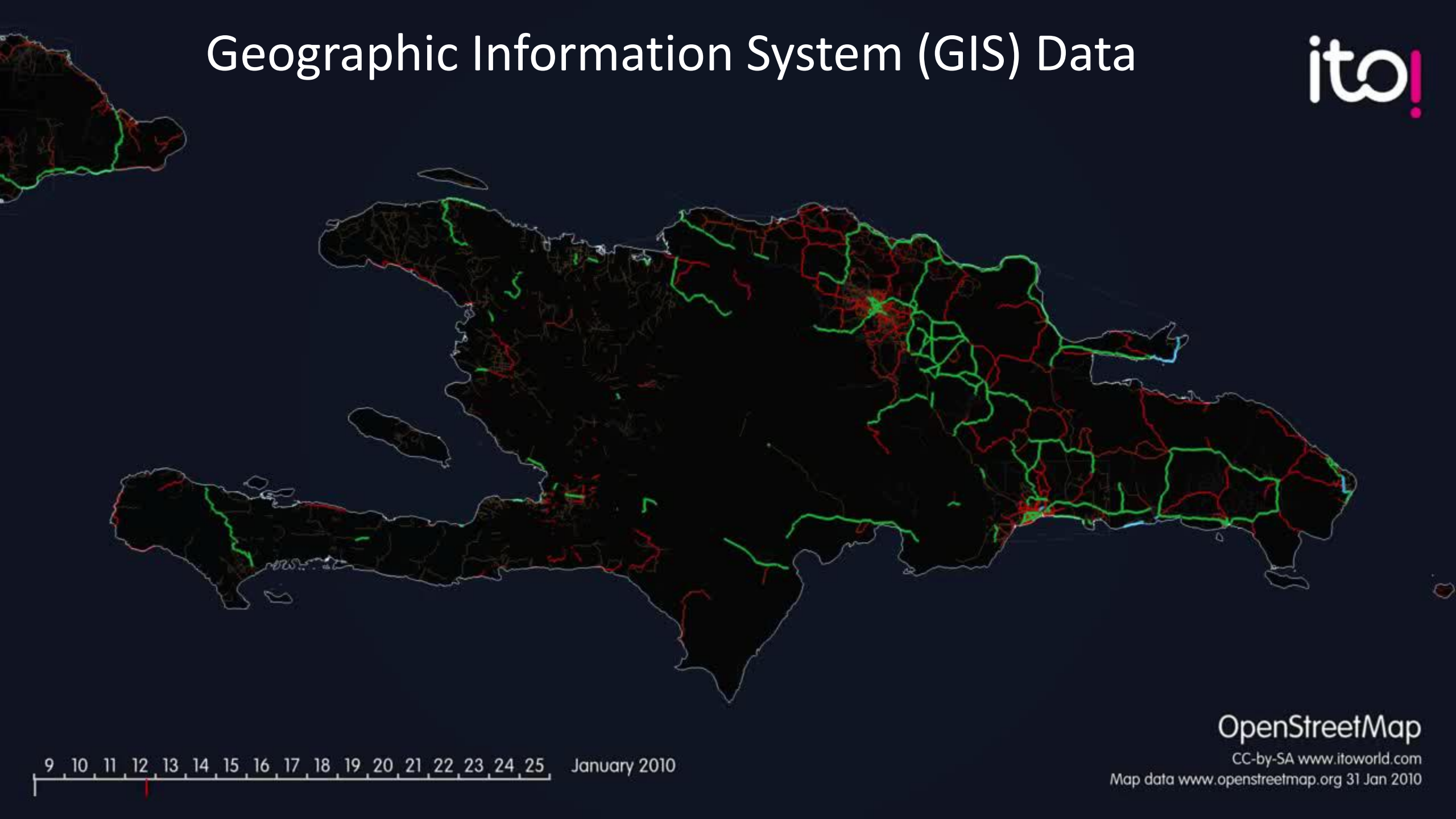








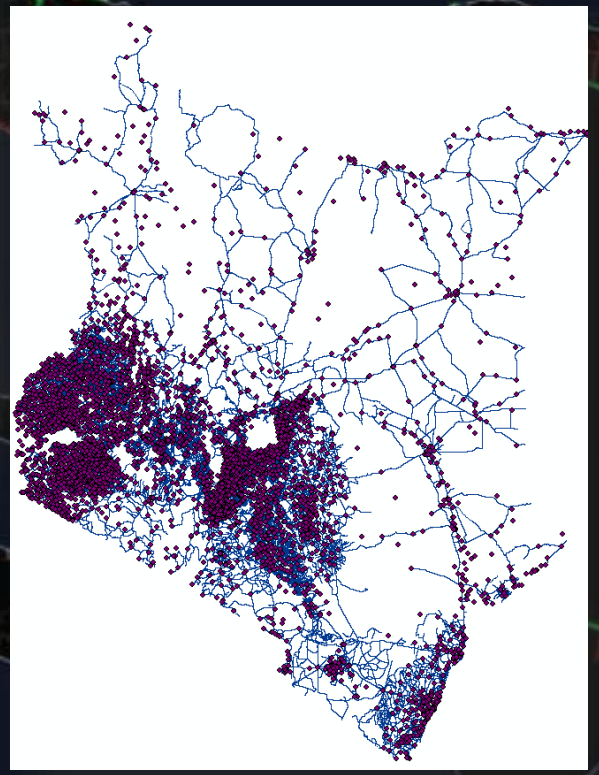
Geographic Information System (GIS) Data

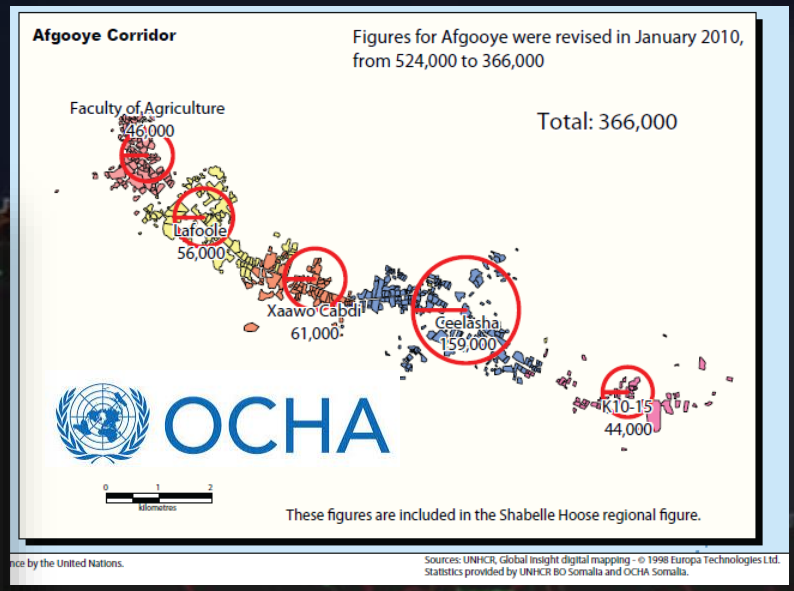


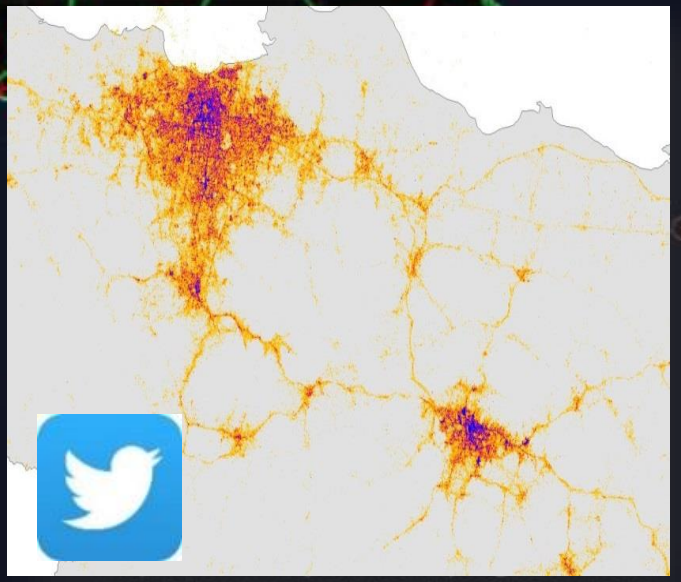
Geographic Information System (GIS) Data

MISSING MAPS

OpenStreetMap

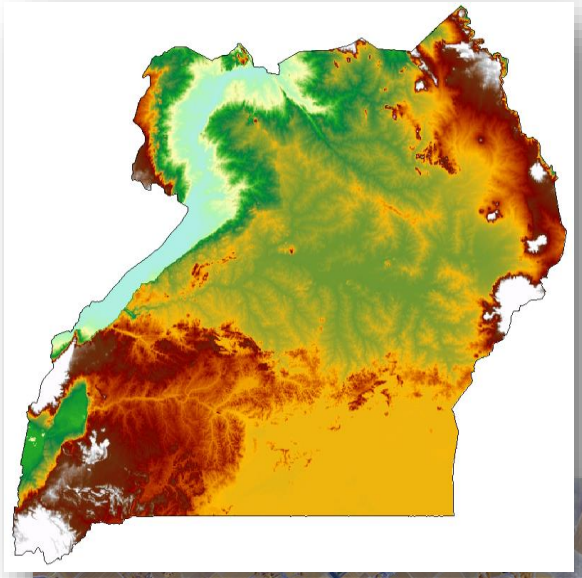


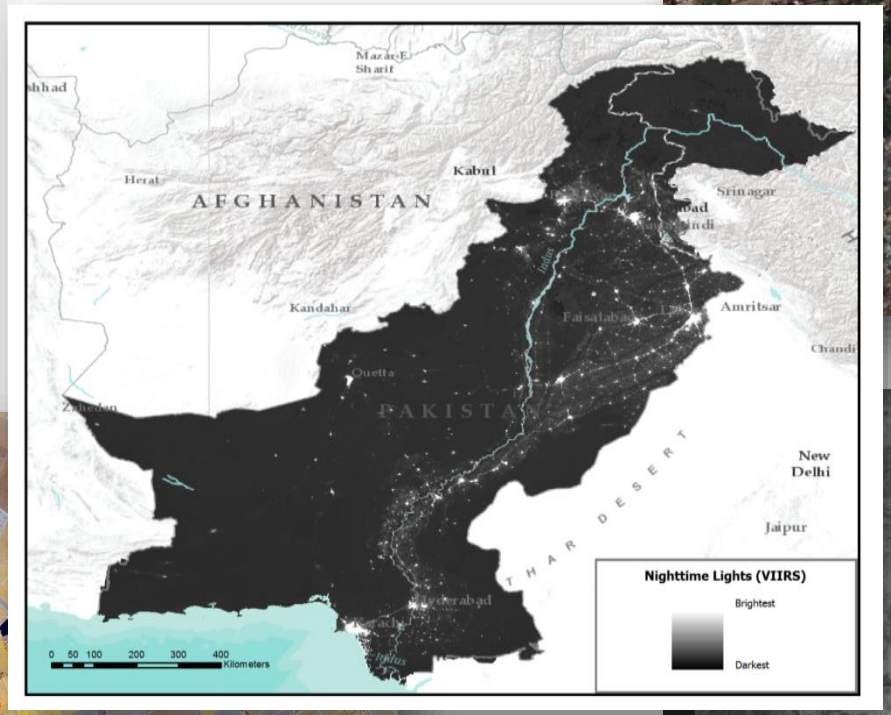


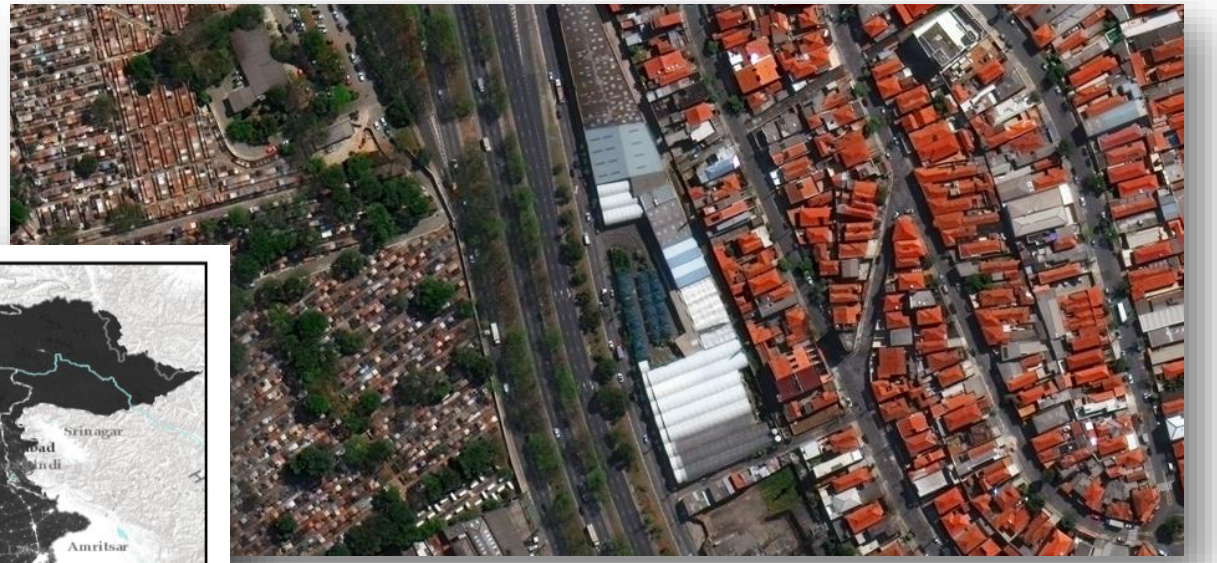


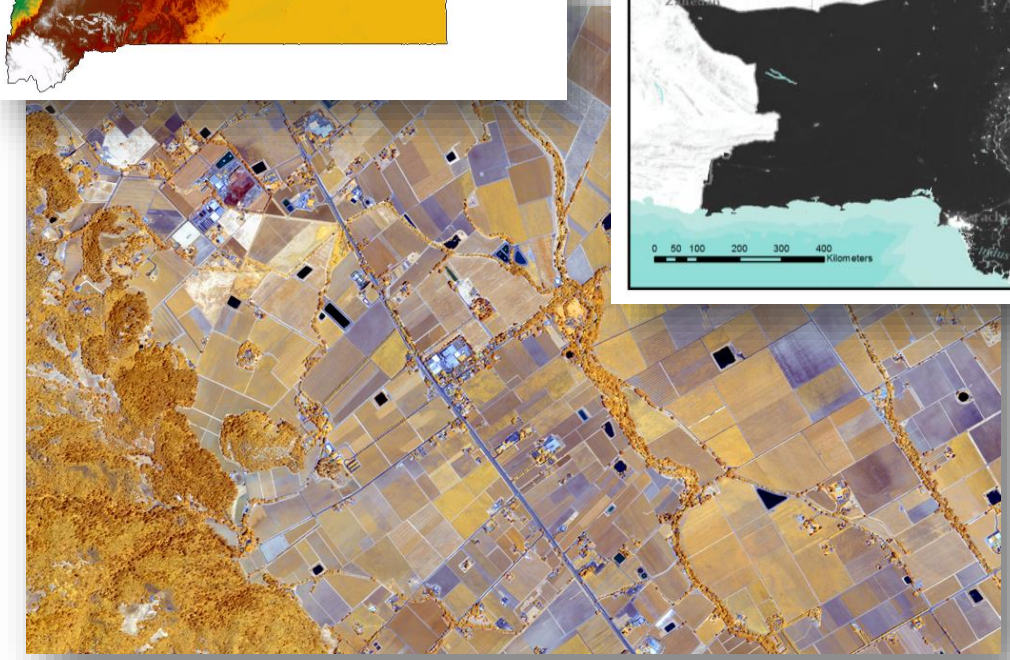
9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 January 2010

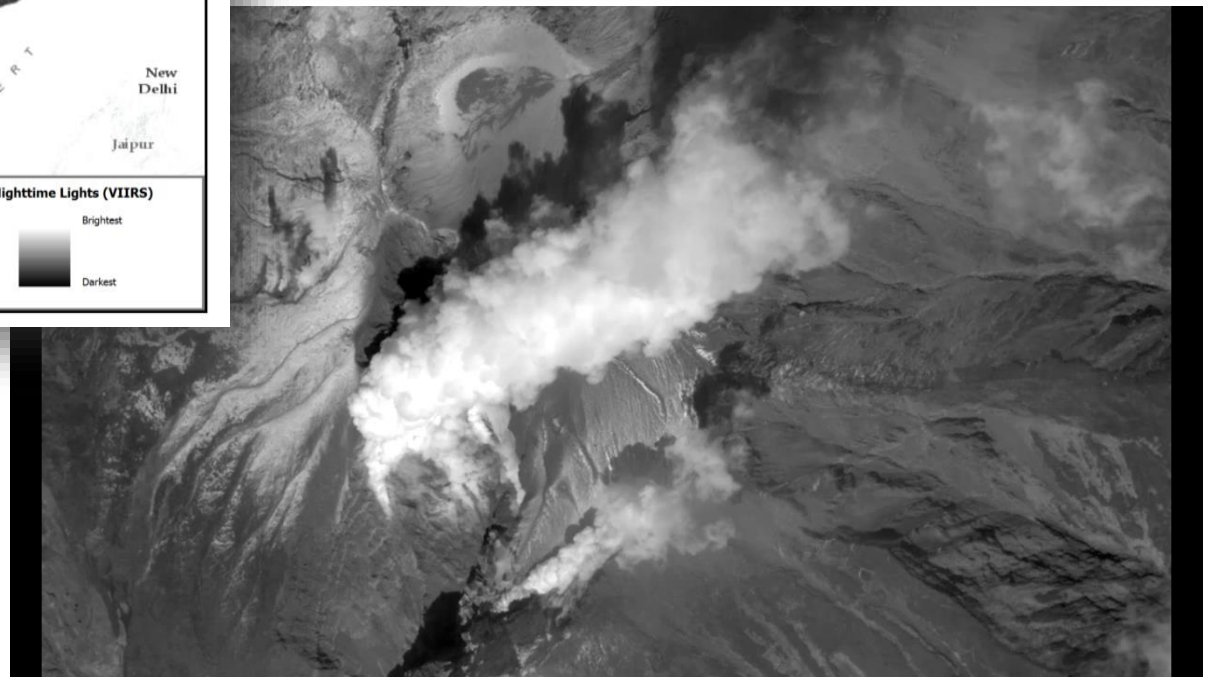
Satellite imagery



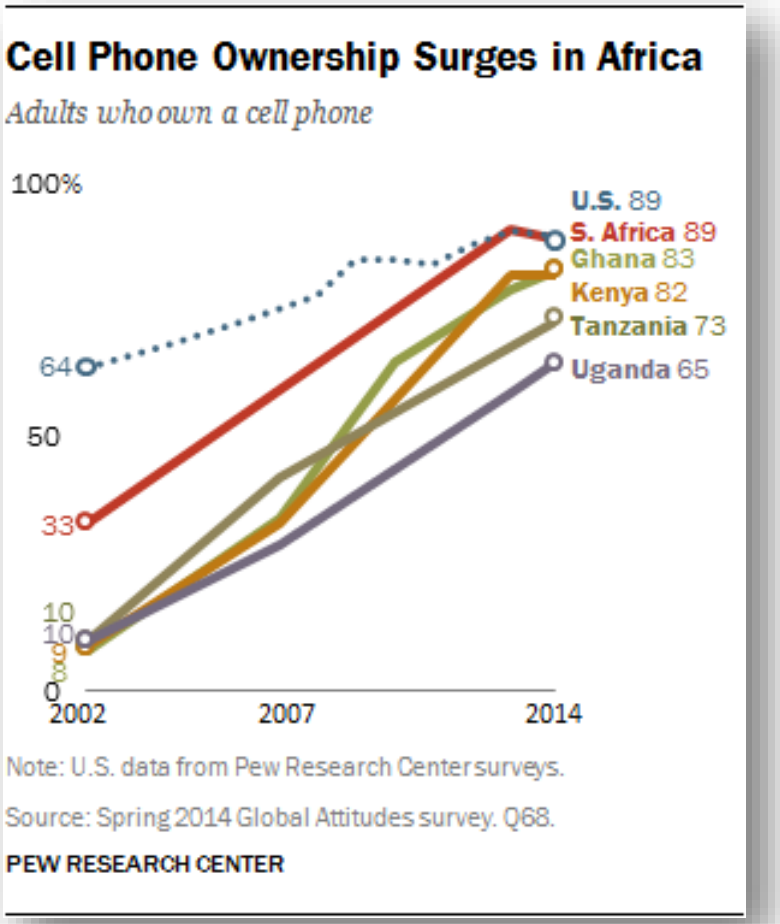








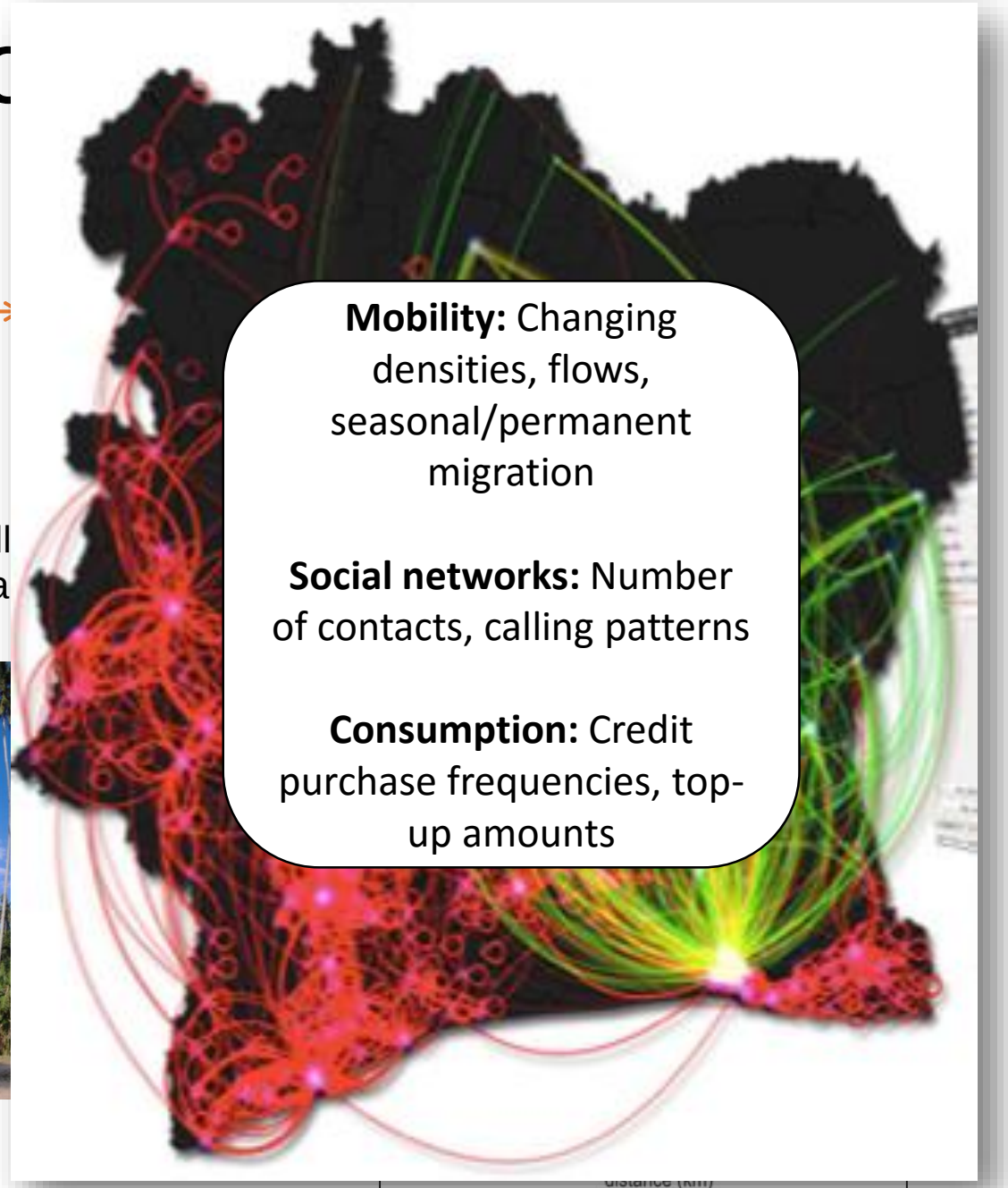
Mobile phone call detail rec



User makes a call from location X

Call
nea

User travels to Y and makes a call

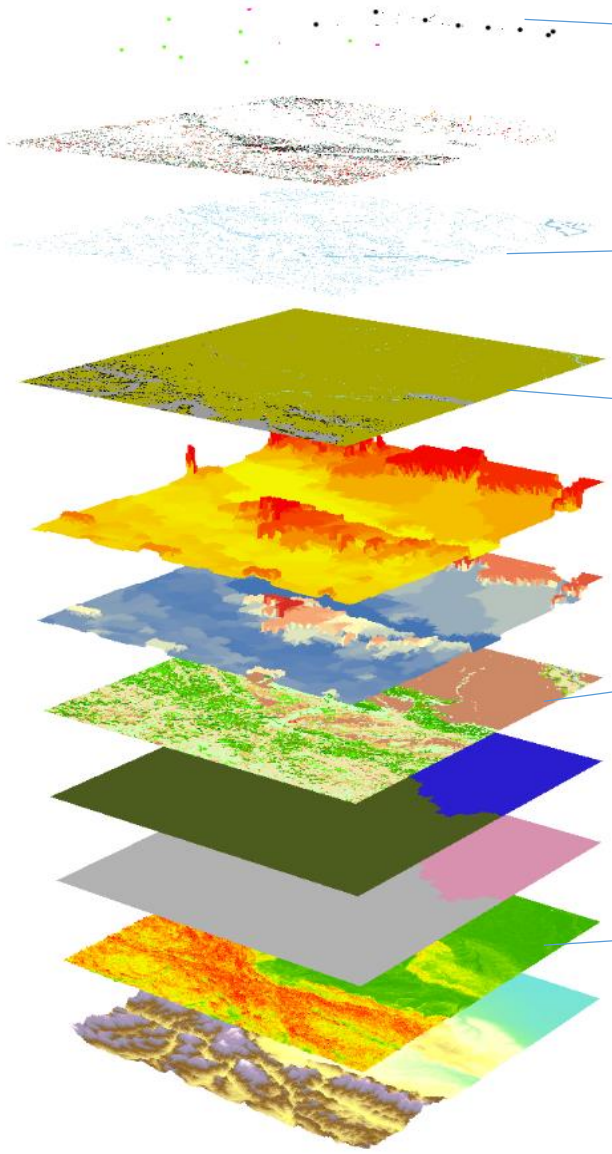


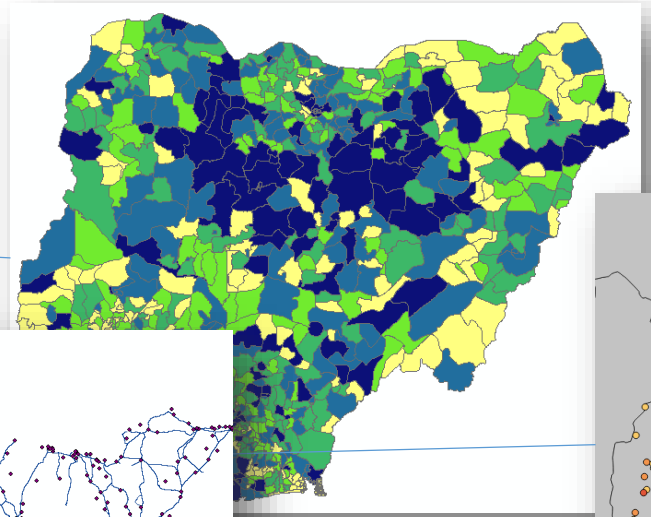
Mobility: Changing densities, flows, seasonal/permanent migration

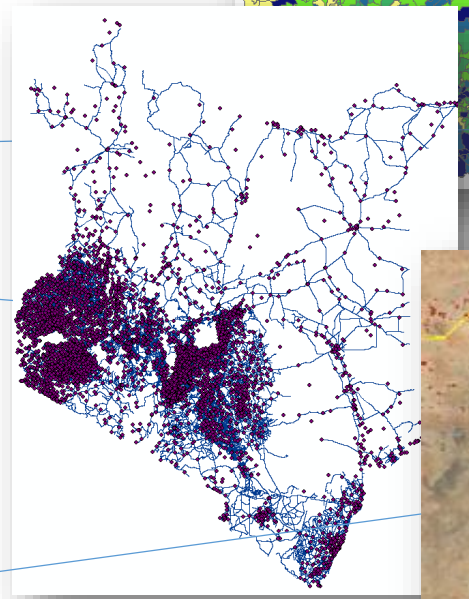
Social networks: Number of contacts, calling patterns

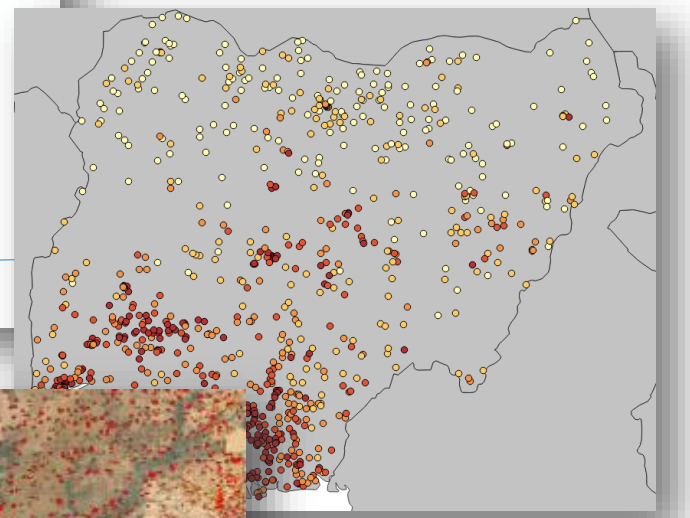
Consumption: Credit purchase frequencies, top-up amounts

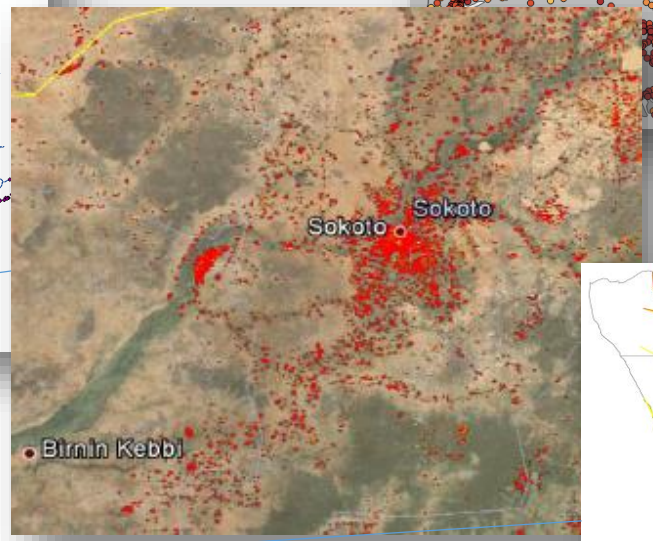
Data integration

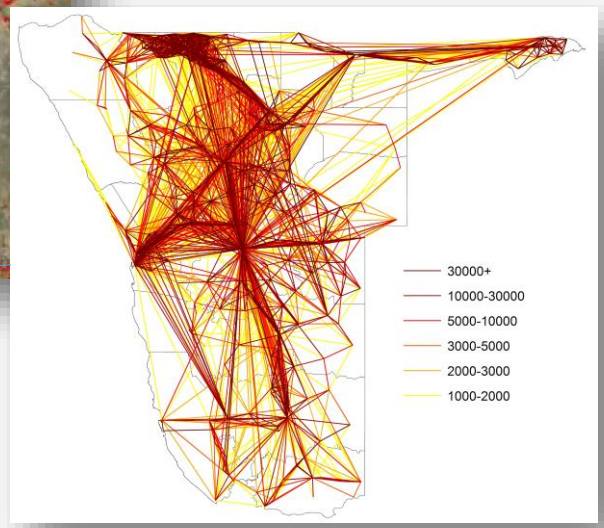








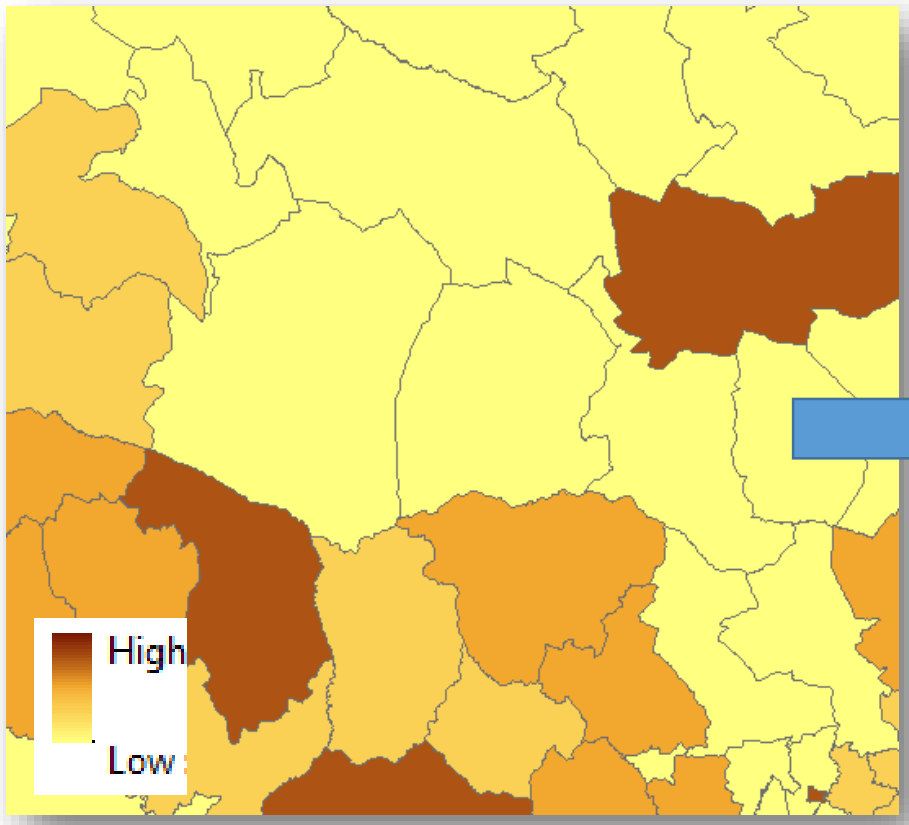


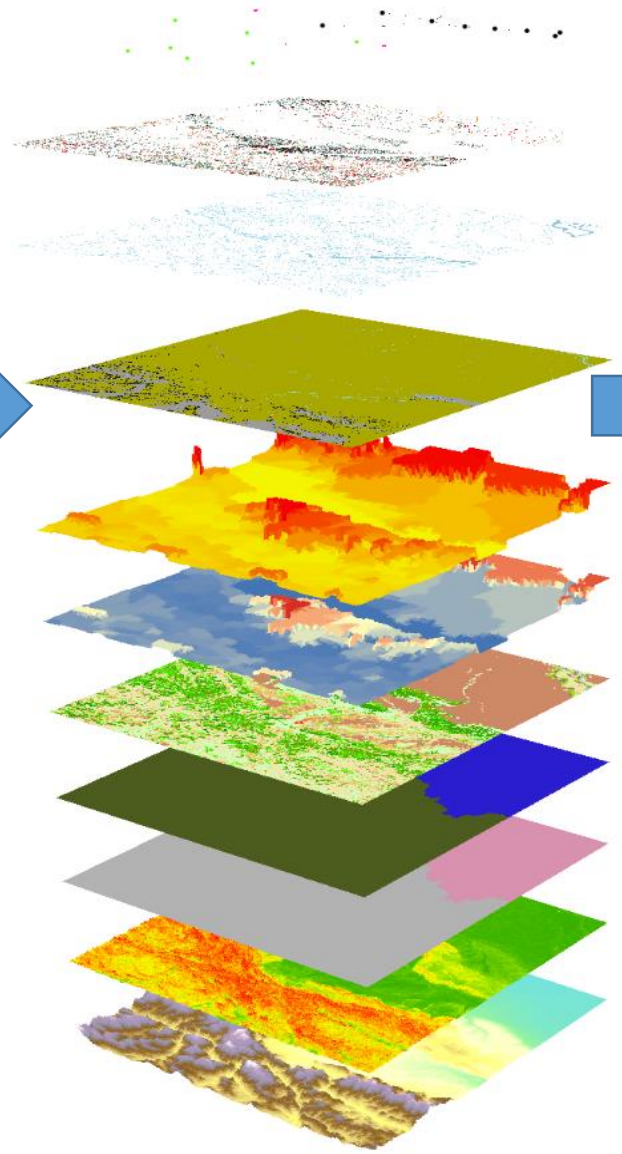


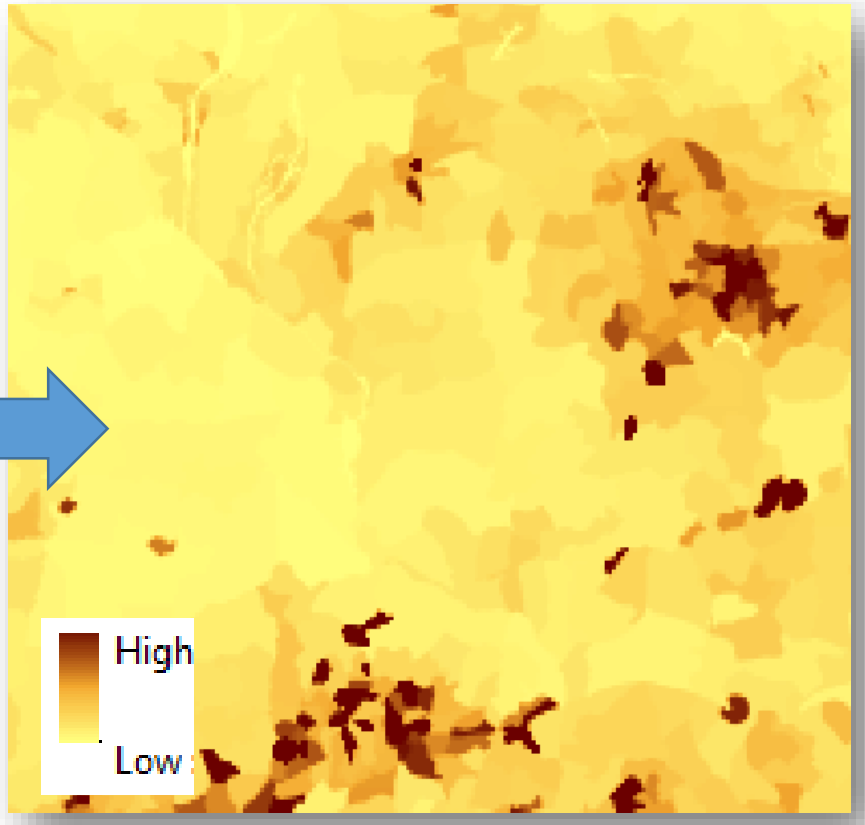
Mapping population distributions, demographics, dynamics

world pop
FLOWMINDER.ORG

Census data disaggregation (‘Top down’)

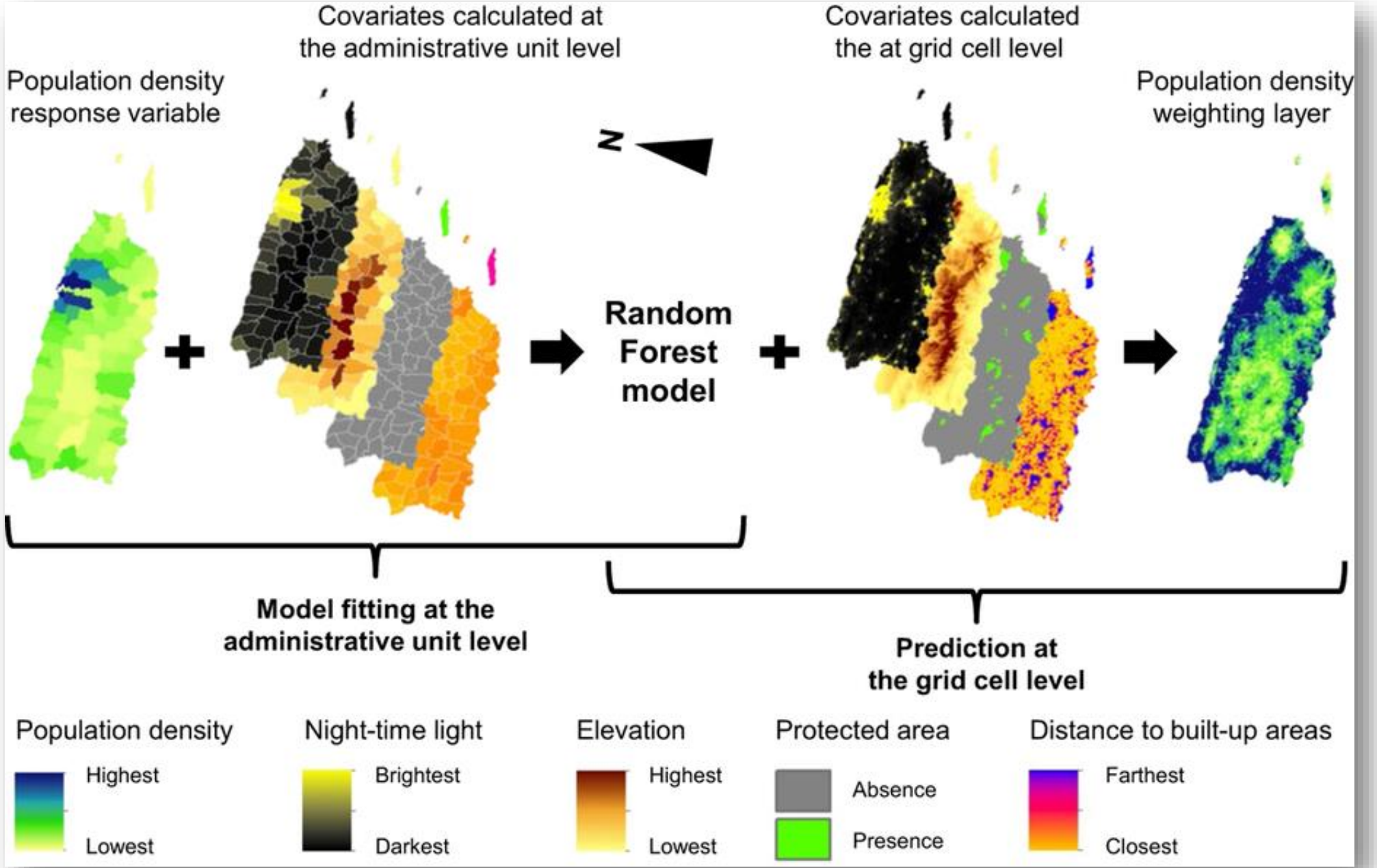






Census counts generally aggregated at coarse, irregular administrative unit level, making integration and comparisons with other data challenging

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

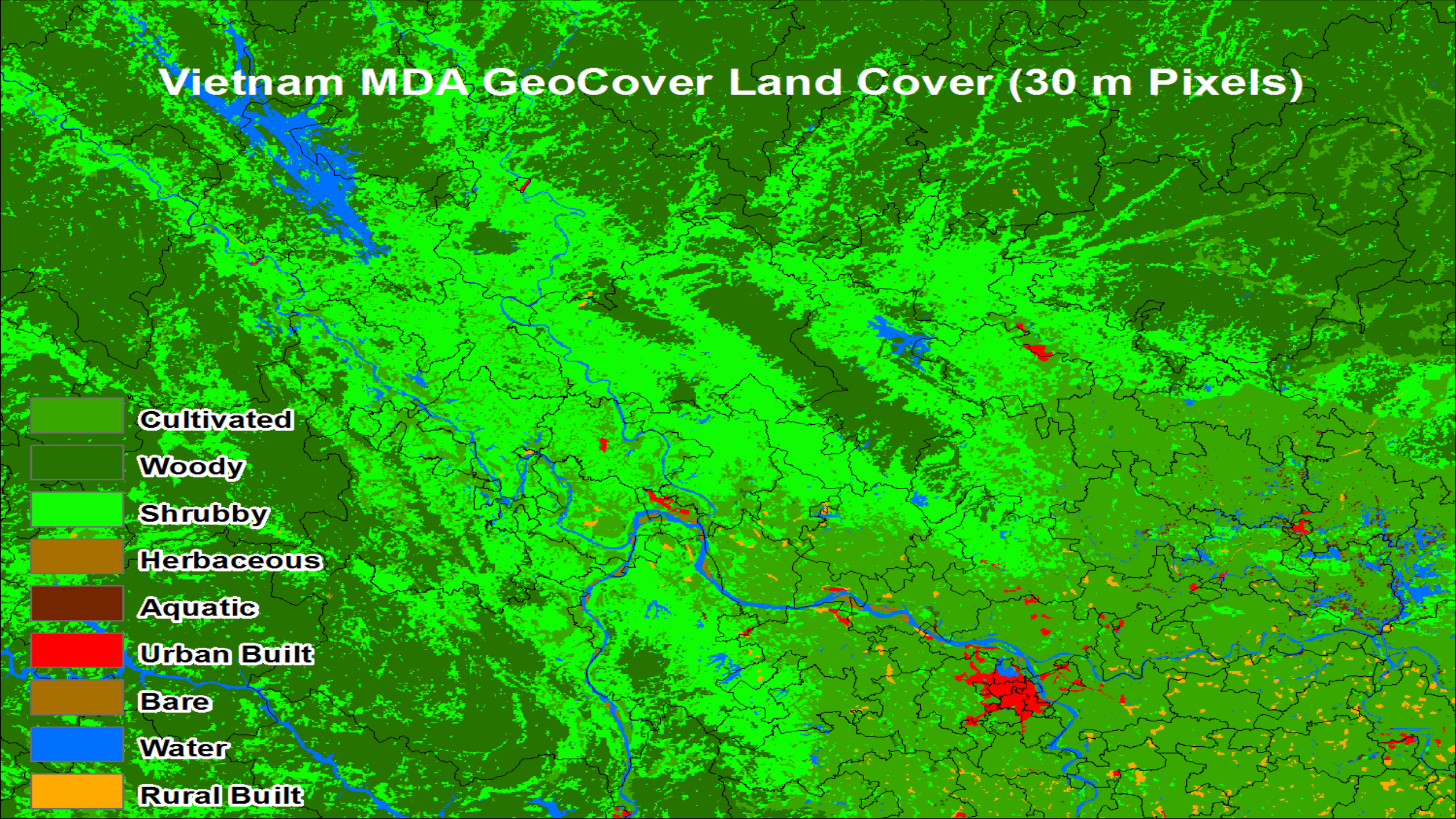


Stevens et al (2016) PLoS ONE; Sorichetta et al (2016) Nature Sci Data

Population Density Vietnam Administrative Unit Level 002

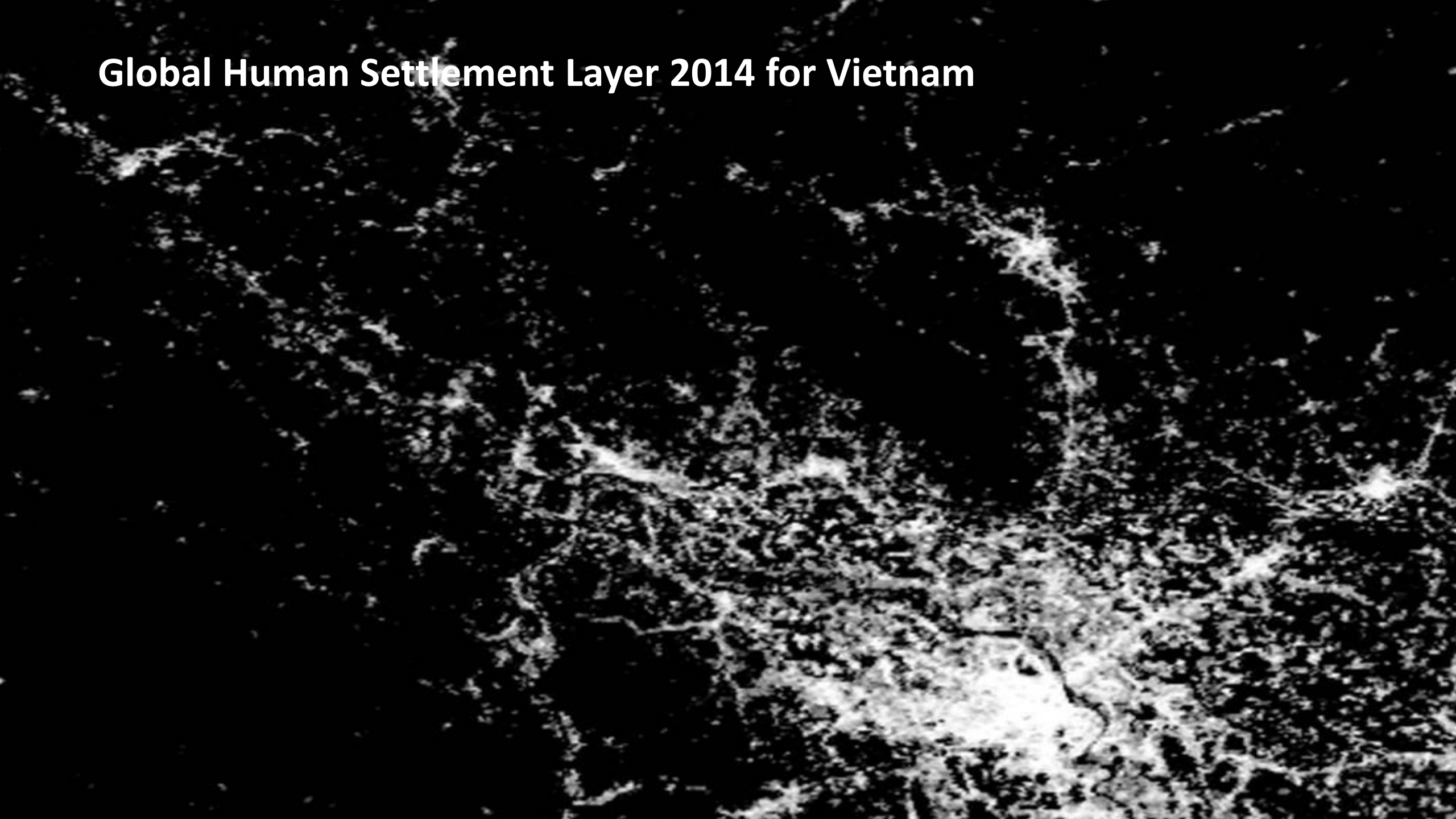
> 30 People Per Ha

0


Vietnam MDA GeoCover Land Cover (30 m Pixels)
Cultivated
Woody
Shrubby
Herbaceous
Aquatic
Urban Built
Bare
Water
Rural Built


NOAA Suomi VIIRS-derived Lights at Night 2012 for Vietnam

Global Human Settlement Layer 2014 for Vietnam



Population Density Vietnam Administrative Unit Level 002

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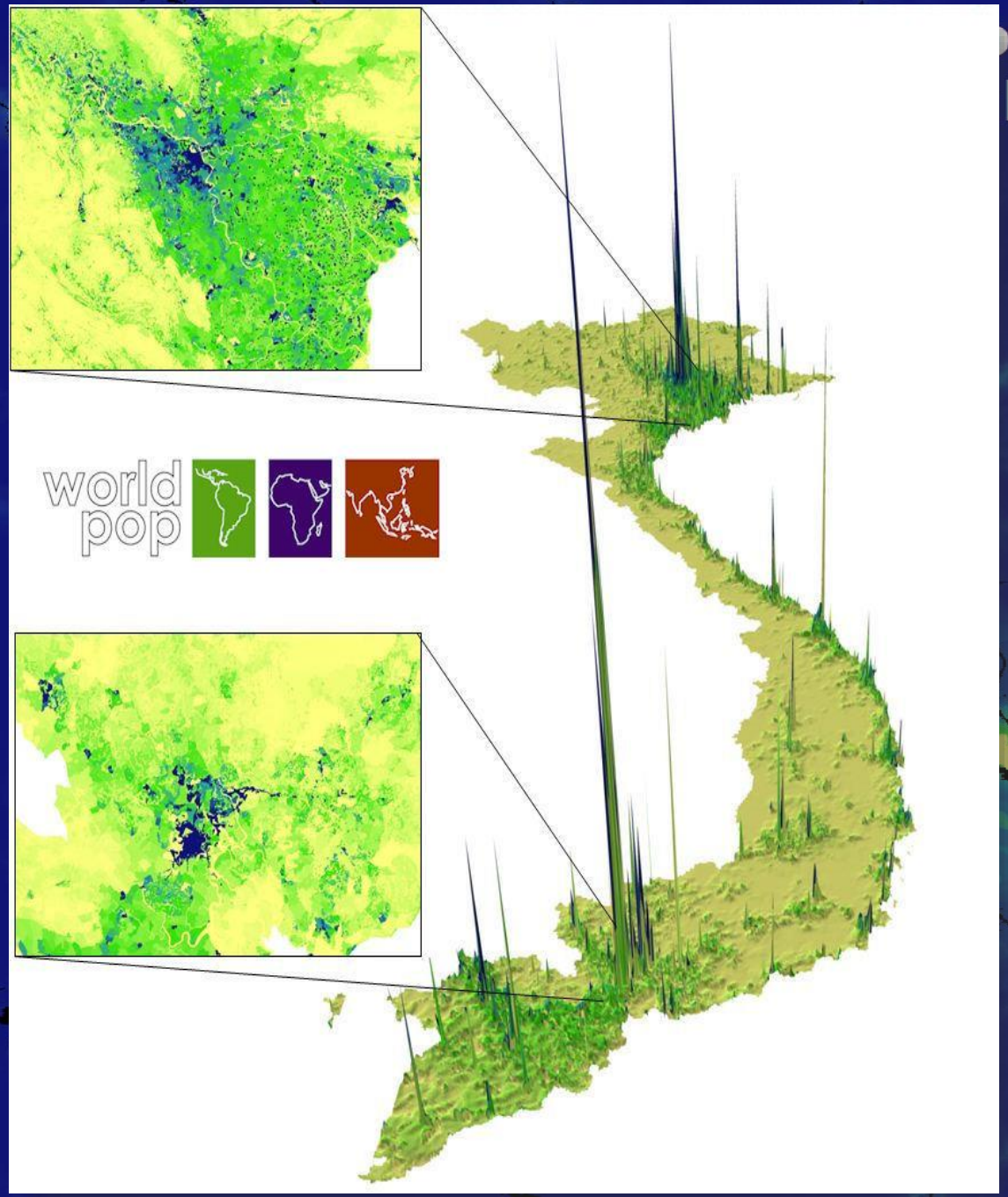
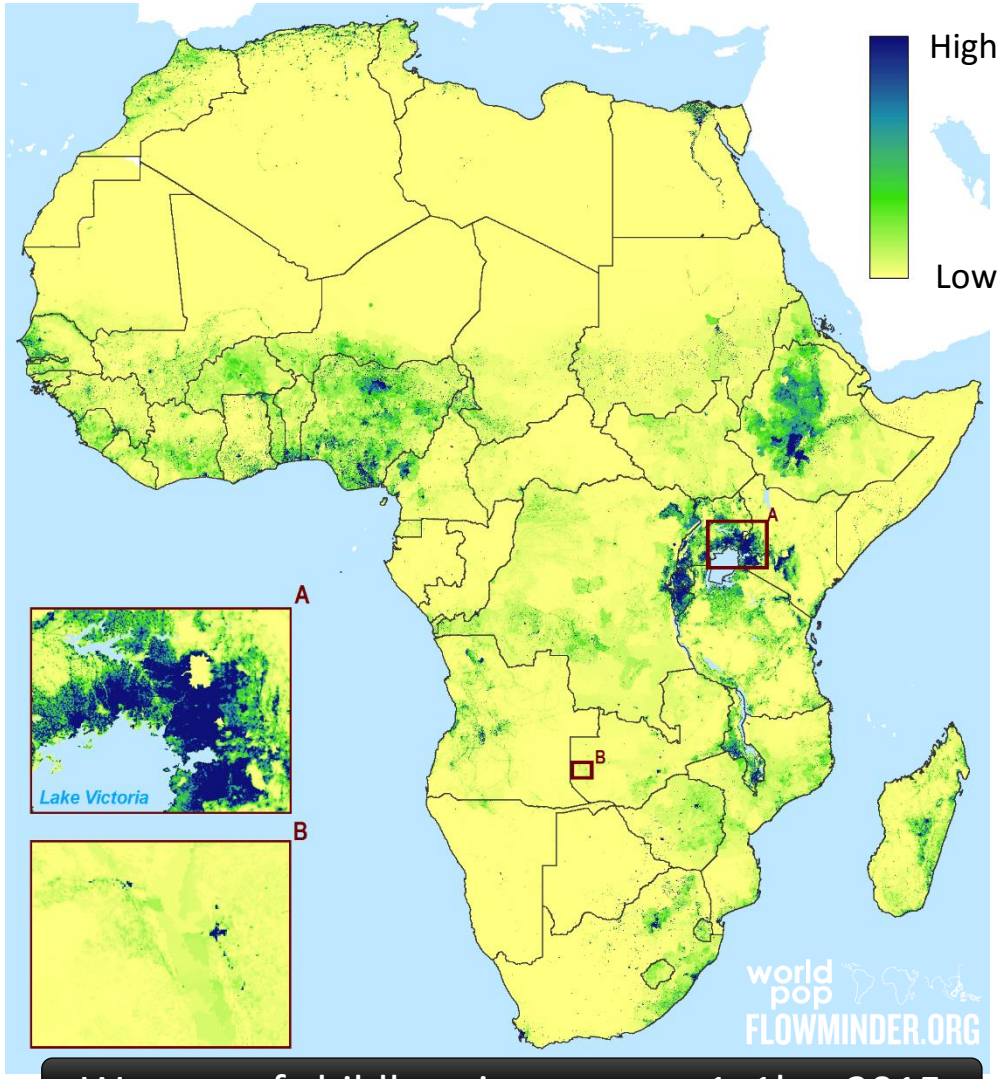
0



uted Population Counts
lt Ancillary Data (OSM)

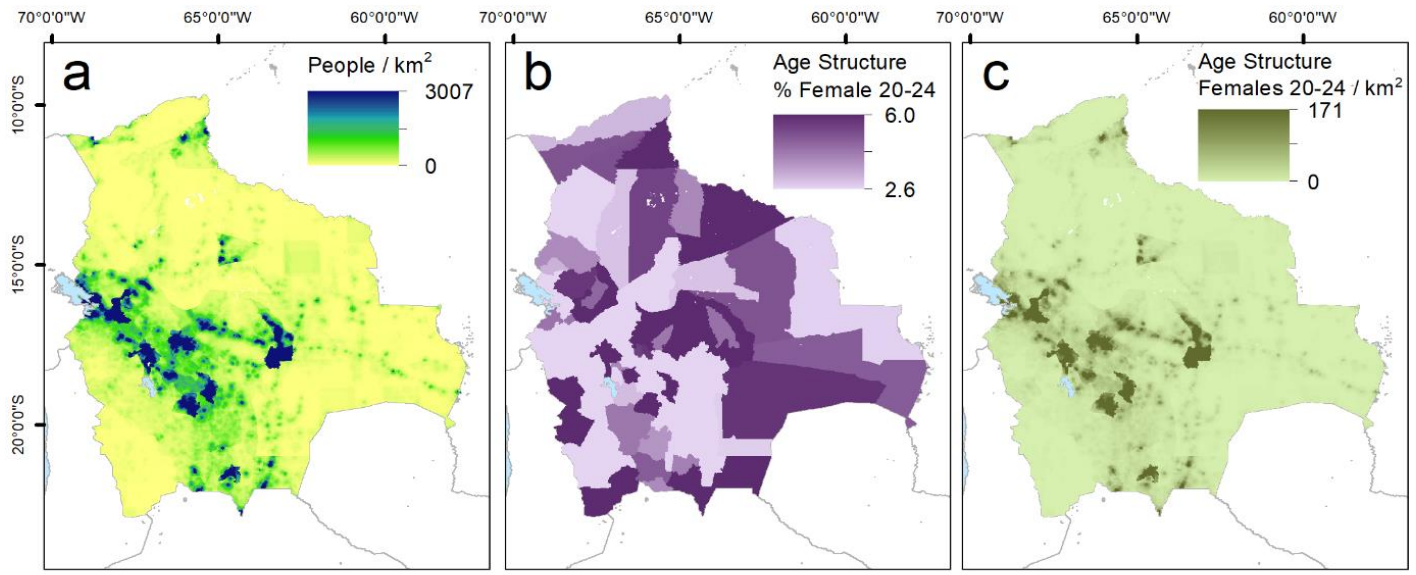
Mapping age structures

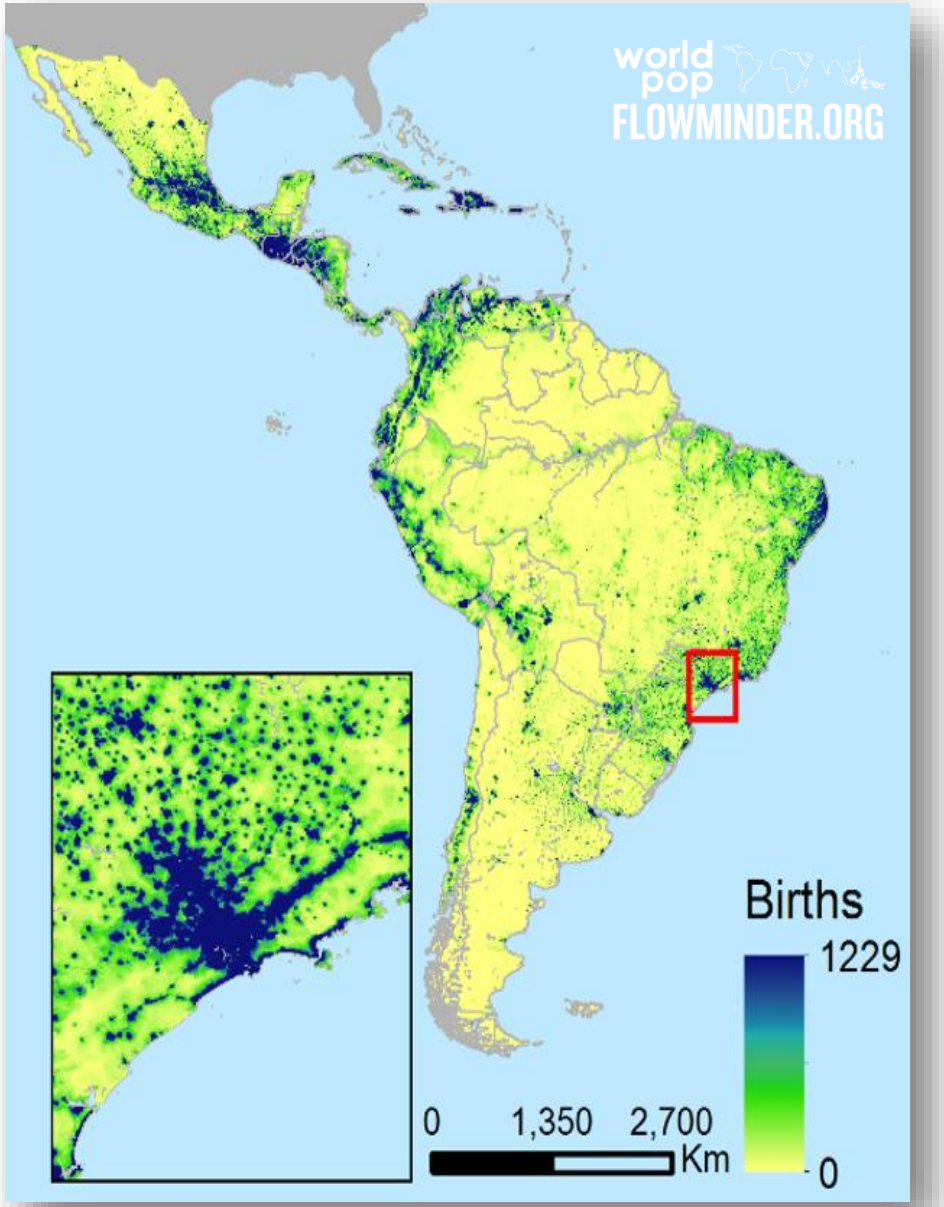


Women of childbearing age per 1x1km 2015

Pezzulo et al (2017) Nature Sci Data; Tatem et al (2013) Pop Health Metrics

Mapping pregnancies and births





Tatem et al (2014) IJHG; Ebener et al (2015) IJHG; James et al (2017) in press

www.worldpop.org

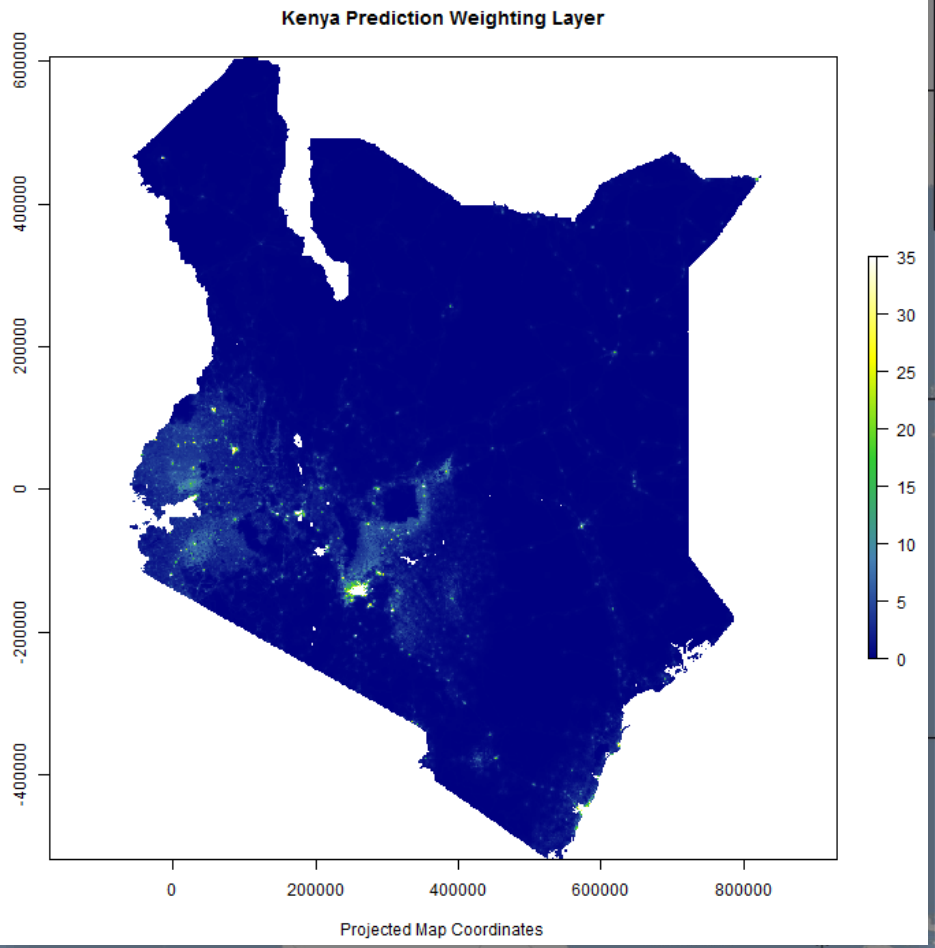
file:///C:/Users/ajt1m11/AppData/Local/Temp/Temp1_KEN-RF.zip/KEN_metadata.html

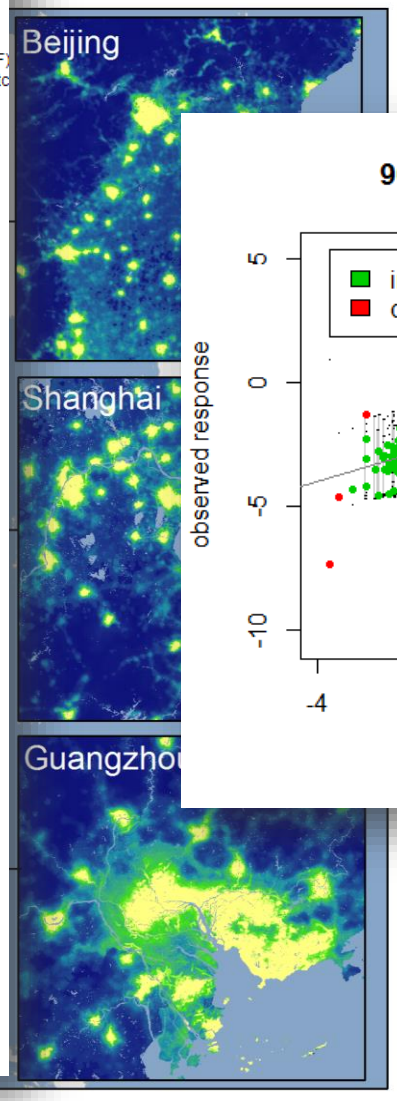
Research Highlights ... | Country/Region | C... | Grants | United Nations Stati... | Downloads | Aqued... | Tw

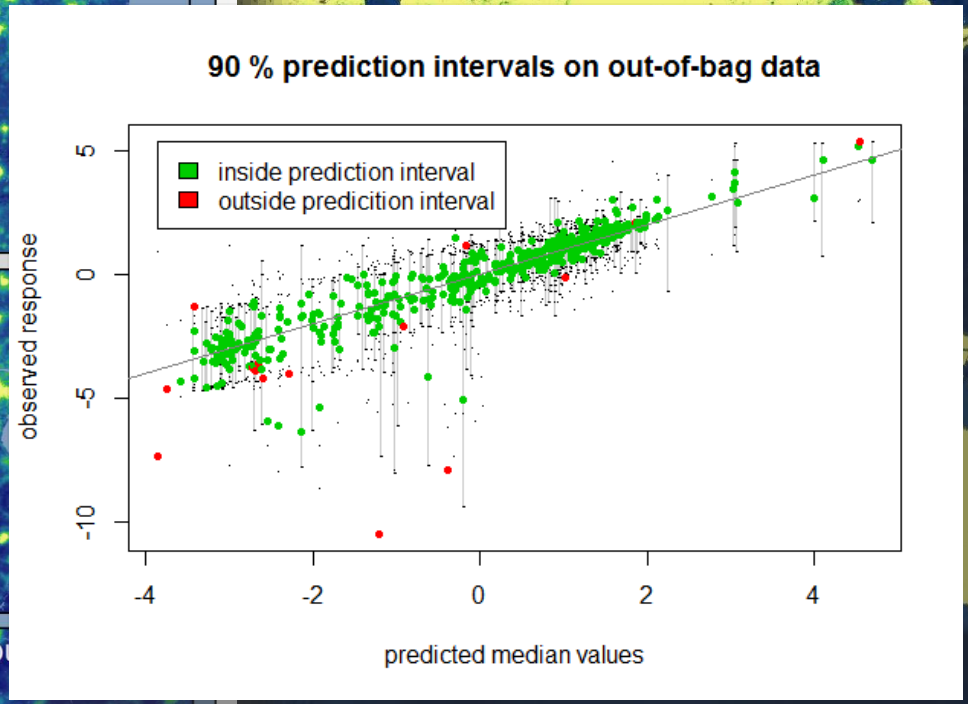
Kenya Population Map Metadata Report

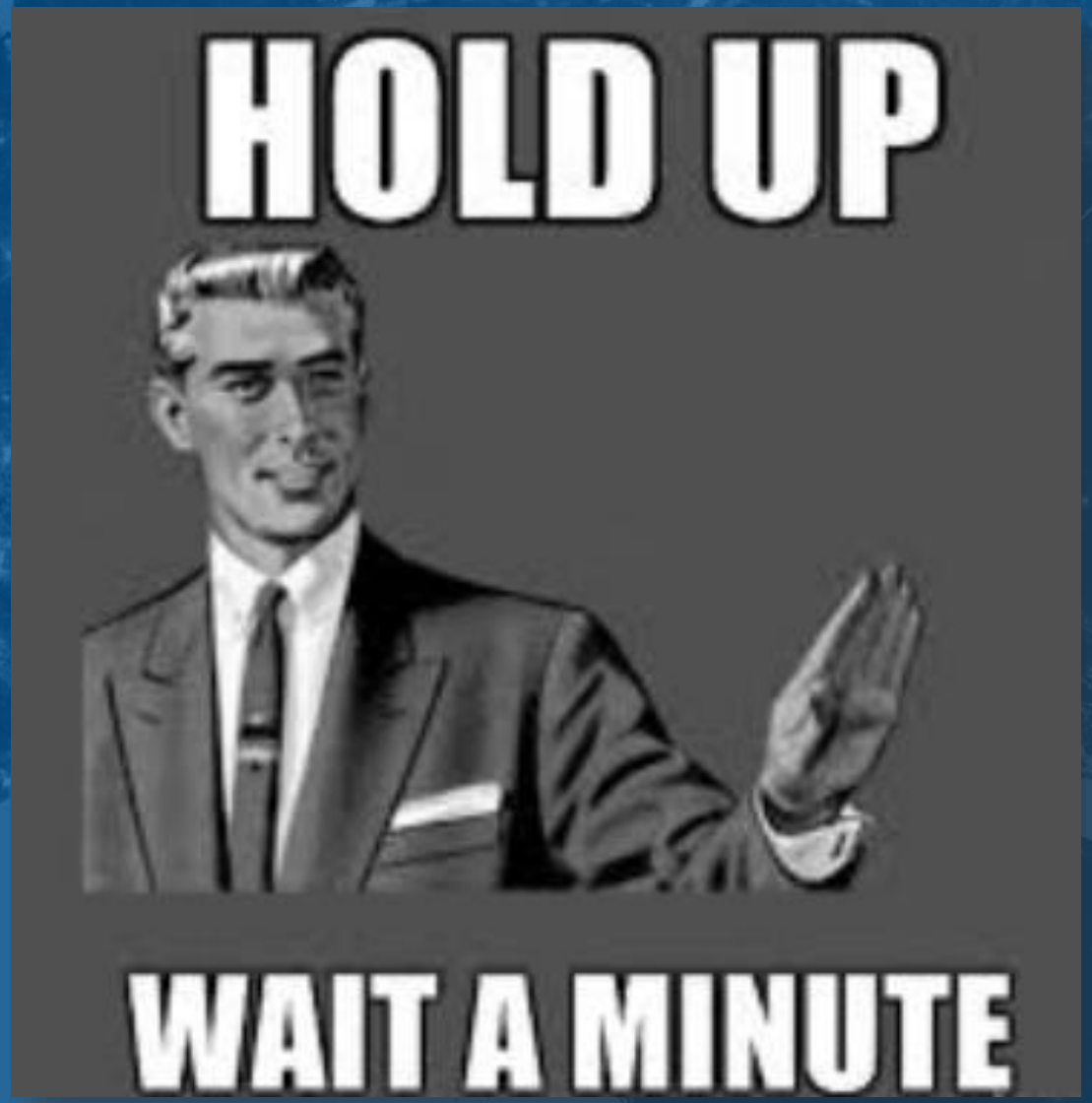
Prediction Weighting Layer Used in Population Redistribution

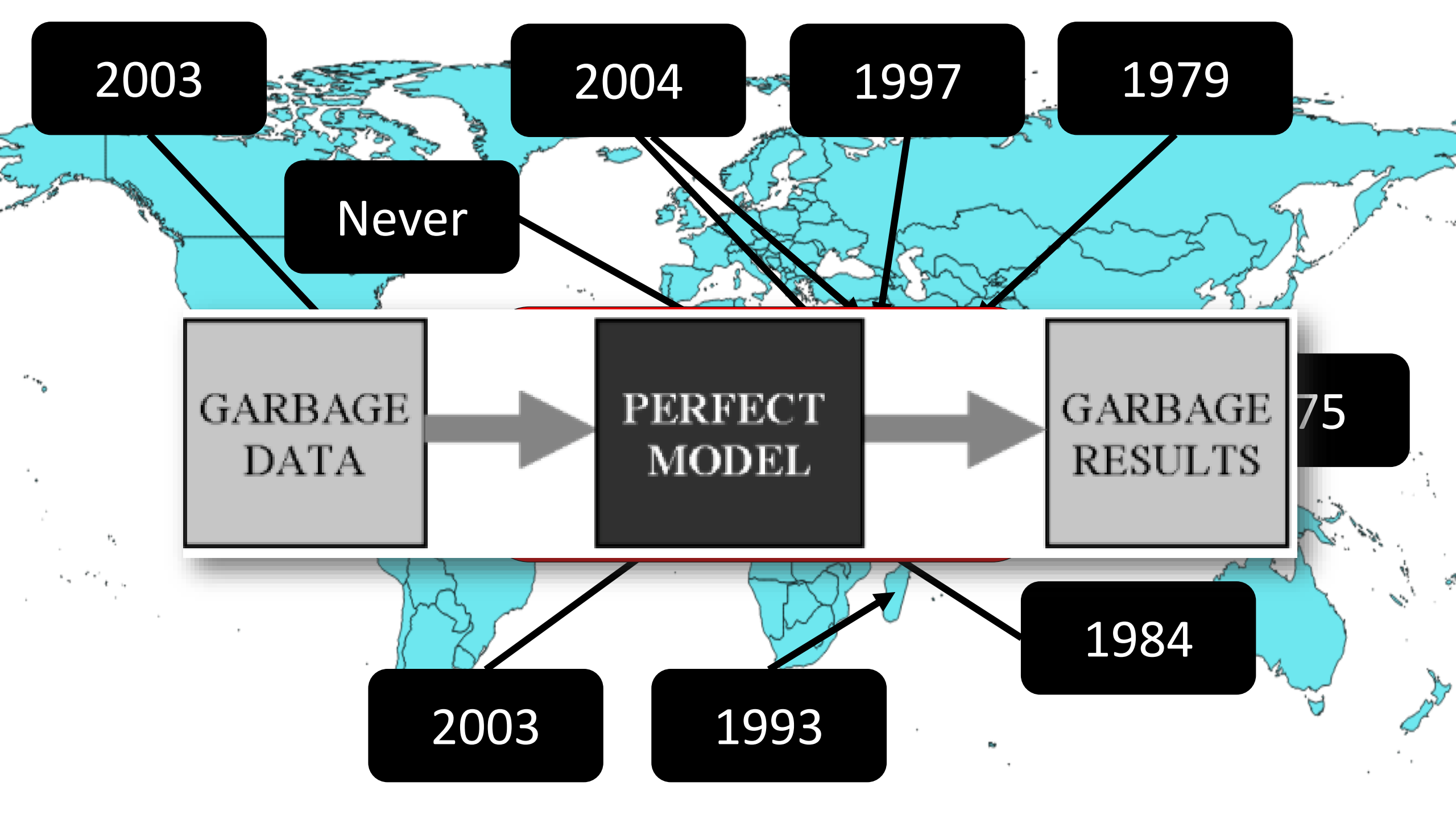
The data presented below represent the predicted number of people per ~100 m pixel as estimated using the random forest (RF)
each covariate. The prediction weighting layer is used to dasymetrically redistribute the census counts and project counts to matc

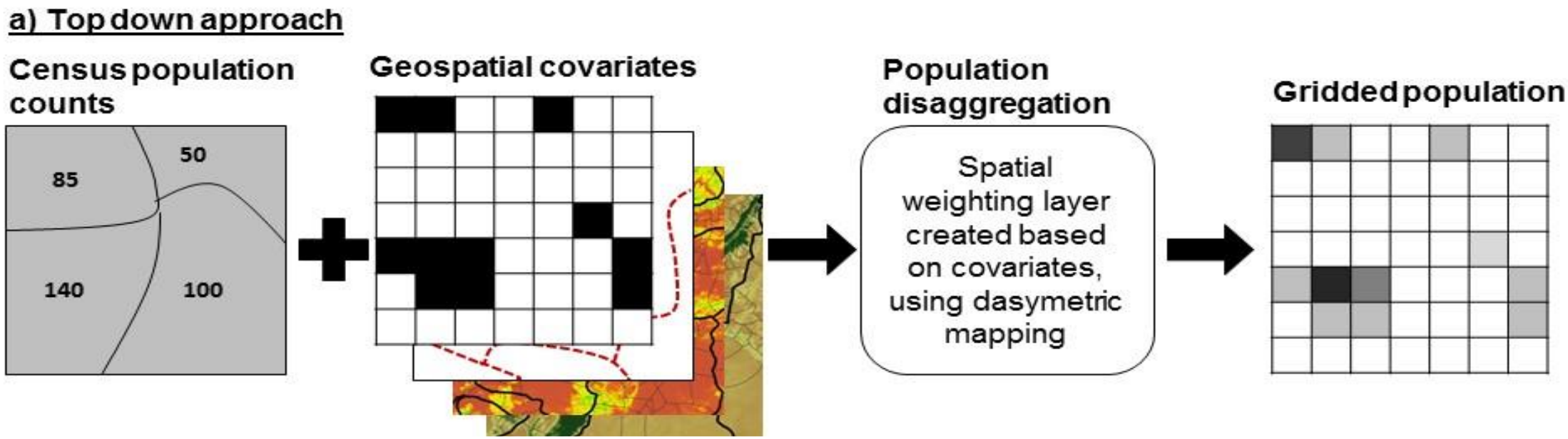




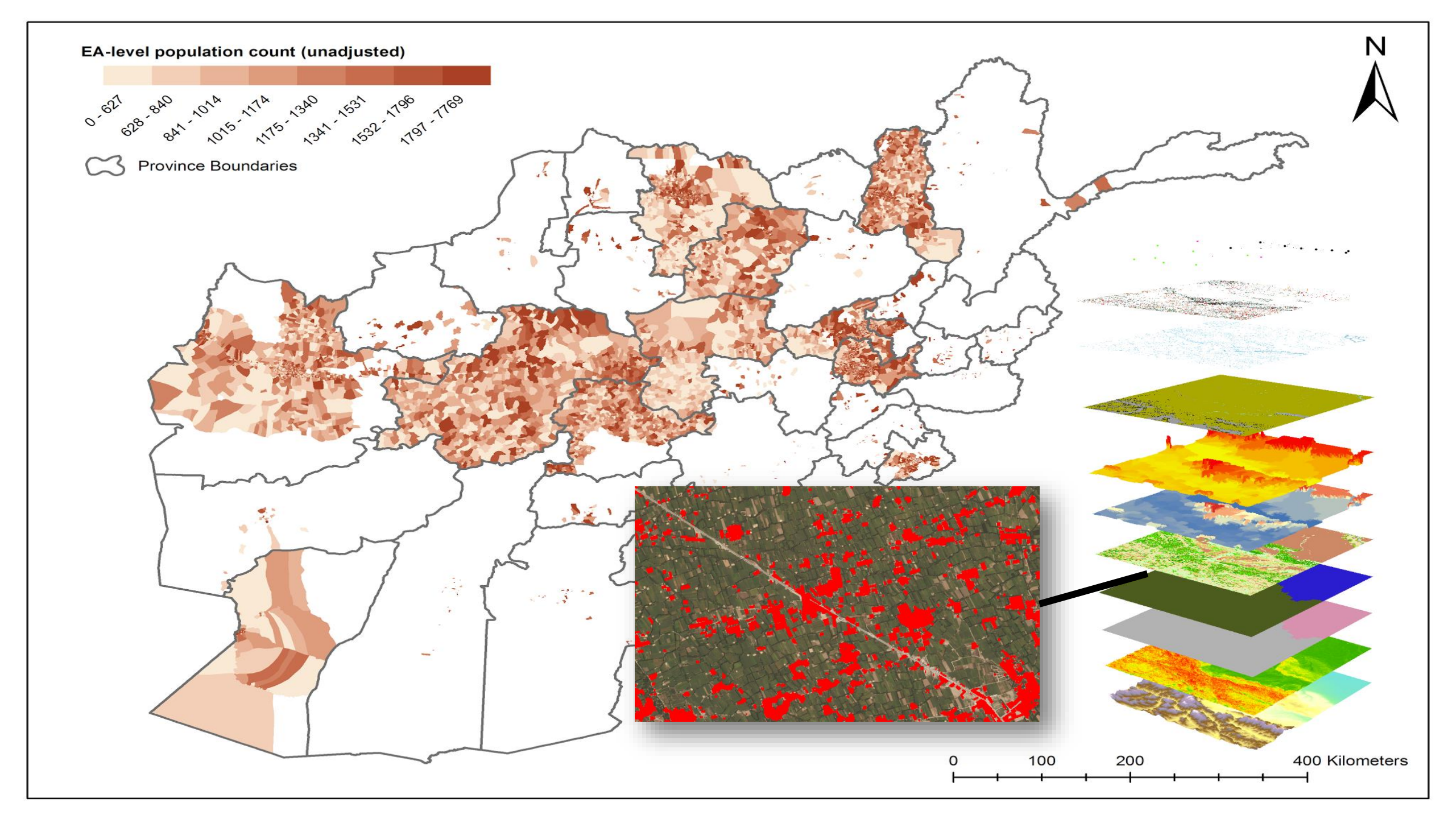


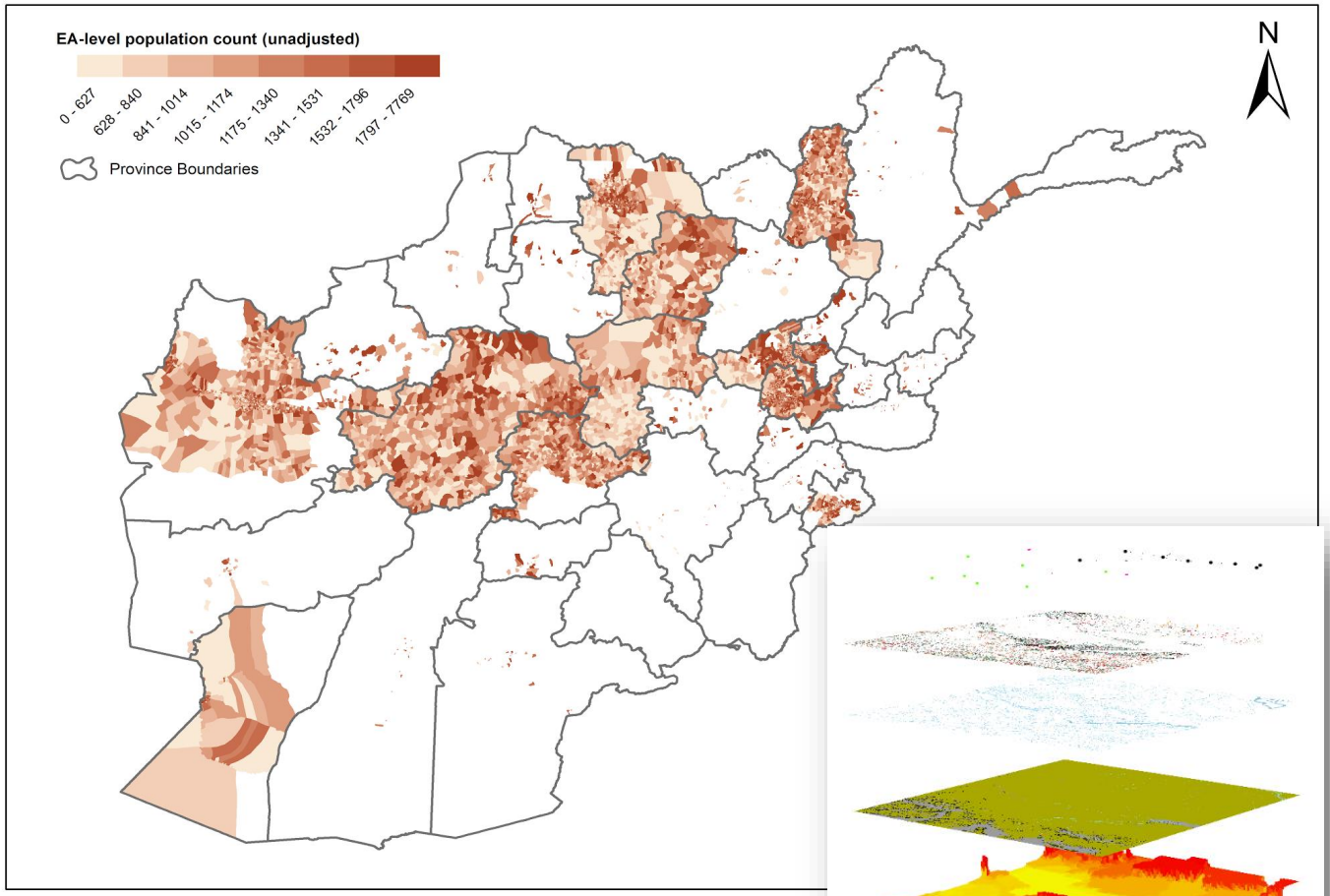

HOLD UP
WAIT A MINUTE


2003
2004
1997
1979
Never
GARBAGE DATA
PERFECT MODEL
GARBAGE RESULTS
75
2003
1993
1984



Tatem (2015) Int Health; Wardrop et al (2017) in press


EA-level population count (unadjusted)
0 - 627
628 - 840
841 - 1014
1015 - 1174
1175 - 1340
1341 - 1531
1532 - 1796
1797 - 7769
Province Boundaries
N
0
100
200
400 Kilometers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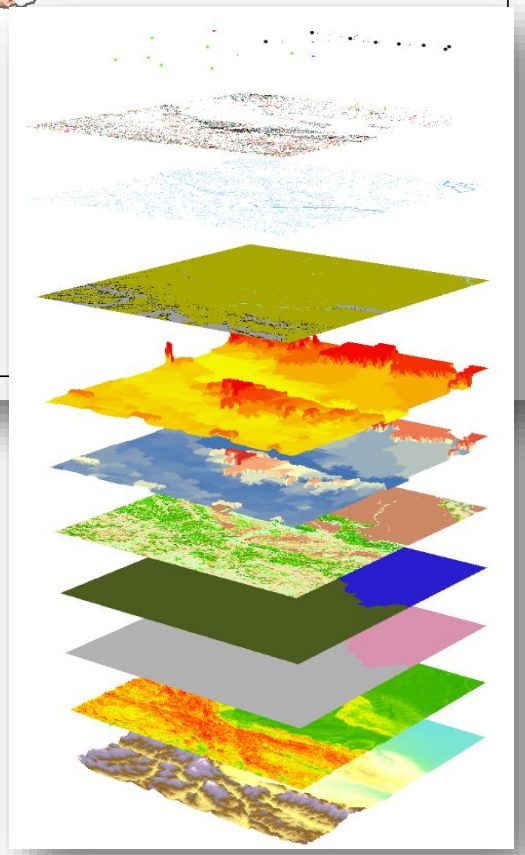
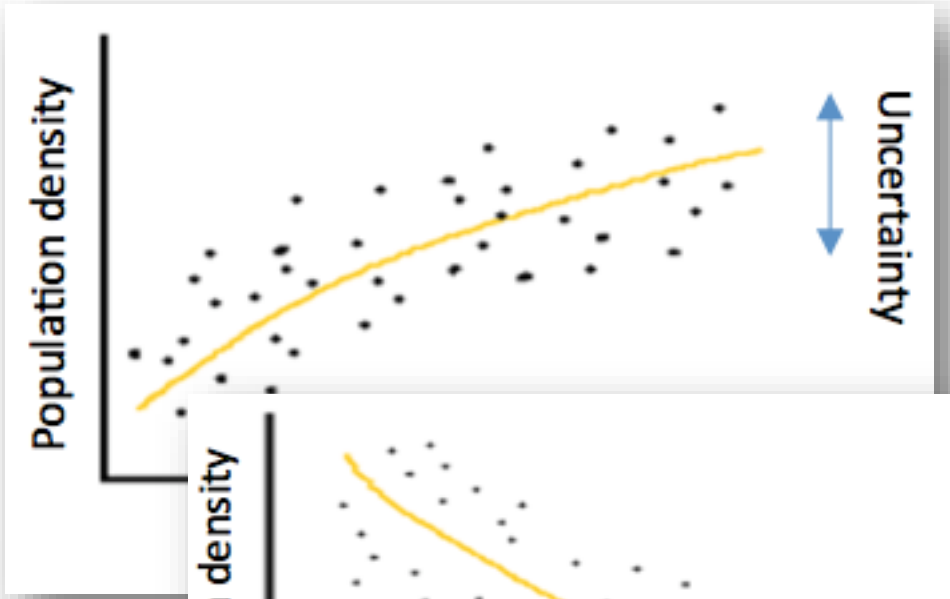
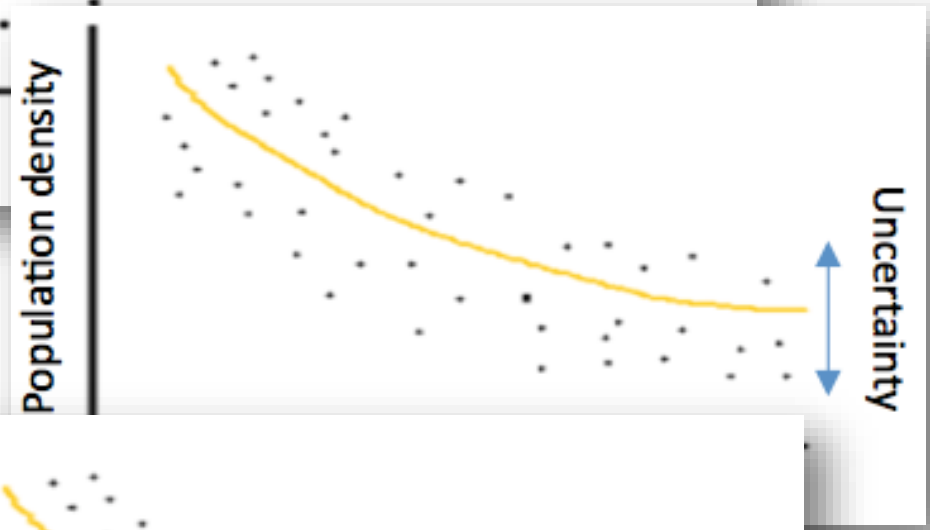
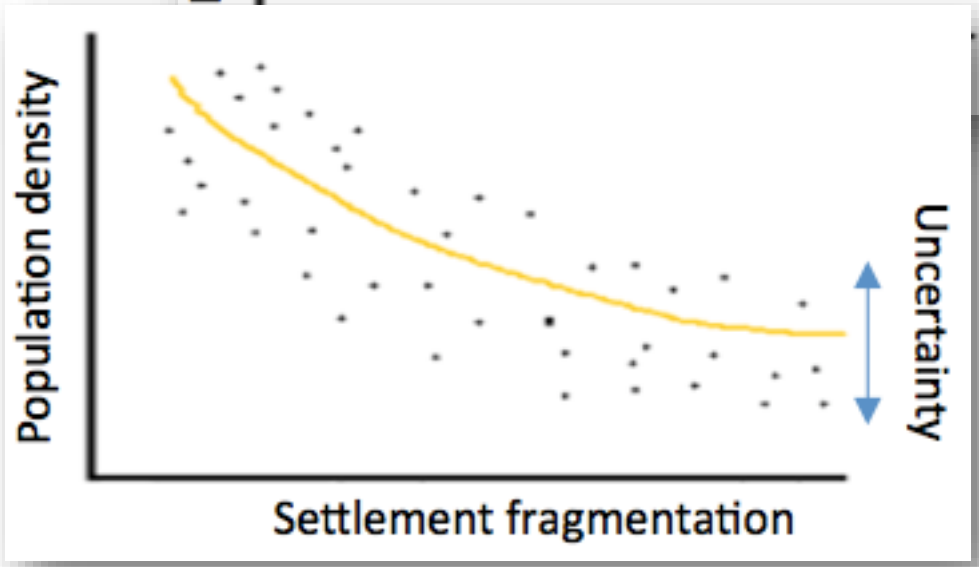
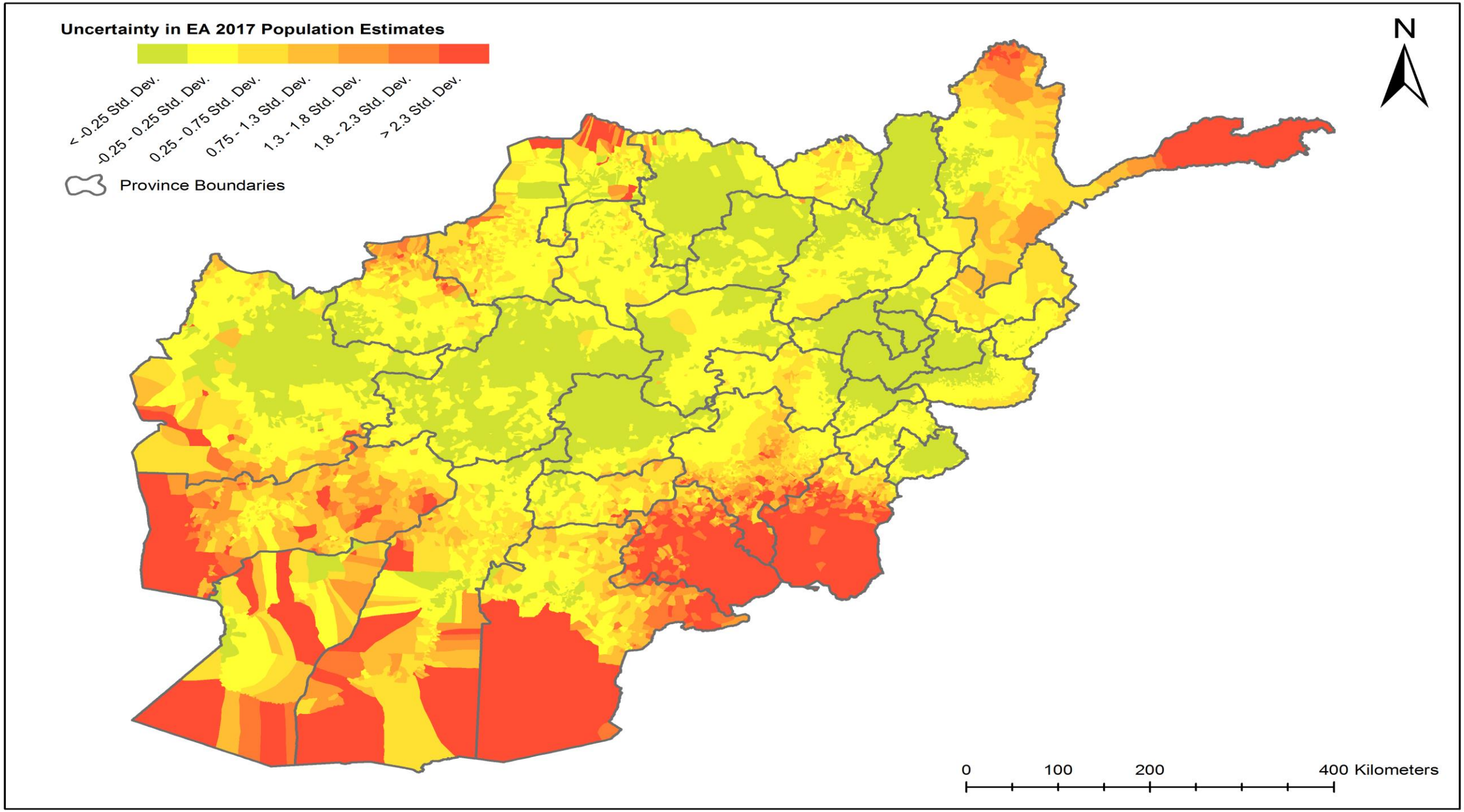
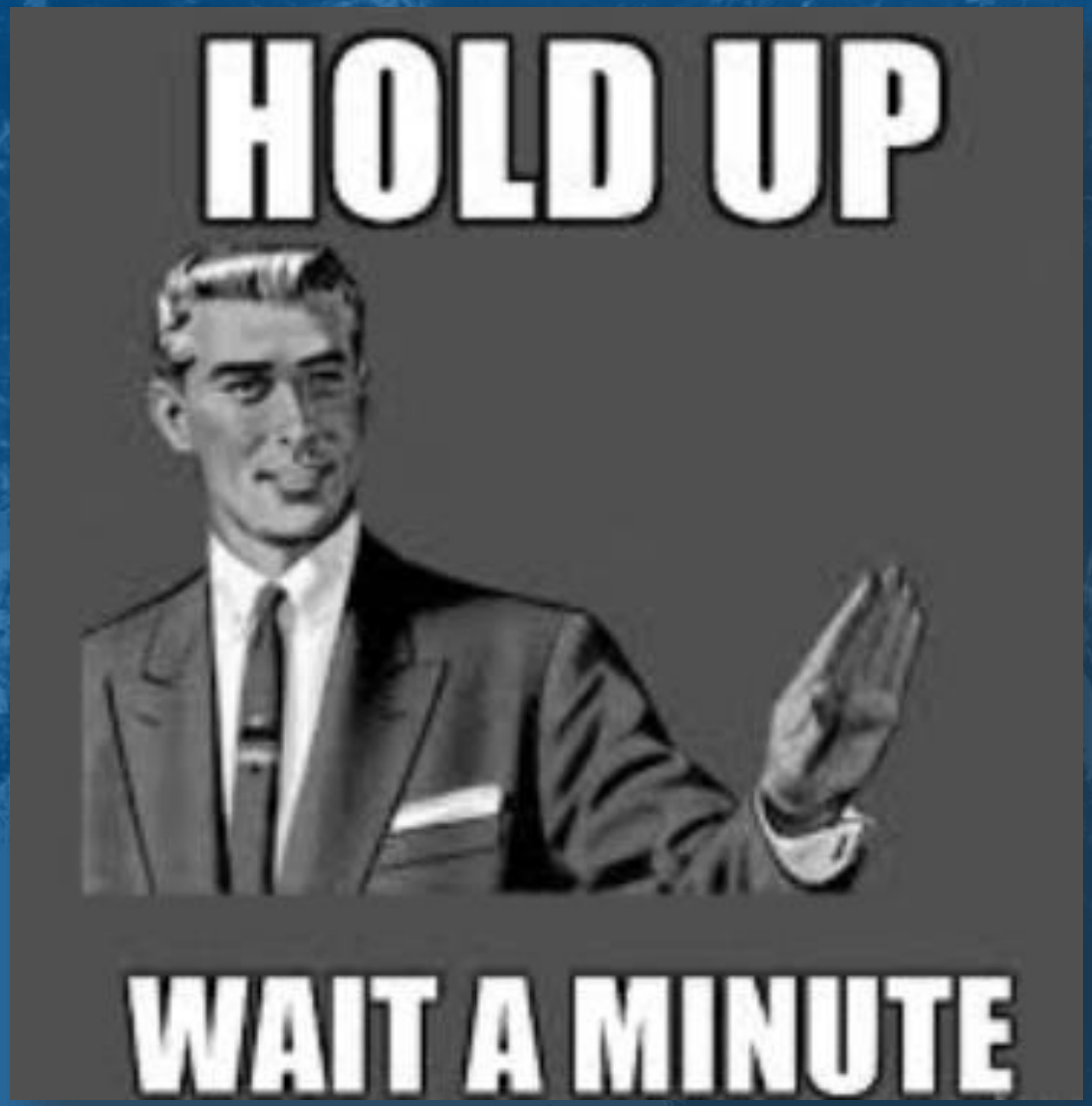



Population density
Uncertainty

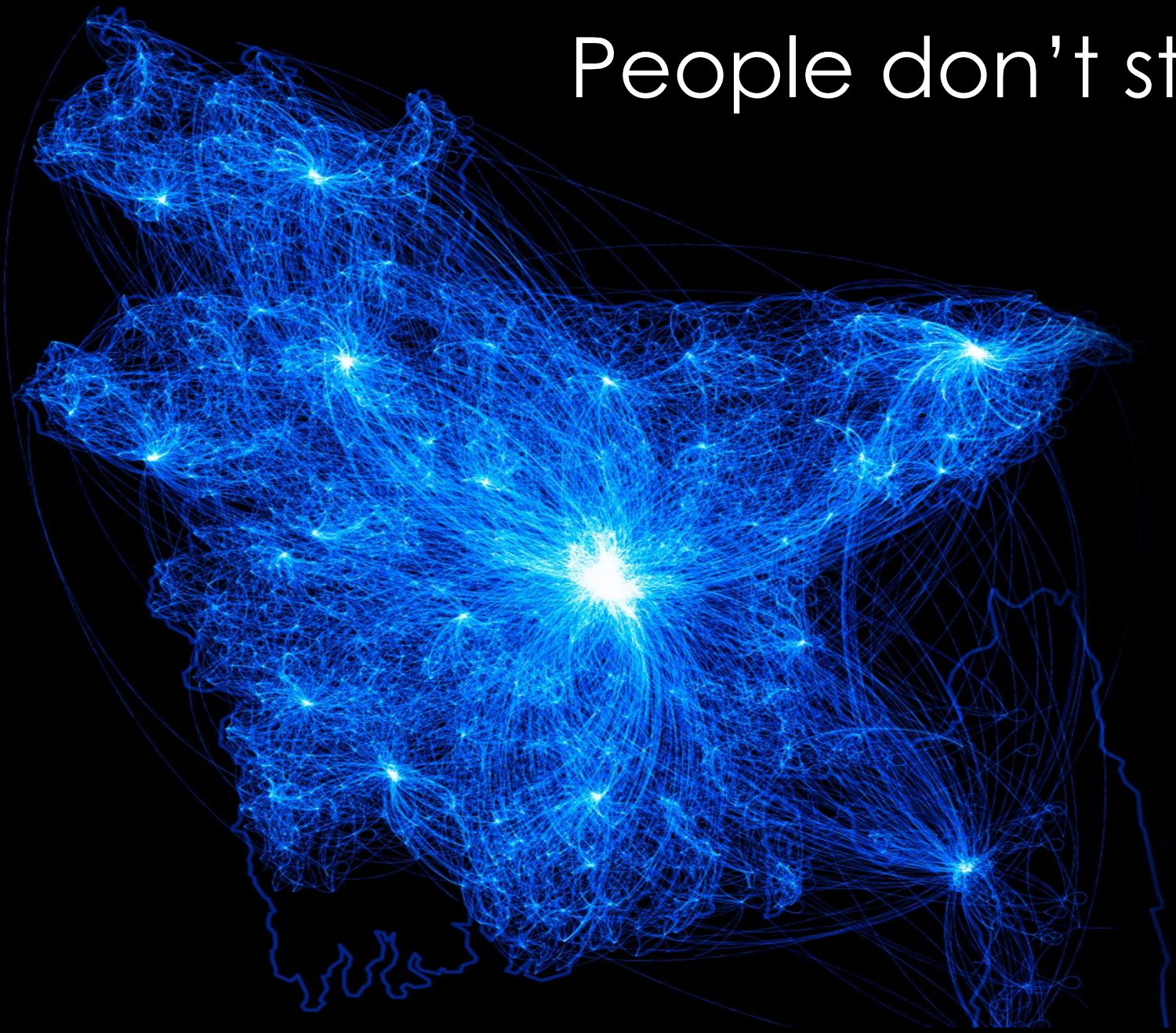

Population density
Uncertainty

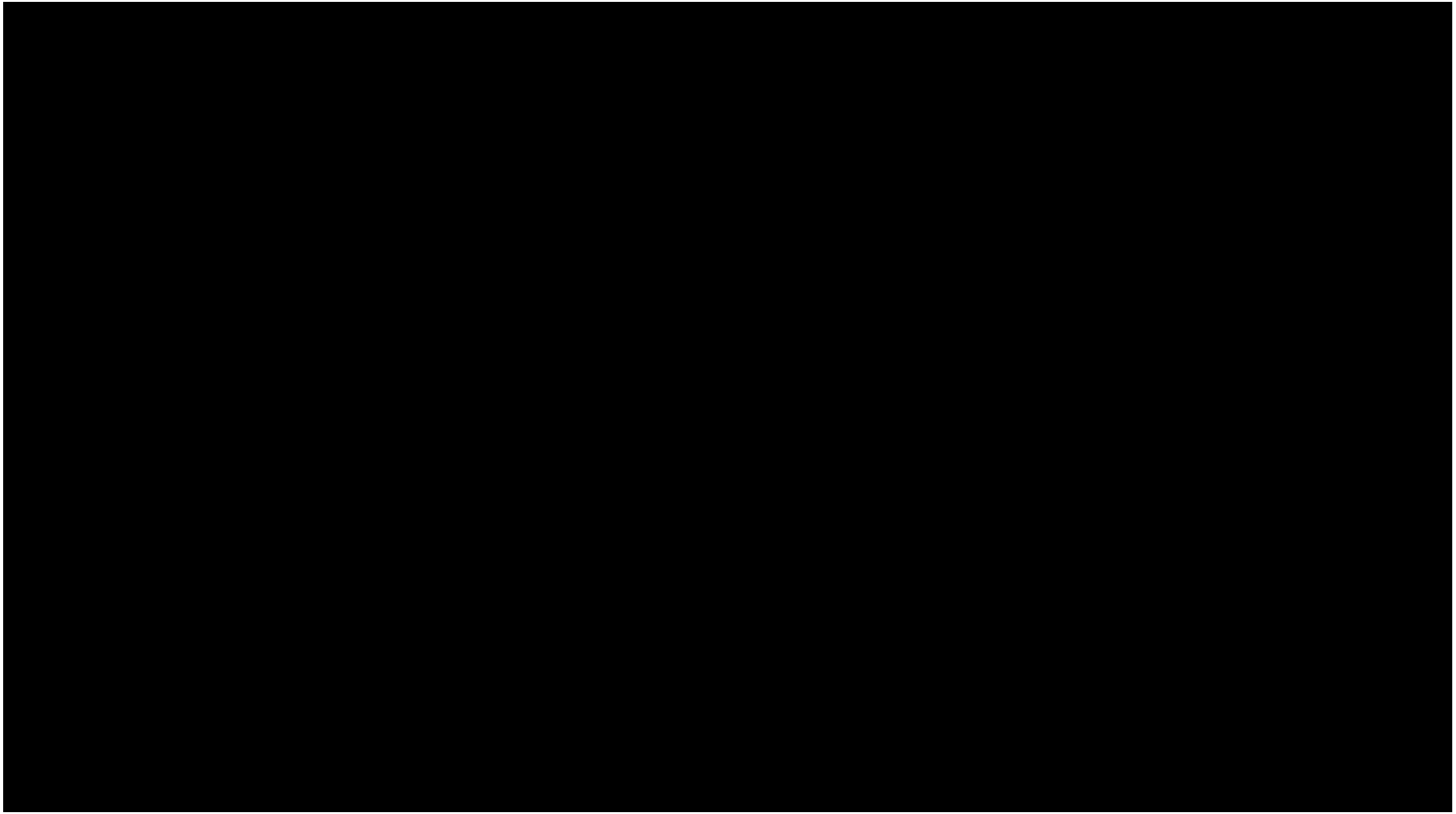

Population density
Uncertainty
Settlement fragmentation


Uncertainty in EA 2017 Population Estimates
< -0.25 Std. Dev.
-0.25 - 0.25 Std. Dev.
0.25 - 0.75 Std. Dev.
0.75 - 1.3 Std. Dev.
1.3 - 1.8 Std. Dev.
1.8 - 2.3 Std. Dev.
> 2.3 Std. Dev.
Province Boundaries
N
0
100
200
400 Kilometers

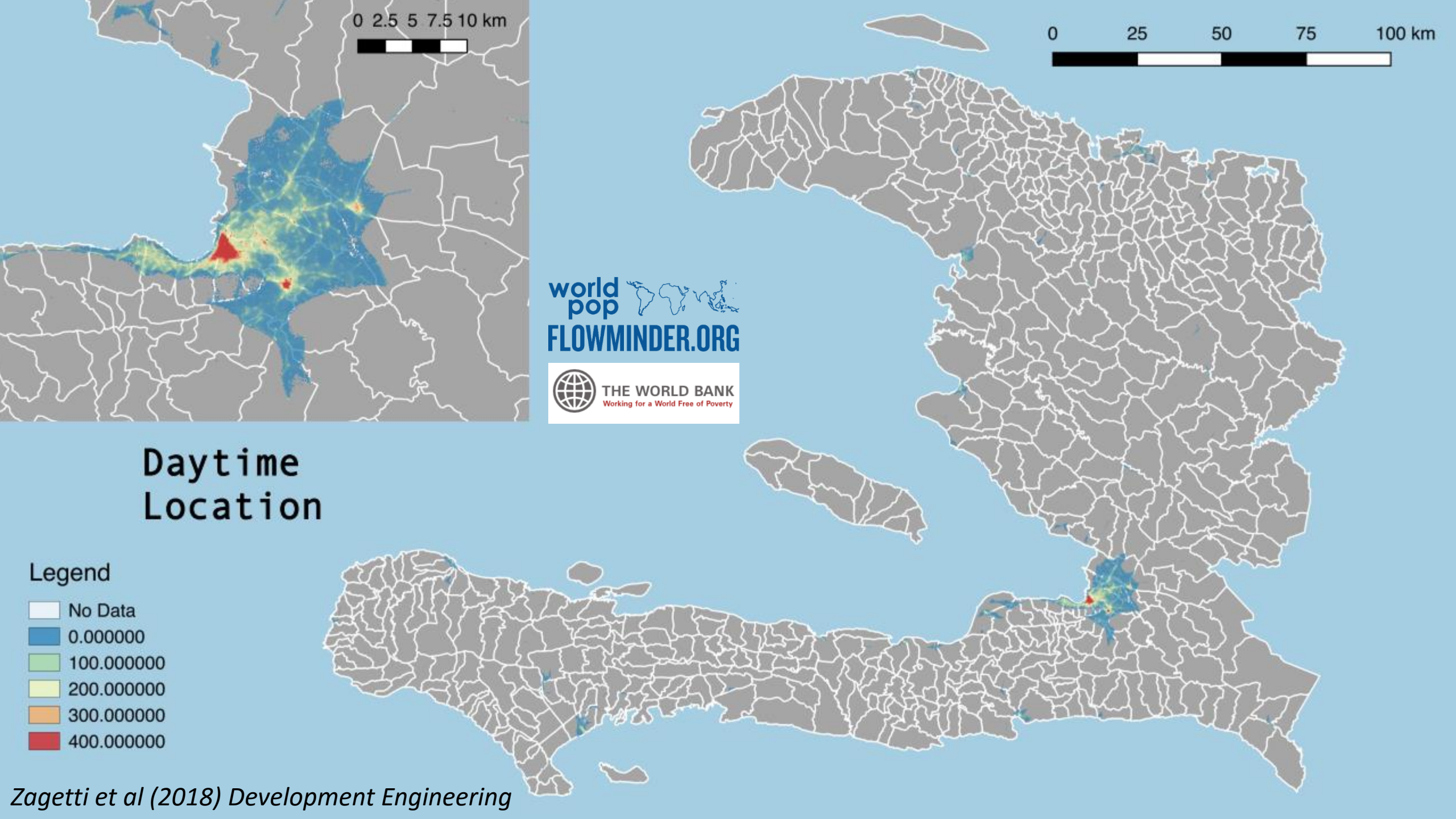

HOLD UP
WAIT A MINUTE

People don’t stay still….

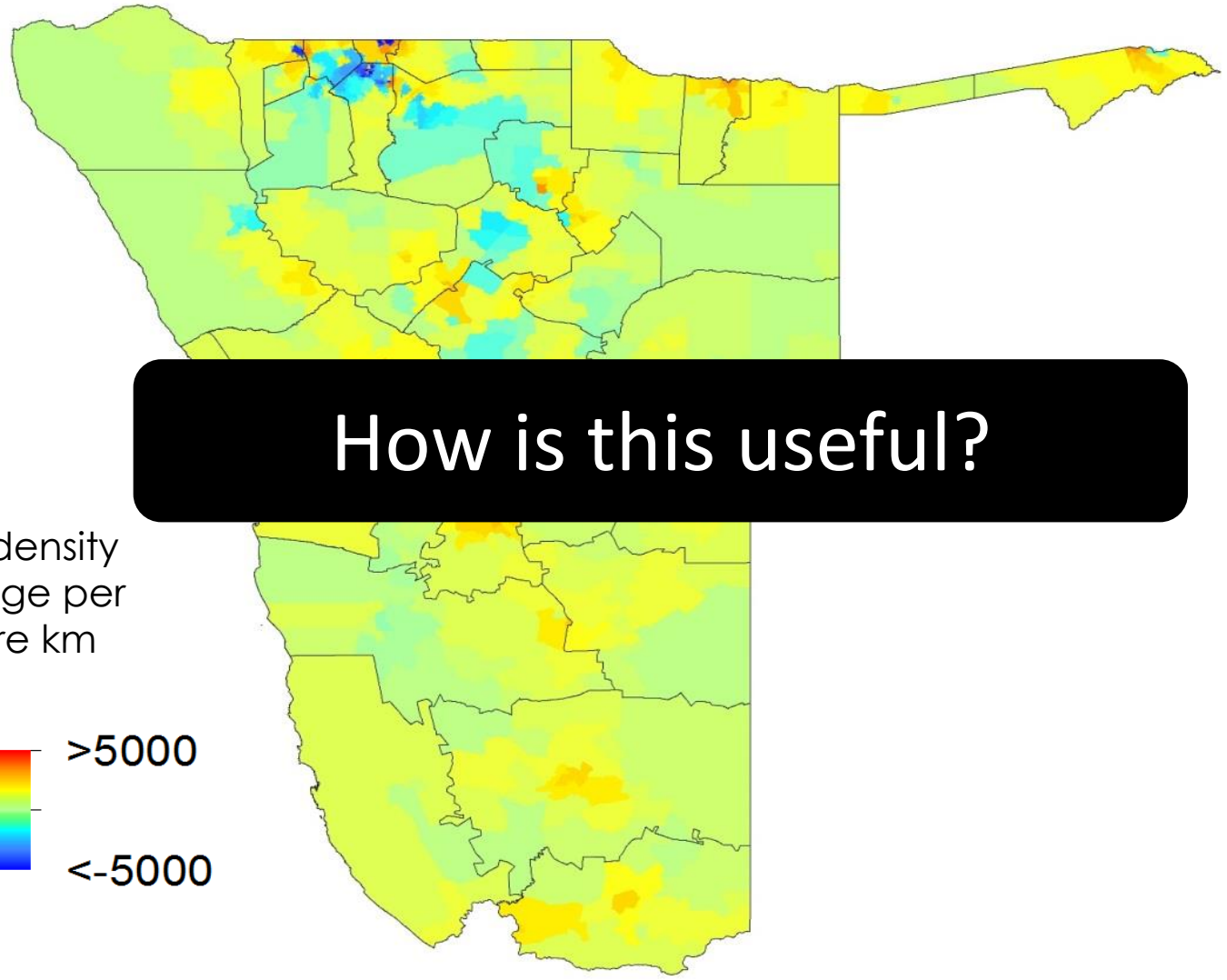




Deville et al (2014) PNAS



Zagetti et al (2018) Development Engineering



How is this useful?

Pop density change per square km

>5000

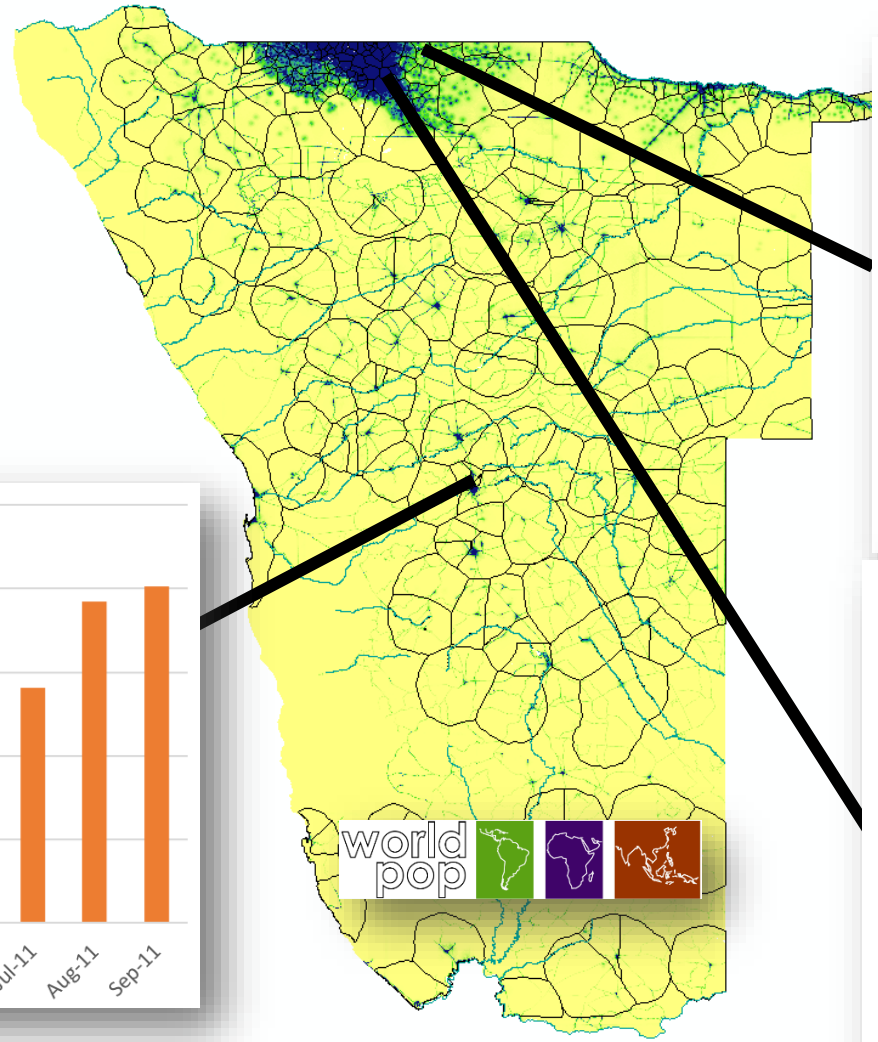
<-5000

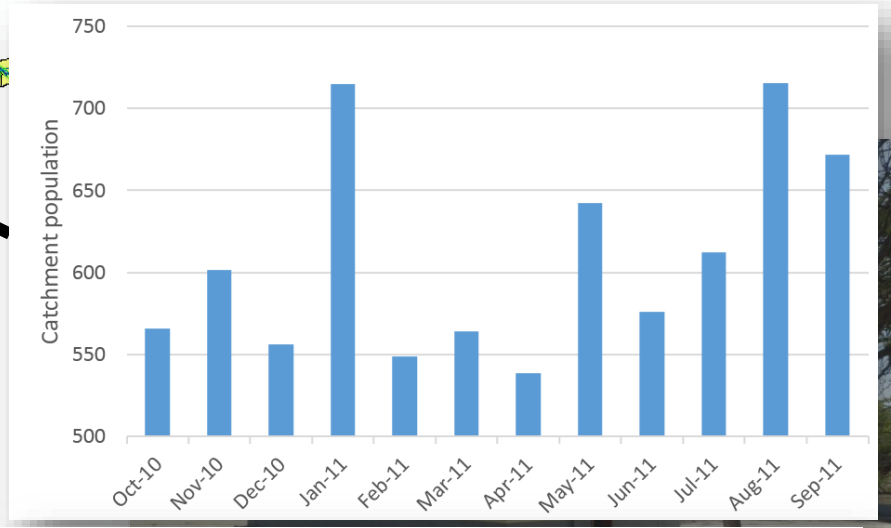
Namibia Pop: 2.3 mill
MTC active subscriptions: 2.1 mill

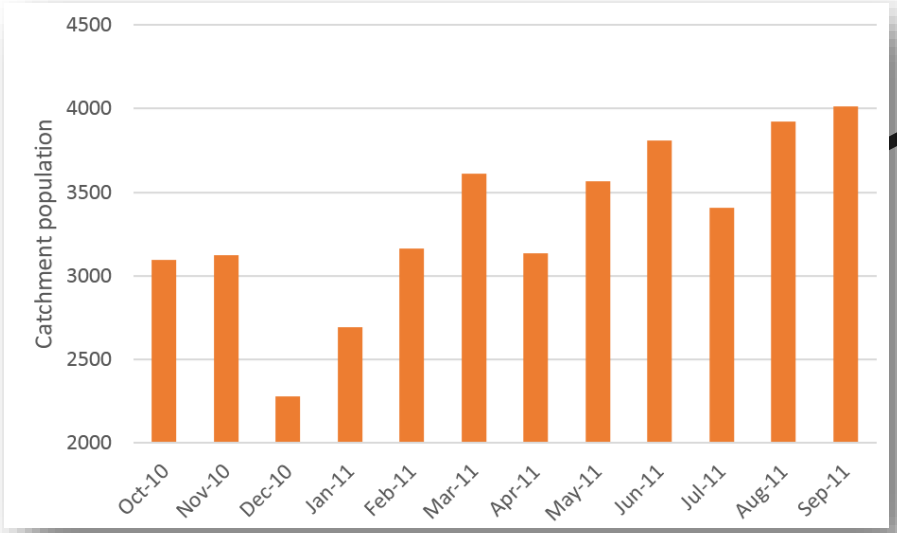
NOV_12 DEC_12 JAN_13 FEB_13 MAR_13 APR_13 MAY_13 JUN_13 JUL_13 AUG_13 SEP_13

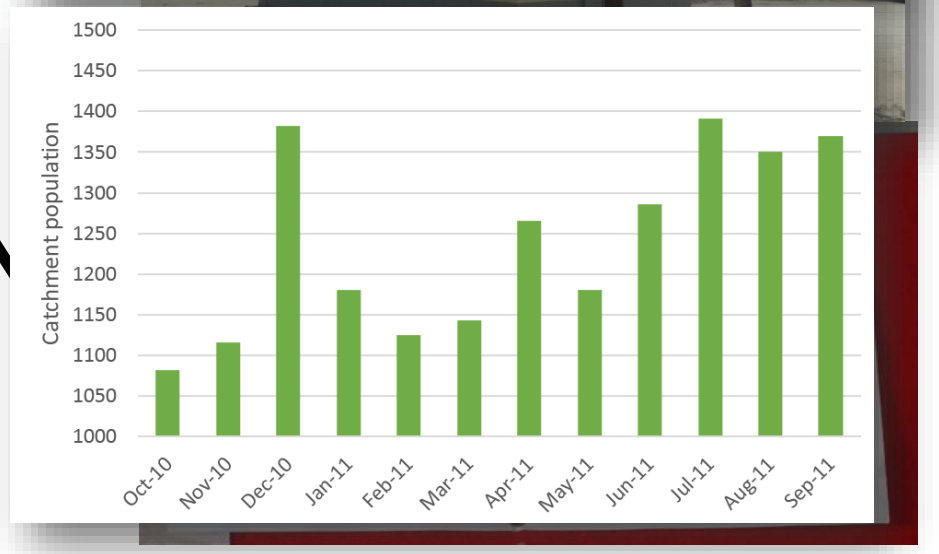
worldpop FLOWMINDER.ORG

Dynamic facility catchment populations



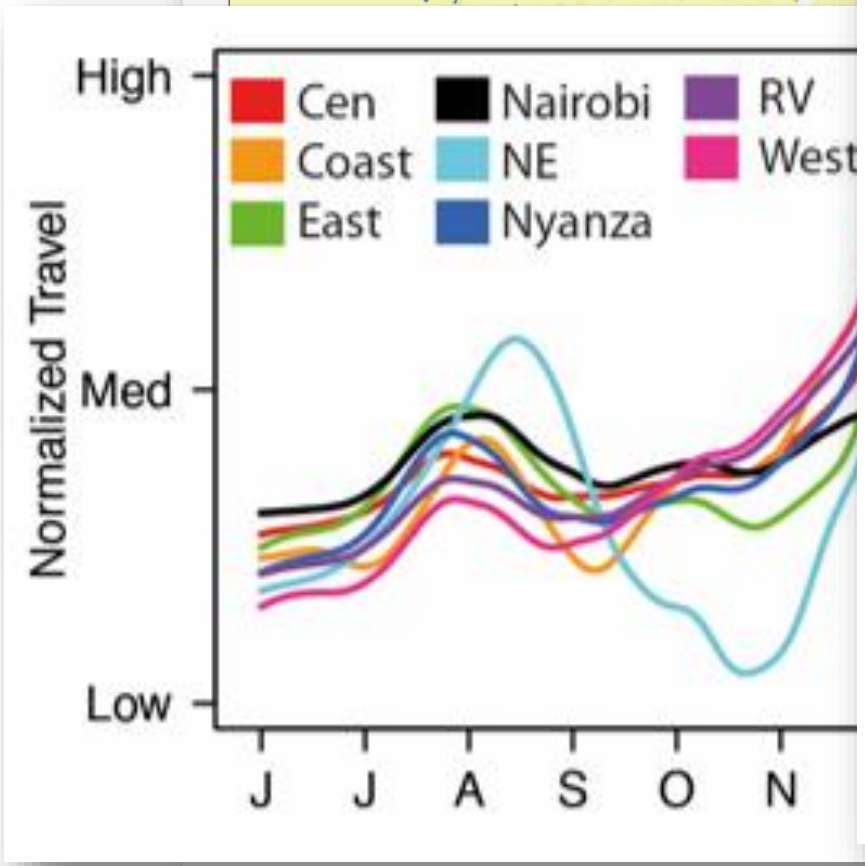


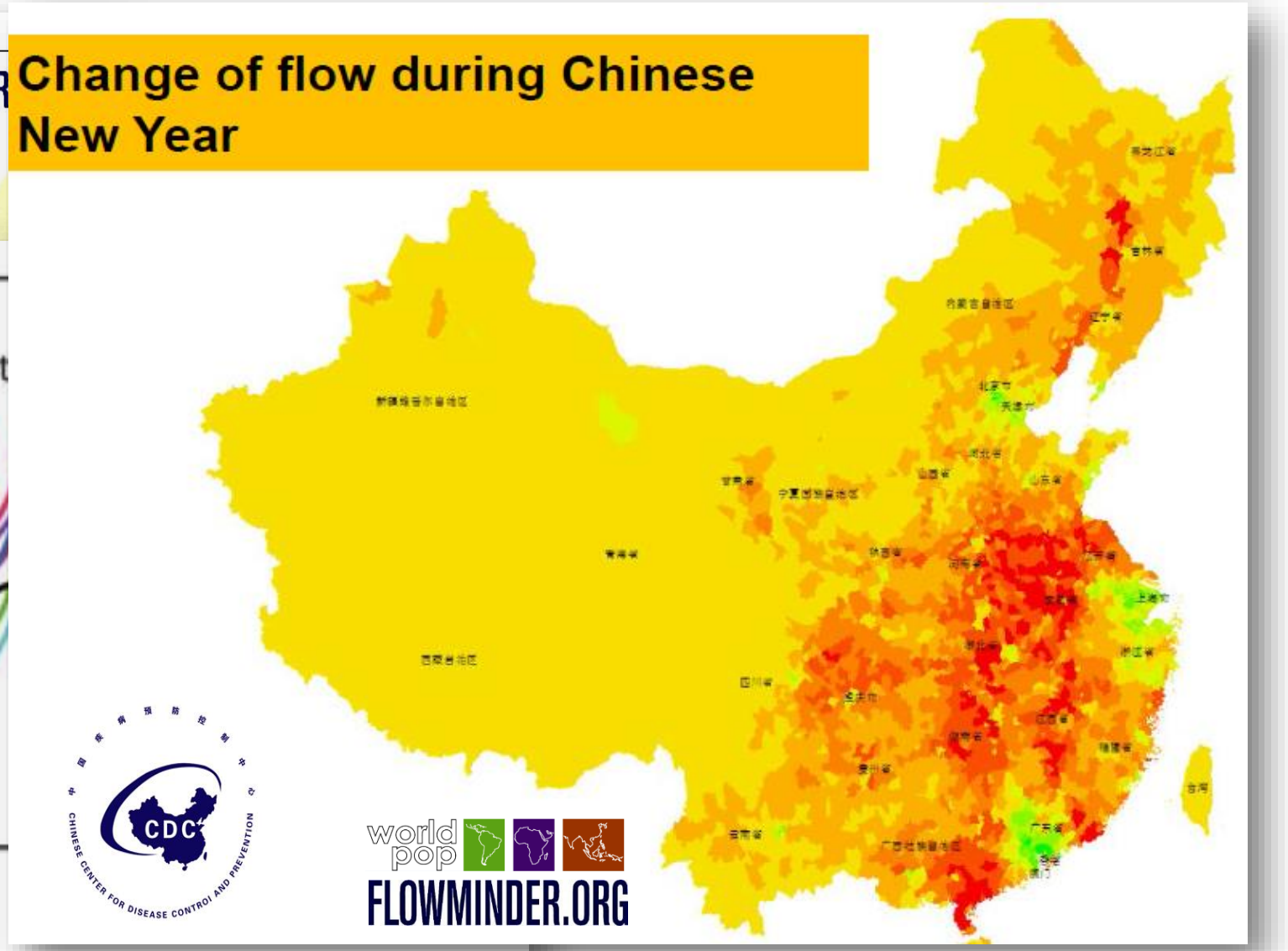




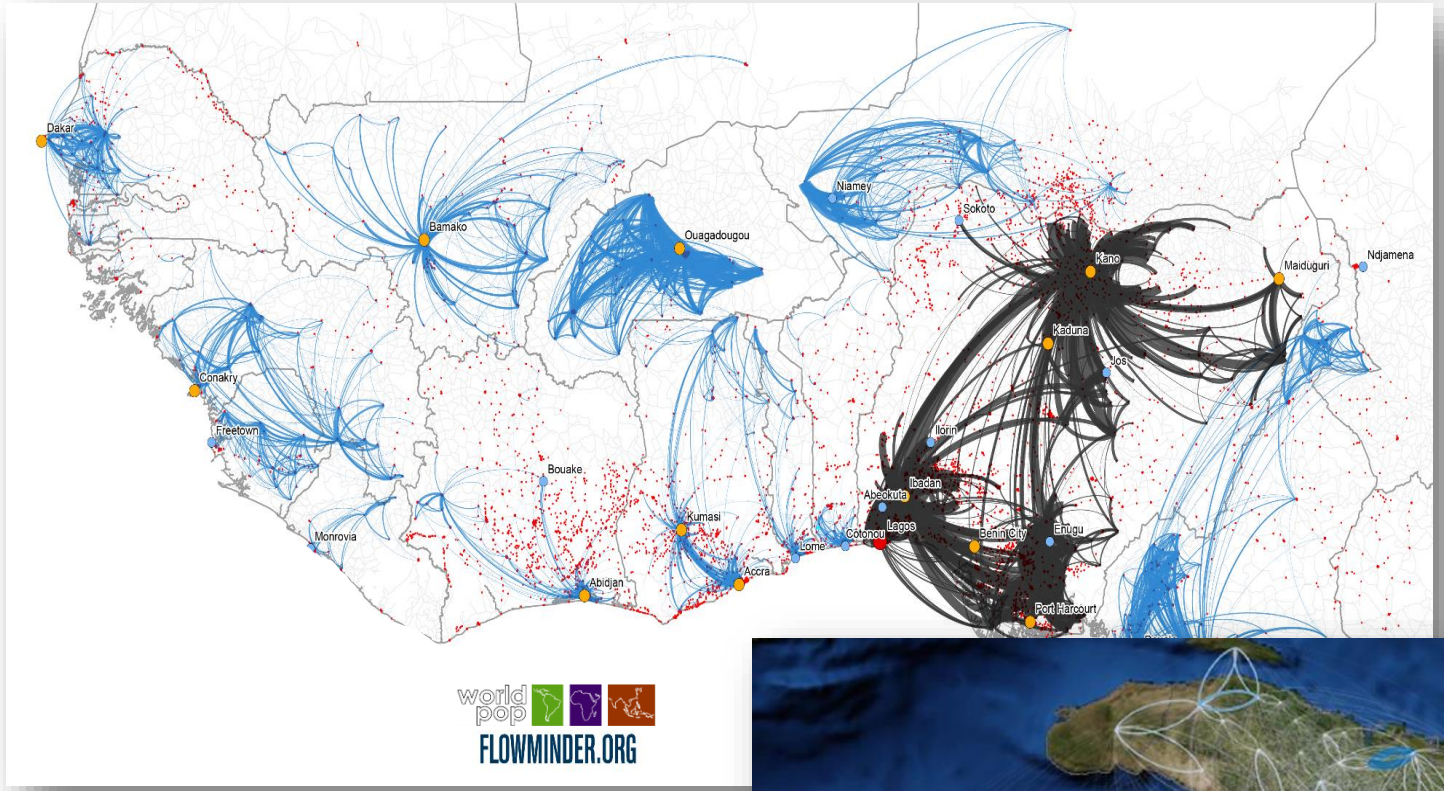
Erbach-Schoenberg et al (2016) Pop Health Metrics

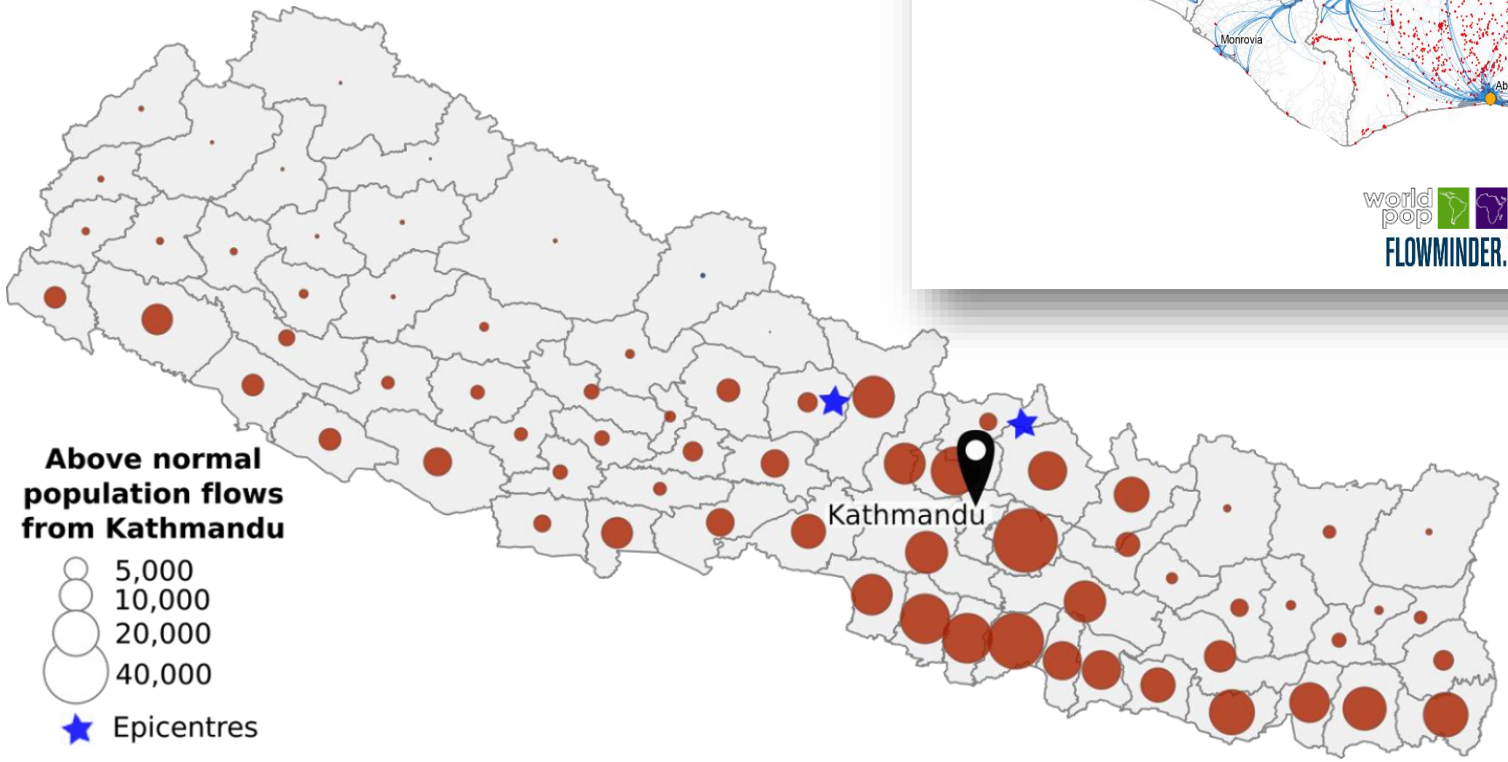
Population dynamics across scales



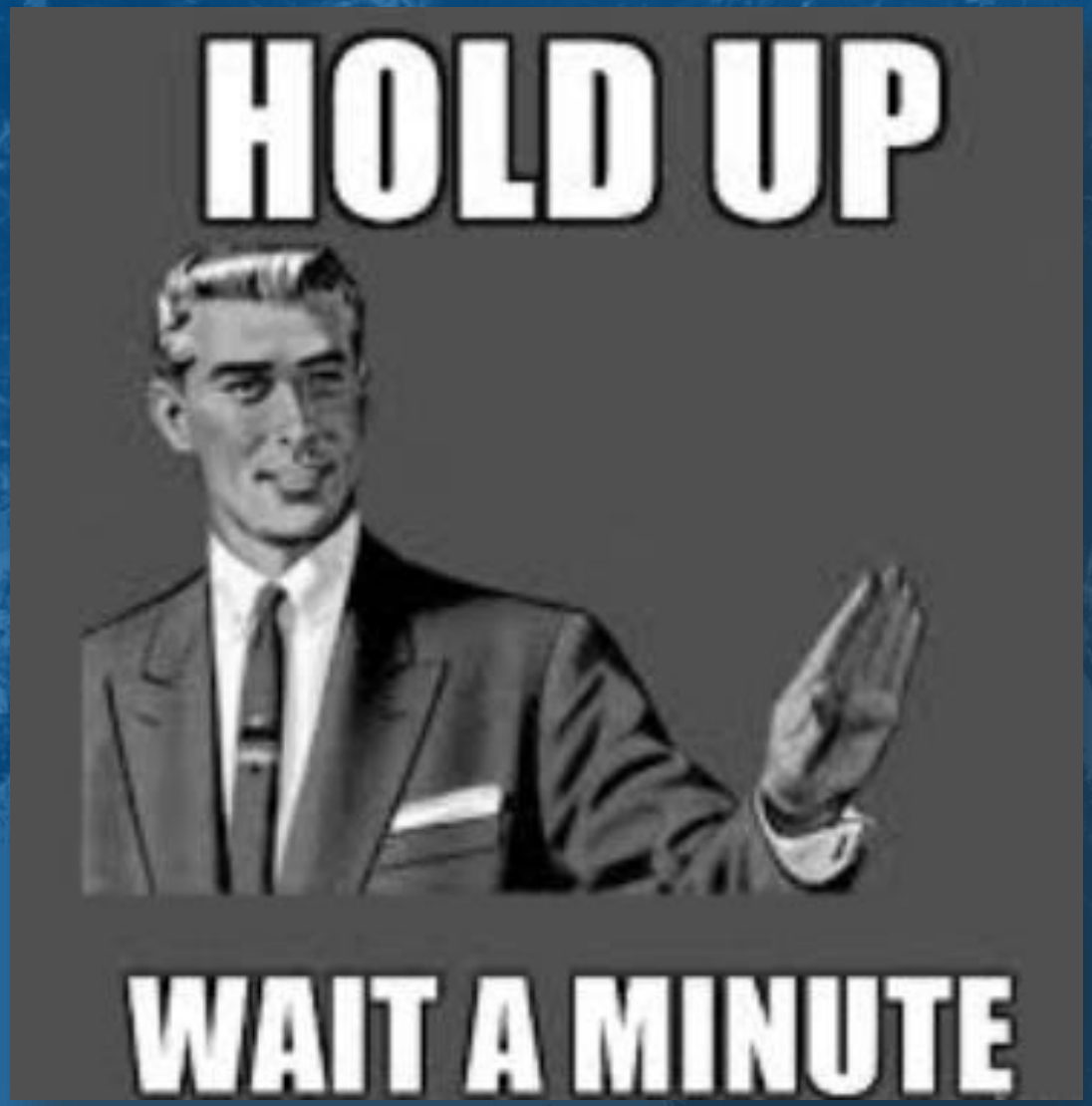


Crisis response

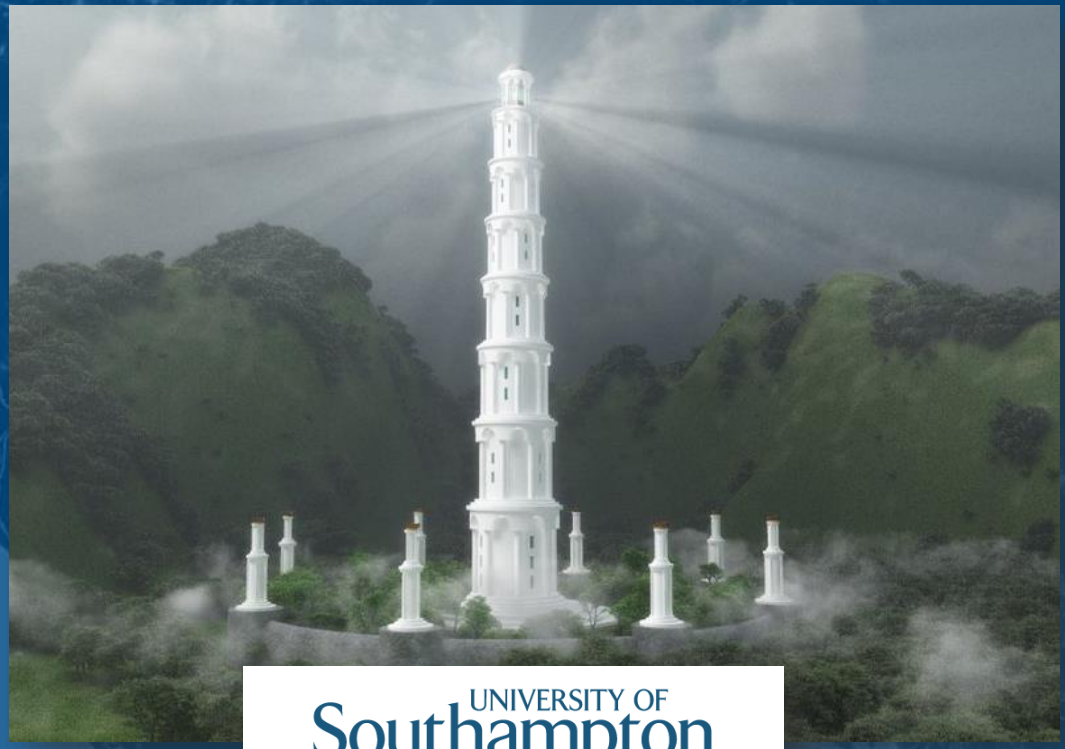




Wilson et al (2016) PLoS Curr Disasters; Bengtsson et al (2015); Wesolowski et al (2014) PLoS Curr Outbreaks


HOLD UP
WAIT A MINUTE

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

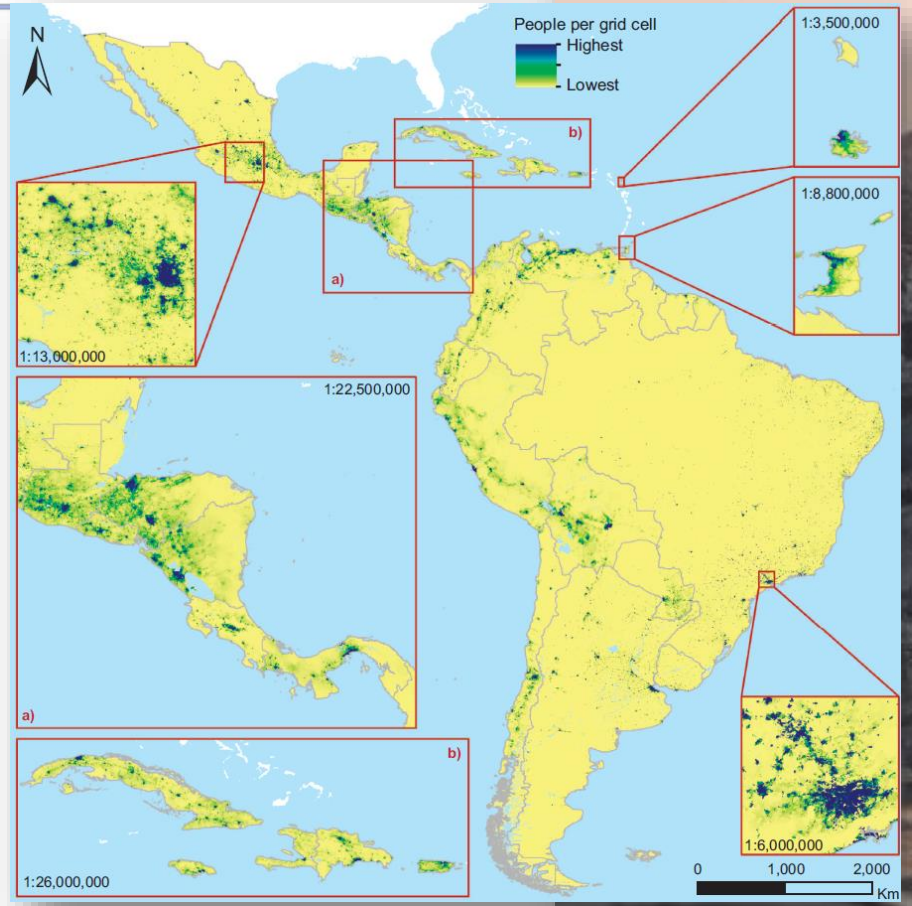


UNIVERSITY OF Southampton

unitar
United Nations Institute for Training and Research

UNOSAT

UNOSAT
Tropical Cyclone IRMA-17.
Population exposure analysis in Caribbean
4 September 2017



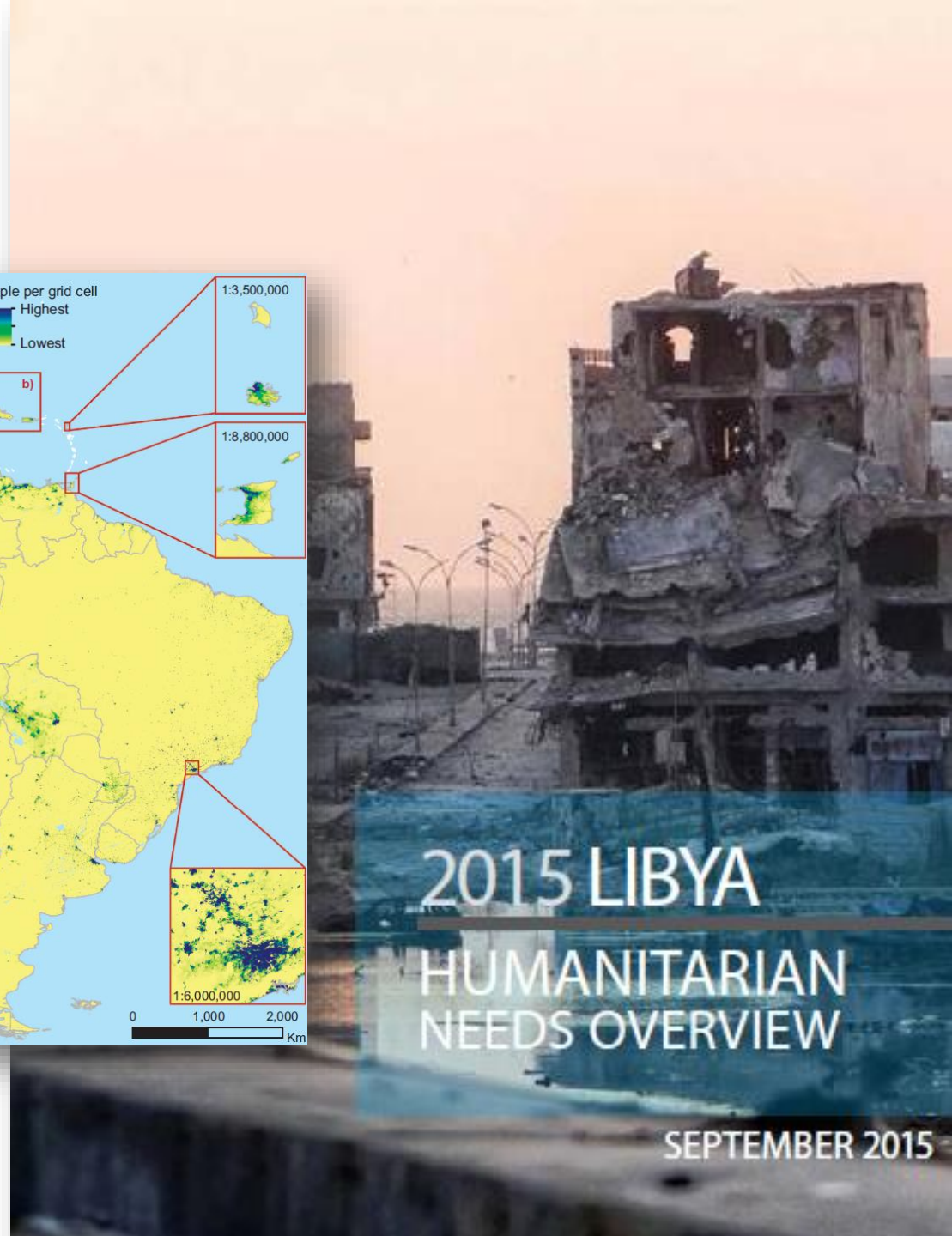
Population Exposure Analysis

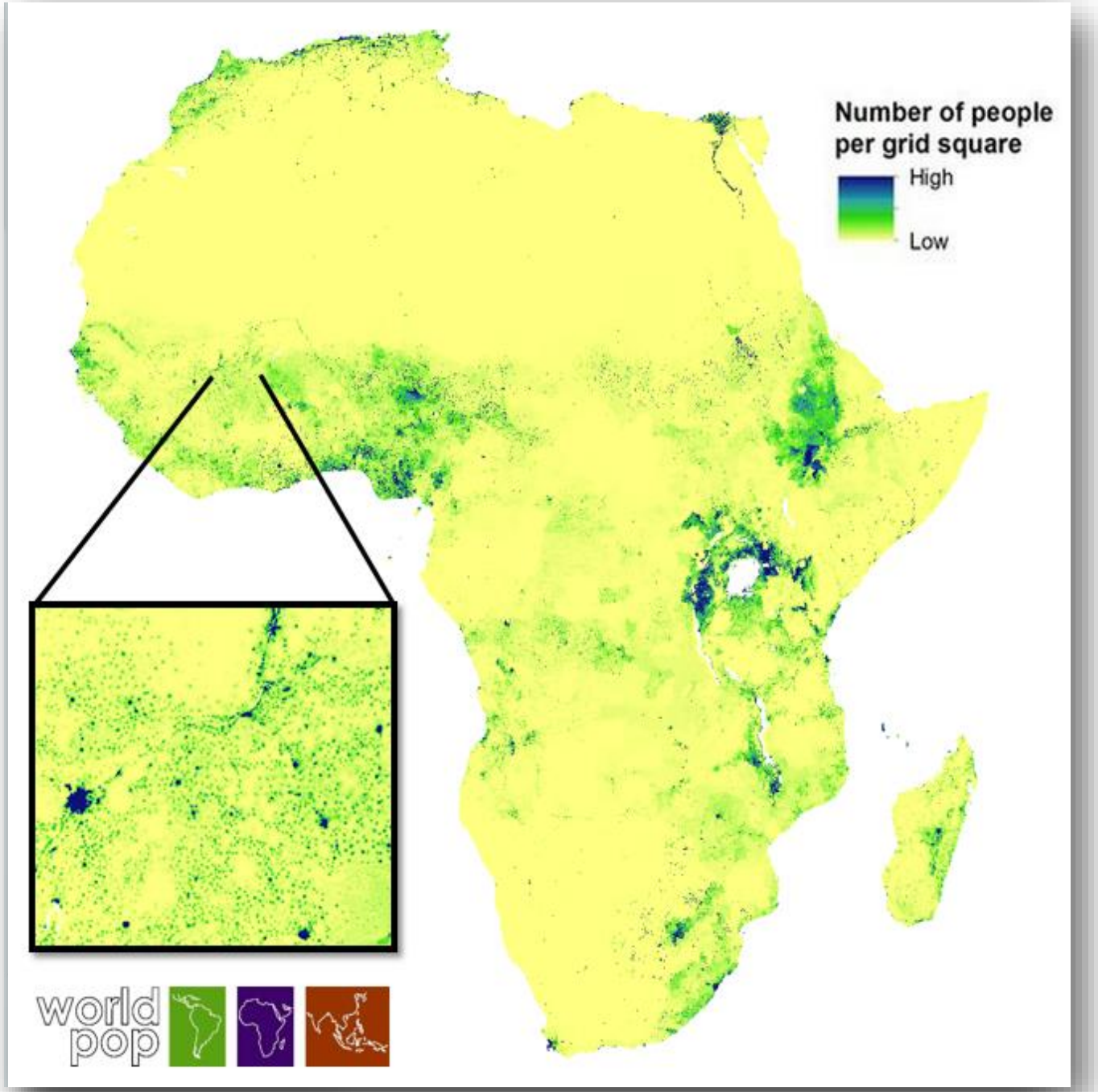
4 September 2017

Geneva, Switzerland

UNOSAT Contact:
Email: unosat@unitar.org
T: +41 22 767 4020 (UNOSAT Operations)
24/7 hotline: +41 76 411 4998

Postal Address:
UNITAR – UNOSAT, IEH
Chemin des Anémones 11,
CH-1219, Genève, Suisse





WORLD MALARIA REPORT 2017

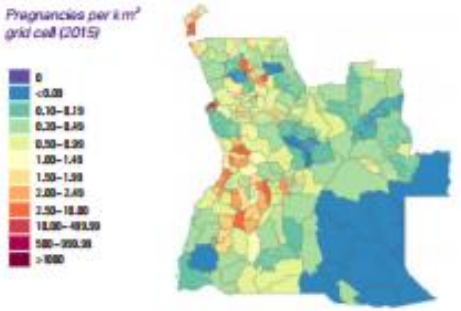
World Health Organization

ANGOLA

In 2015, of an estimated total population of 25.0 million, 57% were living in rural areas and 5.6 million (22%) were women of reproductive age; the total fertility rate was 5.8. By 2030, the population is projected to increase by 57% to 39.4 million. To achieve universal access to sexual, reproductive, maternal, newborn and adolescent (SRMNAH) care, health services must respond to 1.8 million pregnancies per annum by 2030. The health system implications include how best to configure and equitably deploy the SRMNAH workforce to cover at least 100.8 million antenatal visits, 18.3 million births and 71.4 million post-partum/postnatal visits between 2015 and 2030.

WHAT WOMEN AND NEWBORNS NEED (2015)

1,386,000 PREGNANCIES A YEAR = HOW MANY EPISODES OF CARE?



PRE-PREGNANCY	=	12,030,000 family planning visits
ANTENATAL	=	4,029,000 routine visits
BIRTH	=	982,000 skilled birth attendance
POST-PARTUM / POSTNATAL	=	3,926,000 routine visits

WORKFORCE AVAILABILITY (2015)

Country classification of staff working in SRMNAH	Time spent on SRMNAH %
Midwives	aa
Midwives, auxiliary	aa
Nurse-midwives	-
Nurses	-
Nurses or nurse-midwives, auxiliary	aa
Non-physician clinicians	aa
Physicians, generalists	-
Obstetricians & gynaecologists	-

PRE-PREGNANCY · ANTENATAL · BIRTH · POST-PARTUM · POSTNATAL

POTENTIAL MET NEED = NO DATA

workforce time available / workforce time needed

Estimate of potential met need (national aggregate) based on available data.

MIDWIFERY EDUCATION[3]

Minimum high-school requirement to start training	Grade 12+
Years of study required to qualify	4.5
Standardized curriculum? Year of last update	Yes, in process
Minimum number of supervised births in curriculum	20
Number of 2015 graduates/as % of all practising midwives	-/-
% of graduates employed in SRMNAH within one year	-%

MIDWIFERY REGULATION

Legislation exists recognizing midwifery as an autonomous profession	No
A recognized definition of a professional midwife exists	Yes
A government body regulates midwifery practice	Yes
A licence is required to practise midwifery	Yes
A live registry of licensed midwives exists	Yes
Number of EmONC basic signal functions that midwives are allowed to practise (out of a possible 7)	5
Midwives allowed to provide injectable contraceptives/intrauterine devices	Yes/Yes

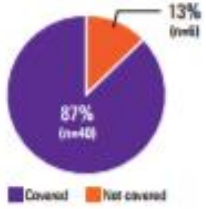
PROFESSIONAL ASSOCIATIONS[4]

Year of creation of professional associations	2002
Roles performed by professional associations:	
Continuing professional development	Yes
Advising or representing members accused of misconduct	Yes
Advising members on quality standards for SRMNAH care	Yes
Advising the Government on policy documents related to SRMNAH	Yes
Negotiating work or salary issues with the Government	No

aa = not applicable; - = missing data

FINANCIAL ACCESSIBILITY

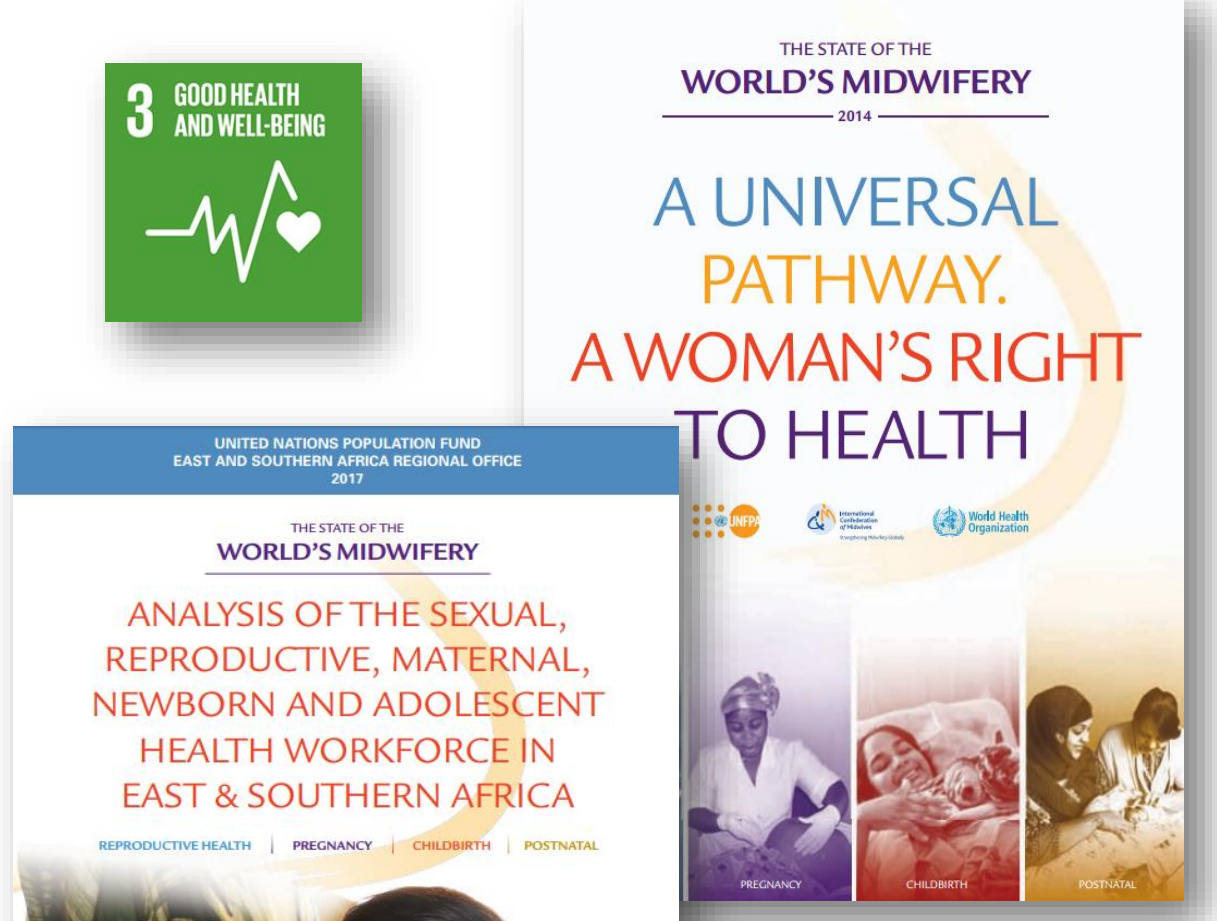
Percentage of 46 RMNH Essential Interventions included in minimum health benefits package, 2015



GEOGRAPHICAL ACCESSIBILITY

Percentage of live births with a skilled birth attendant (SBA)[5]

3 GOOD HEALTH AND WELL-BEING



UNFPA

Mobile phone data and population displacement following hurricane Matthew

tab-9316-1 tab-pane active tab-9316-2

Outflow of people : compared to pre-hurricane

Map to show

- [x] Base map
- [ ] Hurrican Max Wind Speed

Transparency of Flow map

0 0.5 1

Date

2016-07-07 2016-10-12 2016-12-03

Direction of the flow

Outflow

Normalisation

- [x] Compared to pre hurricane
- [ ] % of the population

FLOWMINDER.ORG

world pop

Digicel

WFP World Food Programme wfp.org

Haiti: Hurrican Matthew

Estimated Population Movements as of 22 November 2016

Flowminder Foundation - Digicel Haiti - World Food Programme

Produced on 24 November 2016

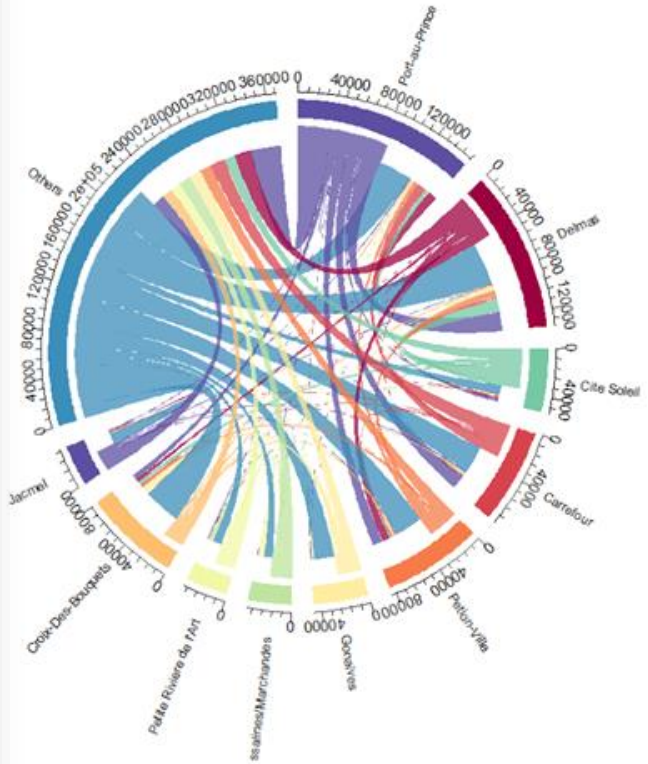
wfp.org

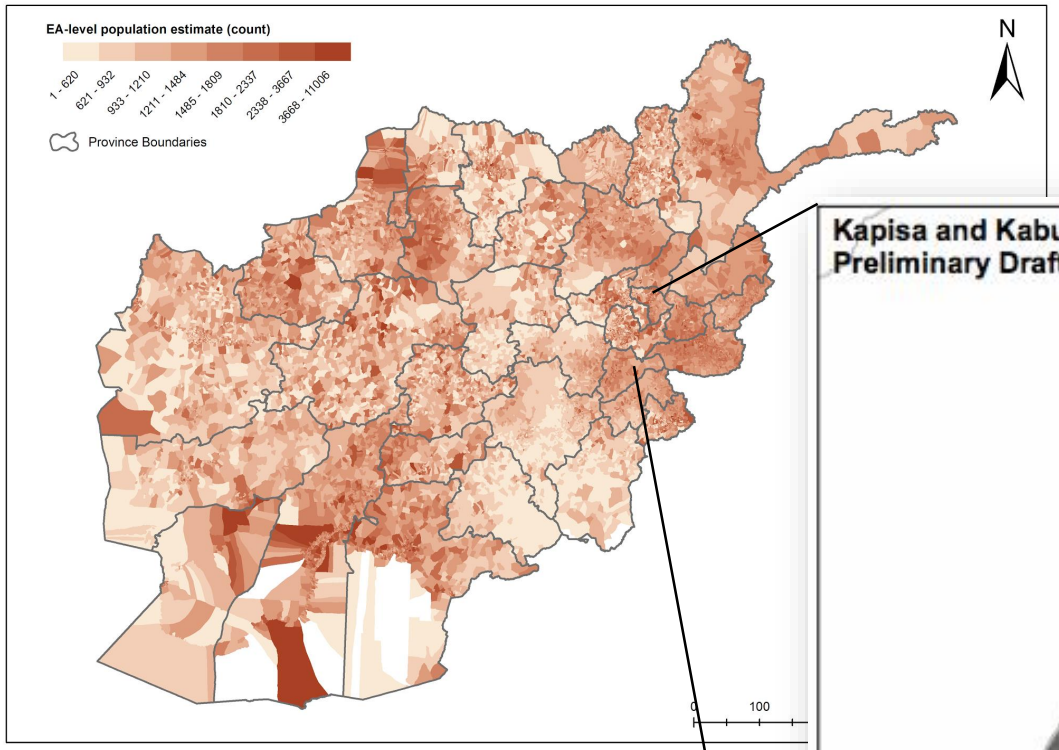
FLOWMINDER.ORG

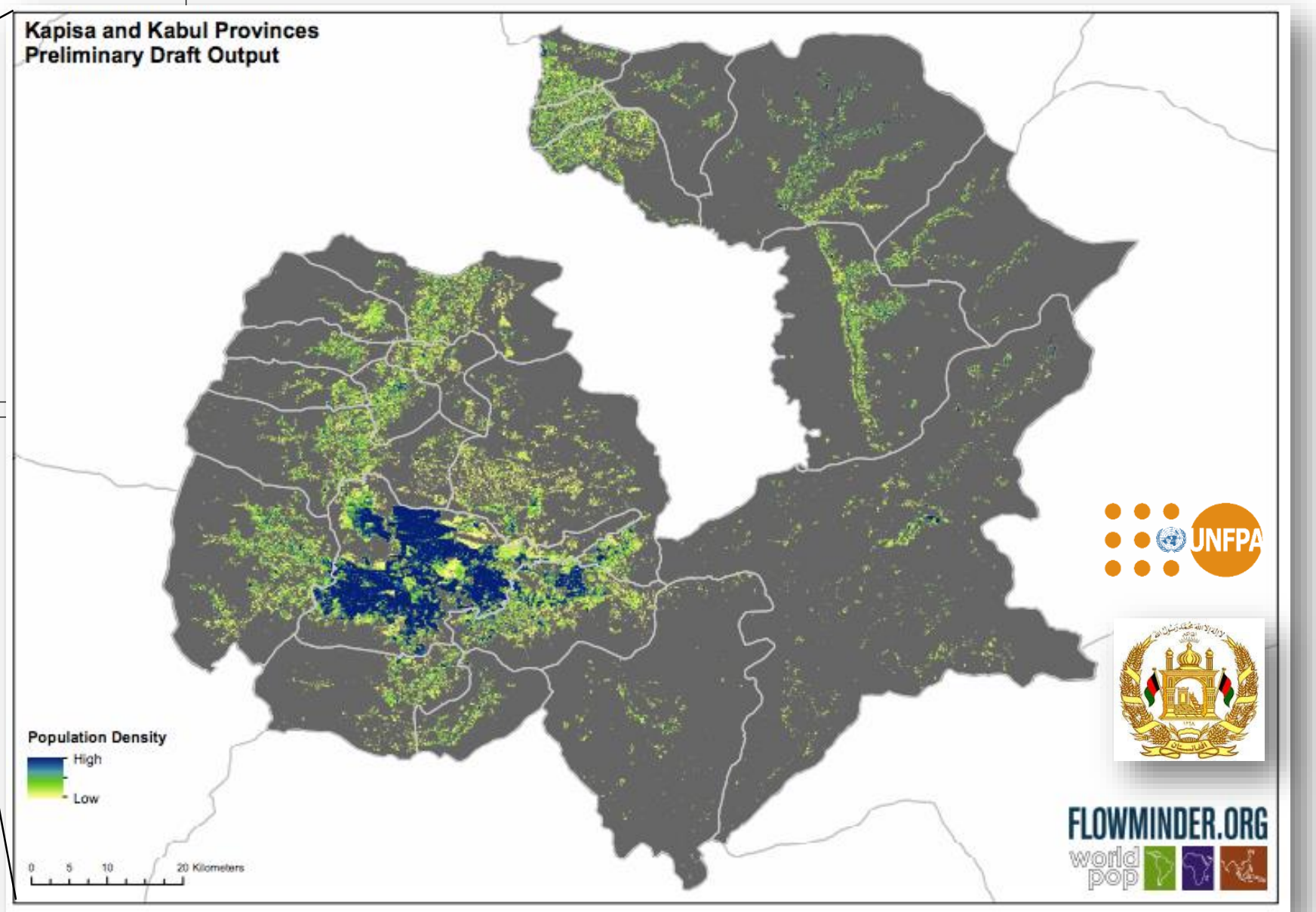
10 flows in Haiti

the peninsula Only top relations Show the locations on the map

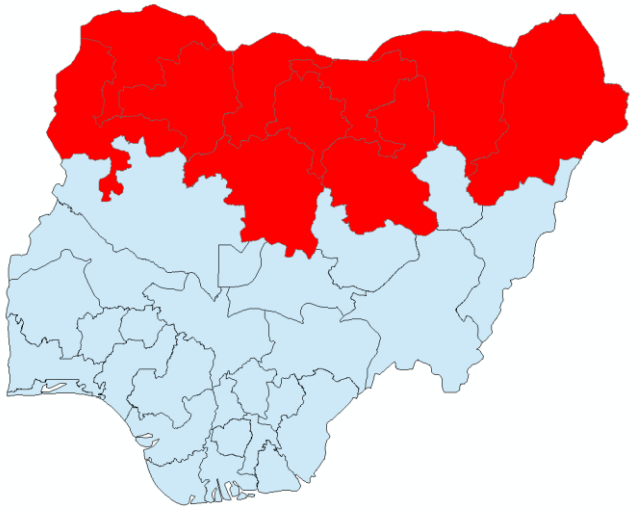
The side of ribbon close to the ring is its origin, the one away is its destination




EA-level population estimate (count)
1 - 620
621 - 932
933 - 1210
1211 - 1484
1485 - 1809
1810 - 2337
2338 - 3667
3668 - 11006
Province Boundaries
N
0
100


Kapisa and Kabul Provinces
Preliminary Draft Output
Population Density
High
Low
0 5 10 20 Kilometers
UNFPA
FLOWMINDER.ORG
world pop

Example application: Vaccination planning needs



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

-Ensure correct amount of vaccine is available for each area

Need to know how many under 5s there are and where they are

-Plan vaccinator logistics and routes

Need detailed maps of the region

BILL & MELINDA GATES foundation

POLIO GLOBAL ERADICATION INITIATIVE

VTS Map

Settlement/Ward/LGA/State

Go to XY

Long:

Lat:

Pop (Total): 28462
Kasuwan Magani

Buda

Pop (Total): 7139

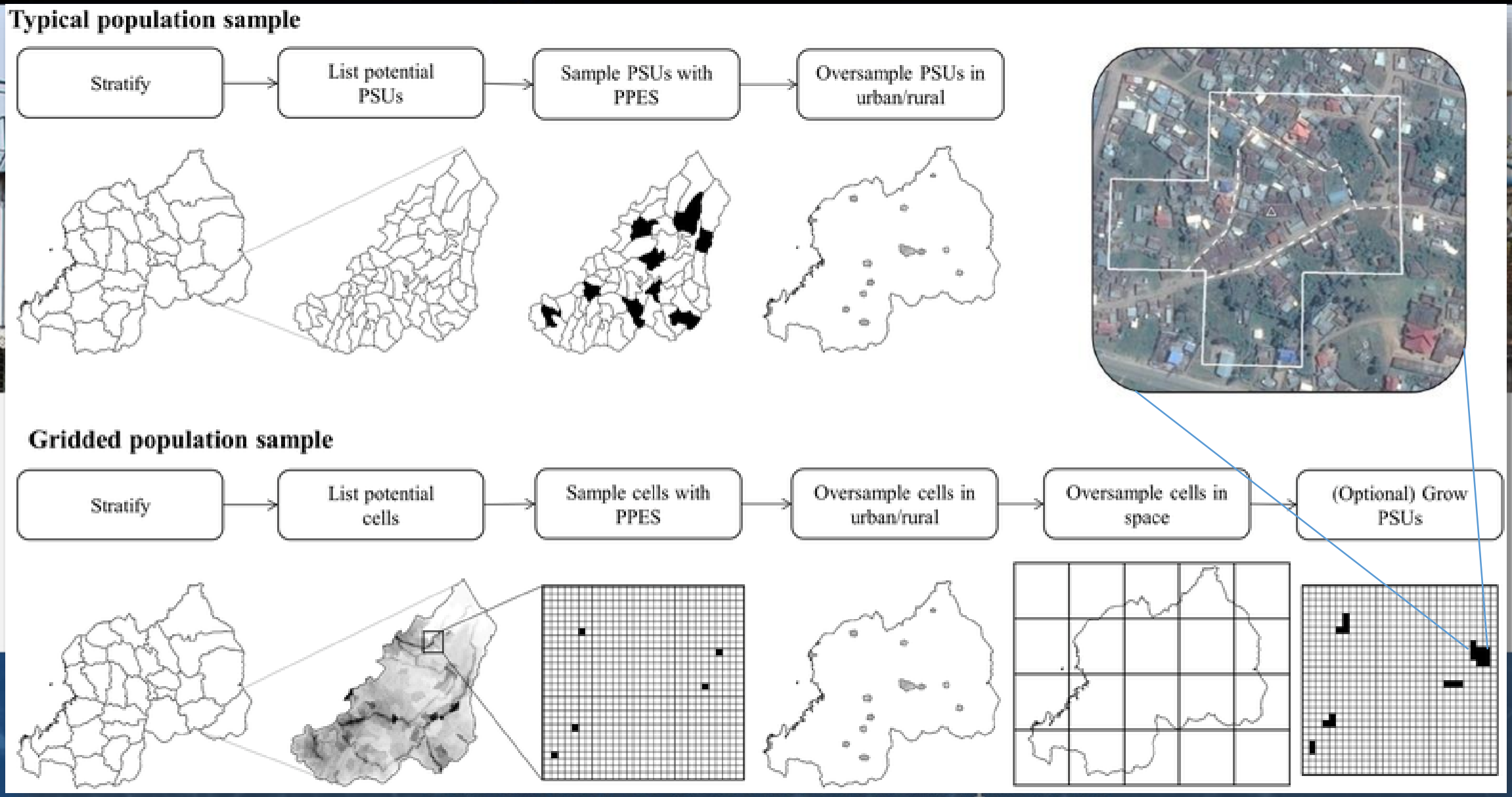
Pop (Under 5): 1792
Pop (Total): 9279
Kajuru

Pop (Under 5): 2786
Pop (Total): 14553
Afogo

Pop (Under 5): 6498
Pop (Total): 33782
Kufana

THE VACCINATION TRACKING SYSTEM (VTS) - SUPPORTING **POLIO ERADICATION** IN NIGERIA

http://vts.eocng.org/



Tutorial →

Thomson et al (2017) Int J Health Geographics

GRID3

GEO-REFERENCED INFRASTRUCTURE AND DEMOGRAPHIC DATA FOR DEVELOPMENT

grid3.org

BILL & MELINDA GATES foundation

UKaid from the British people

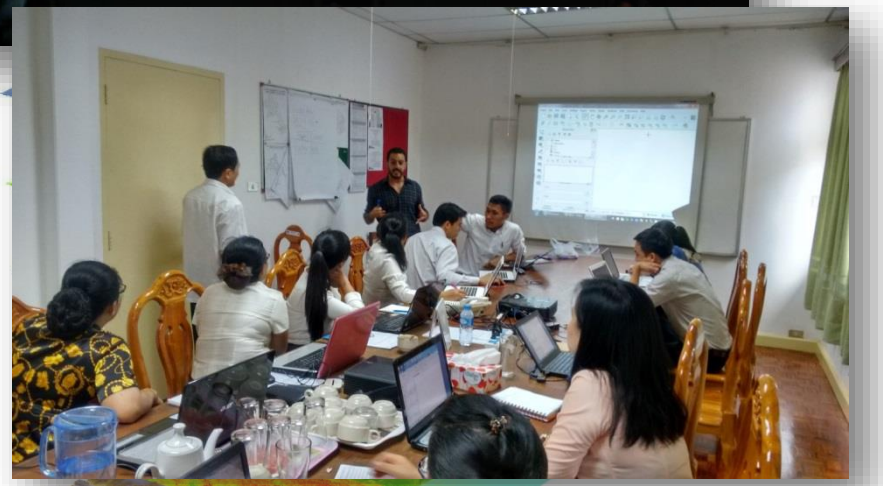
world pop FLOWMINDER.ORG

UNFPA

Center for International Earth Science Information Network

EARTH INSTITUTE | COLUMBIA UNIVERSITY

Key messages



- Spatially disaggregated and regularly updated demographic data are a pre-requisite for planning/operational needs and monitoring progress towards development goals
- We are seeing an explosion of ‘big’ geospatial data, but every dataset has its biases and gaps: *data integration and measurement of uncertainty are key*
- Methods exist to undertake this, *complimenting traditional sources* to support health and development needs
- *Local ownership* and ongoing engagement with stakeholders are key to sustainable implementation

Further information

www.worldpop.org
@WorldPopProject

www.flowminder.org
@Flowminder

E-mail: A.J.Tatem@soton.ac.uk