Development Progress from the Bottom Up

Geospatial Data and Tools for Planning and Evaluation

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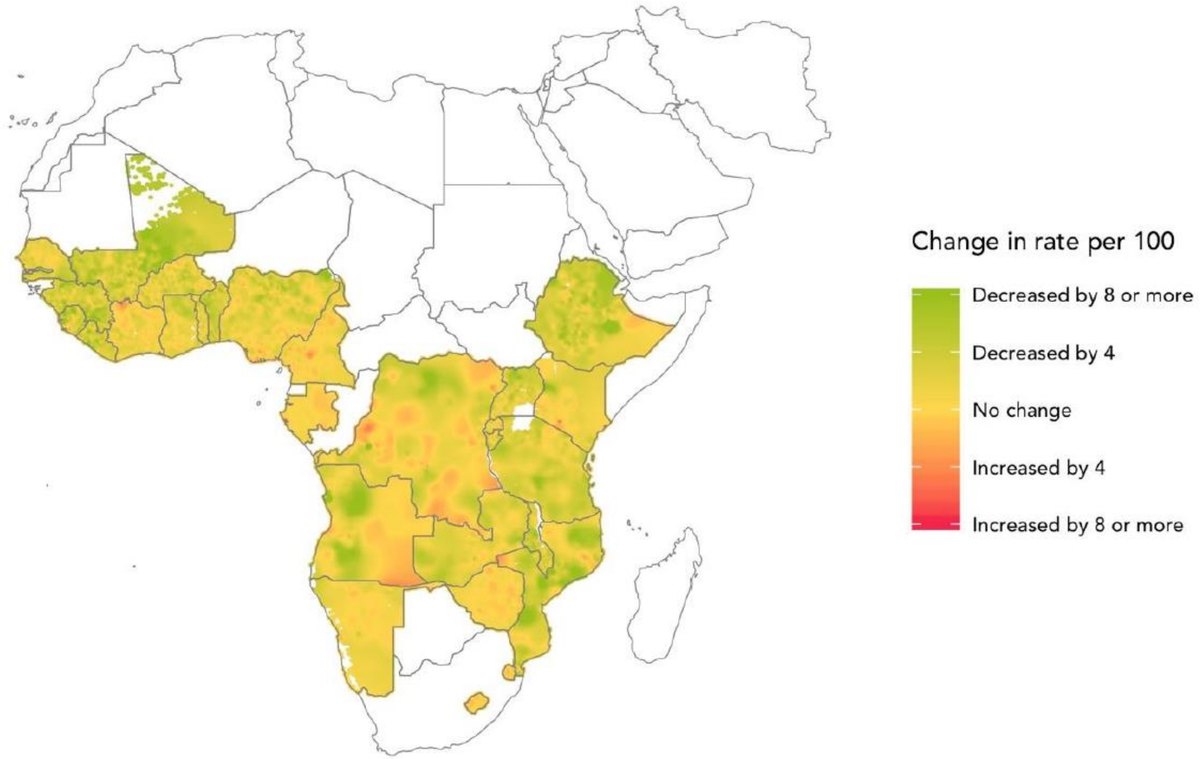
A Research Lab at William & Mary

BEYOND THE TYRANNY OF AVERAGES

Child mortality has fallen in many areas…
… while no changes (or even increases) have occurred in nearby areas

Figure 5: Subnational Changes in Under-5 Mortality in Sub-Saharan Africa between the 1980s and 2000s:



Note: *Source is Burke, Heft-Neal, and Bendavid (2016.)*

BEYOND THE TYRANNY OF AVERAGES

More aid goes to poorer countries …
… but not poorer regions within countries

Figure 9: Poorer Countries Receive More Aid

Relationship between GDP Per Capita and Aid Per Capita by Country, 1995-2014

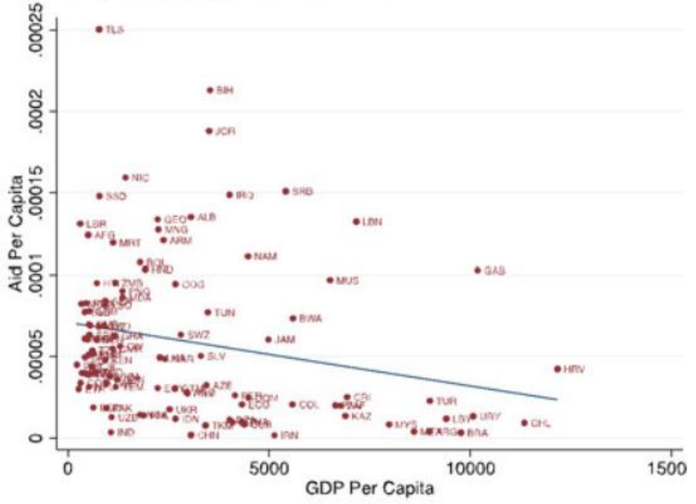
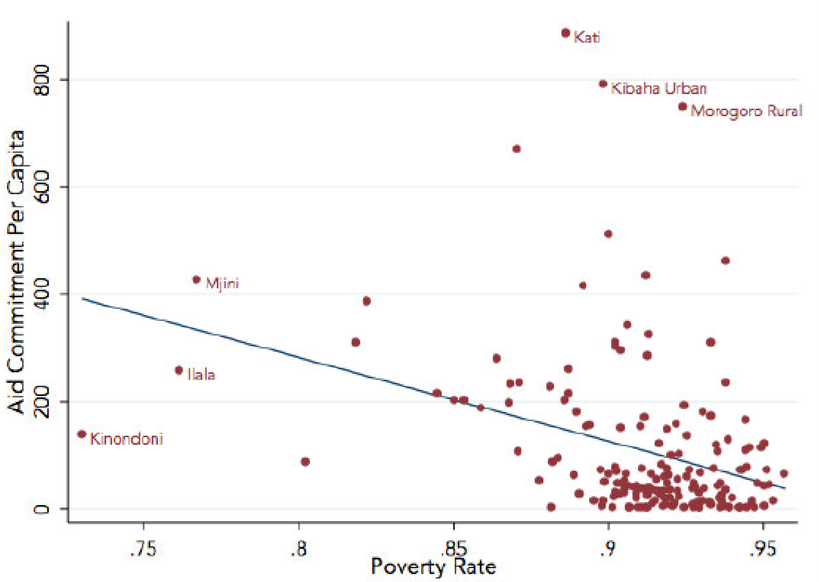


Figure 11: Poverty Rates and Estimated Amount of World Bank Aid Commitments Per Capita by ADM2 Region, 1995-2014



BEYOND THE TYRANNY OF AVERAGES

Is aid being allocated efficiently?

Correlations

- Aid goes to less poor, more densely population areas

Political economy drivers

- Aid allocated to swing districts prior to elections
- Aid used to spur conflict in some cases
- Some aid provided to birth region of leaders

Overall efficiency

- As total country budgets change (countries cross IDA threshold, join UNSC), no clear changes in proportion to needier areas
- Some projects have larger impacts under some geospatial conditions…
- ... As we uncover these heterogeneous effects, better targeting will be possible

GEOSPATIAL IMPACT EVALUATION

Answering the key questions

Can we find conditions under which aid is (especially) effective?

Can we learn something rigorous about already completed projects?

Can we bring down the costs of rigorous evaluations?

GEOSPATIAL IMPACT EVALUATION

Advantages

- Useful when impractical or unethical to randomize assignment into a (spatially-distributed) program
- Cheaper and faster to implement than RCTs (because they often leverage existing data rather than custom baseline and endline surveys)
- Often produce results with strong external validity in both the spatial and temporal sense
- Can be conducted remotely and retrospectively
- Enables evaluation of long-run (post-program) impacts
- Can be applied at project or portfolio level

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GEOSPATIAL IMPACT EVALUATION

Applications in a growing number of sectors

- Municipal governance (Colombia, Niger)
- Road and electricity infrastructure (West Bank and Gaza, Liberia)
- Violence prevention (Afghanistan)
- Malaria prevention (DRC)
- Reintegration of combatant soldiers into local communities (Burundi)
- Economic development (Liberia)
- Agricultural productivity (Afghanistan)
- Biodiversity conservation (Tanzania, Cambodia)
- Land tenure (Brazil)

Early adopters

Independent Evaluation Office
GLOBAL ENVIRONMENT FACILITY

KFW

BILL & MELINDA GATES foundation

MILLENNIUM CHALLENGE CORPORATION
UNITED STATES OF AMERICA

USAID

MacArthur Foundation

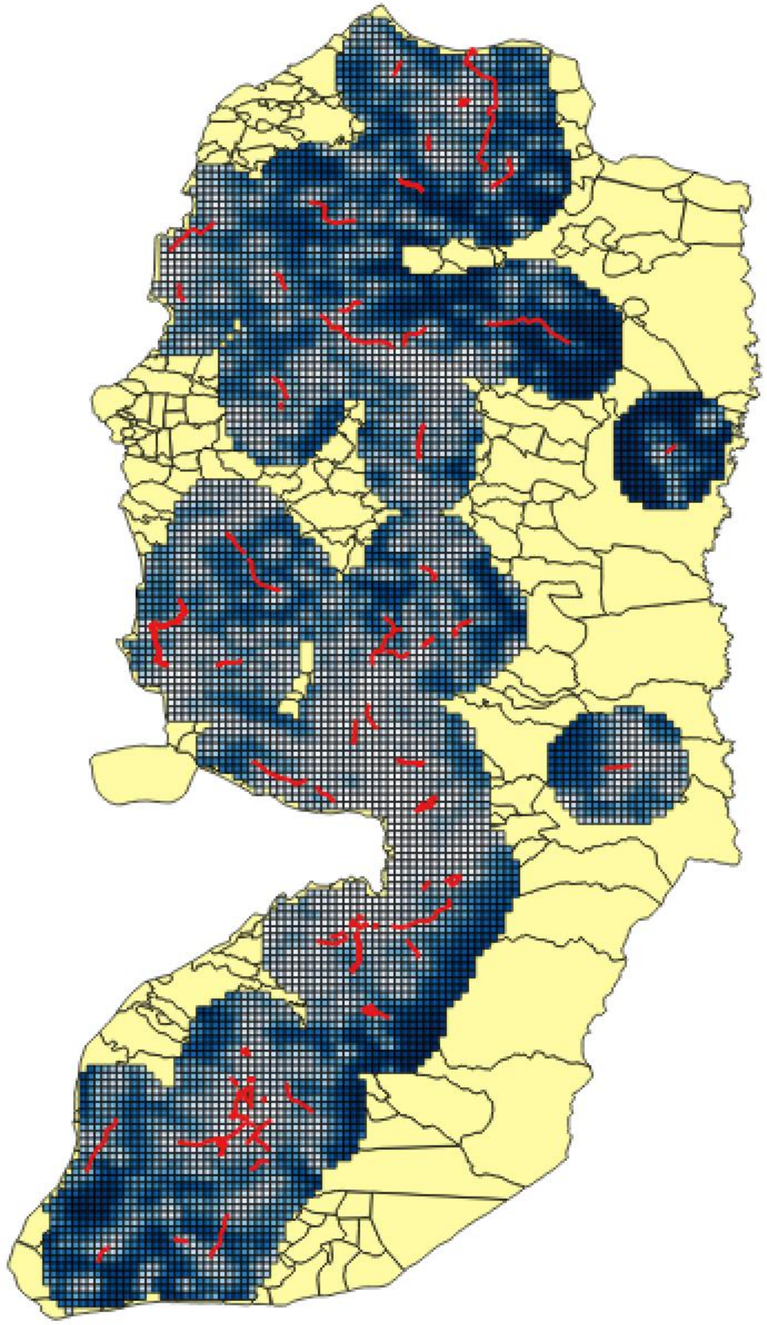
THE WORLD BANK

PBSO
United Nations Peacebuilding Support Office

GEOSPATIAL IMPACT EVALUATION

West Bank/Gaza: USAID-funded rural road infrastructure program

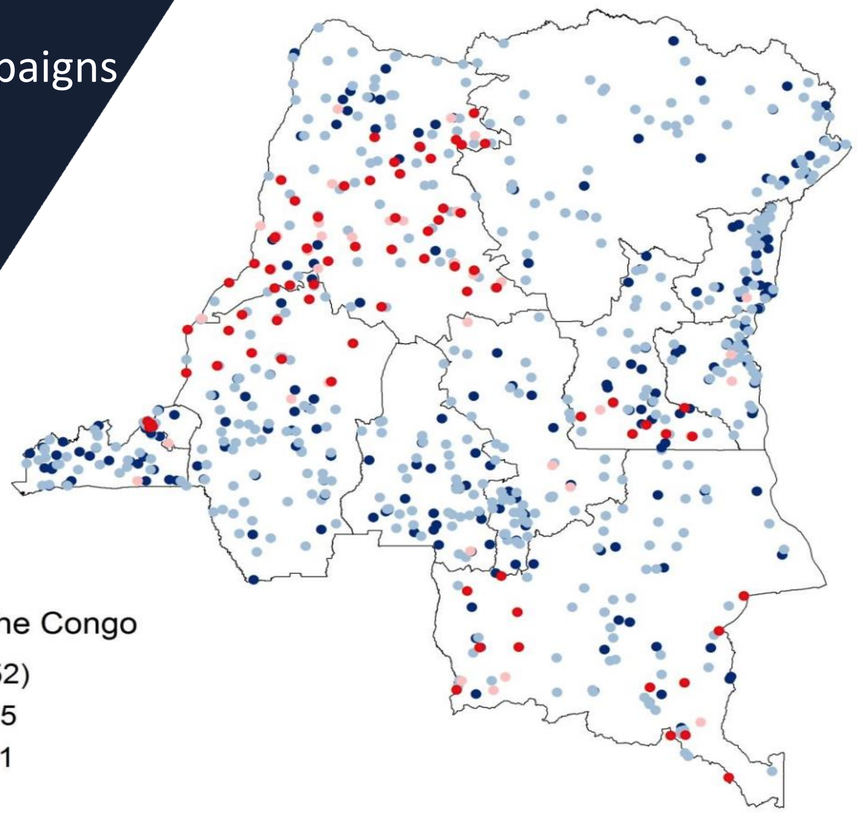
Economic gains measured in nighttime lights, available from the Visible Infrared Imaging Radiometer Suite (VIIRS) at ½ km x ½ km

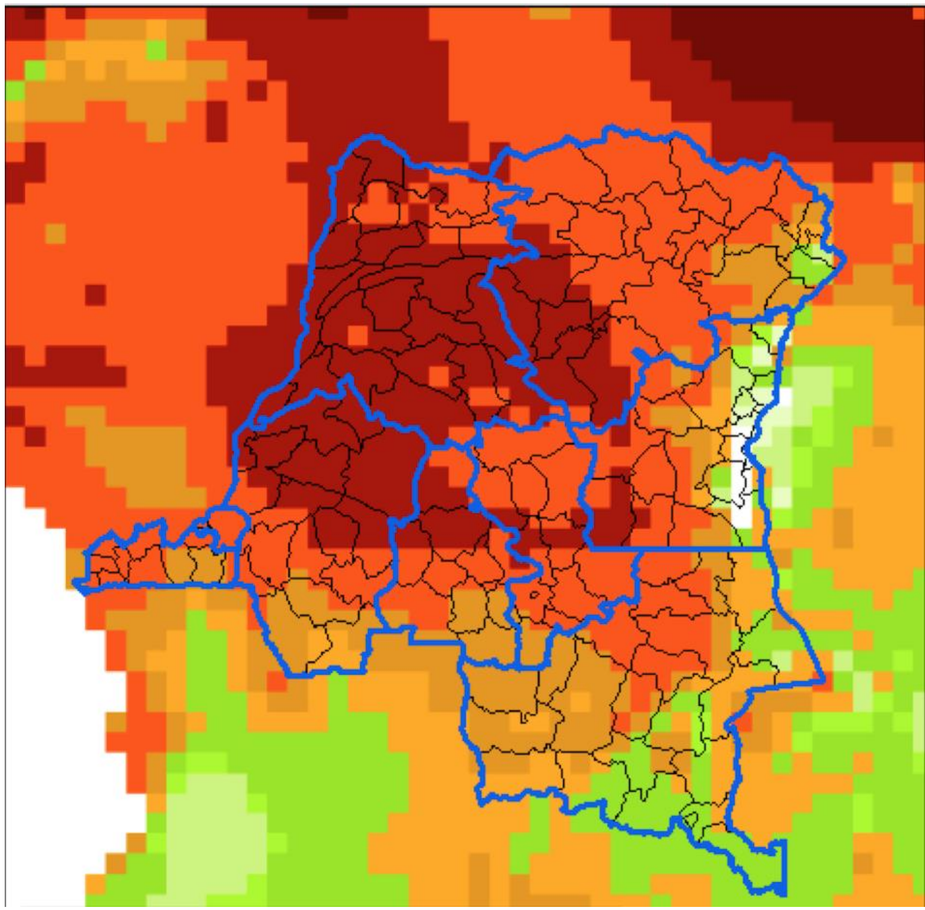


GEOSPATIAL IMPACT EVALUATION

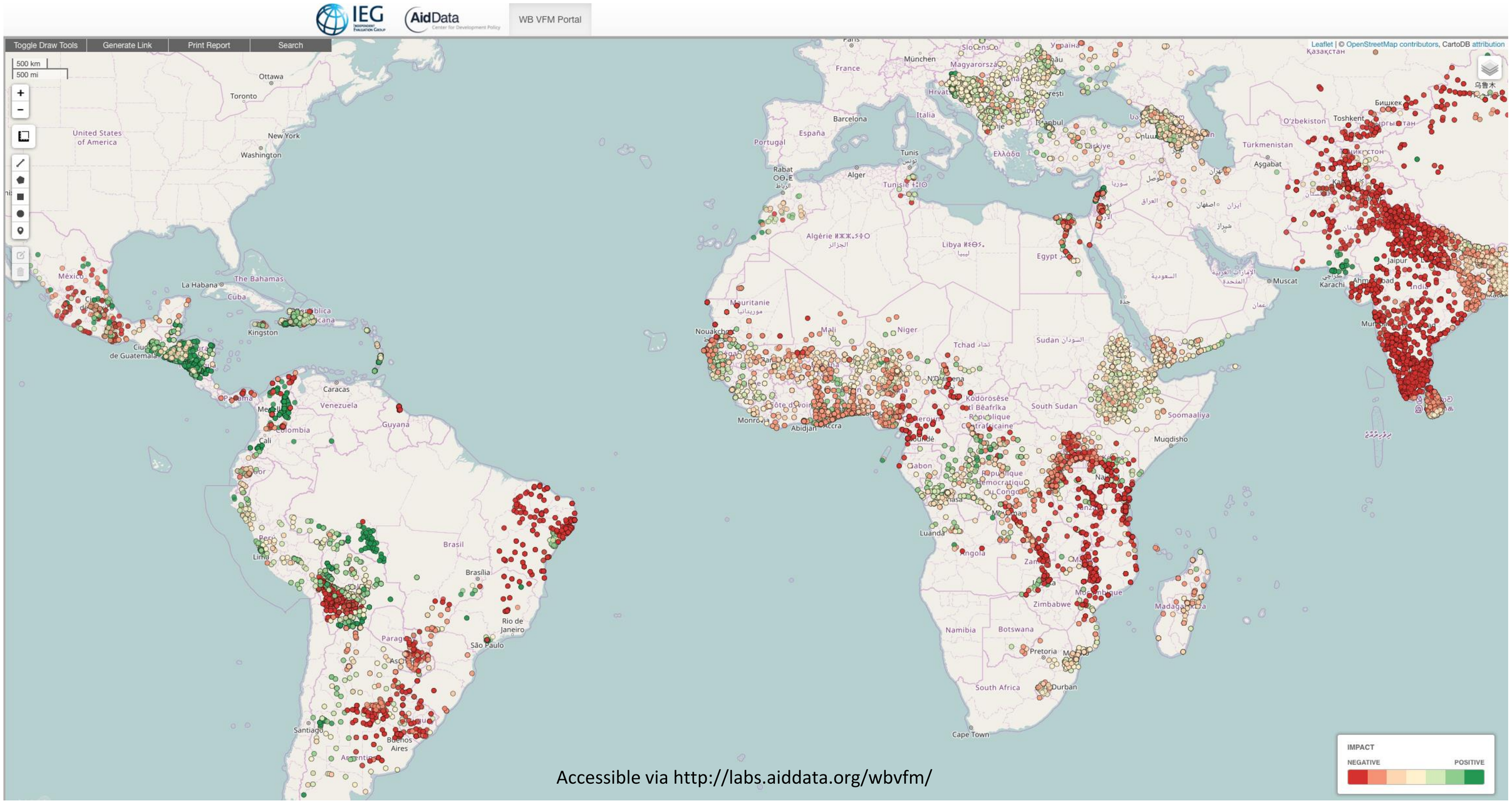
World Bank DRC Malaria Bednet Distribution Evaluation

$500M in 2012-2016
Evaluation finds that campaigns only effective
at reducing child mortality in areas with high levels of malaria transmission





Evaluating spatially heterogeneous impacts



Accessible via http://labs.aiddata.org/wbvfm/

GEOSPATIAL IMPACT EVALUATION

WB/KFW-funded PPTAL project in Brazil

Land tenure protections for 106 indigenous communities in 1995-2008
Evaluation finds no effects on deforestation

Georeferenced intervention data

Georeferenced outcome data

GEOSPATIAL IMPACT EVALUATION

What are the key ingredients?

Spatial information on program (investment) activities

- Where did the activities take place (and when)?

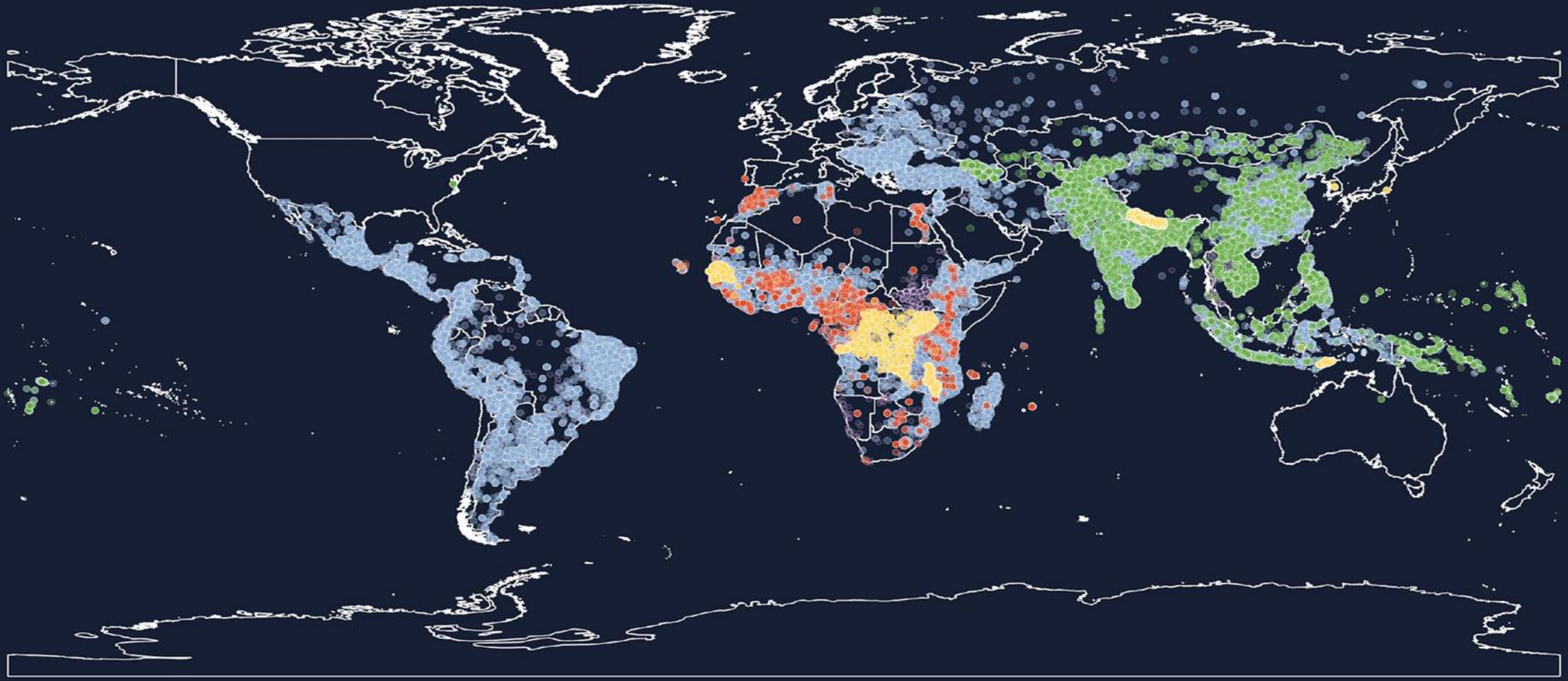
High-resolution, time-varying geo-referenced outcome and covariate data

- Geo-referenced census and survey data (e.g. child mortality)
- Remotely sensed data (forest cover, crop yields, nighttime light, household wealth)
- Remotely generated event data
- Administrative data

Quasi-experimental methods of causal attribution

- Use of matching, difference-in-differences, fixed effects, and regression discontinuity techniques
- Can say with confidence that the program caused change in outcome of interest – or not

205,000 geocoded development interventions worth over $1.23 trillion



Source: http://aiddata.org/subnational-geospatial-research-datasets

GEOCODING

The State of the Art

Retrospective coding

Cover historical portfolio from:

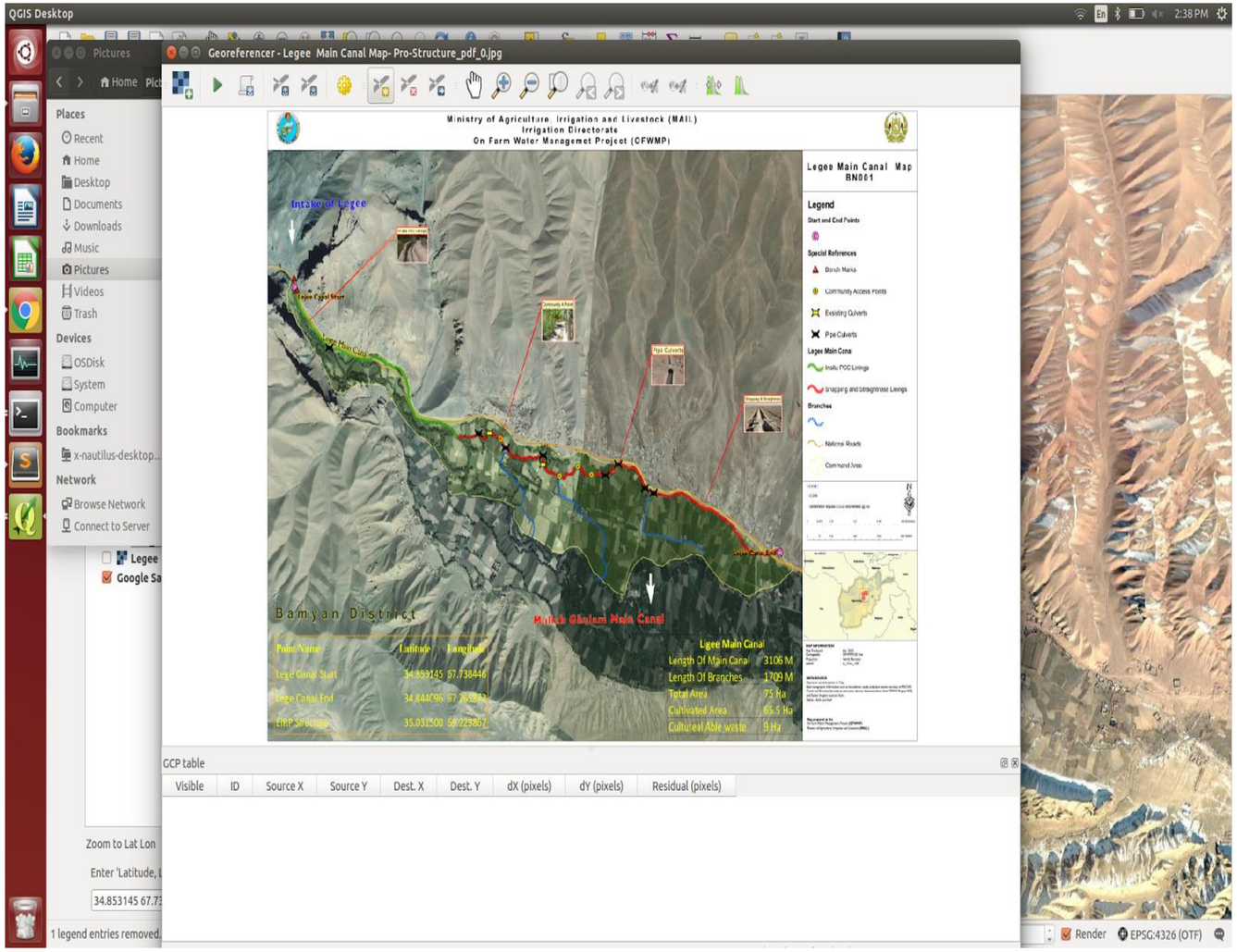
- PDFs (e.g., World Bank, GEF)
- In-country fellows gathering location lists (Aid Information Management Systems)
- Donor information systems (AsDB, DADs)
- Media and third-party sources (China)

New advances in geocoding

- Linear infrastructure (roads, power, irrigation)
- Polygons (land tenure, protected areas, etc.)

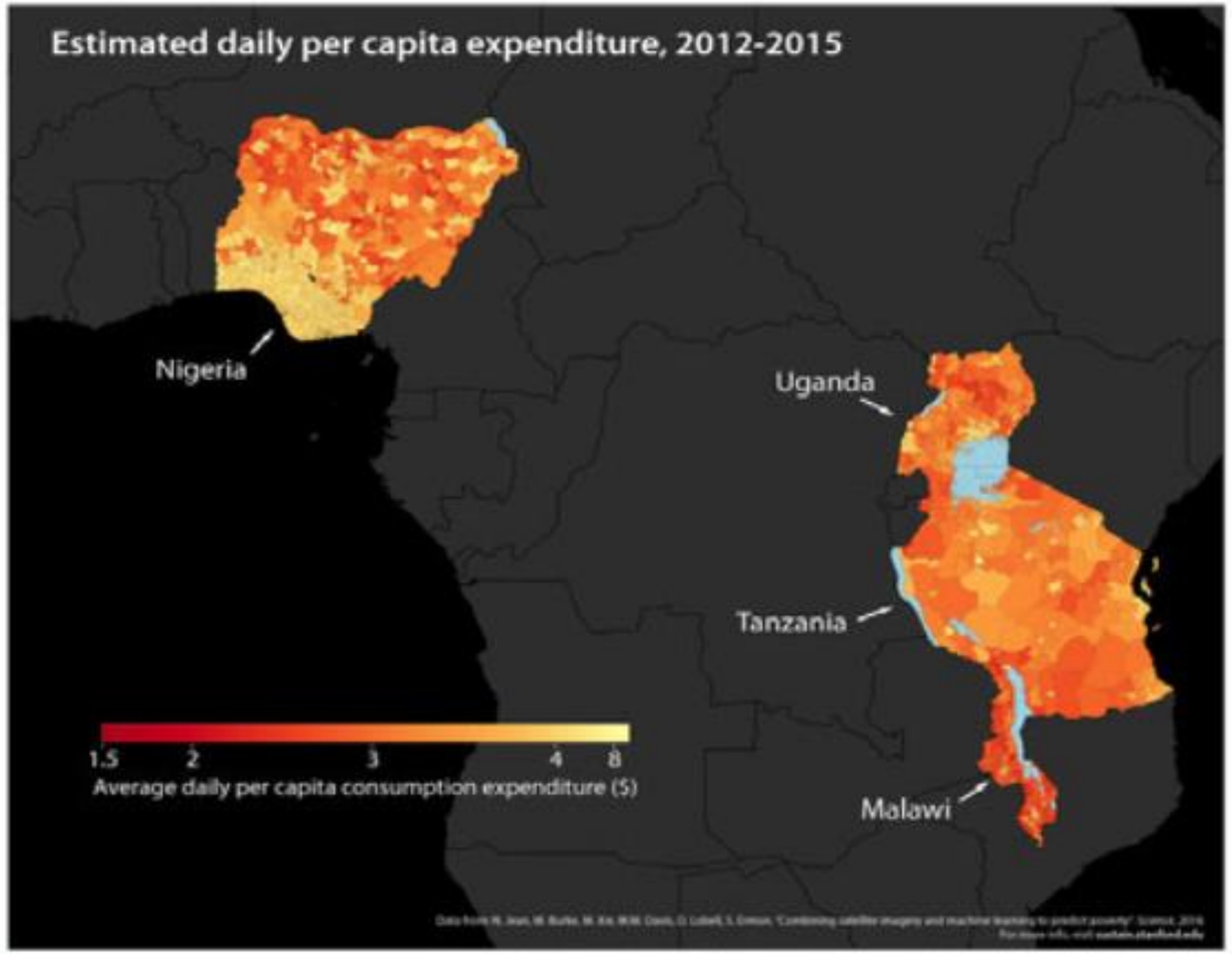
GEOCODING

Geocoding 2.0:
Richer, more precise data on activities



SATELLITE-BASED POVERTY MEASURES

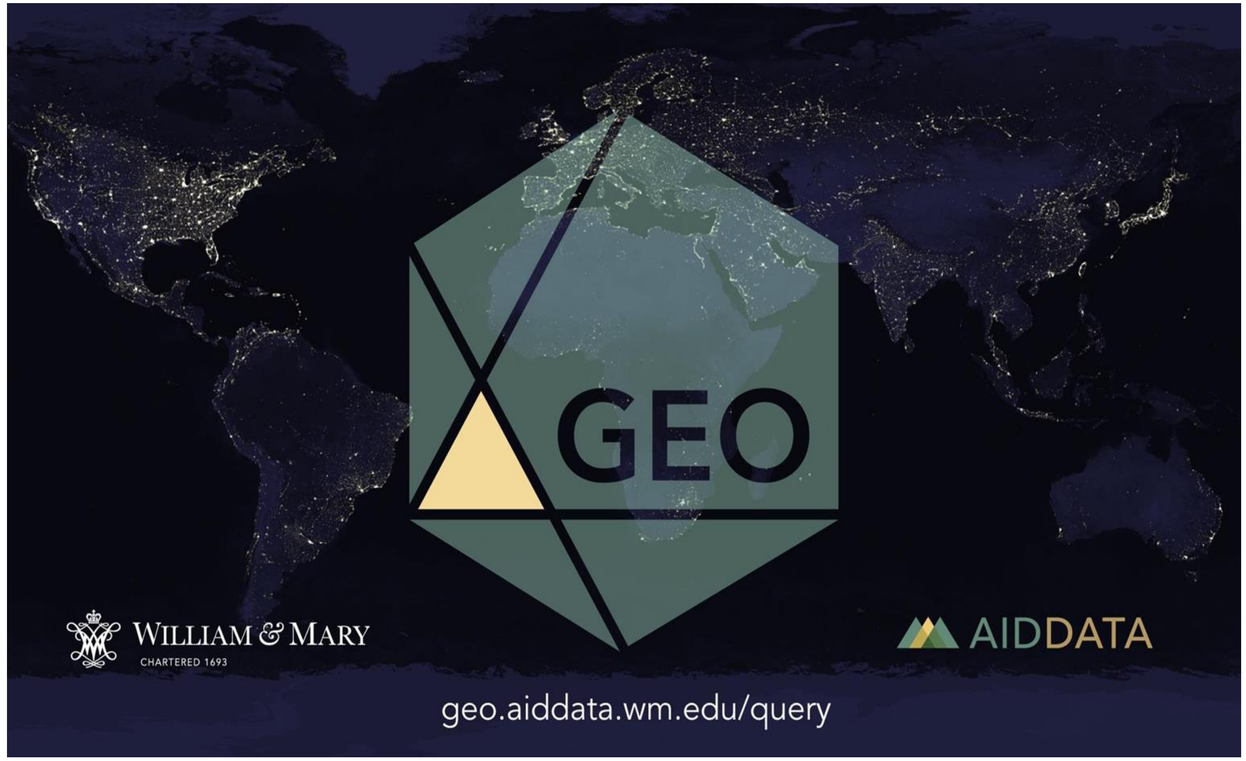
Jean et al. 2016 *Science*



Source: http://sustain.stanford.edu/predicting-poverty

ACCESSING GIS DATA ON OUTCOMES

Our geo portal at geo.aiddata.org



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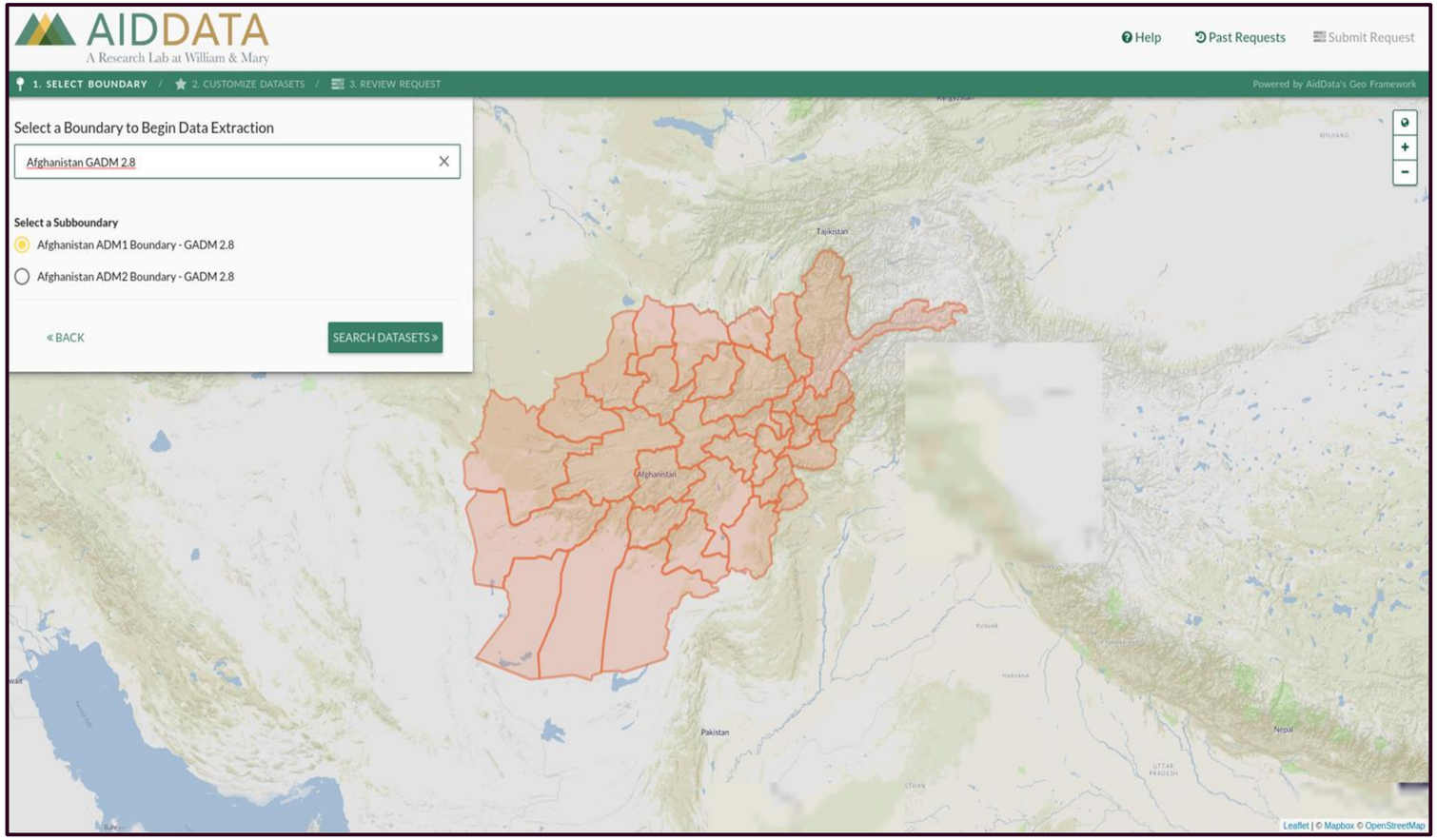

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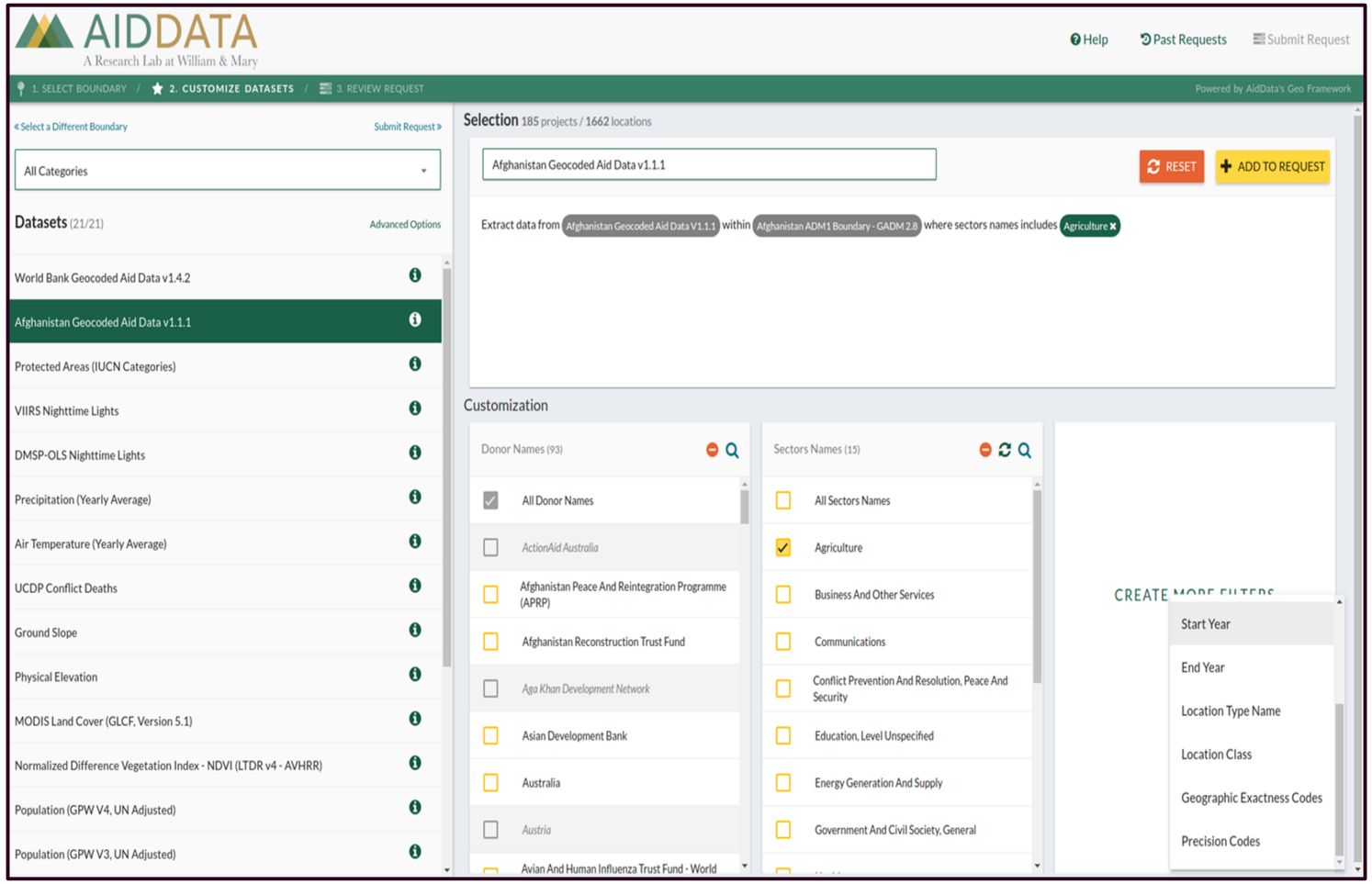

ACCESSING GIS DATA ON OUTCOMES

Our geo portal at geo.aiddata.org

- Nighttime Lights (VIIRS, DMSP)
- Greenness (NDVI)
- Population (CIESIN)
- Roads
- Child Mortality in Africa (Burke et al)
- Natural resource deposits
- Conflict
- Particulate matter
- … and many more coming soon

GEOGRAPHIC TREAMENT SPILLOVER

- Geographic treatment spillover to (nearby) control units can result in erroneous estimates of causal impact
- Example: when a clinic may not only improve health outcomes in the geographic neighborhood where it is located, but also in nearby neighborhoods
- Geomatch is a wrapper around another R package, MatchIt, that AidData has developed to account for potential bias due to geographic treatment spillover
- A measure of distance decay – specifically, Moran's I over different distances – is used to establish spatial thresholds and penalize propensity-score matches such that matches with a low probability of geographic treatment spillover are favored.

SPATIAL HETEROGENEITY IN TREATMENT EFFECTS

- AidData and W&M Computer Science Dept. are using machine learning techniques—specifically, a new approach that leverages classification and regression trees—to examine spatially heterogeneous treatment effects across large numbers of intervention sites
- For technical details, see Runfola et al. 2017 at http://www.mdpi.com/2071-1050/9/3/409
- Ability to measure geographically heterogeneous treatment effects can support future project siting decisions

SPATIAL MEASUREMENT IMPRECISION

- When an project is sited in a district, but the exact location within the district is unknown
- geo(simex) – an R-based statistical package currently under development at AidData – first simulates the effect of adding measurement error to a given spatial variable
- Then, once the trend in measurement error has been estimated, geo(simex) back-extrapolates to conditions of no spatial measurement error
- The purpose of this simulation-based method is to reduce bias in estimates of causal impact that result from use of variables that are measured with imprecision—a defining feature of many spatial data
- For technical details, see https://dl.dropboxusercontent.com/u/1562312/Papers/Runfola%20et%20al%20%282016%29.pdf

GEOSPATIAL IMPACT EVALUATION

Limitations

- Only useful for programs that are spatially distributed (implemented in some locations but not others)
- Not always possible to measure the exact timing of program rollout
- A growing number of outcome variables are available, but not for all sectors and intervention types (yet)
- Unobserved confounds; not always possible to measure pre-treatment levels and trends

EXTRA SLIDES

GEOSPATIAL IMPACT EVALUATION

Application # 2 in Afghanistan: On-Farm Water Management Project (OFWMP)

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OFWMP provided water to 19,000 hectares of land through the rehabilitation of 100 canals between 2011 and 2015.

AidData digitized static maps of the canals and surrounding cultivated areas and linked this with administrative program data to identify exact location and timing of improvements for OFWMP Phase 1 canals.

For crop productivity outcome data, we use Landsat satellite observations of vegetation at the 30m x 30m grid cell level.

Our analysis includes quarterly vegetation data for 300,000 grid cells between 2006 and 2016, in addition to other relevant covariates measured annually.

The month and year of canal rehabilitation serve as the timing of treatment for each of the 30m cells that fall within the canal's cultivated area, allowing the utilization of a difference-in-differences estimation strategy to examine OFWMP's impact on crop productivity.

GEOSPATIAL IMPACT EVALUATION

Example from the WB/KFW-funded PPTAL project in Brazil

Evaluation Period: 1995-2010

Unit of Analysis: 151 communities; ~400,000 4km x 4km grid cells

Treatment: Boundaries of community lands + administrative data on demarcation dates

Outcome: Normalized Difference Vegetation Index (NDVI), a satellite-based measure of greenness satellite

Covariates: Slope, elevation, precipitation, temperature, urban travel time, population density, distance to roads and rivers, and pre-treatment levels and trends in NDVI

Methods: Propensity score matching to compare rates of deforestation across matched treatment and comparison communities

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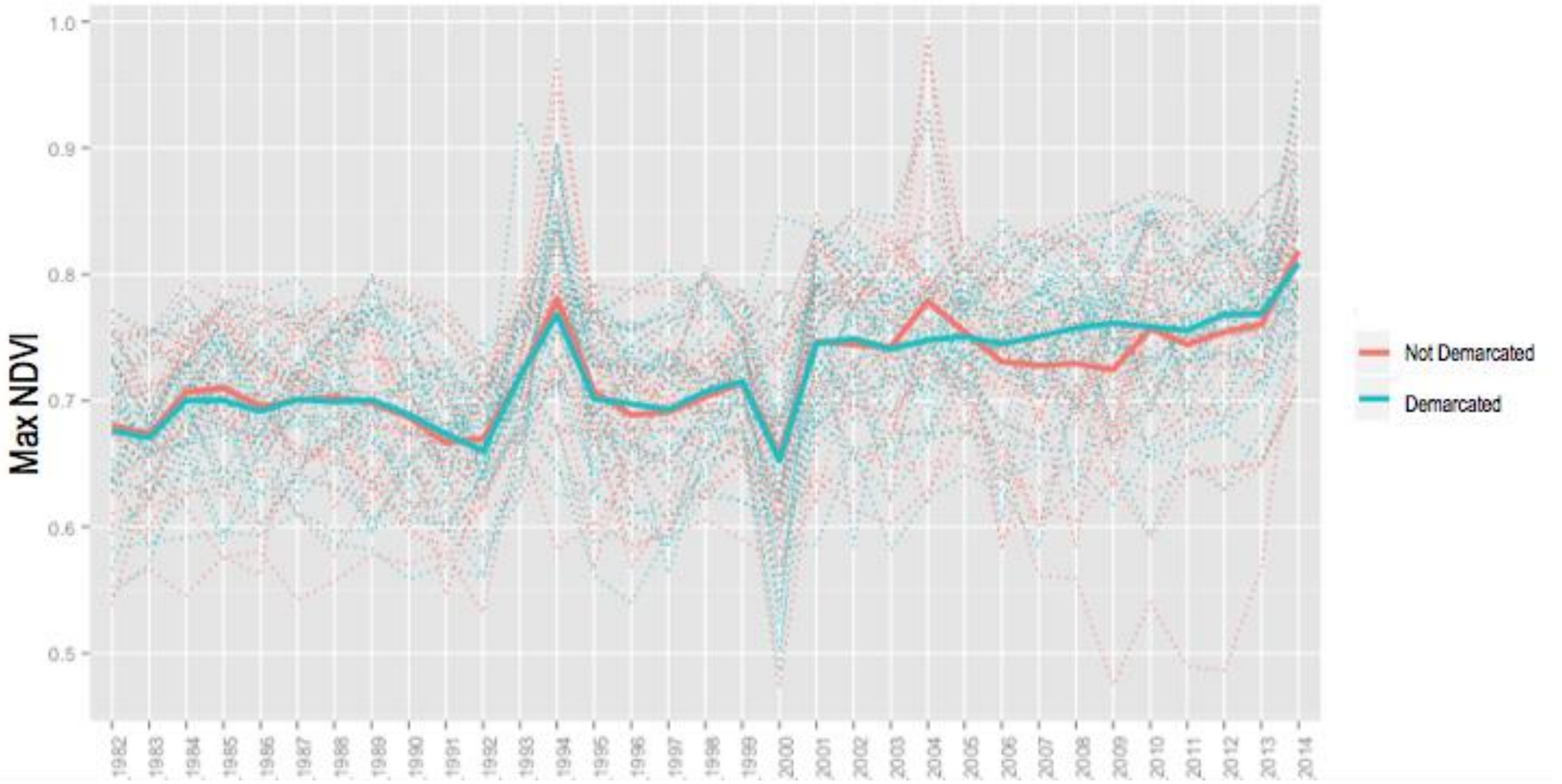
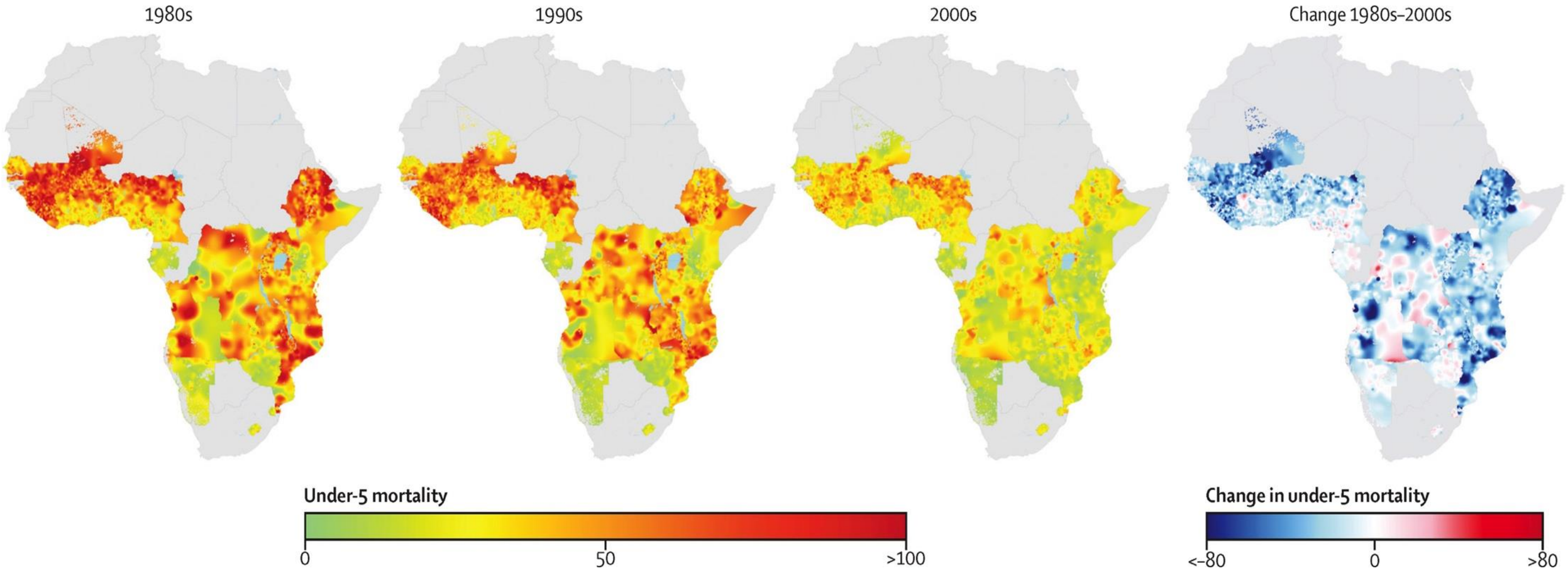
Source: BenYishay et al 2016



Source: BenYishay et al 2016

Last mile targeting to ensure no one is left behind



Source: Burke, Marshall, Sam Heft-Neal, and Eran Bendavid. 2016. Understanding variation in child mortality across Sub-Saharan Africa: A spatial analysis. *The Lancet Global Health* 4 (12): e936-e945.

GEOSPATIAL OUTCOME DATA

What is available?

Available Now

- Nighttime light, 1992-2017 (NOAA)
- Normalized Difference Vegetation Index (NDVI), 1982-2015 (NASA)
- Tree Cover Loss, 2000-2014 (Hansen et al.
- Point-based LSMS and DHS data, various countries and years
- Rasterized DHS child mortality data for 1980s, 1990s, 2000s (Burke, Heft-Neal and Bendavid 2016)
- Conflict event data from ACLED, UCDP, SCAD
- Georeferenced Afrobarometer data (1999-2015)

Coming Soon

- Satellite- and machine learning-based poverty estimates (based on Jean et al. 2016)
- Small-area crop yield estimations (based on Burke and Lobell 2016)

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INTERVENTION DATA

Available Now

- IDA and IBRD projects, 1995-2014 (more than 61,000 intervention sites)
- Chinese development projects in Africa, 2000-2013 (more than 3,000 interventions sites)
- Various partner country-specific aid information management systems (e.g. Malawi, Nepal, Senegal, Timor-Leste, Nigeria, Somalia, Afghanistan, Colombia)
- Overseas Humanitarian Assistance Shared Information System (more than 20,000 intervention sites)

Coming Soon

- Asian Development Bank project portfolio, active and historical
- Global Environment Facility projects, active and historical
- Chinese development projects worldwide, 2000-2014

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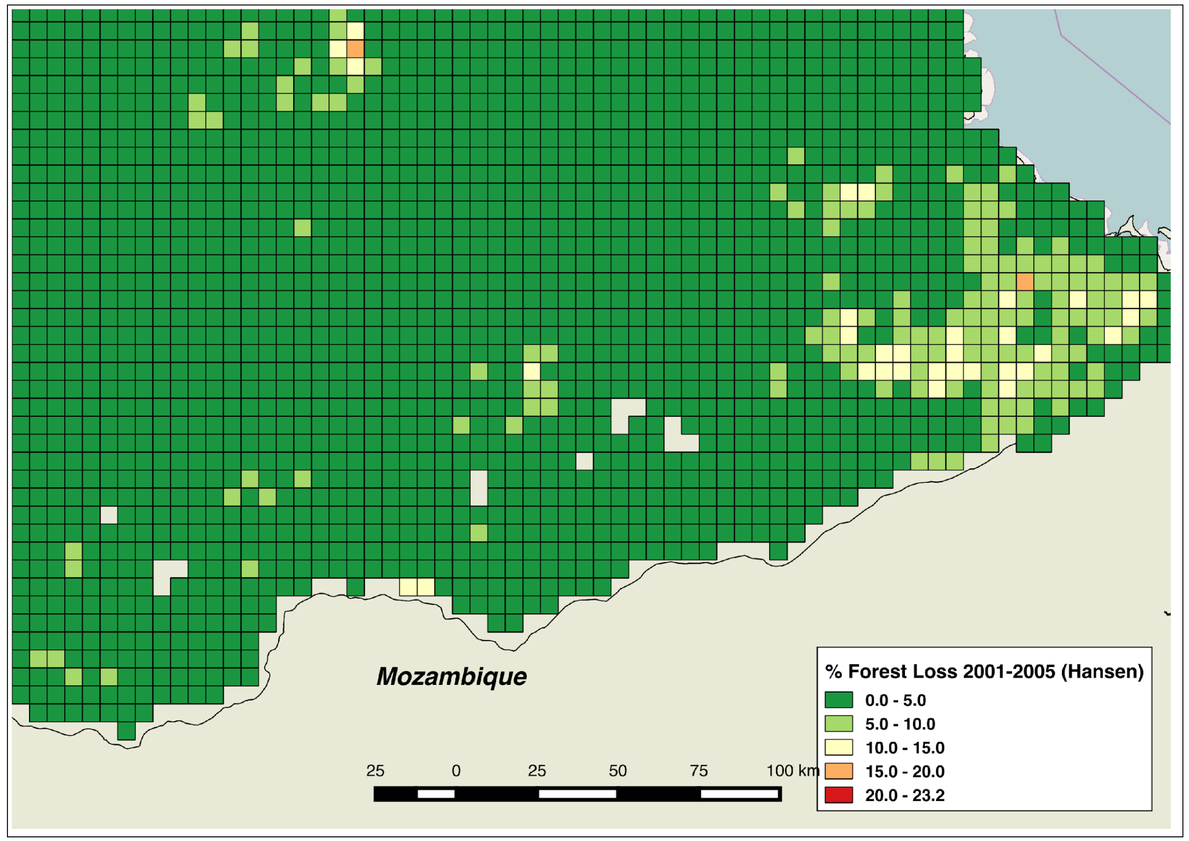
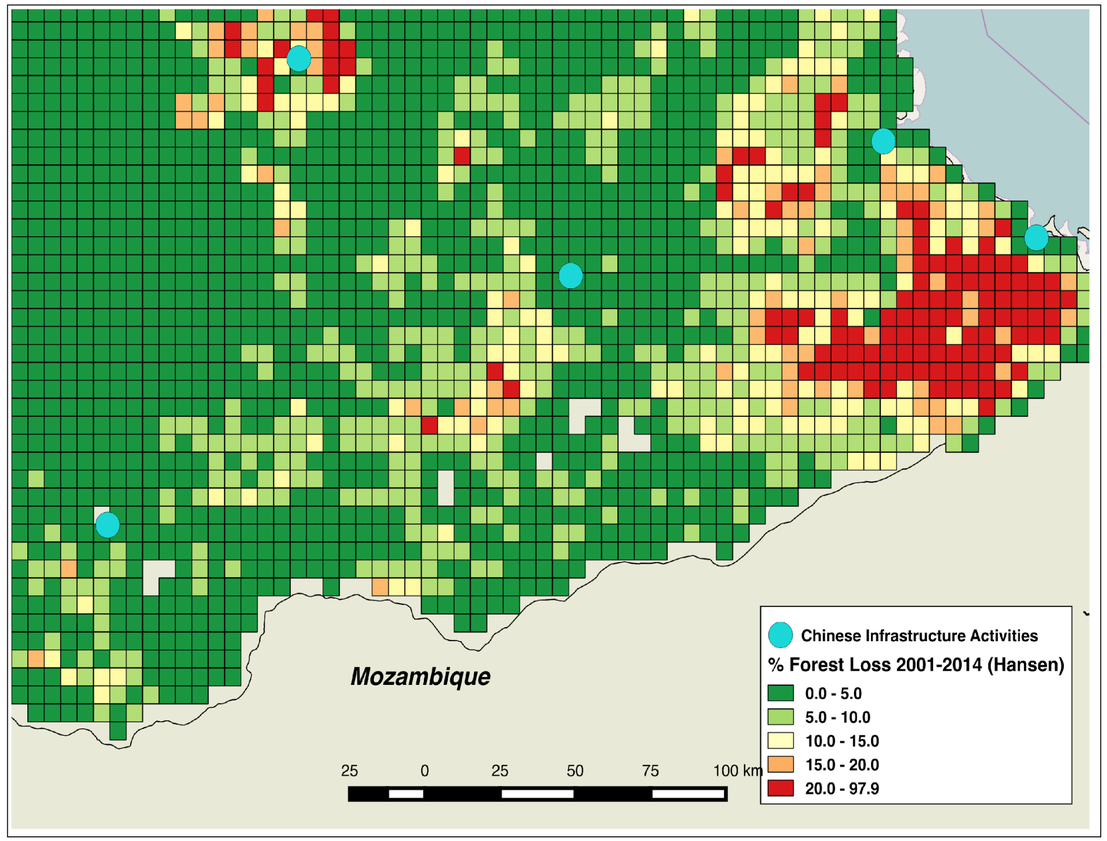
The Ability to Account for Pretreatment Outcome Levels & Trends

Deforestation in Southeast Tanzania Before Project Rollout



Deforestation in Southeast Tanzania Over Project Rollout Period



Source: BenYishay et al 2016

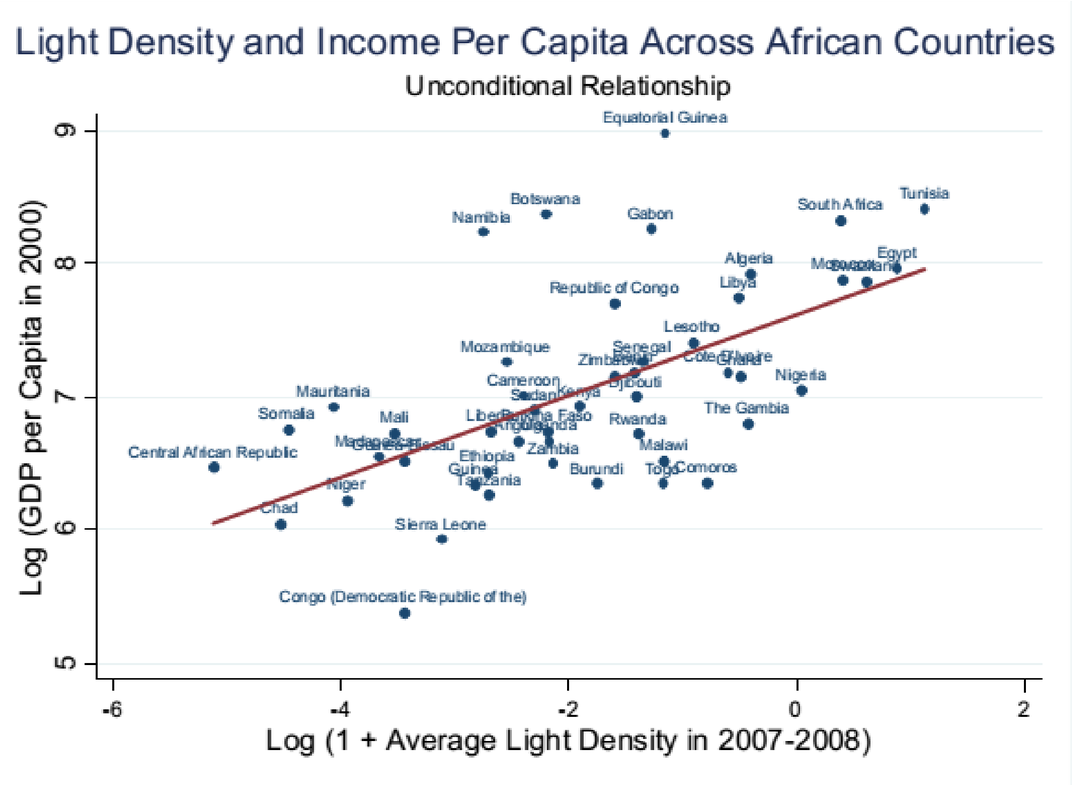


Figure 3*a*

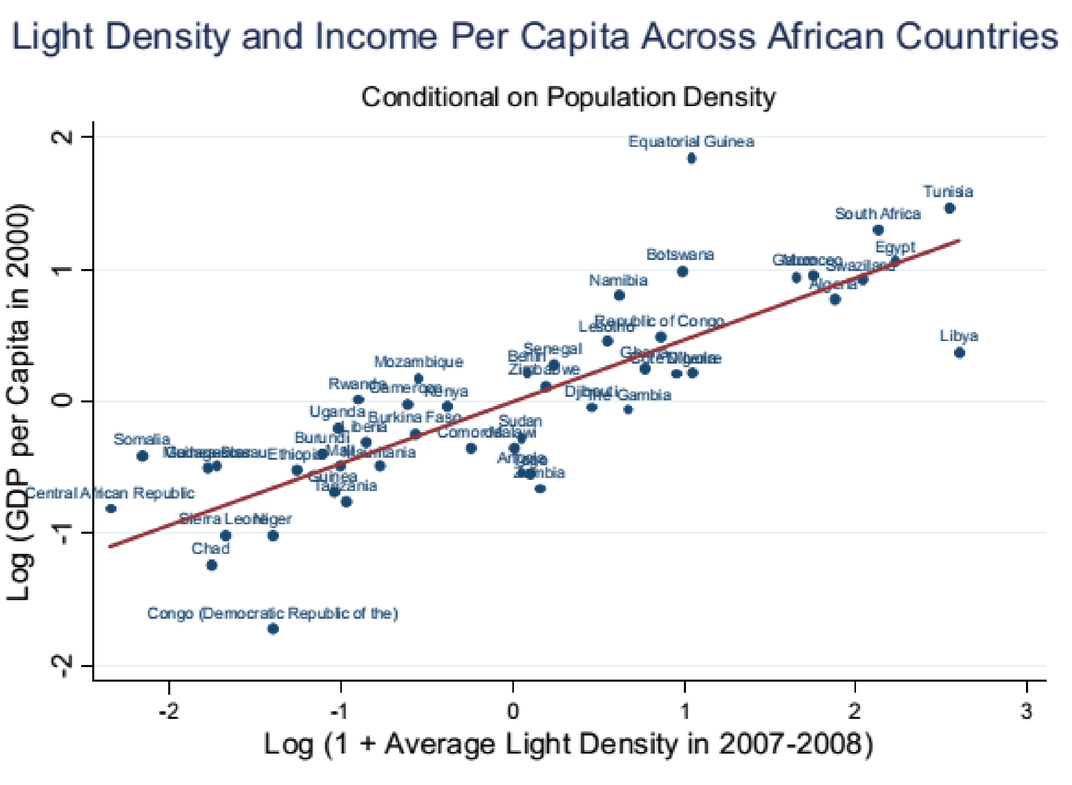


Figure 3*b*

Michalopolous and Papaioannou (2014)

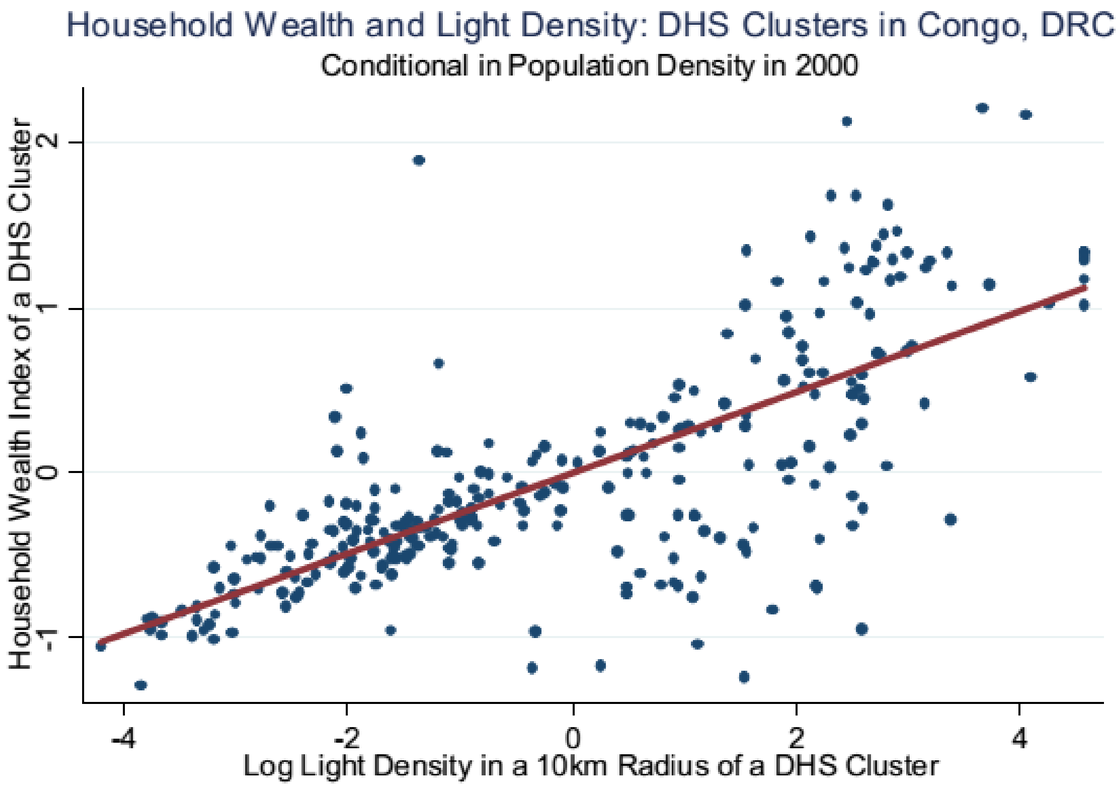


Figure 5*c*

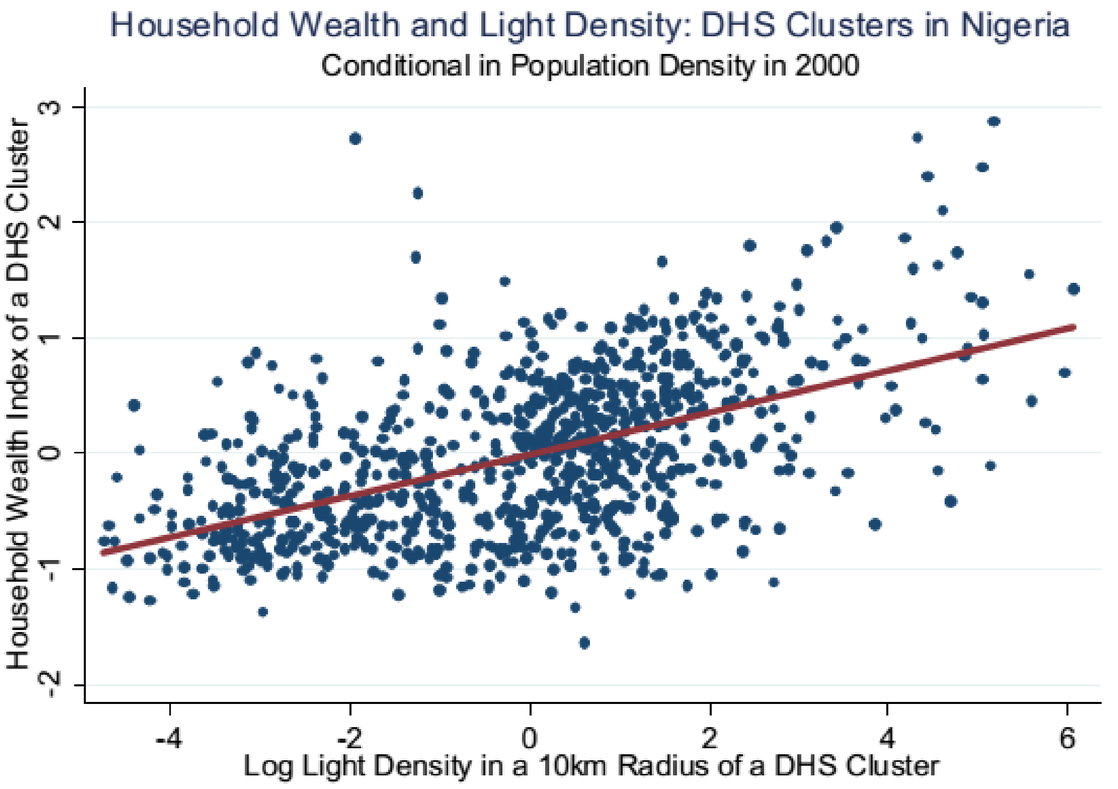


Figure 5*d*

Michalopolous and Papaioannou (2014)

NIGHTTIME LIGHT

Limitations

- Overglow problem – light spill over from one spatial unit to an adjacent unit – is particularly acute in well-lit, urban areas; this makes it difficult to reliably detect changes at fine spatial scales

- In very poor, unlit areas (grid cells with values of 0 on the 0-63 luminosity scale), it is difficult to detect (modest) changes in local economic development outcomes; it is therefore difficult to detect treatment effects among the ultra-poor

- Detection limit of the sensor (unobserved wealth beyond 63)

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NDVI

Advantages

- Monthly data available at 4km x 4km level from 1981 to present
- Consistently measured across time and space; calibrated and cross-validated with in-situ measurements (that serve as training set data)
- Ability to measure pre-treatment outcome levels and trends for both treatment and control areas
- Monthly measurement makes it possible to test for robustness with different versions of NDVI (e.g. max NDVI in given year captures “greenest” period of the year but its is more sensitive to noise, while mean NDVI is generally more reliable but can also fail to capture greenness due to averaging across seasons)
- From 2000 onward, available at 250m resolution

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NDVI

Limitations

- Sensitive to climatic conditions, although easy to control for temperature and precipitation at the same temporal and spatial scales
- Changes over time do not always unambiguously measure forest gain and forest loss; can capture crops with high levels of chlorophyll content
- Top-end saturation can make it difficult to detect forest densification in some areas

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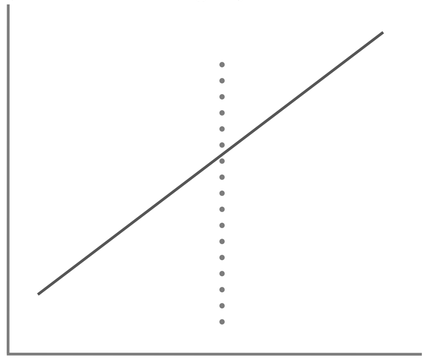
WOULD MY PROGRAM BENEFIT FROM A LONG-RUN IE?

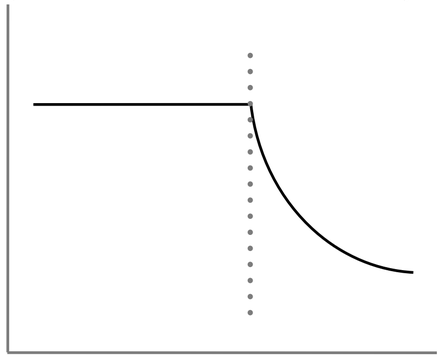
Program impact trajectories can vary dramatically. Need to think about the "functional form" of the intervention.

For a more detailed review of program impact trajectory thiniing, read Woolcock. Michael. 2009. Toward a plurality of methods in project evaluation: a contextualised approach to understanding impact trajectories and efficacy. Journal of Development Effectiveness 1 (1): 1-14.

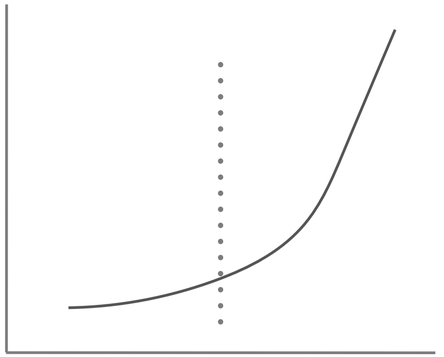
Higher Education
(Outcome: Wages)



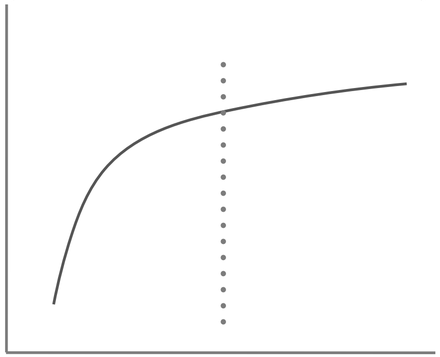
Anti-Retrovirals
(Outcome: Death from infection)



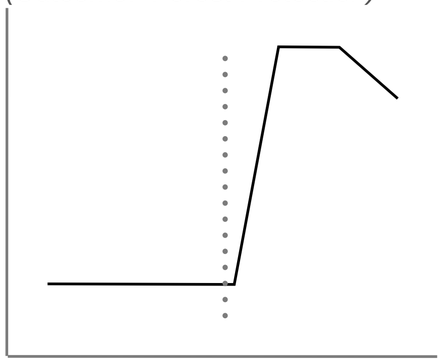
Roads
(Outcome: Economic Development)



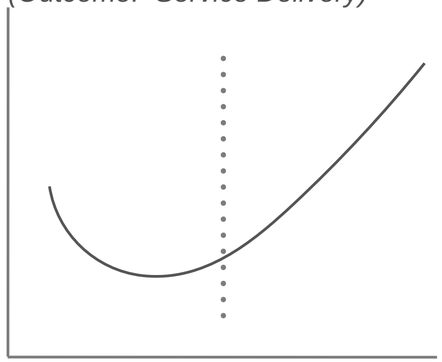
Measles
(Outcome: Reduction in infection)



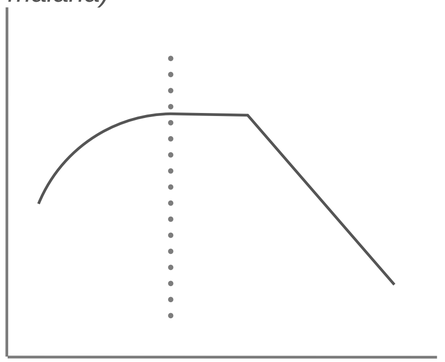
Land Rights
(Outcome: Forest Protection)

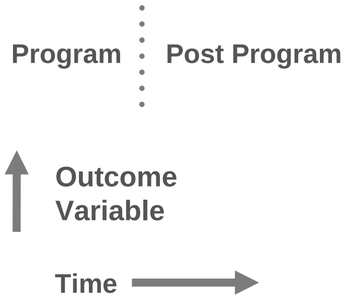


Decentralization
(Outcome: Service Delivery)



Spraying for mosquitos
(Outcome: Prevented cases of malaria)





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