Using artificial intelligence (AI) and remote sensing for poverty measurement

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The motivating problem

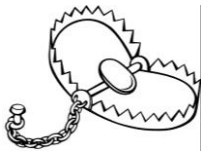
Despite the progress humanity has made in the last century, “many children die every day globally due to poverty and unequal access to resources” (UNICEF 2020)

A major question is whether life in poor communities fundamentally is so different that it can trap people in cycles of poverty (Banerjee and Duflo 2012)

Do poverty traps exist, where, and how?

The "trapped poor farmer":

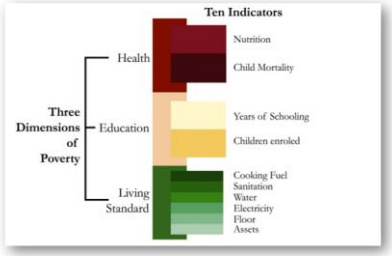
- **Initial situation**: Imagine a farmer with low yield. With a fertilizer, he could increase yield. Because of poverty he cannot buy a fertilizer. He remains poor indefinitely.
- **Policy intervention**: The only way to break this cycle of poverty is to give this farmer a fertilizer.
- **Expectation**: The farmer can increase yield, earn money, and invest in his community.

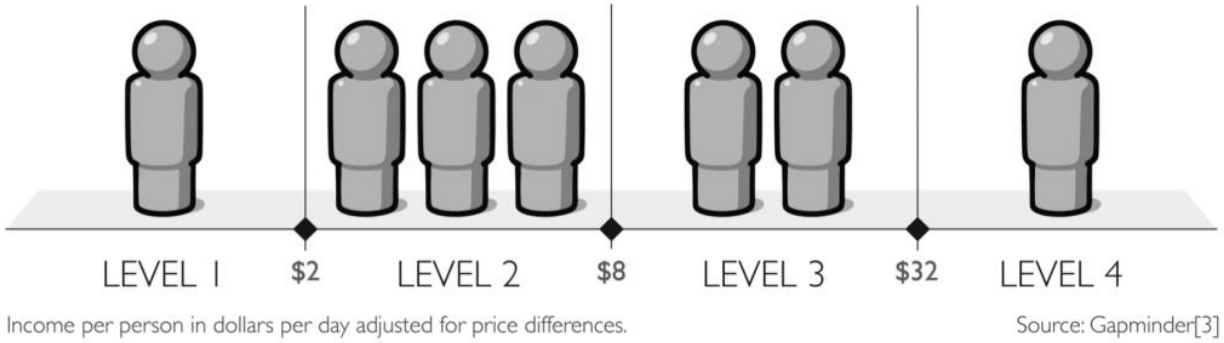


The "fertilizer" is a metaphor for other "resources", for example, income, governance, health systems, education, or infrastructure.

Poverty traps can exist in several dimensions

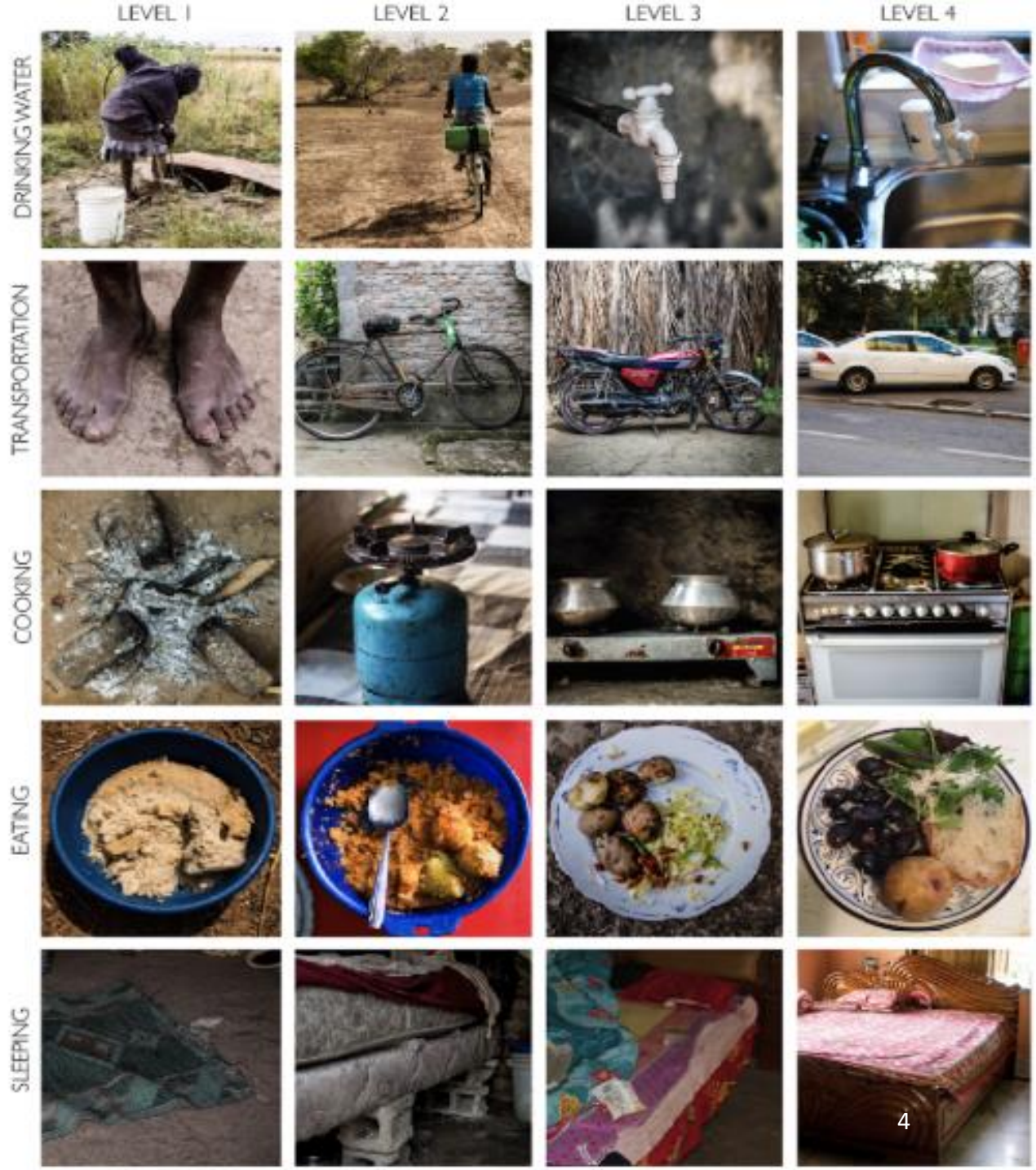
$Y =$

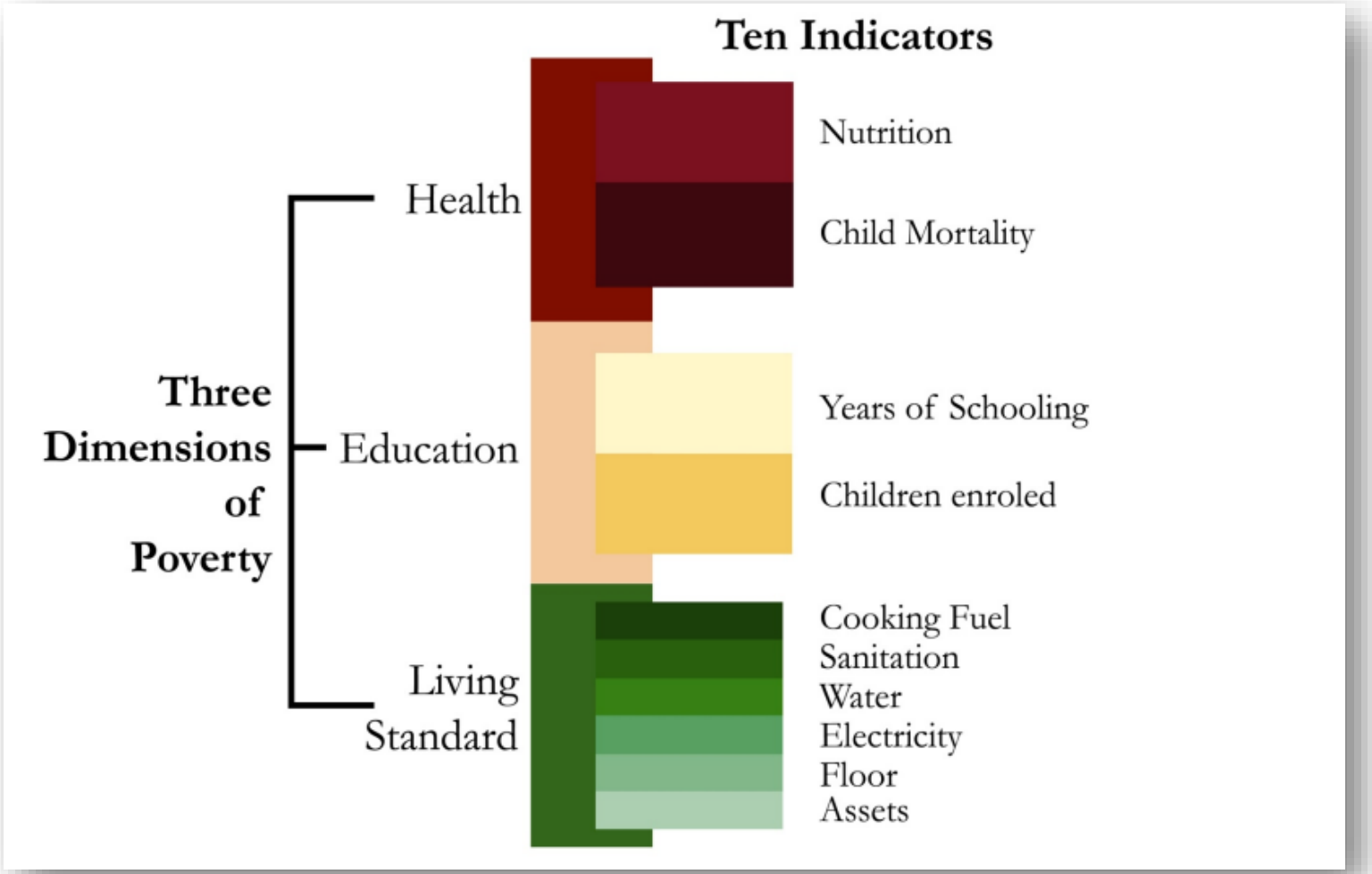




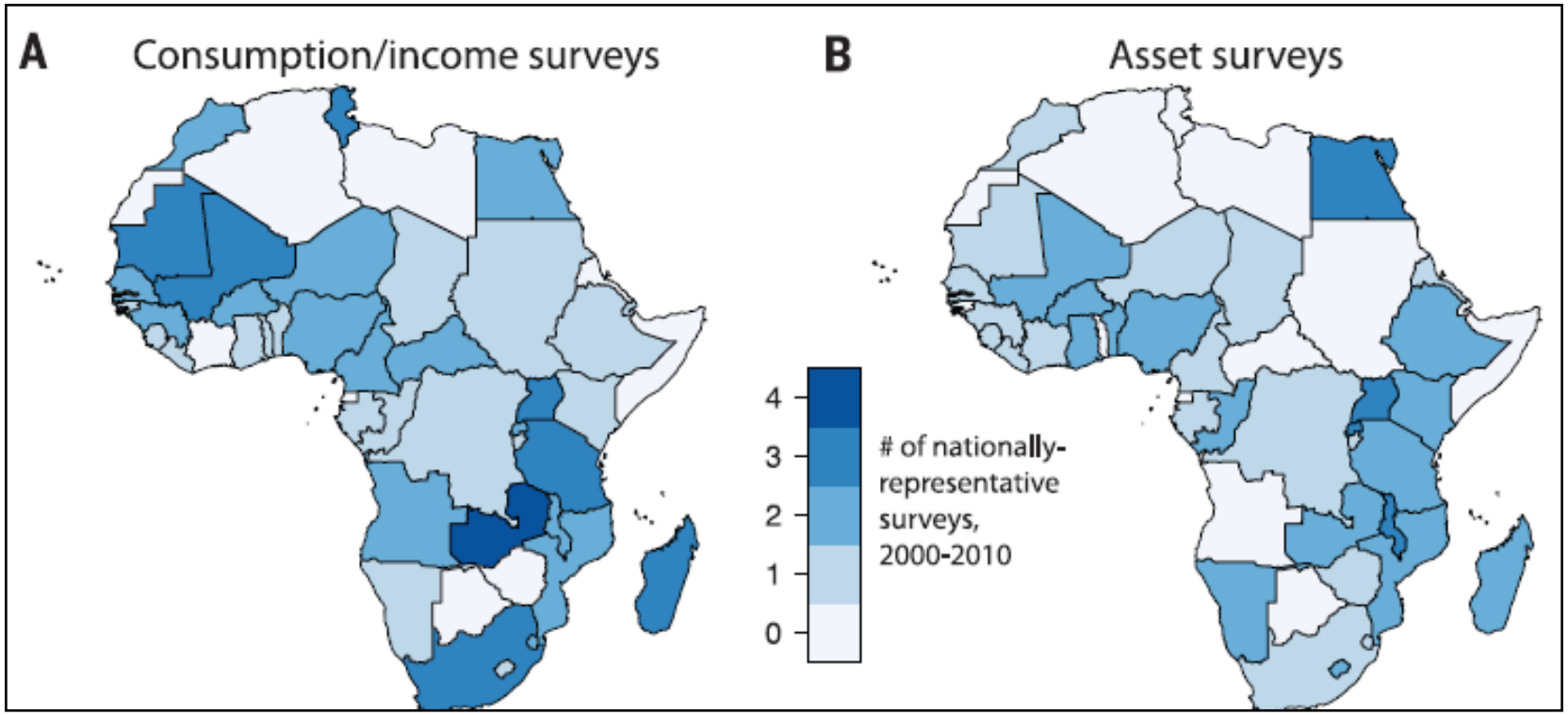
Income per person in dollars per day adjusted for price differences.

Source: Gapminder[3]




Ten Indicators
Three Dimensions of Poverty
Health
Education
Living Standard
Nutrition
Child Mortality
Years of Schooling
Children enroled
Cooking Fuel
Sanitation
Water
Electricity
Floor
Assets

Because of a lack of high-frequency human-development data across time and space, scholarship is limited on poverty traps and the efficiency of aid.

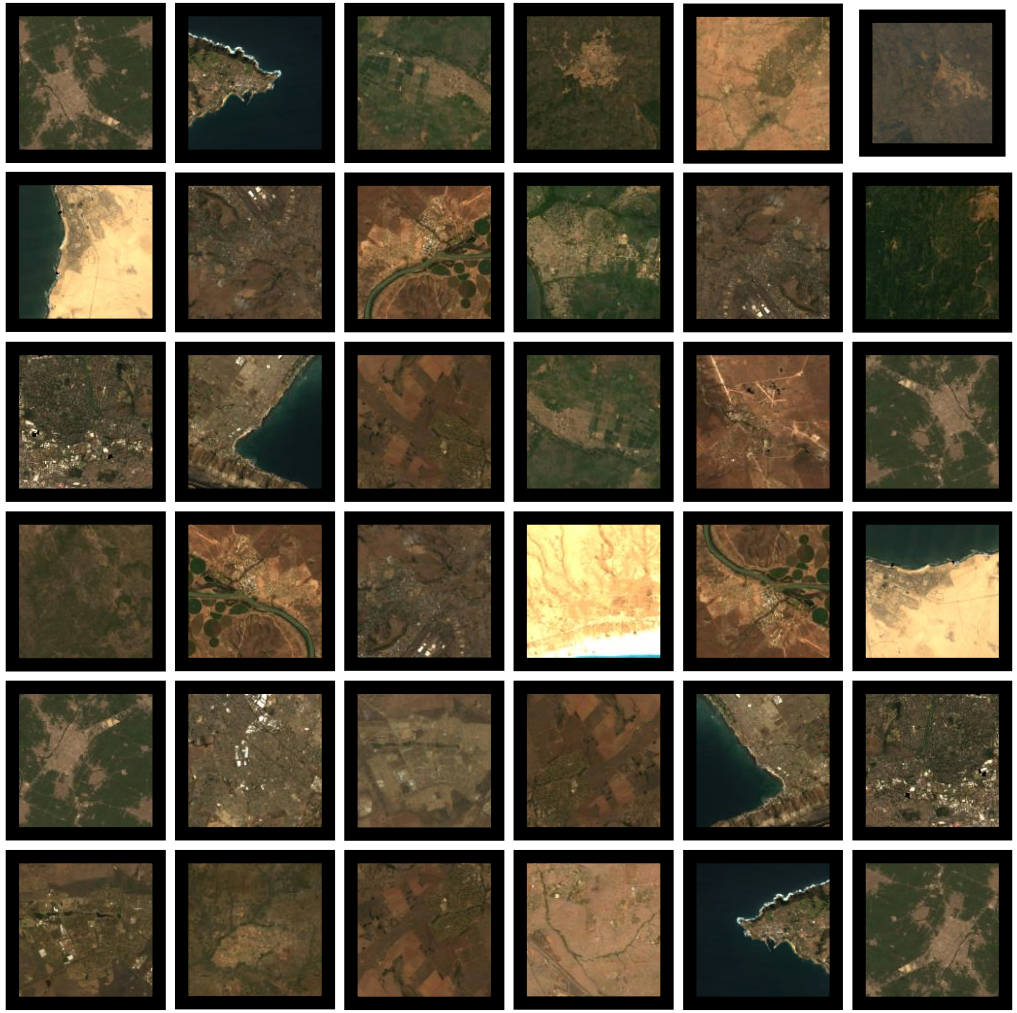


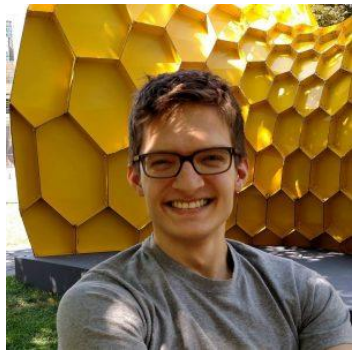
Source: Jean et al 2016

The AI and Global Development Lab

The vision of our Lab is to

"…combine AI and earth observation to analyze the causes and consequences of human development historically, geographically, and globally—thereby enhancing sustainability."











Funded mainly by the Swedish Research Council (SRC)

Combining AI and satellites

- Currently, the Lab is recreating historical and geographical human-development trajectories from satellite images from 1990s to 2020.
  - These new data will measure poverty at unprecedented temporal and spatial granularity


Google Earth Timelapse
Cape Town South Africa

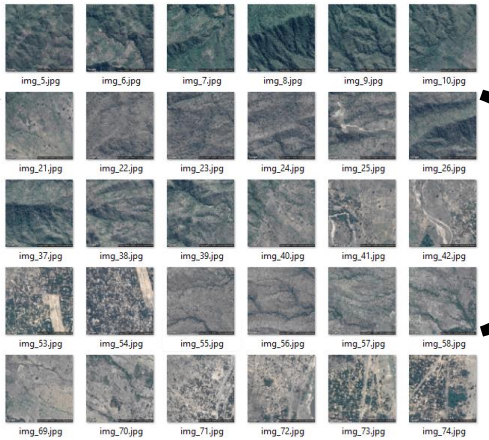
Temporal information

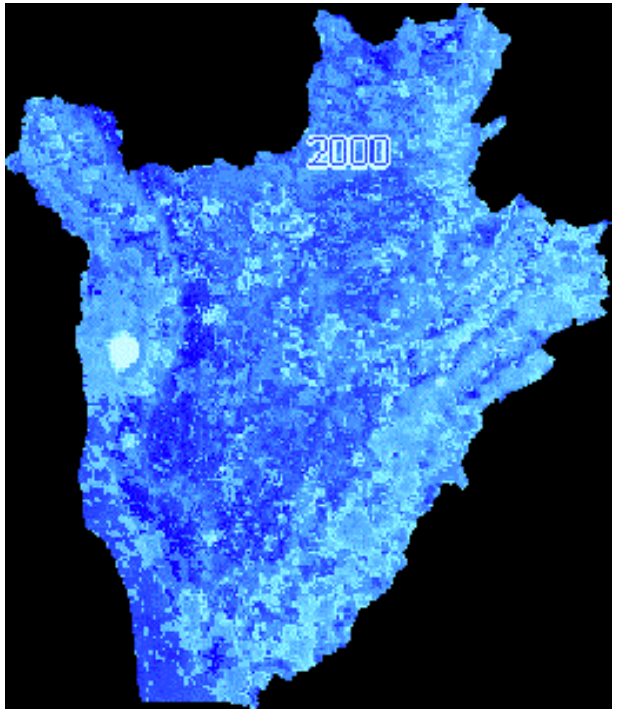
2020

1984 - 2020

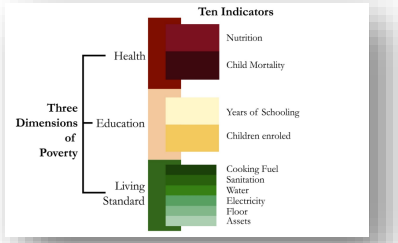
Constructing an algorithm for poverty measurement

$$f\left(\right)$$



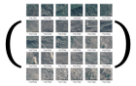


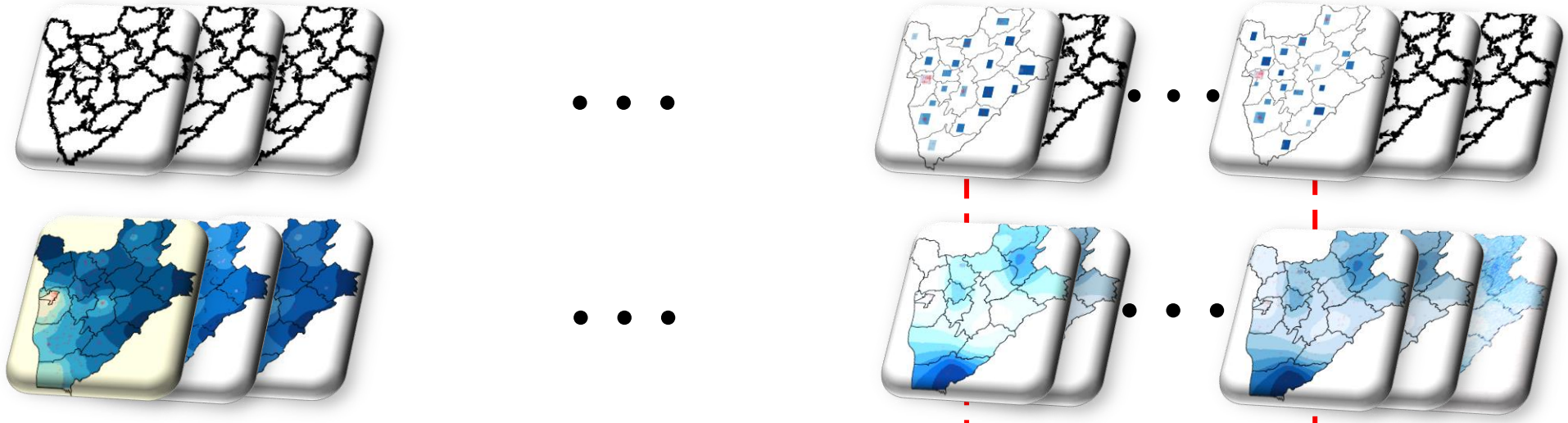
Our data product



Without our project

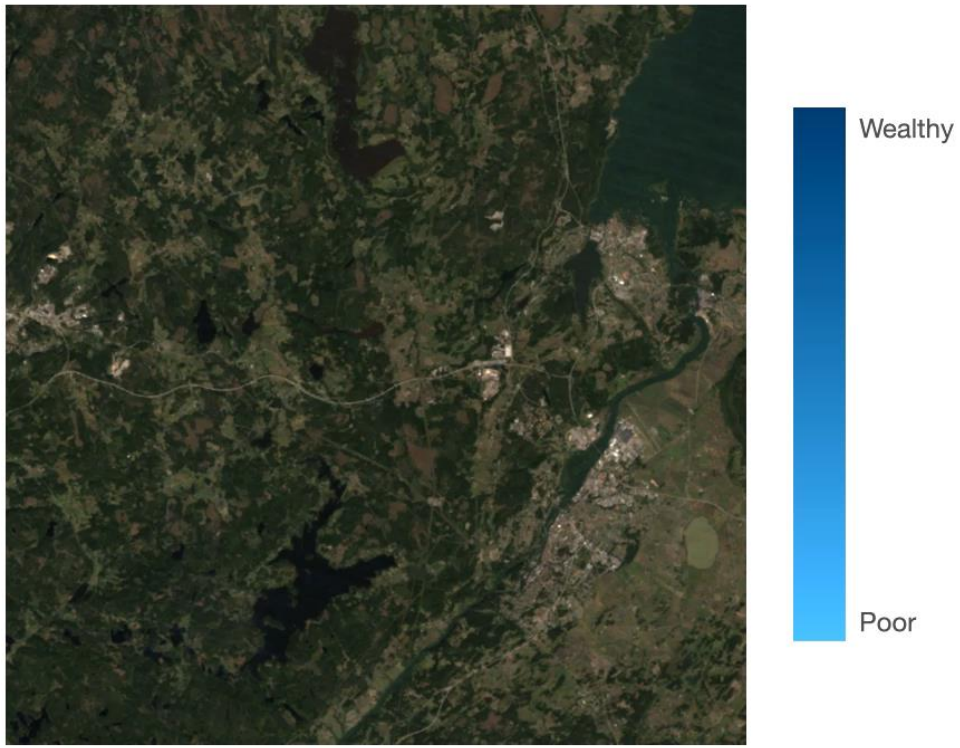
With our project

$f($  $)$ →



Problem description

Spatial poverty map



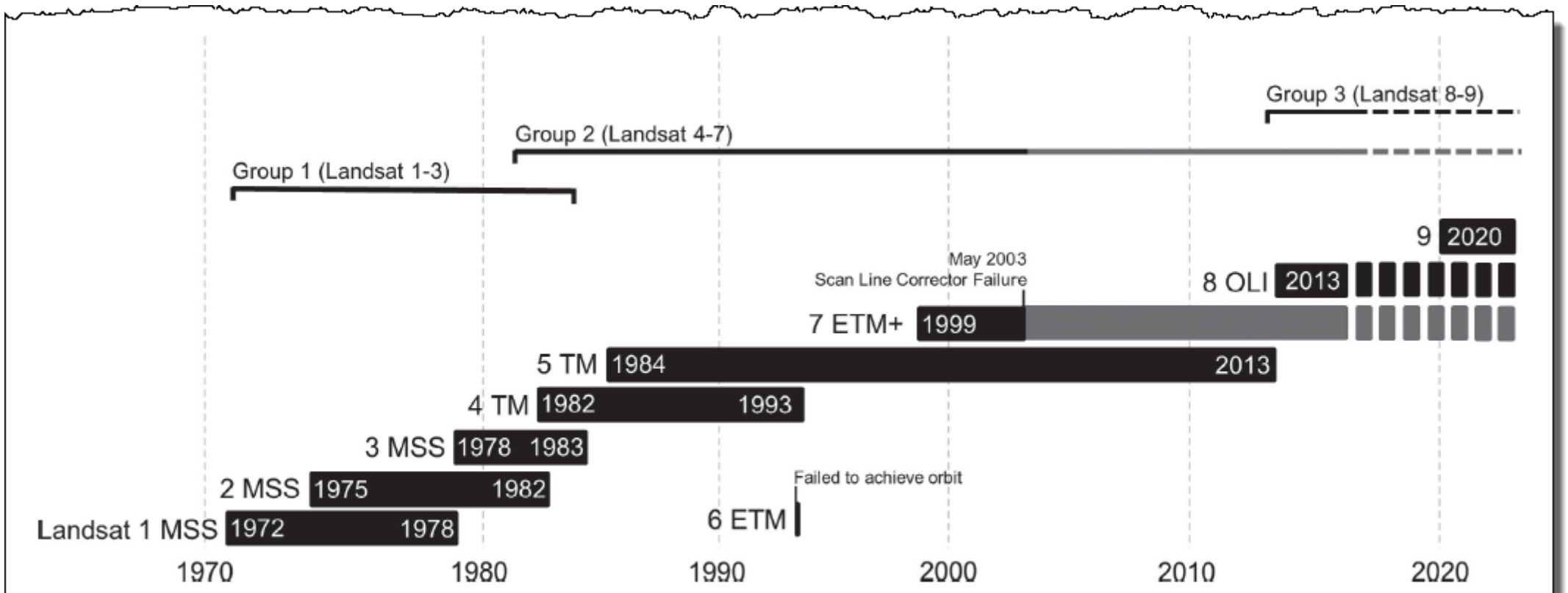


FIG. 1. A timeline of Landsat satellites and sensors. Landsat 9 launch date is based on recent congressional appropriations language.

Source: Young et al 2017

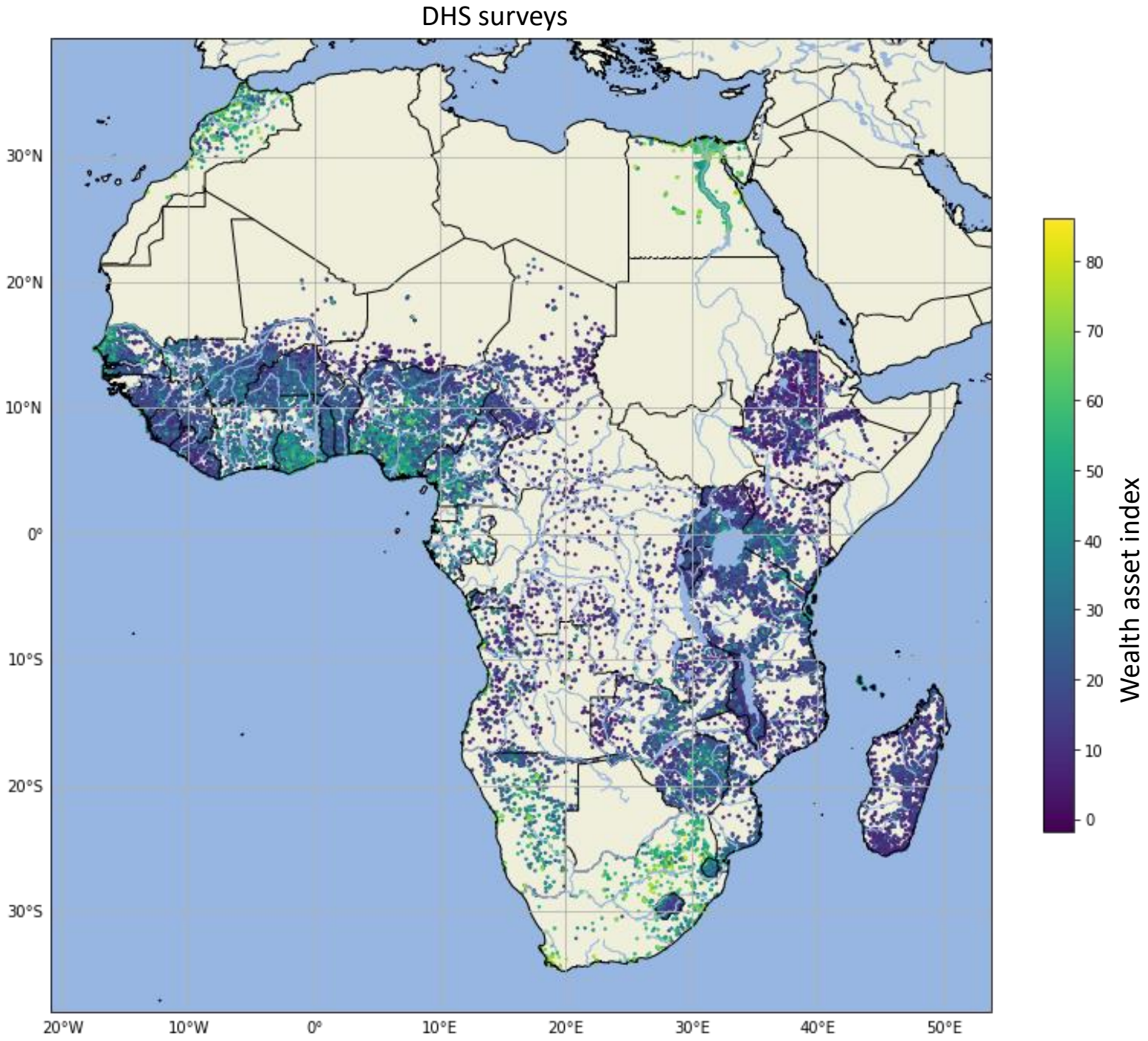
Results from Africa

Credit to Markus Pettersson and Julia Ortheden

(scientific article in progress)

Ground truth

- International wealth index (material assets)
- ~ 57 000 DHS surveys
- From 36 countries
- 1991 - 2019



International Wealth Index (IWI)

With TV =12.73

Without TV = 4.12

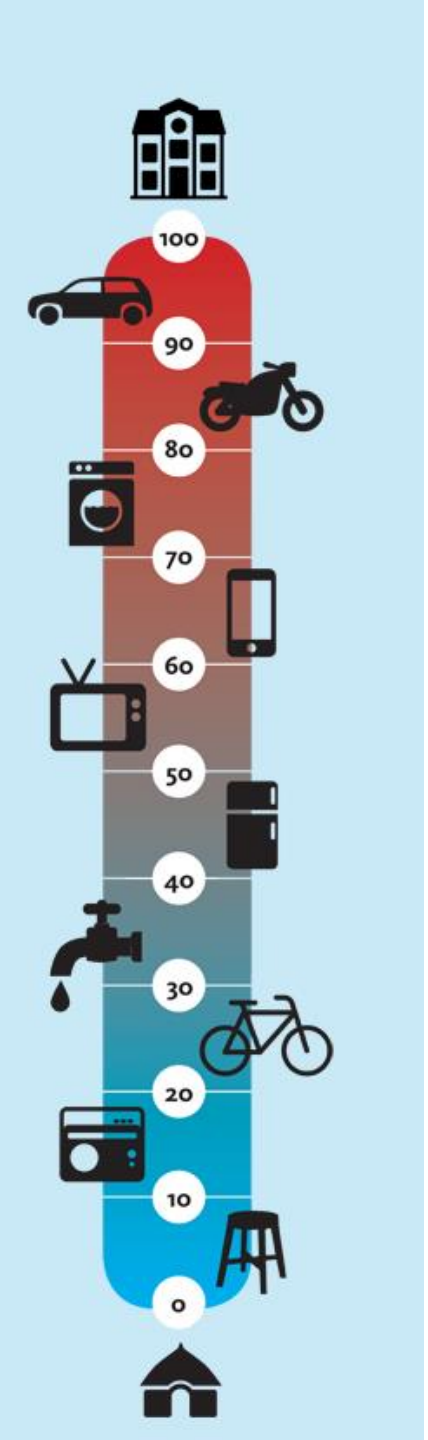
Does the household own or have a:

TV:	(•) Yes	( ) No	( ) Unknown
Refrigerator:	( ) Yes	(•) No	( ) Unknown
Phone:	( ) Yes	(•) No	( ) Unknown
Bike:	( ) Yes	(•) No	( ) Unknown
Car:	( ) Yes	(•) No	( ) Unknown
Cheap utensils (<$50):	(•) Yes	( ) No	( ) Unknown
Expensive utensil (>$300):	( ) Yes	(•) No	( ) Unknown
Electricity:	( ) Yes	(•) No	( ) Unknown

What is the quality of the...

Main source drinking water?:	(•) Low	( ) Middle	( ) High	( ) Unknown
Toilet facility usually used?:	(•) Low	( ) Middle	( ) High	( ) Unknown
Main floor material?:	(•) Low	( ) Middle	( ) High	( ) Unknown
Nr. of rooms used for sleeping:	(•) One	( ) Two	( ) Three+	( ) Unknown

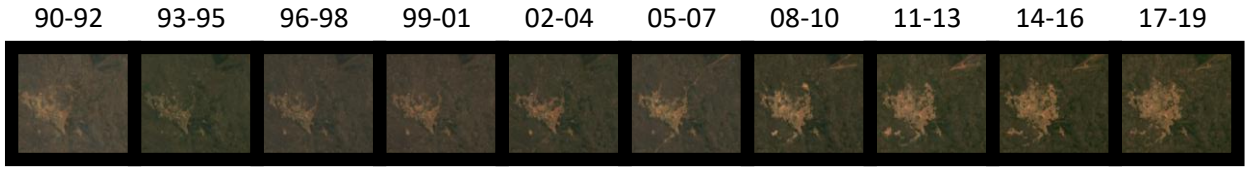
The household's IWI score is: **12.73**

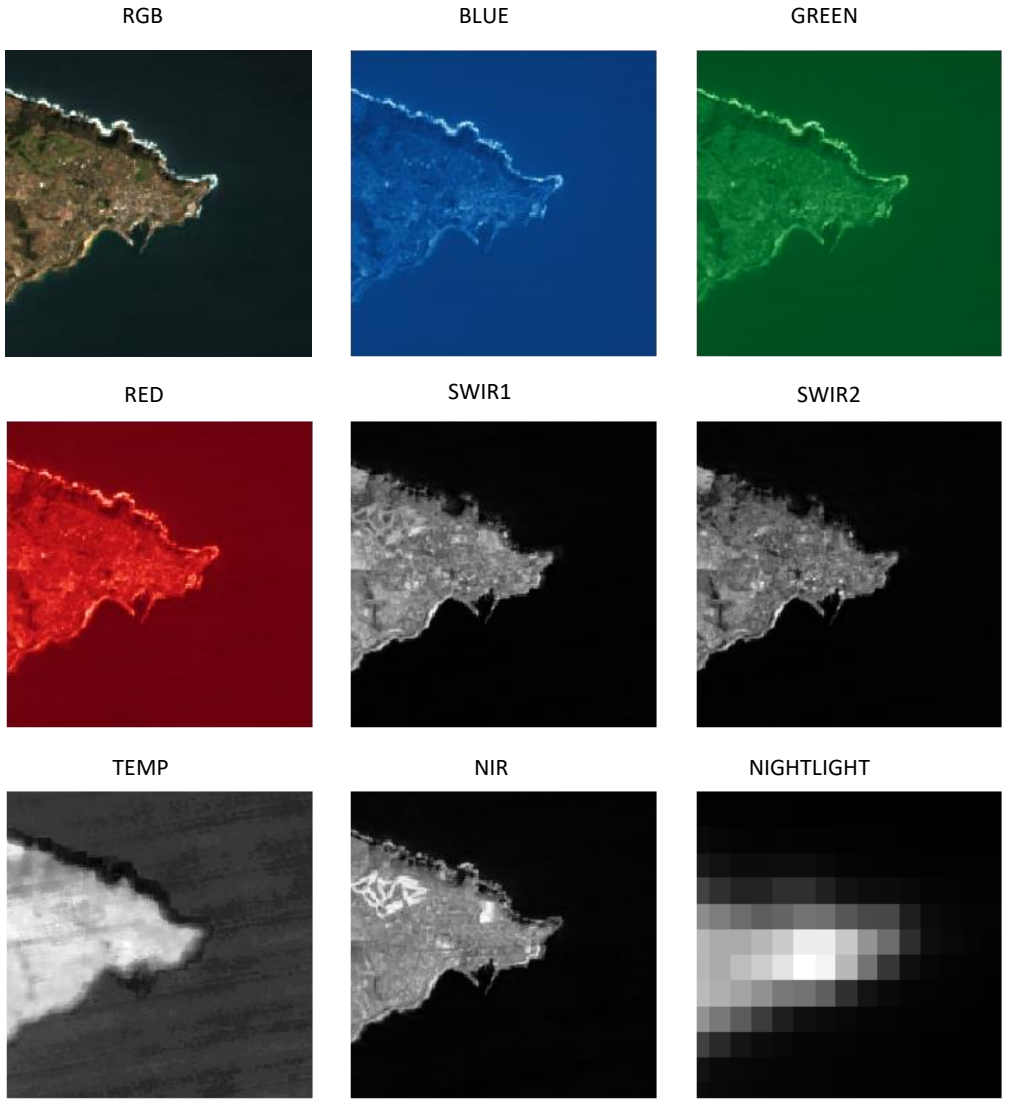


https://globaldatalab.org/iwi/form/

Satellite data

- 7 multispectral bands, 1 nightlight band
- 3-year image composites
  - Median of cloud-free pixels
  - 10 images for 30 years

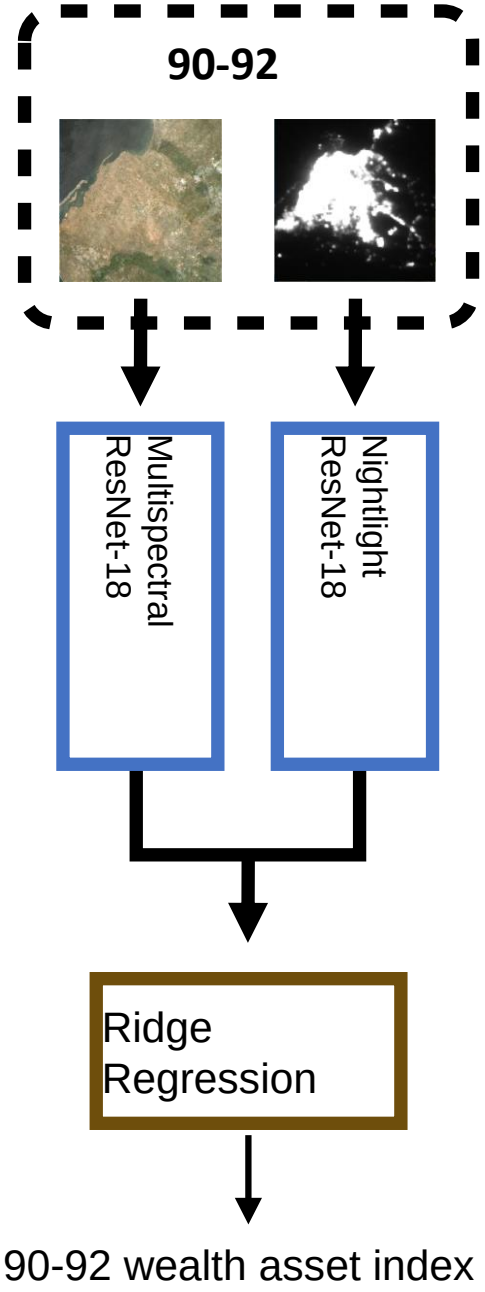




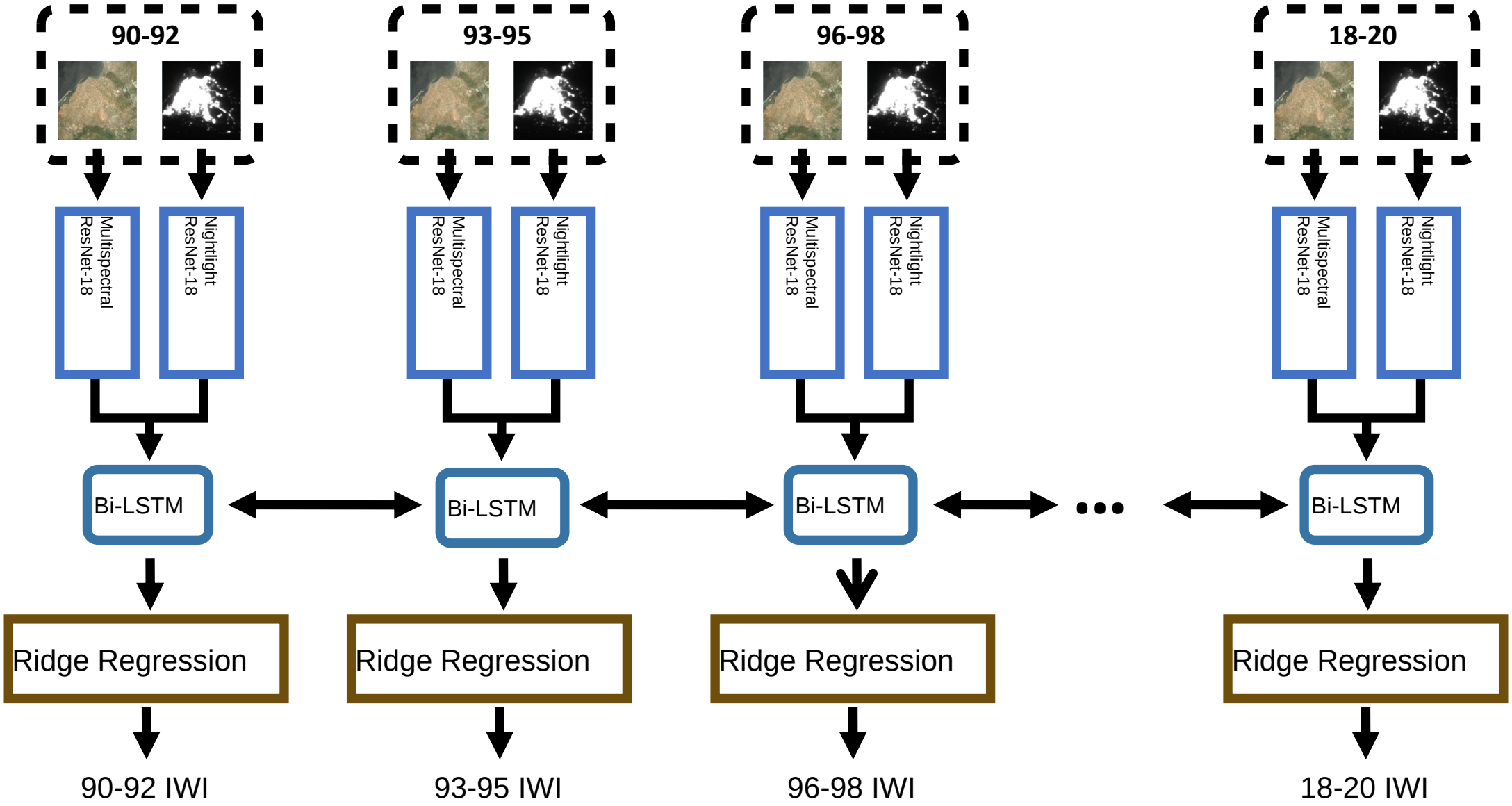
The state-of-the-art: Single-frame model

- Research by Yeh et al.
- Input both Multispectral and Nightlight data
- Concatenate output from the ResNets

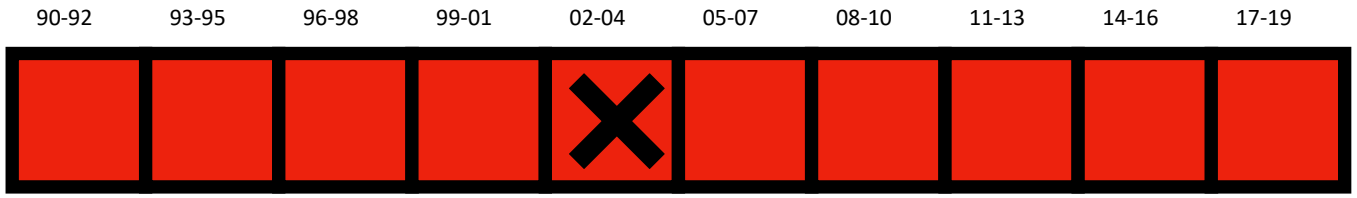
Current algorithmic architectures do not explicitly account for temporality!



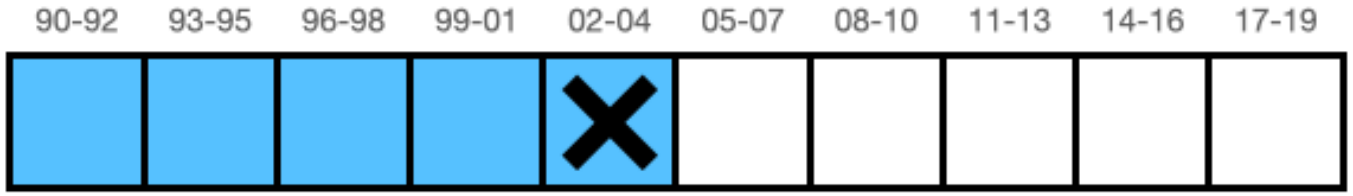
Multi-frame model



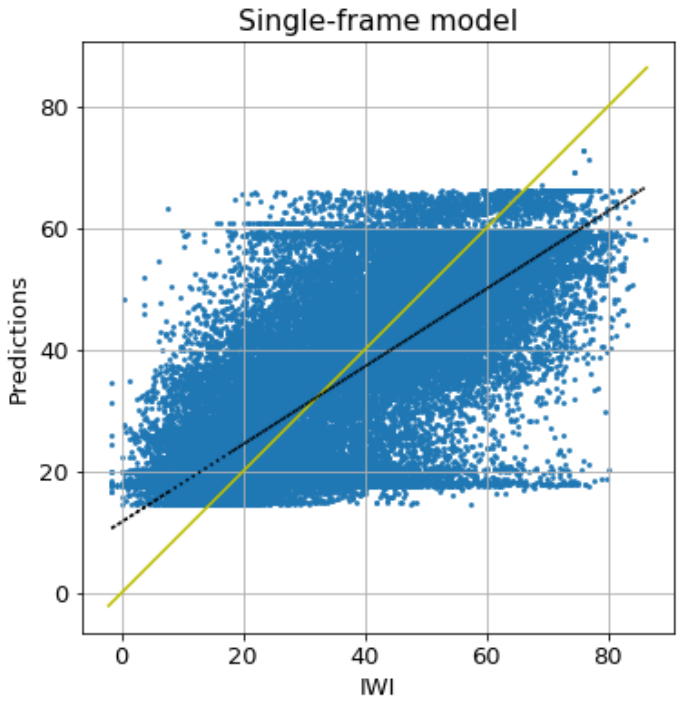
30-years model



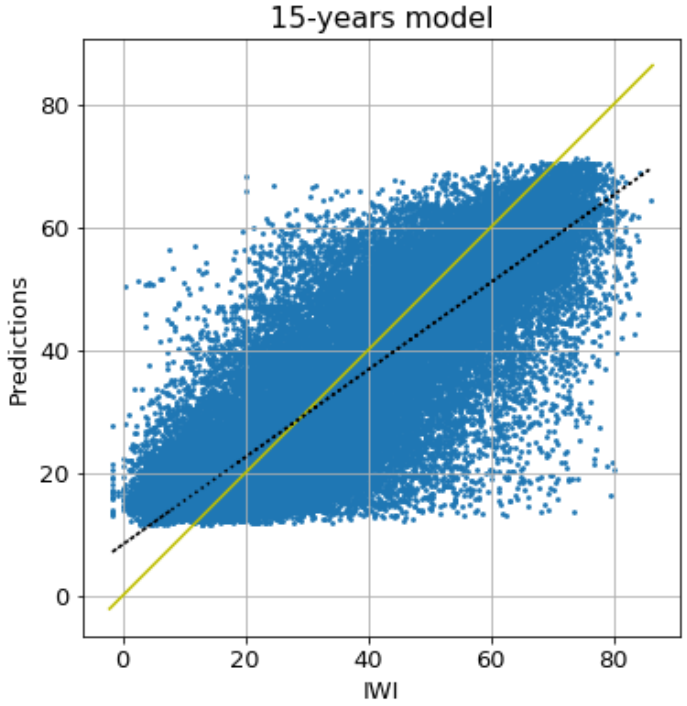
15-years model



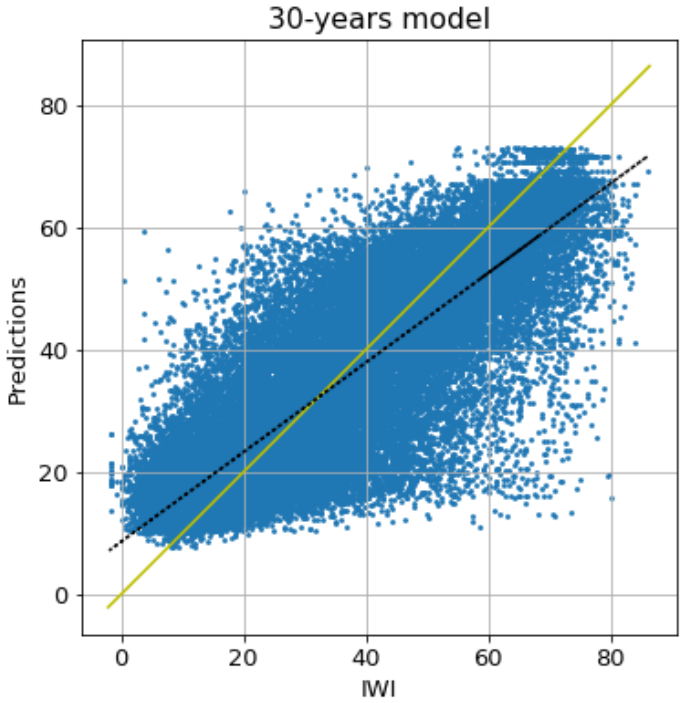
Prediction performance with temporal data



r^2 = 0.63

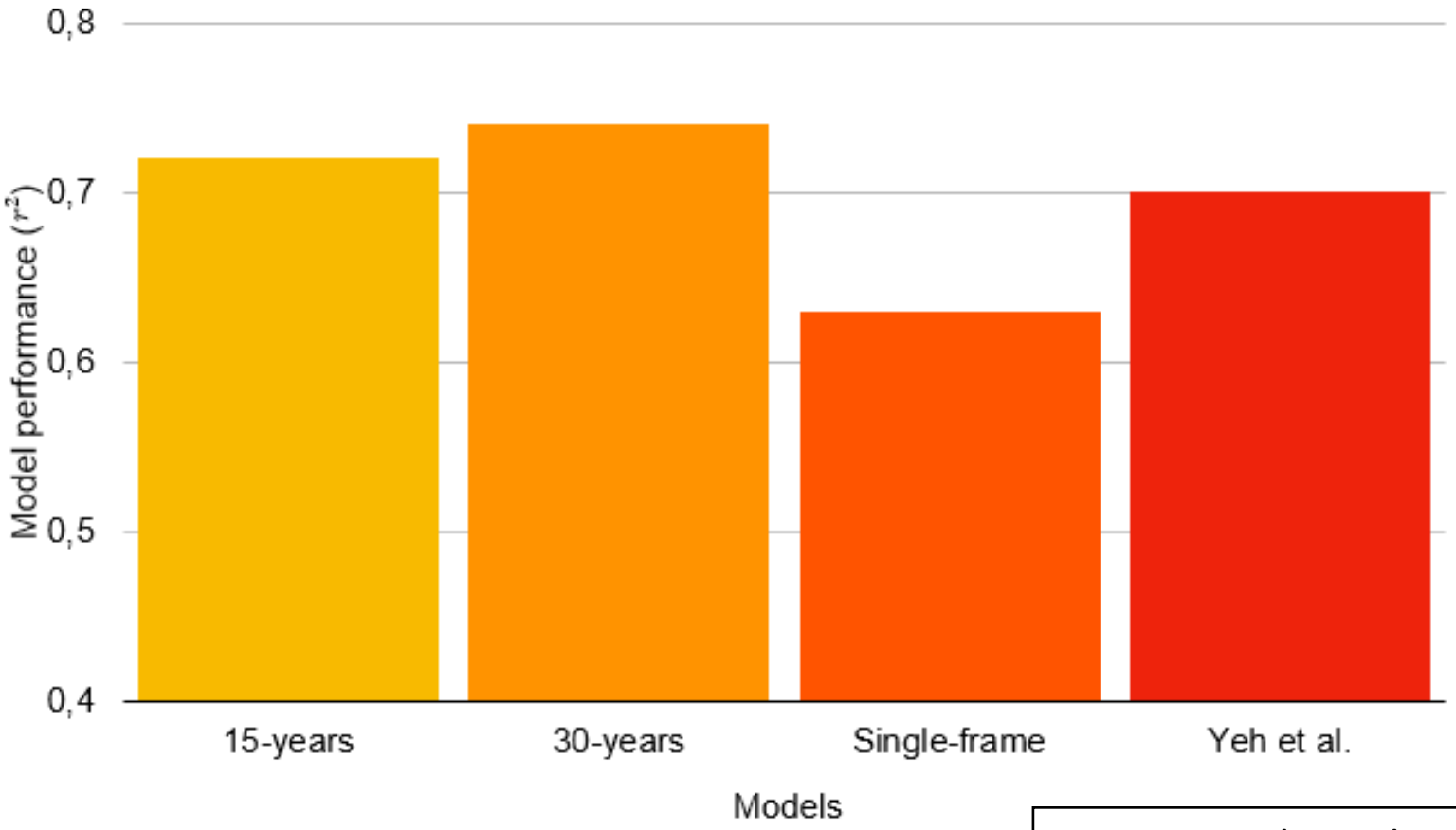


r^2 = 0.72



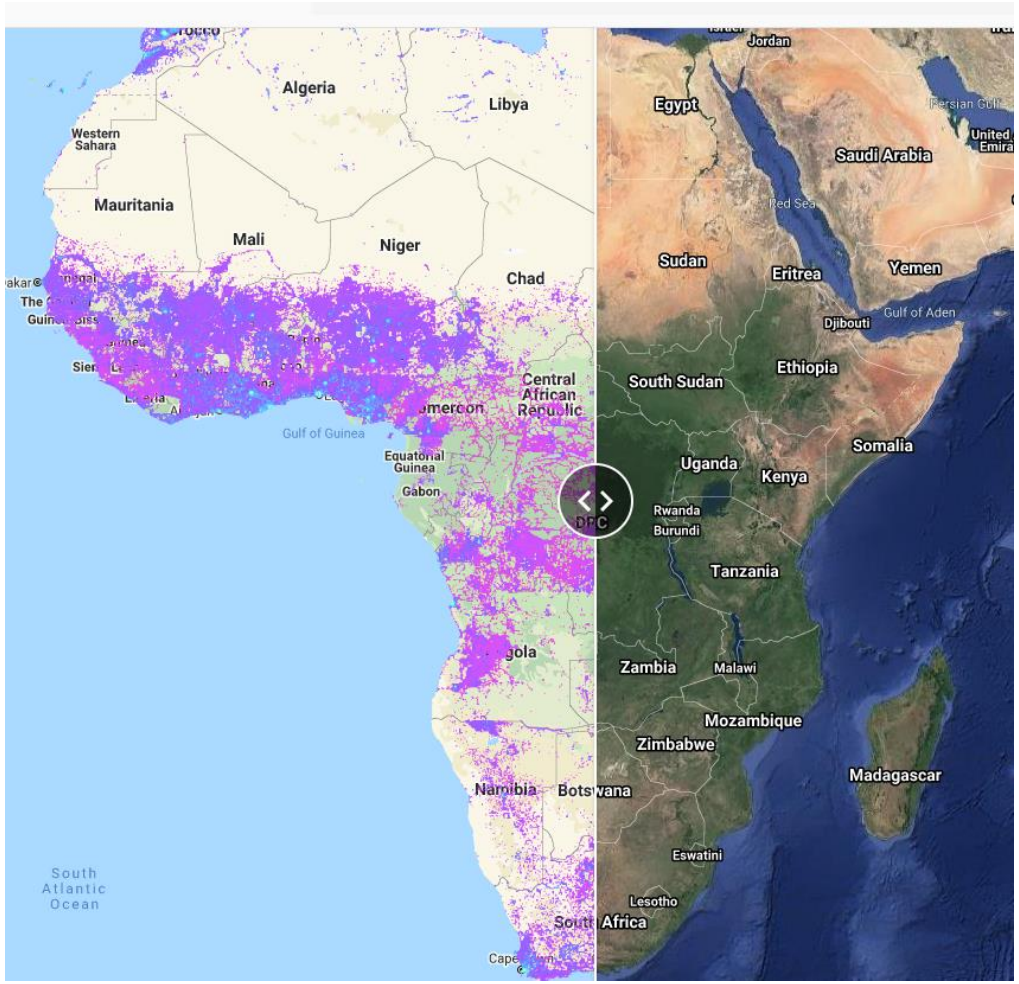
r^2 = 0.74

Comparison to the state-of-the art

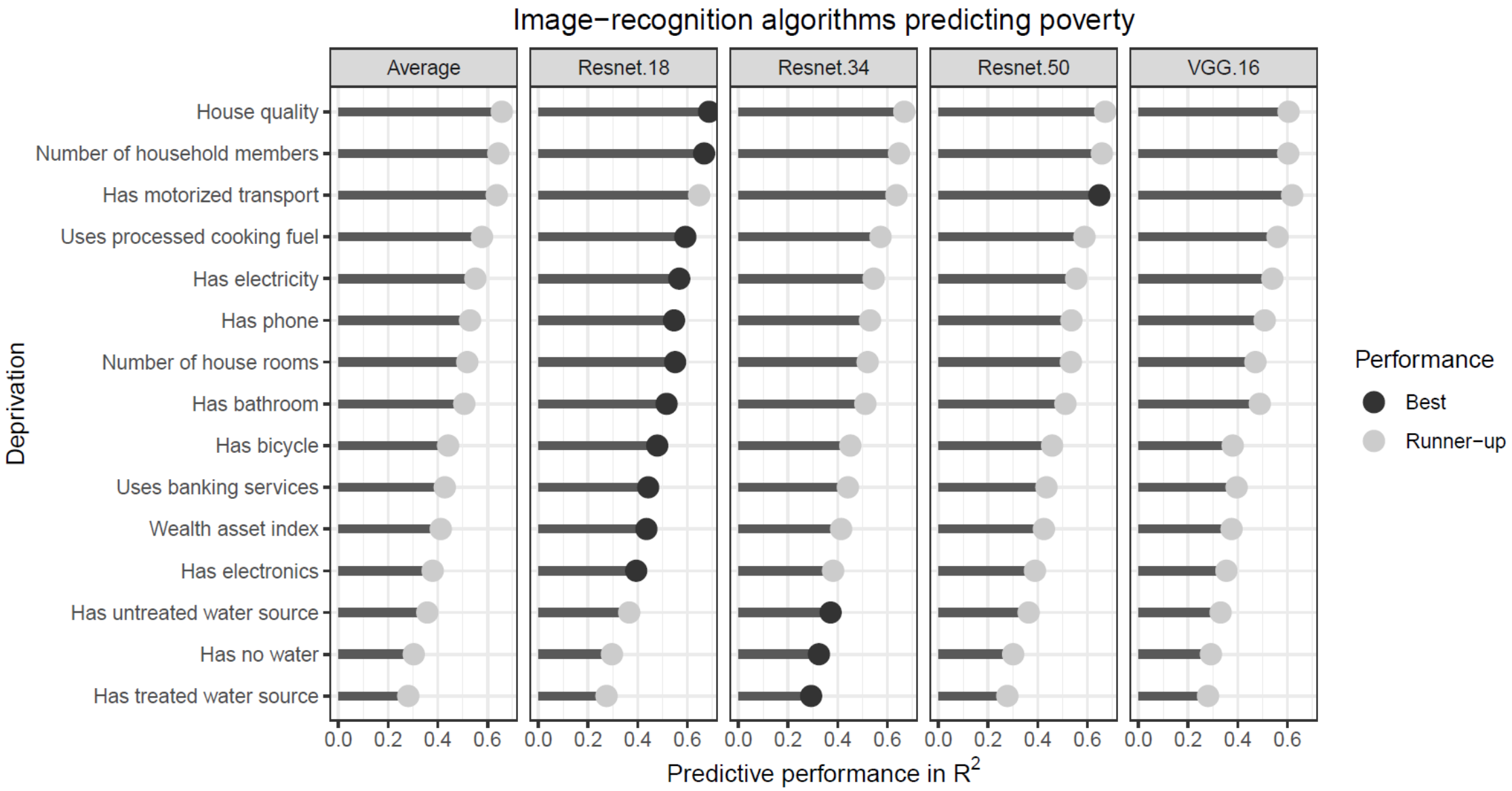


Yet et al. used smaller dataset

Living conditions map



Results from India



Preliminary crossectional results, based on Landsat 7 for six states of India

https://web.iitd.ac.in/~suban/satellite/asset-model/

Concurrent research and future plans

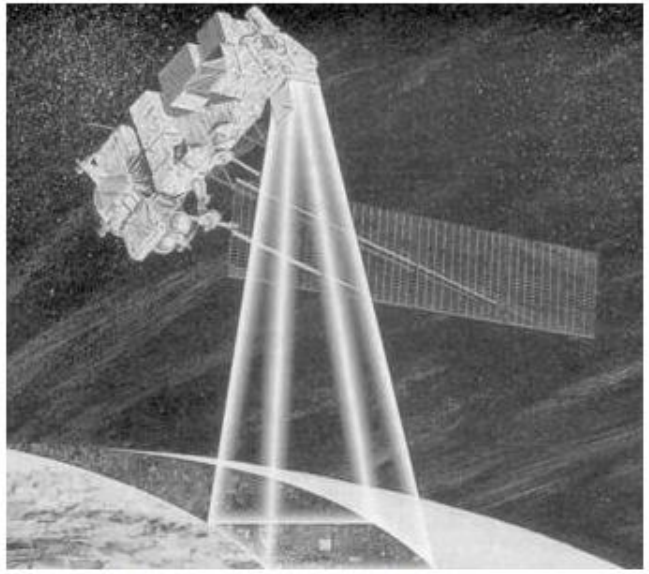
- Besides creating a data product, the AI and Global Development Lab is researching
  - analyzing the effects of international aid and development programs in Africa.
  - creating data products to support the development researcher's community.
  - developing a method for using satellite images for causal inference.
  - Surveying local conditions in selected African countries for validation
  - producing GEE, R, and Python packages and visualization software for researcher.

- Near-future research plans
  - use even higher-resolution satellite images from e.g. Planet Labs and Pléiades
  - incorporate all low- and middle-income countries, as we are currently focusing on Africa (primary) and India (secondary).
  - AI for Social Good, supporting policymakers to alleviate poverty (personalized aid)

Our research program would not be possible without our colleagues on earth and our partners in space!

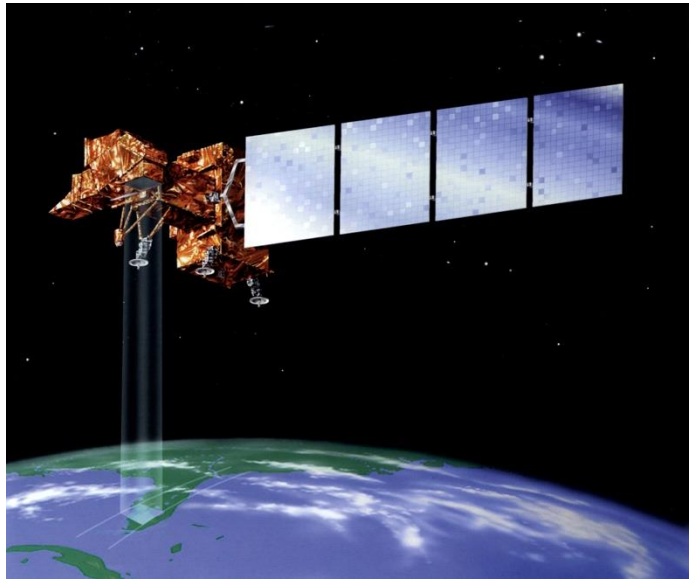
Landsat 4-5 (retired)

Landsat 6 (*killed in action*)



A sketch of what the Landsat 6 satellite would have looked like in orbit.

Landsat 7



Landsat 8

Landsats 1 to 3 did not contribute enough…

Welcoming Landsat 9!

- As of Sep 27, 2021, Landsat 9 is contributing to earth observations “a for monitoring the health and state of the Earth. Landsat users can now take advantage of more frequent observations (every 8 days using two satellites)” (NASA).

A rendering of the Landsat 9 spacecraft. Image credit: Northrop Grumman

Your questions and remarks are welcomed.

More information is going live soon at *global-lab.ai*