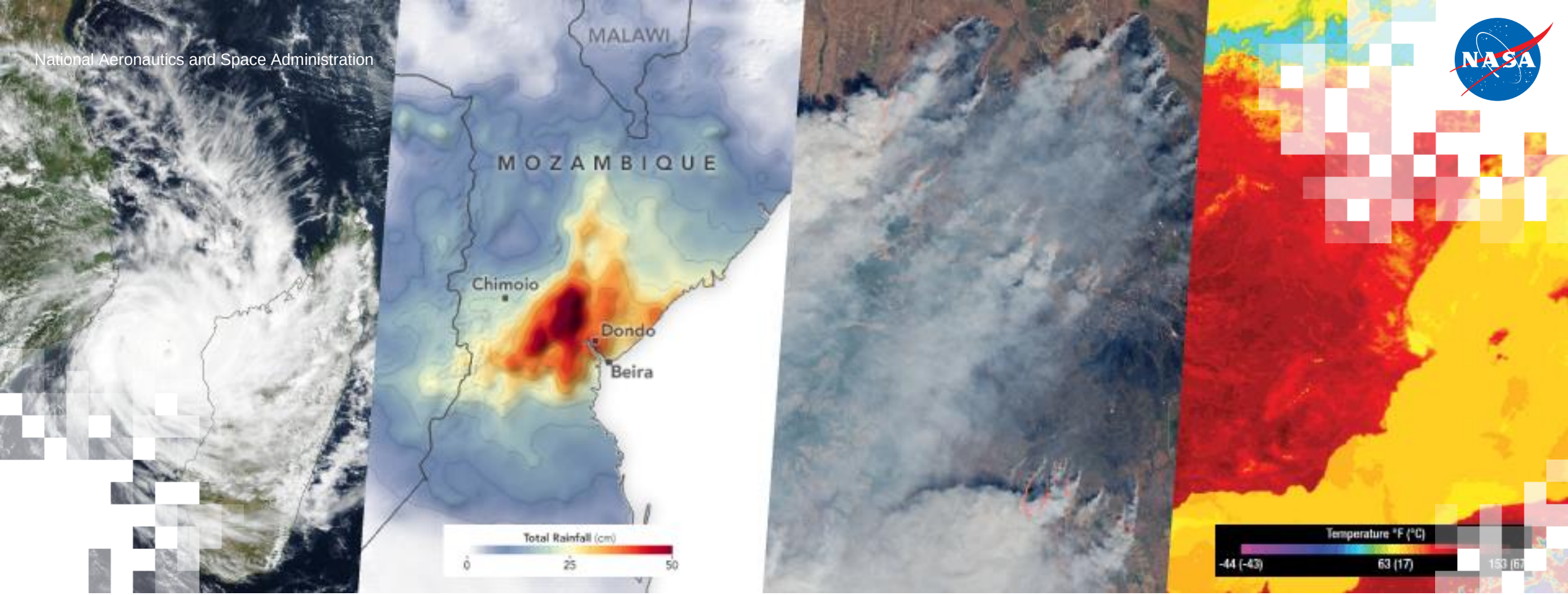


Earth Observations for Disaster Risk Assessment and Resilience

Susana B. Adamo, Ph. D., CIESIN

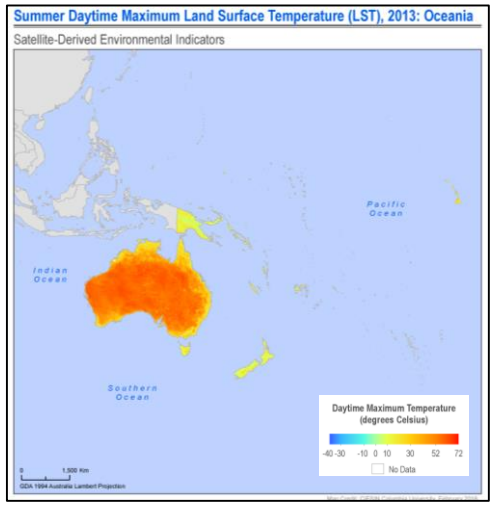
Socioeconomic Data and Applications Center (SEDAC)

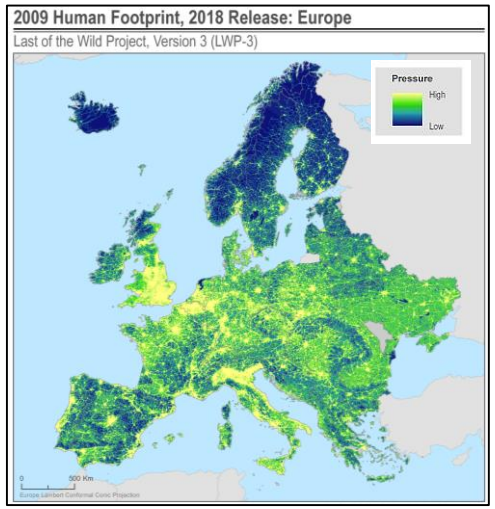
https://sedac.ciesin.columbia.edu/

- SEDAC data provide the human context for NASA's remote sensing data:
- Role within the NASA DAACs:
  - to function as the ***information gateway between the physical sciences and the social sciences*** to support (a) greater public understanding of the impacts of global change and (b) the generation of ***policy relevant information*** to inform strategies for mitigation and adaptation.
  - to facilitate the analysis and portrayal of the ***human dimensions of global change***;
  - to provide for the archive of and access to relevant socioeconomic data sets.

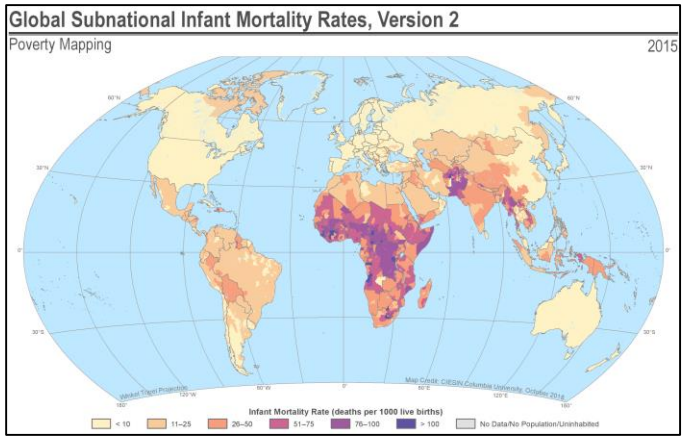
Hosted by CIESIN at Columbia University. One of the Distributed Active Archive Centers (DAACs) in the Earth Observing System Data and Information System (EOSDIS) of the U.S. National Aeronautics and Space Administration (NASA)

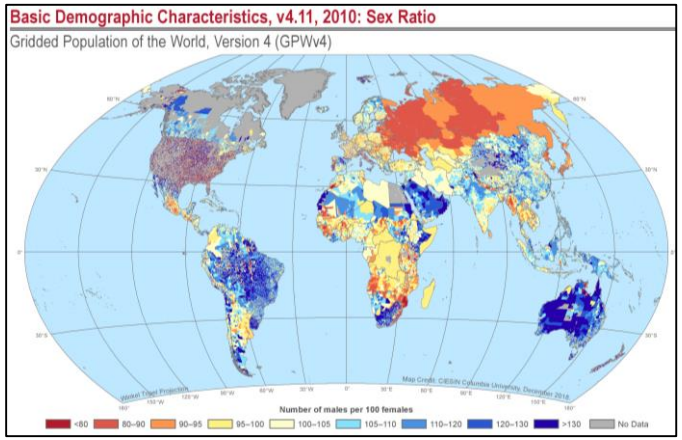
Socioeconomic Data and Applications Center (Cont.)





- Priorities:
  - **Human settlement, infrastructure, and population data** drawing on a range of remote sensing and other data sources.
  - **Policy-relevant sustainable development indicators**, especially in areas where selected NASA remote sensing datasets are valuable.
  - **Operational use of SEDAC data and services** through a range of user interfaces;
  - **Value of integrating remote sensing and socioeconomic data** in both research and applications.
- Direct support to scientists, applied and operational users, decision makers, and policy communities.
- Strong links to geospatial data community.
- Big emphasis on data integration, tools and services





Exposure and Vulnerability

- *Exposure:*
  - the ***presence*** of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected. {IPCC Working Group II}

- *Vulnerability:*
  - the ***propensity or predisposition*** to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. {IPCC Working Group II}

IPCC, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf.

SEDAC Data for Exposure and Vulnerability Assessment

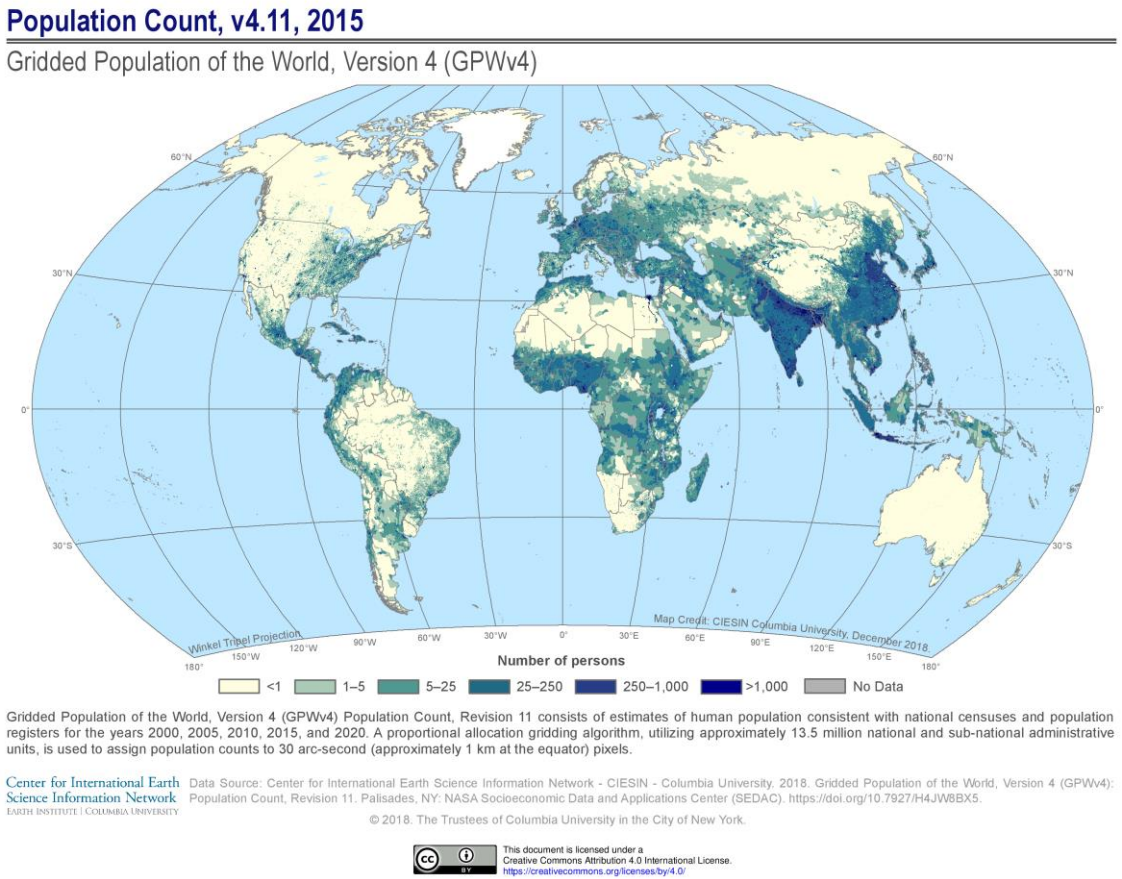
- ***Exposure:***
  - Population distribution: Gridded Population of the World (GPW), v4
    - Population counts.
  - Infrastructure location:
    - Global Reservoirs and Dams (GRandD), v1
    - Global Roads Open Access Data Set (gROADS), v1
    - Population Exposure Estimates in Proximity to Nuclear Power Plants, Locations, v1

- ***Vulnerability:***
  - Basic Demographic Characteristics, v4.11 (part of the GPW4 collection)
    - Children
    - Older adults
    - Gender
  - Global subnational infant mortality rates, v2 (2015)

Gridded Population of the World (GPW), version 4

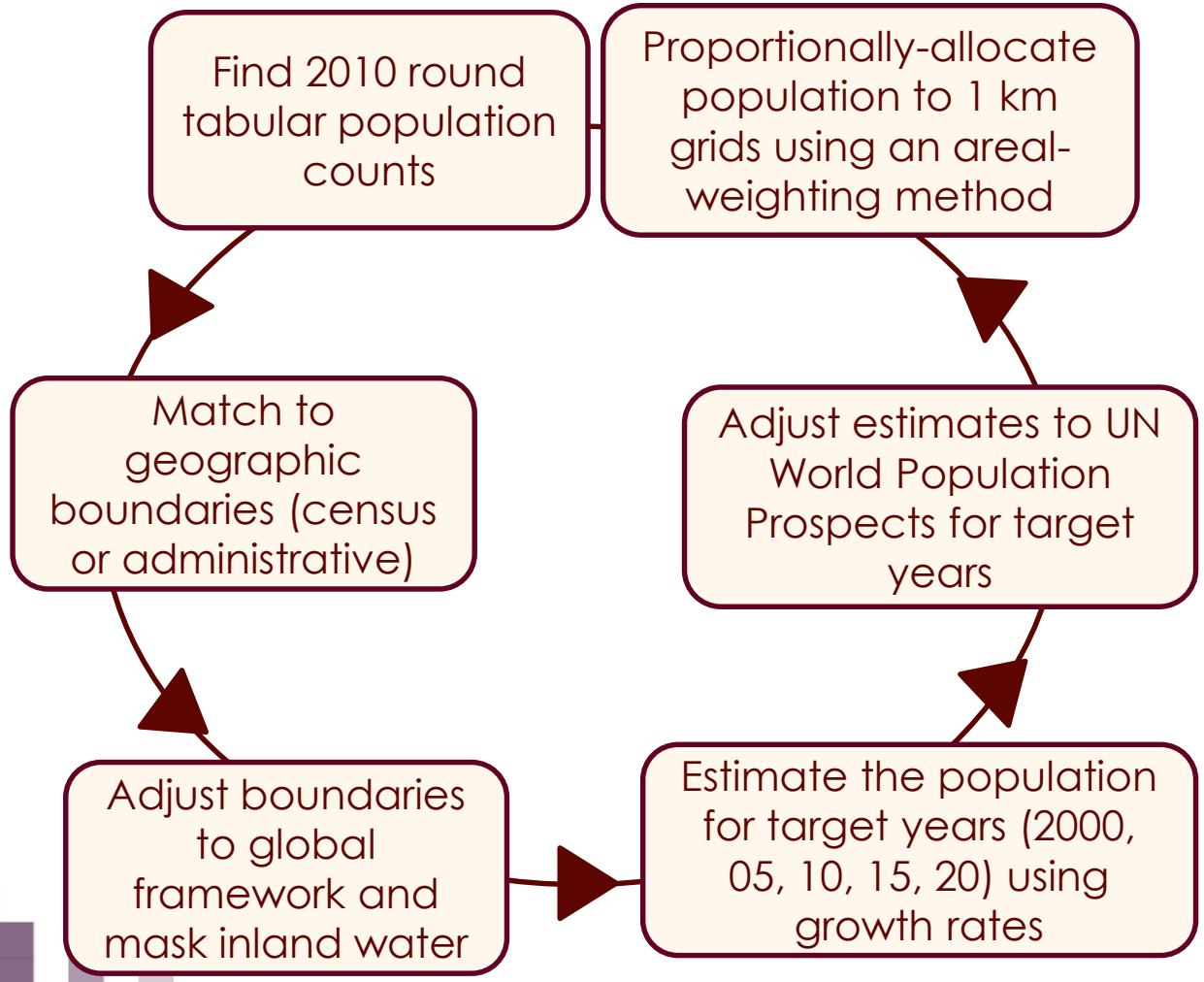
https://sedac.ciesin.columbia.edu/data/collection/gpw-v4

- GPWv4 models the distribution of human population (counts and densities) on a continuous global raster surface
- Purpose: to provide a spatially disaggregated population layer that is compatible with data sets from social, economic, and Earth science disciplines, and remote sensing
- Globally consistent and spatially explicit data for use in research, policy-making, and communications
- Essential inputs: population census tables and corresponding geographic boundaries



Gridded Population of the World (Contd.)

Methods

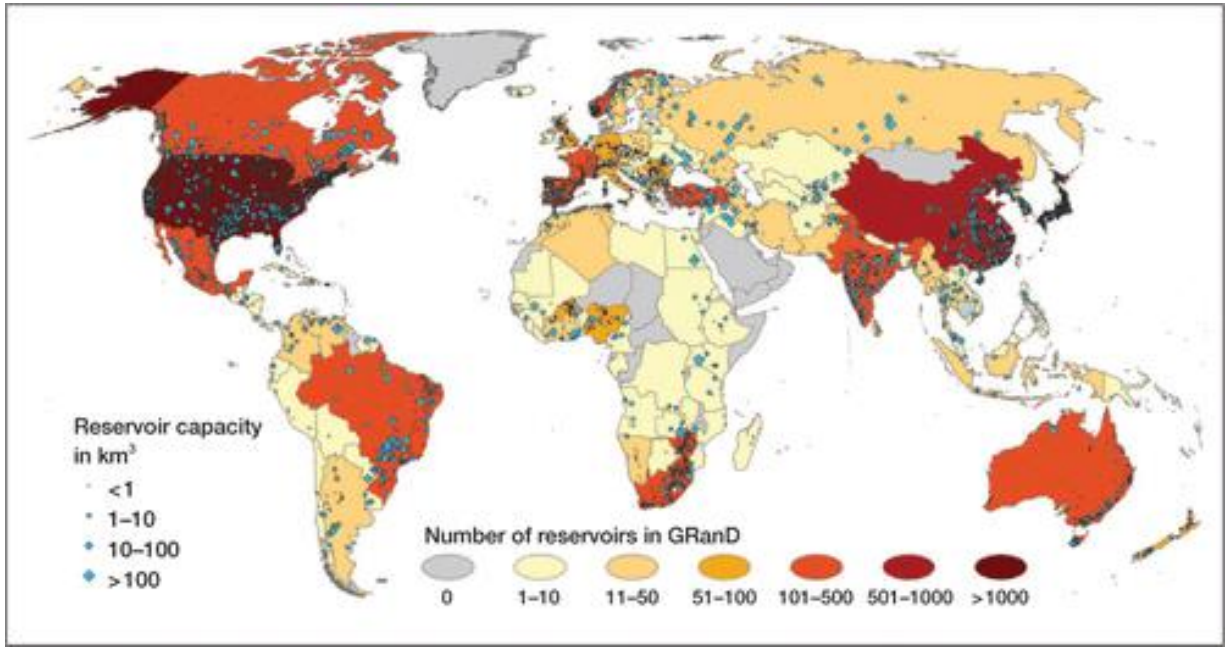


- Proportional allocation or areal-weighting method: uniformly distributes population based on land area;
  - Maintains fidelity to input data.
- The accuracy of GPW pixel estimates is directly related to the size of the input census units:
  - Average input unit resolution for very high development regions is 944 sq. km
  - Average input unit resolution for very low human development countries is 3,518 sq. km

Dams

- Part of the Global Reservoir and Dam Database (GRanD), an outcome of the Global Water System Project (GWSP)
- Purpose: to provide a single, geographically explicit and reliable global database describing reservoirs and dams' characteristics and geographical distribution.
  - 6,862 records of reservoirs and their associated dams with a cumulative storage capacity of 6,197 cubic km.

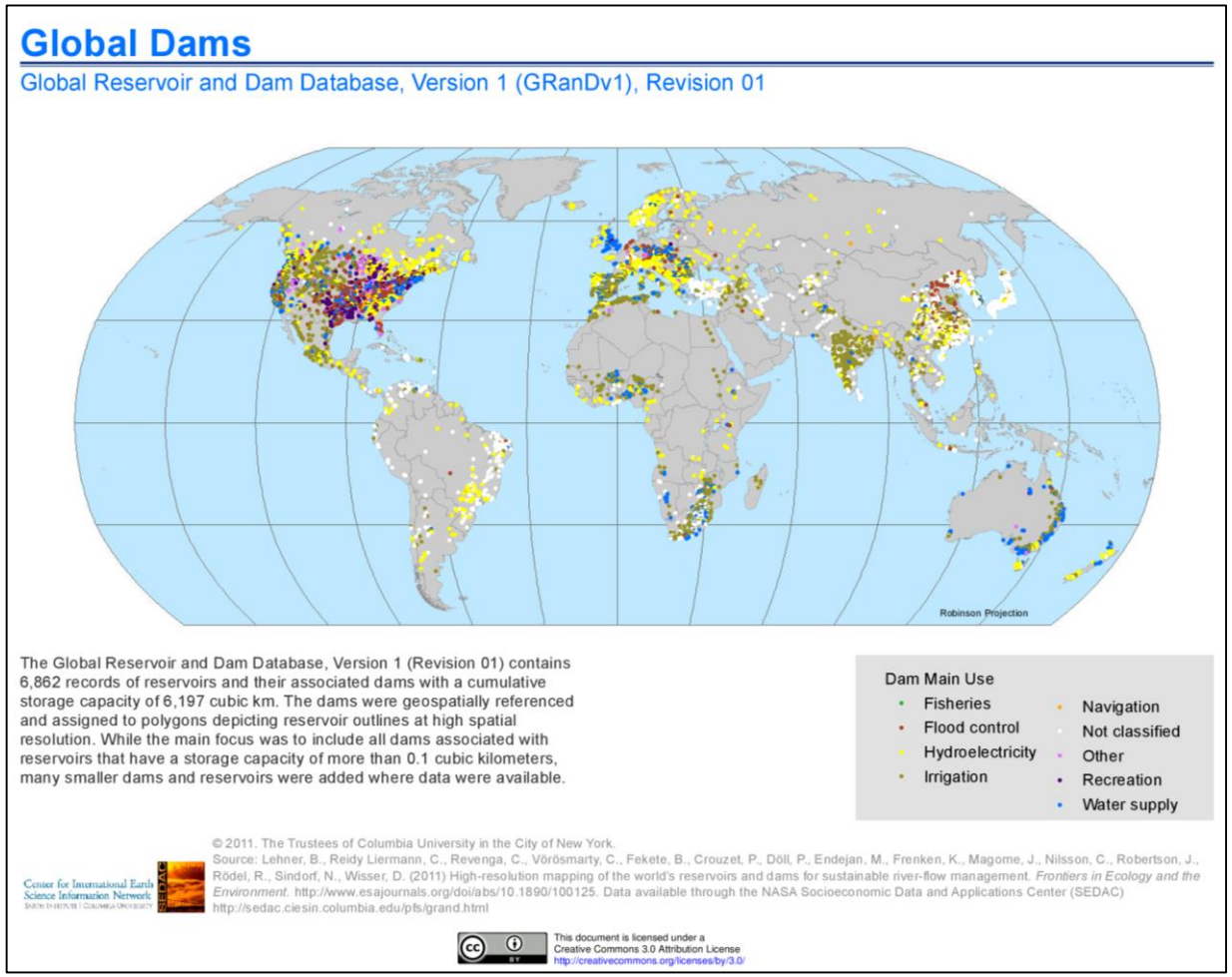
High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management



Source: Frontiers in Ecology and the Environment, Volume: 9, Issue: 9, Pages: 494-502, First published: 31 May 2011, DOI: (10.1890/100125)

Dams (Cont.)

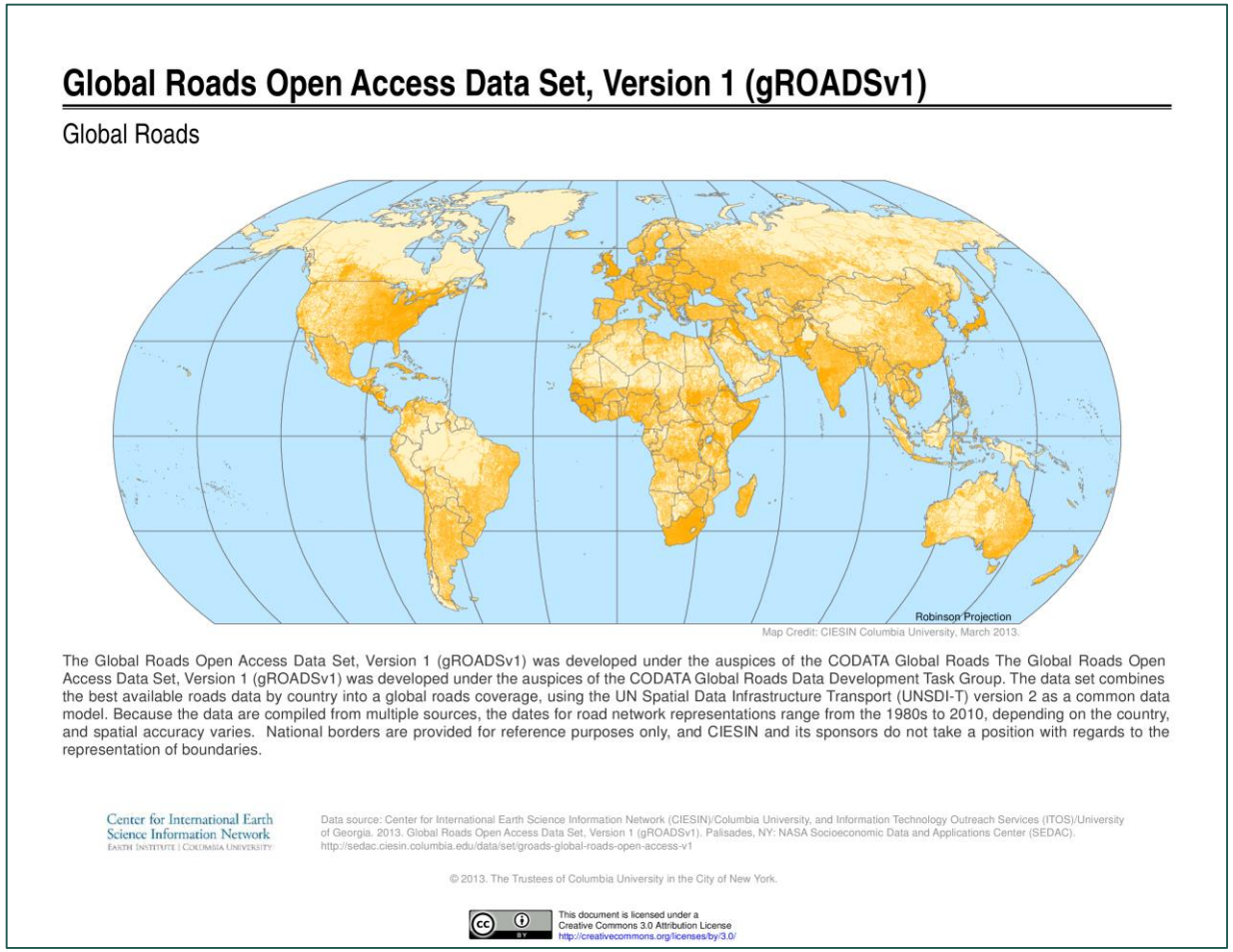
- Methods:
  - The dams were geospatially referenced and assigned to polygons depicting reservoir outlines at high spatial resolution.
  - Dams have multiple attributes, such as primary use, nearest city, area, name of impounded river, year of construction (or commissioning).
  - https://sedac.ciesin.columbia.edu/downloads/docs/grand-v1/grand-v1-technical-documentation-v1-1.pdf



Global Roads Open Access Data Set (gROADS), v1

https://sedac.ciesin.columbia.edu/data/set/groads-global-roads-open-access-v1

- An outcome of the CODATA Global Roads Data Development Task Group, led by CIESIN
- Purpose: to provide an open access, well documented global data set of roads between settlements using a consistent data model (UNSDI-T v.2)[1] which is, to the extent possible, topologically integrated;
- Working on a new service to disseminate regularly updated OpenStreetMap roads data in GIS-ready file formats.



Global Roads Open Access Data Set, Version 1 (gROADSv1)

Global Roads

Robinson Projection

Map Credit: CIESIN Columbia University, March 2013.

The Global Roads Open Access Data Set, Version 1 (gROADSv1) was developed under the auspices of the CODATA Global Roads The Global Roads Open Access Data Set, Version 1 (gROADSv1) was developed under the auspices of the CODATA Global Roads Data Development Task Group. The data set combines the best available roads data by country into a global roads coverage, using the UN Spatial Data Infrastructure Transport (UNSDI-T) version 2 as a common data model. Because the data are compiled from multiple sources, the dates for road network representations range from the 1980s to 2010, depending on the country, and spatial accuracy varies. National borders are provided for reference purposes only, and CIESIN and its sponsors do not take a position with regards to the representation of boundaries.

Center for International Earth Science Information Network
Earth Institute | Columbia University

Data source: Center for International Earth Science Information Network (CIESIN)/Columbia University, and Information Technology Outreach Services (ITOS)/University of Georgia. 2013. Global Roads Open Access Data Set, Version 1 (gROADSv1). Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://sedac.ciesin.columbia.edu/data/set/groads-global-roads-open-access-v1

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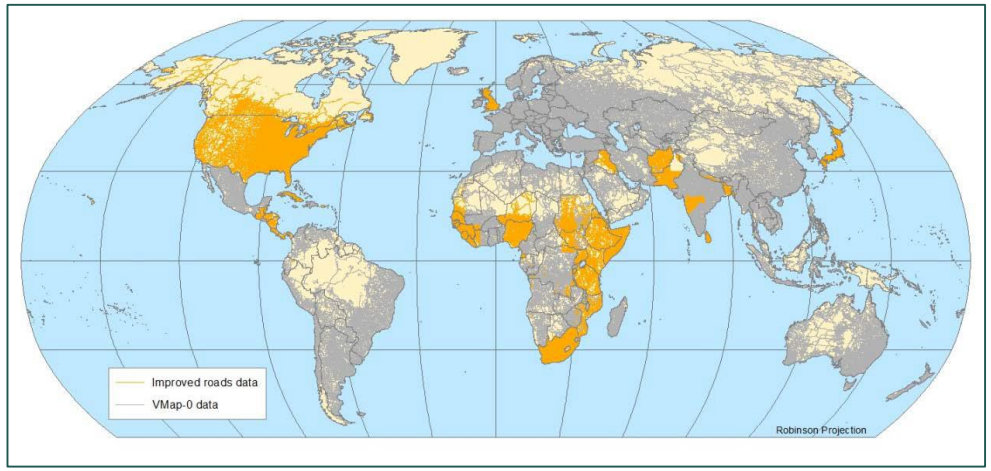
[1] http://www.ungiwg.org/content/united-nations-spatial-data-infrastructure-unsdi

gROADS (Cont.)

- Methods (CIESIN 2013)
  - gROADS combines the best available public domain roads data by country into a global roads coverage, using the UN Spatial Data Infrastructure Transport (UNSDI-T) version 2 as a common data model.
  - Country road networks have been joined topologically at the borders, and many countries have been edited for internal topology.
  - Source data as a percentage of the total road network for each country are provided in the documentation.
  - Because the data are compiled from multiple sources, the dates for road network representations ranges from the 1980s to 2010 depending on the country (most countries have no confirmed date), and spatial accuracy varies.

gROADSv1 source coverage: VMAP0 versus other sources



Documentation for gROADSv1

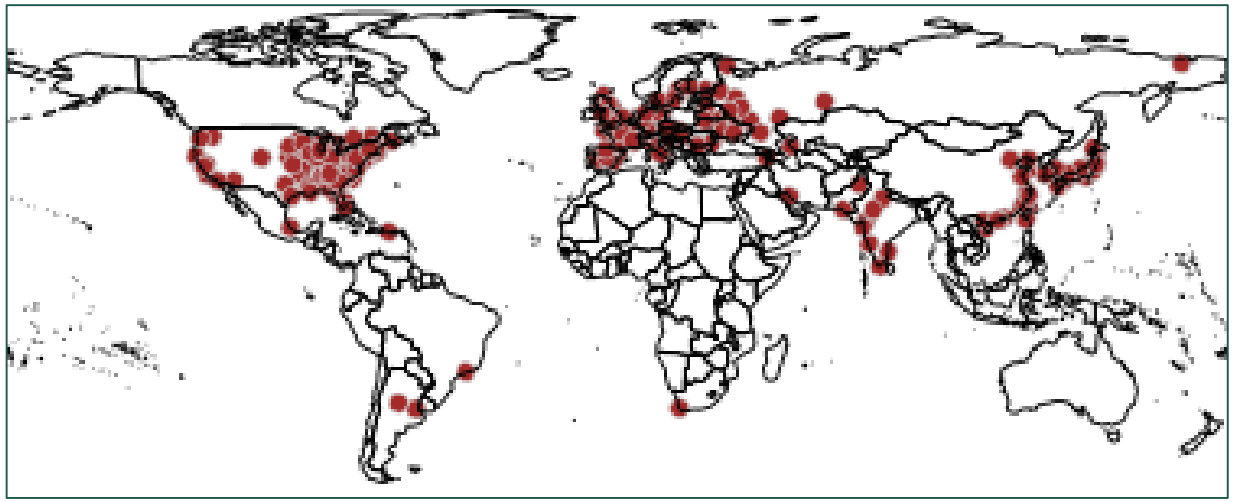
Population Exposure Estimates in Proximity to Nuclear Plants, Locations, v1 (1956-2012)

https://sedac.ciesin.columbia.edu/data/set/energy-pop-exposure-nuclear-plants-locations

- This data set combines information from a global data set developed by Declan Butler of *Nature News,* and the Power Reactor Information System (PRIS), an up-to-date database of nuclear reactors maintained by the International Atomic Energy Agency (IAEA).

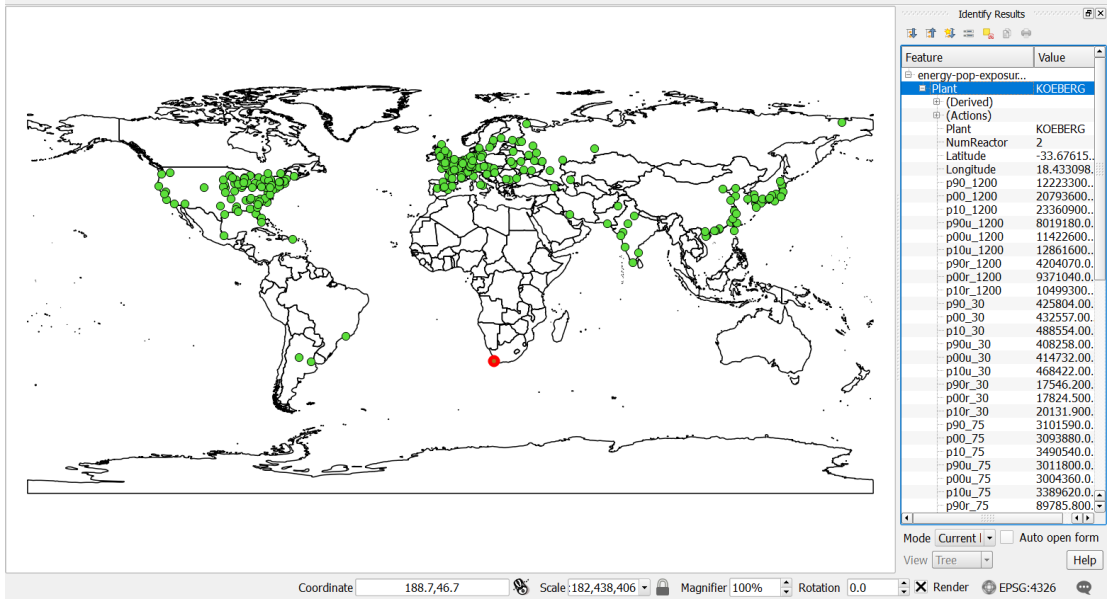
- Purpose: To provide a global data set of point locations and attributes describing nuclear power plants and reactors

Nuclear Power Plant Location



Population Exposure in Proximity to Nuclear Plants (Cont.)

- Methods:
  - The locations of nuclear reactors around the world are represented as point features associated with reactor specification and performance history attributes as of March 2012
  - The Country-Level Aggregates data set consists of country-level estimates of total, urban and rural population, and land area that are in proximity to a nuclear power plant
  - The power plant locations are represented as point features associated with population exposure estimates for the years 1990, 2000, and 2010 within six buffer zones.

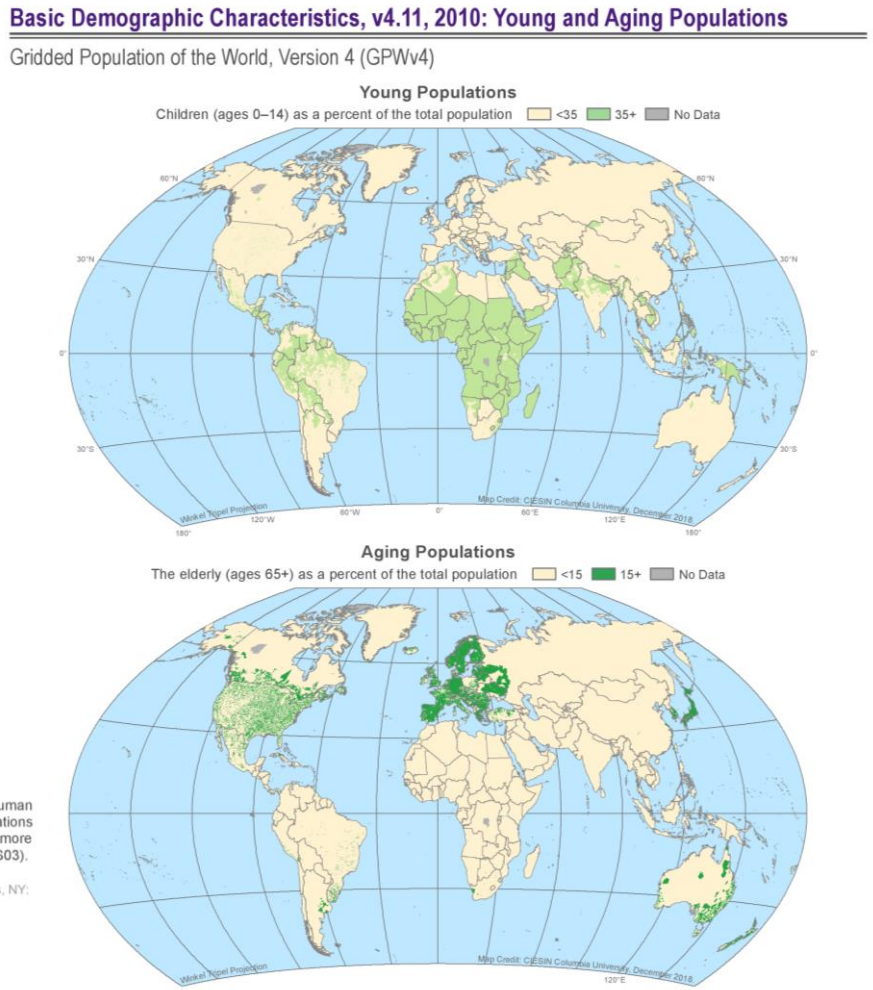


Nuclear plants points and attributes: the table on the right displays the information for the Koeberg nuclear plant in South Africa (the red dot in the map)

Basic Demographic Characteristics

https://sedac.ciesin.columbia.edu/data/set/gpw-v4-basic-demographic-characteristics-rev11

- GPW version 4 includes age (as five-year age groups) and sex surfaces at the subnational level.
- Purpose: to provide estimates of population counts by age and sex for the year 2010 as raster data, to facilitate data integration.
- Global rasters at 30 arc-second horizontal resolution (approximately 1 km at the equator).



Gridded Population of the World, Version 4 (GPWv4) Basic Demographic Characteristics, Revision 11 consists of estimates of human population by age and sex consistent with national censuses and population registers for the year 2010. Young and aging populations refer to populations which have a greater proportion of young or old individuals, respectively. A young population has 30–35% or more of its population under age 15, while an aging population has 10–15% or more of its population over age 65 (papp.iussp.org, 101-S03).

Center for International Earth Science Information Network
Earth Institute | Columbia University

Data Source: Center for International Earth Science Information Network - CIESIN - Columbia University. 2018. Gridded Population of the World, Version 4 (GPWv4): Basic Demographic Characteristics, Revision 11. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/H46M34XX.

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Basic Demographic Characteristics Method

(where *P* is the 2010 estimated population; *c* is the census population; *m*, *f*, and *t* represent male, female, and total population; and *i* is the age group in the set of all age groups)

1. Estimates of male and female populations, 2010:

$$P_m = \frac{c_m}{c_m + c_f} * P_t$$

$$P_f = \frac{c_f}{c_m + c_f} * P_t$$

2. Estimates of populations by age and sex, 2010:

$$P_{m,i} = \frac{c_{m,i}}{\sum_i c_m} * P_m$$

$$P_{f,i} = \frac{c_{f,i}}{\sum_i c_f} * P_f$$

3. For countries with available data, five upper age group classes were calculated from the age estimates: 65+, 70+, 75+, 80+, and 85+. Highest global coverage: 65+

4. Male and female age groups were summed to produce the estimated total population in each age group for 2010:

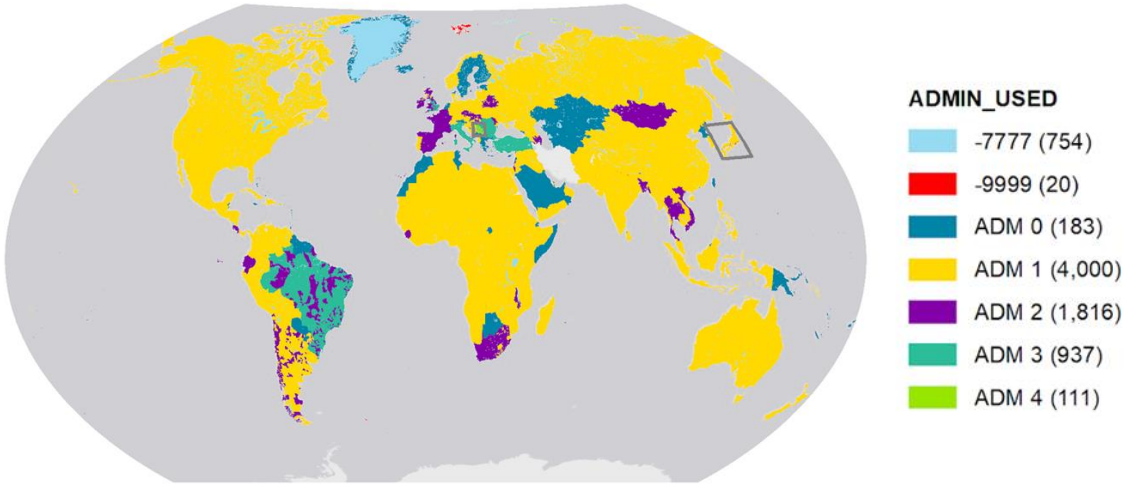
$$P_{t,i} = P_{m,i} + P_{f,i}$$

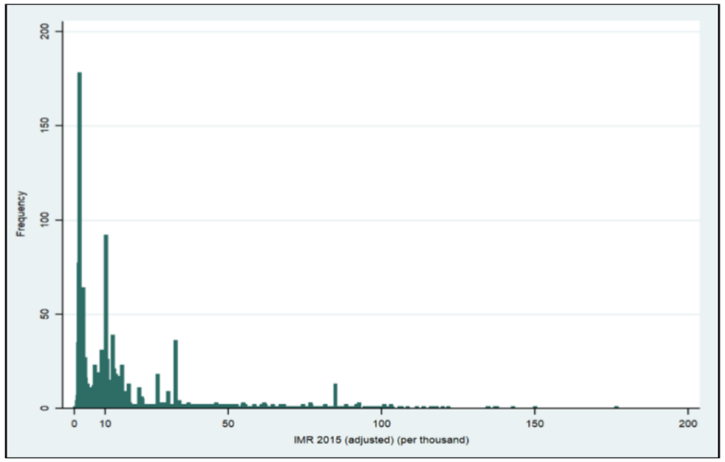
5. Population data were matched to geographic boundaries (census or administrative) and boundaries were adjusted to a global framework

6. Population data were allocated proportionally by age and sex to 1-km grids using an areal-weighting method

Global Subnational Infant Mortality Rates, v2 (2015)

https://sedac.ciesin.columbia.edu/data/set/povmap-global-subnational-infant-mortality-rates-v2



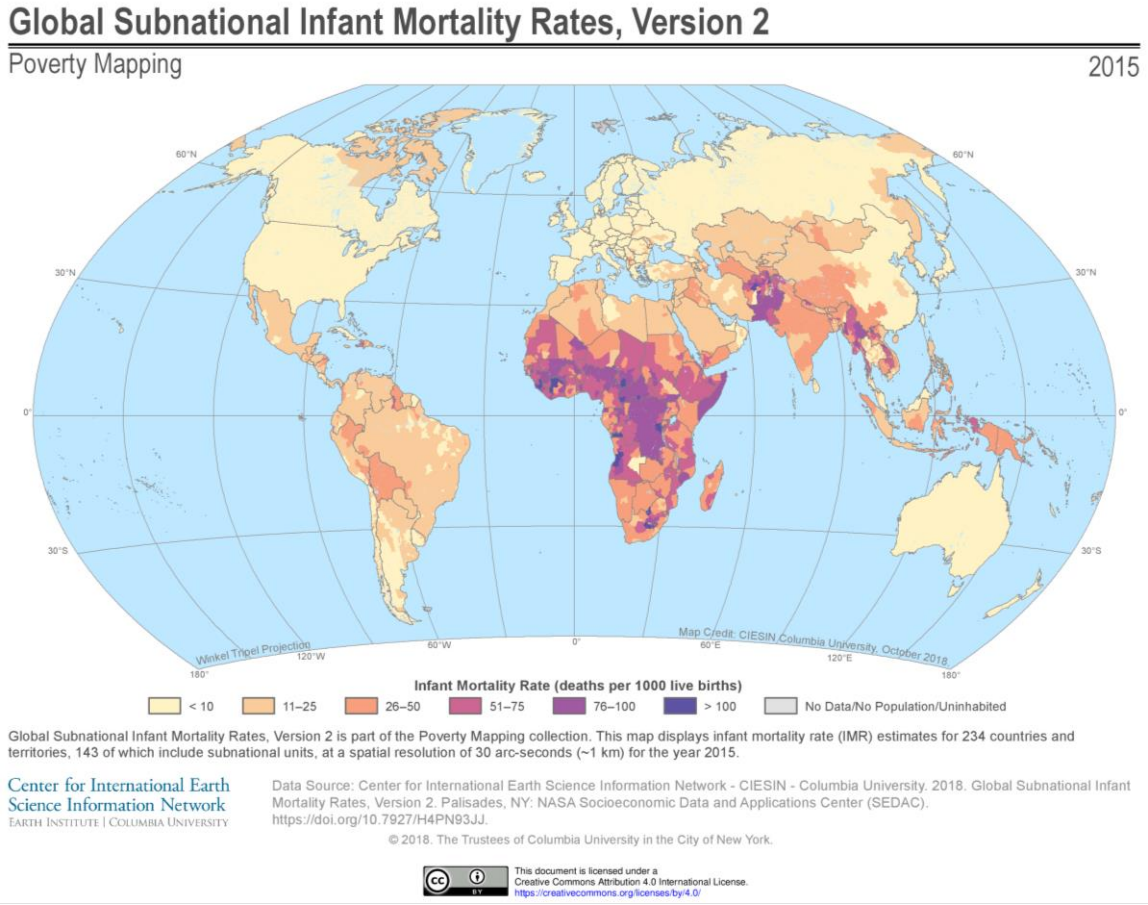


Distribution of IMR input values

- Purpose: to provide a global subnational surface of infant mortality rate estimates for the year 2015, to be used by a wide user community in interdisciplinary studies of health, poverty, and the environment.
- The dataset includes infant mortality rate (IMR) estimates for 234 countries and territories, 143 of which include subnational units.

Global Subnational Infant Mortality Rates (Cont.)

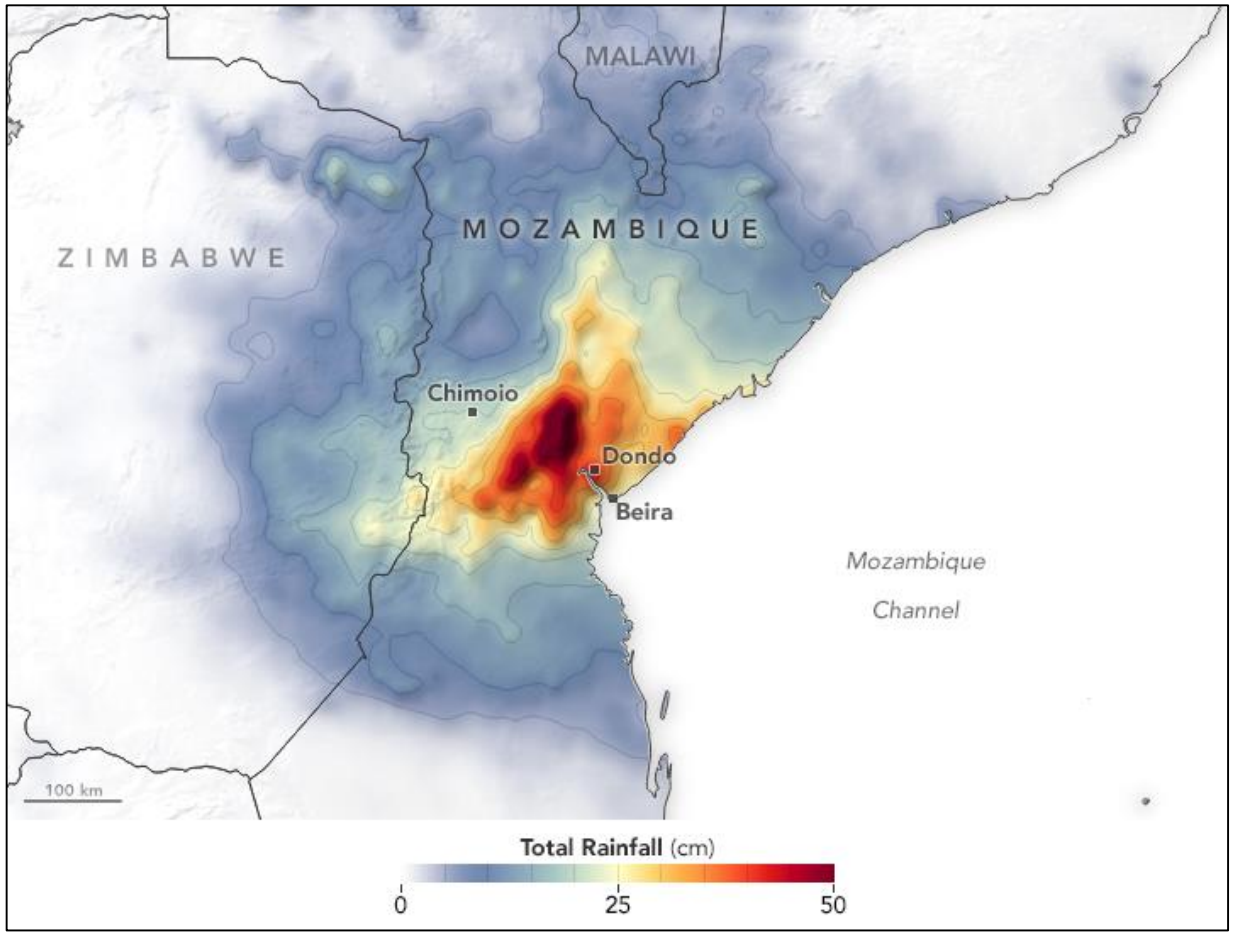
- Methods:
  - IMRs were collected from vital registration records, surveys, models, or other estimates
  - Alternatively, they were estimated using reported live births and infant deaths data
    - IMR = (deaths of infants less than 1 year old /live births) * 1000
  - Input data was adjustment to account for multiple input sources spanning from 2006 to 2014;
    - It is consistent with the United Nations Inter-agency Group for Child Mortality Estimation 2017's national estimates for the year 2015.



Cyclone *IDAI*

- Characteristics of the event:
  - Intense Tropical Cyclone IDAI made landfall in Mozambique, close to Beira, on 14 March;
  - Landed as a category 4 (out of 5) on the scale used in Mozambique;
  - Winds: 165 km/h winds, gust of up to 230 km/h;
  - Torrential rains, very high seas (waves height reached 10 meters);
  - Major, deadly inland flooding due to heavy rains from 13-21 March (Búzi and Púngùe rivers)

Rainfall accumulation from March 13-20, 2019



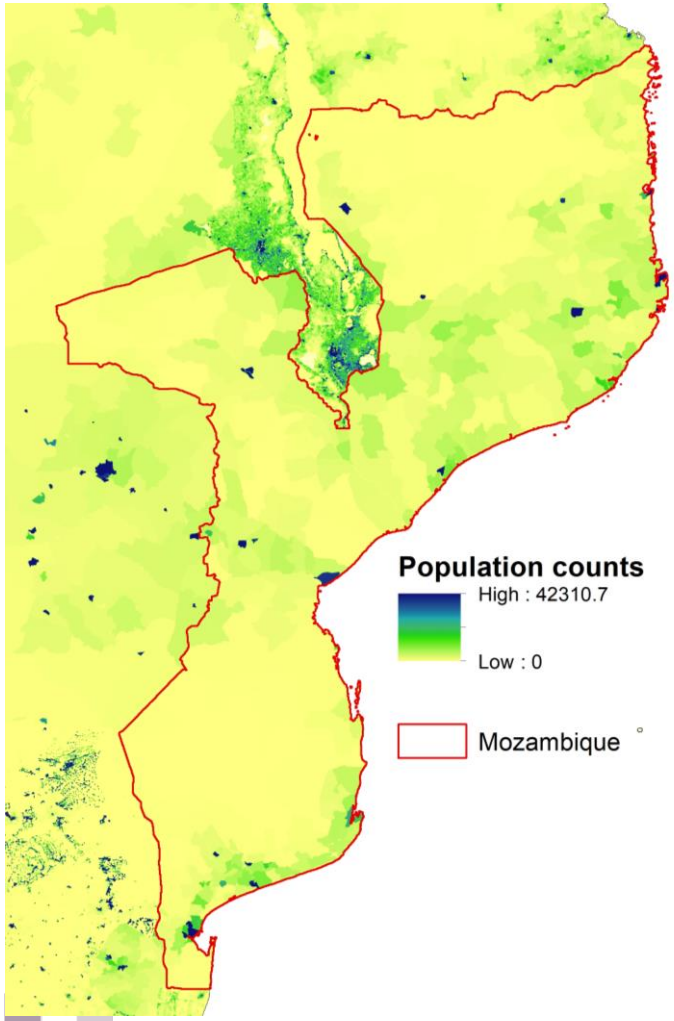
Cyclone *IDAI* (cont.)

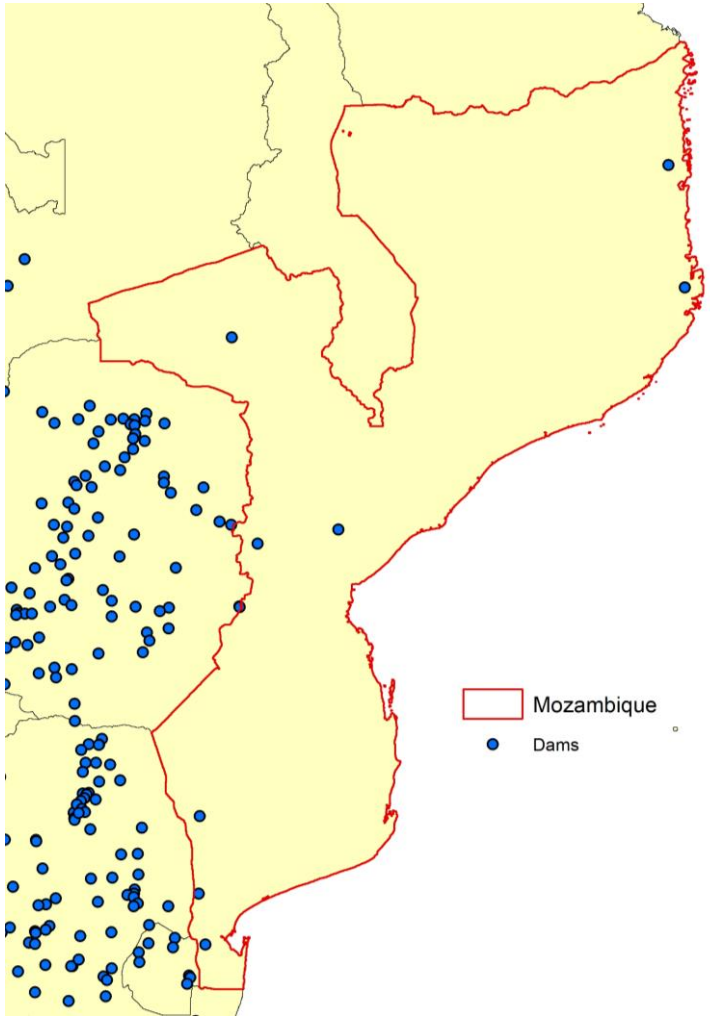
- Impact of the event
  - More than 600 deaths;
  - About 1600 injured;
  - More than 1.8 million affected;
  - An estimated USD 773 million in damages to buildings, infrastructure and agriculture.

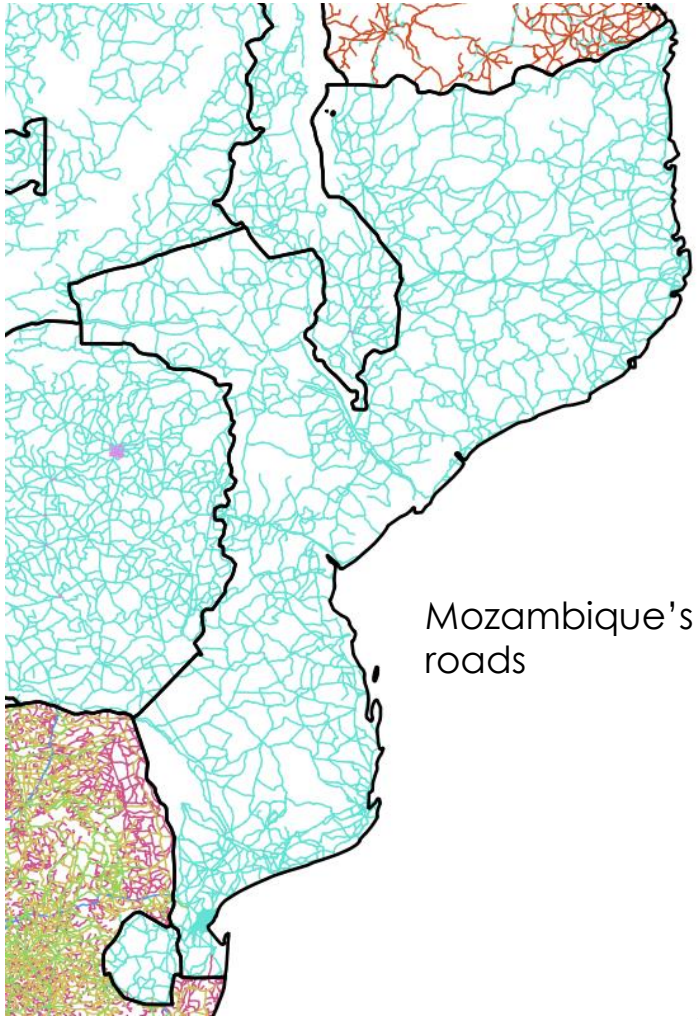
Text Source: WHO, Image Credit: Club of Mozambique

How SEDAC Data is Applicable to Cyclone *IDAI*

Population and Infrastructure Exposure

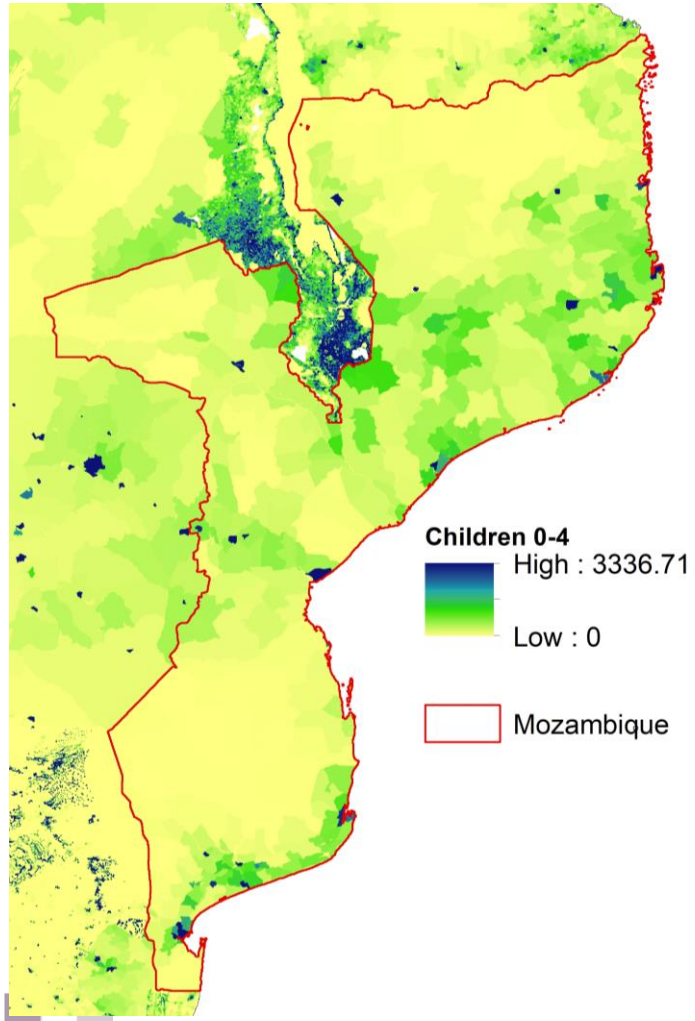


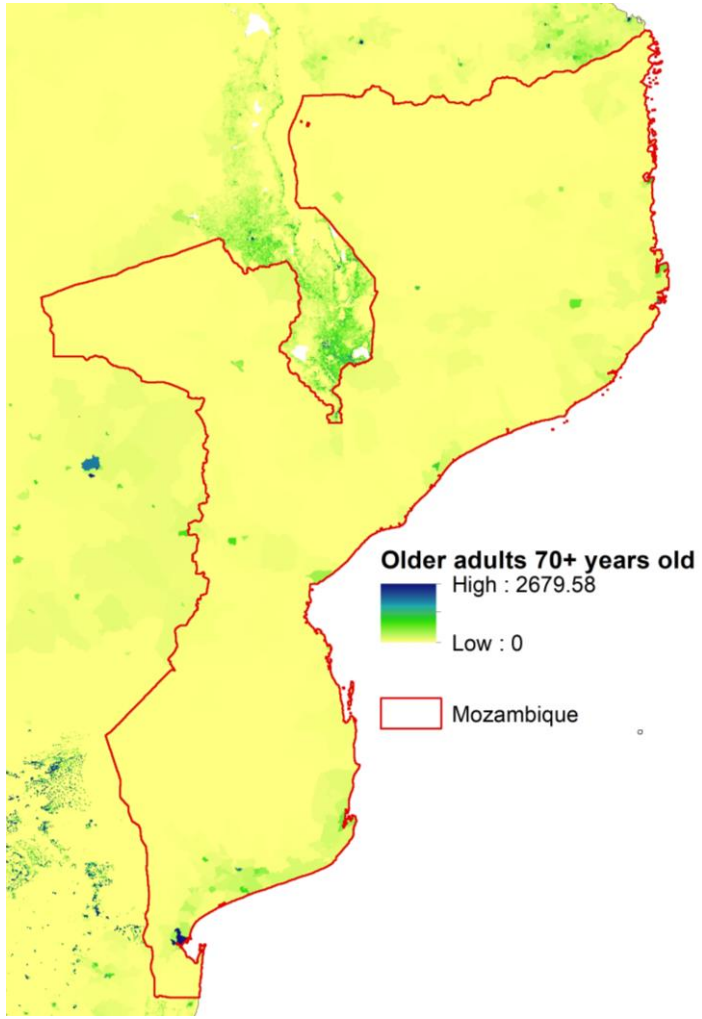


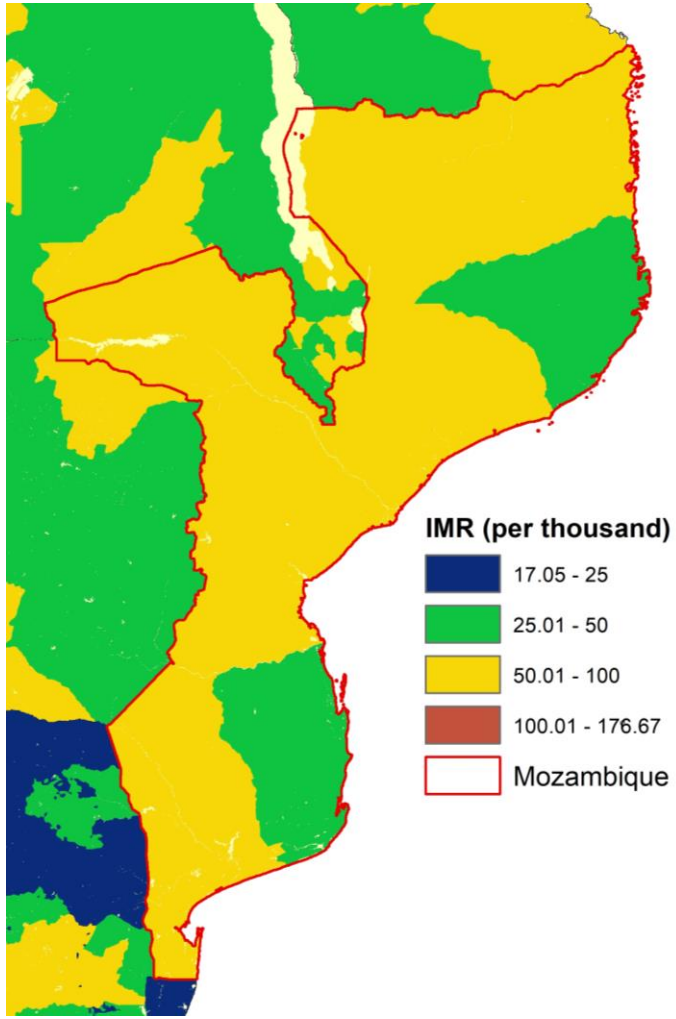


How SEDAC Data is Applicable to Cyclone *IDAI* (Cont.)

Vulnerability: Age Composition & Infant Mortality (Proxy for Living Conditions)







Links to SEDAC datasets

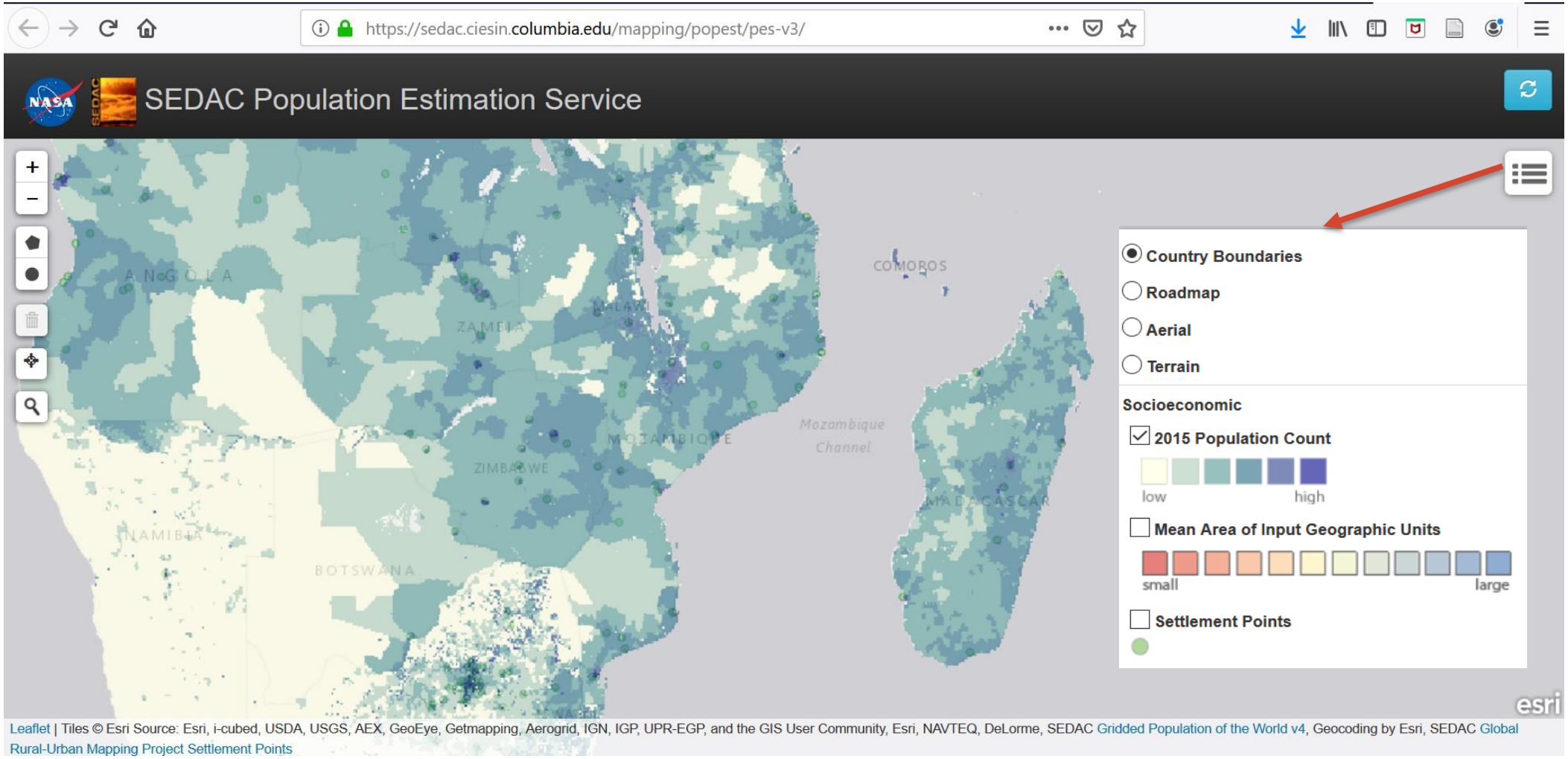
- Gridded population of the world, version 4.11
  https://sedac.ciesin.columbia.edu/data/collection/gpw-v4
- Basic demographic characteristics, version 4.11 (2010)
  https://sedac.ciesin.columbia.edu/data/set/gpw-v4-basic-demographic-characteristics-rev11
- Global subnational infant mortality rates, v2 (2015)
  https://sedac.ciesin.columbia.edu/data/set/povmap-global-subnational-infant-mortality-rates-v2
- Global Reservoir and Dam (GRanD), v1
  https://sedac.ciesin.columbia.edu/data/collection/gran-v1
- Global Roads Open Access Data Set (gROADS), v1
  https://sedac.ciesin.columbia.edu/data/set/groads-global-roads-open-access-v1
- Population Exposure Estimates in Proximity to Nuclear Plants, Locations, v1 (1956-2012)
  https://sedac.ciesin.columbia.edu/data/set/energy-pop-exposure-nuclear-plants-locations

SEDAC Tools for Visualizing Exposure and Vulnerability Information

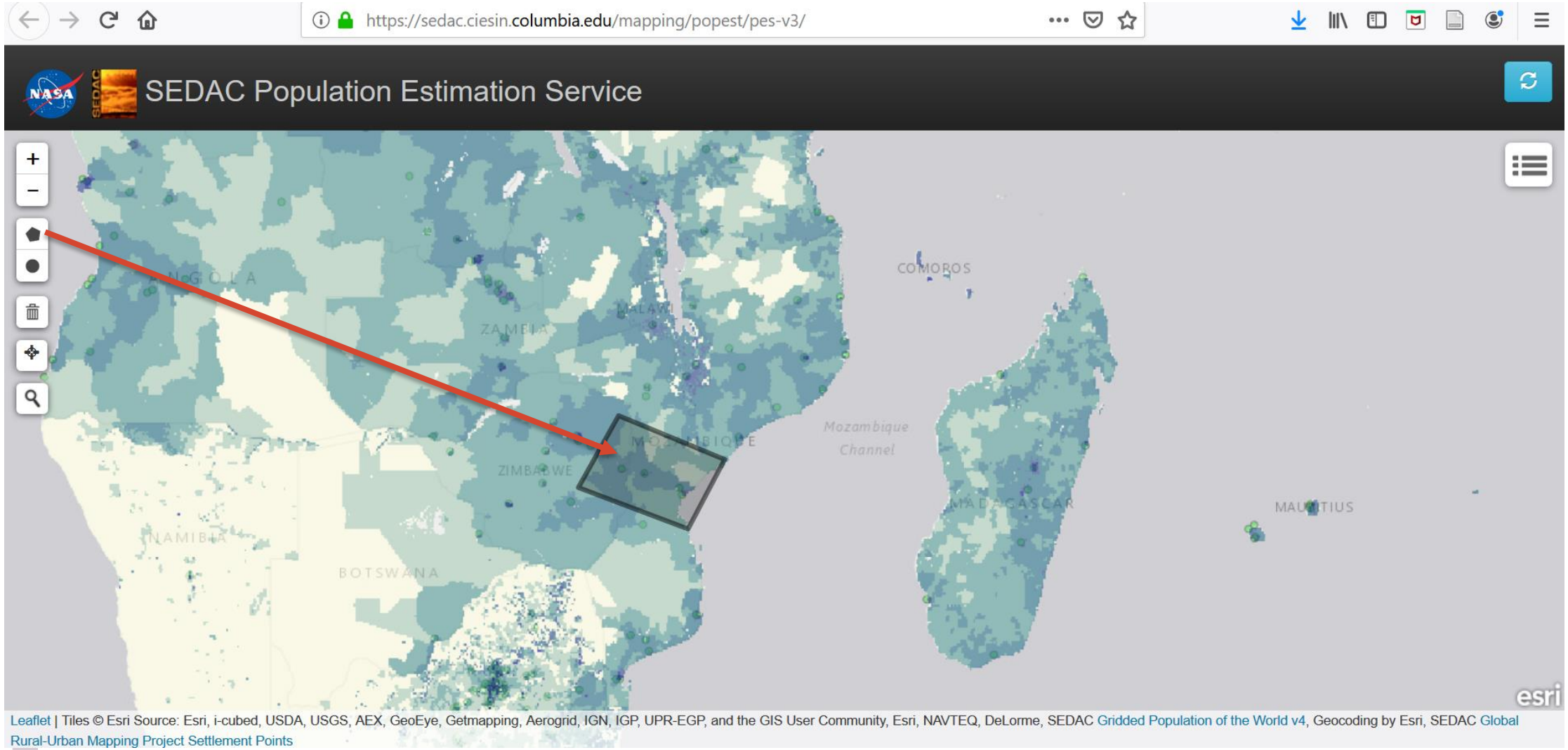
- SEDAC Population Estimator Service:
  - a Web-based service for estimating population totals, basic demographic characteristics, and related statistics within a user-defined region.
- SEDAC Hazard mapper & SEDAC Hazards and Population Mapper app (Apple version, Android version coming soon!):
  - enables users to visualize data and map layers related to Socioeconomic, Infrastructure, Natural Disasters, and Environment and analyze potential impacts and exposure.
- POPGRID Data Collaborative:
  - Map Viewer comparing population grids from different data providers

SEDAC Population Estimator

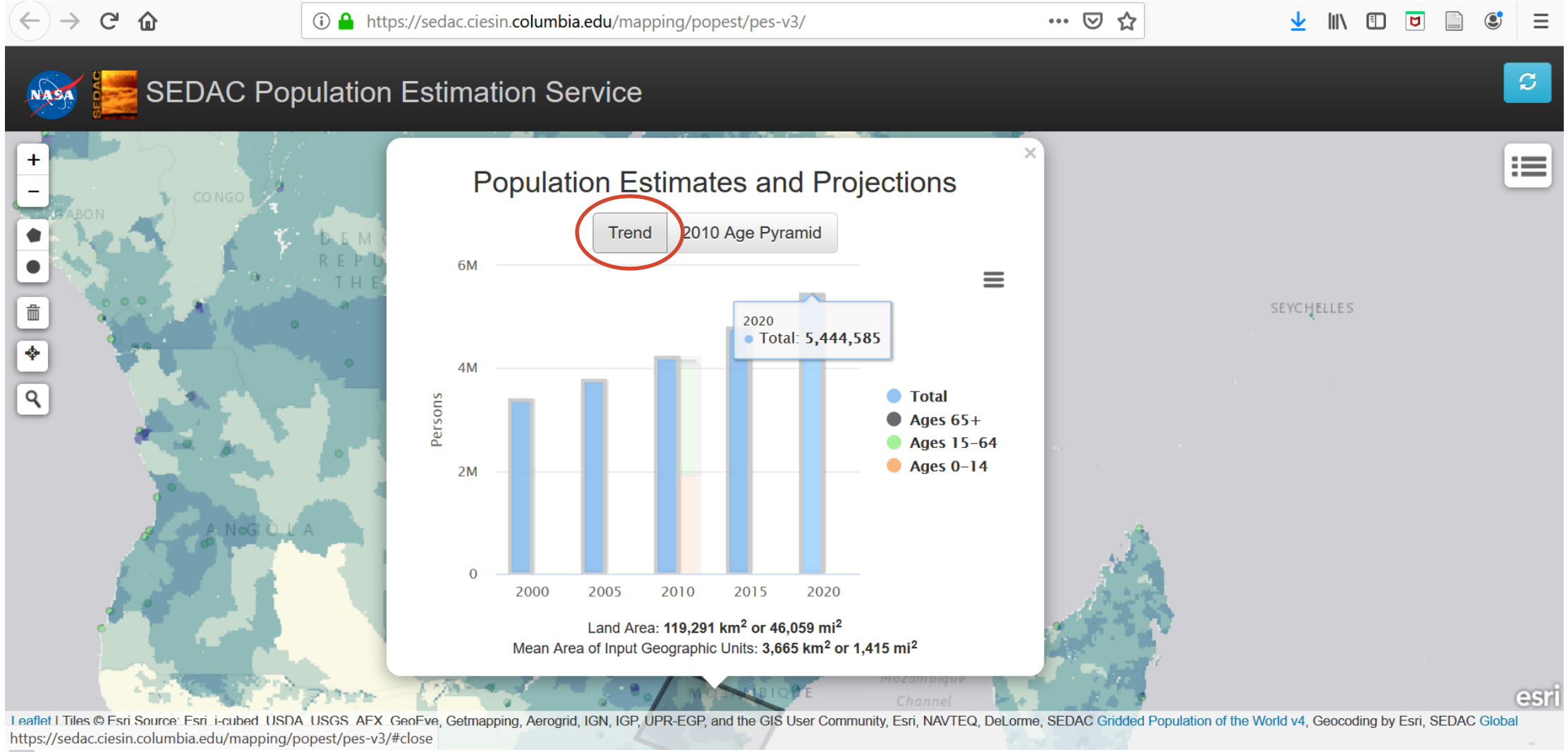
A First Glimpse to the Magnitude of Exposure and Degrees of Vulnerability



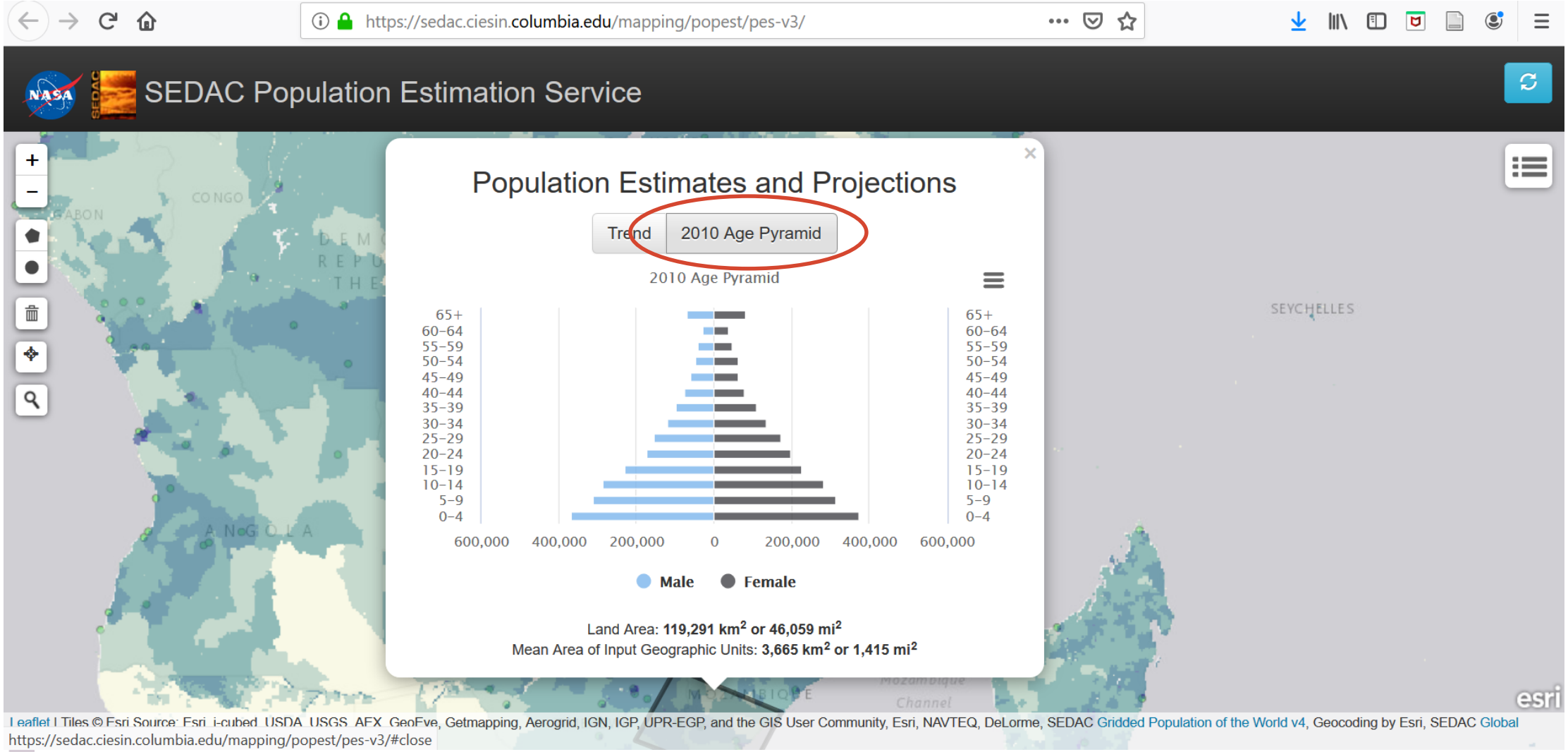
SEDAC Population Estimator (Cont.)



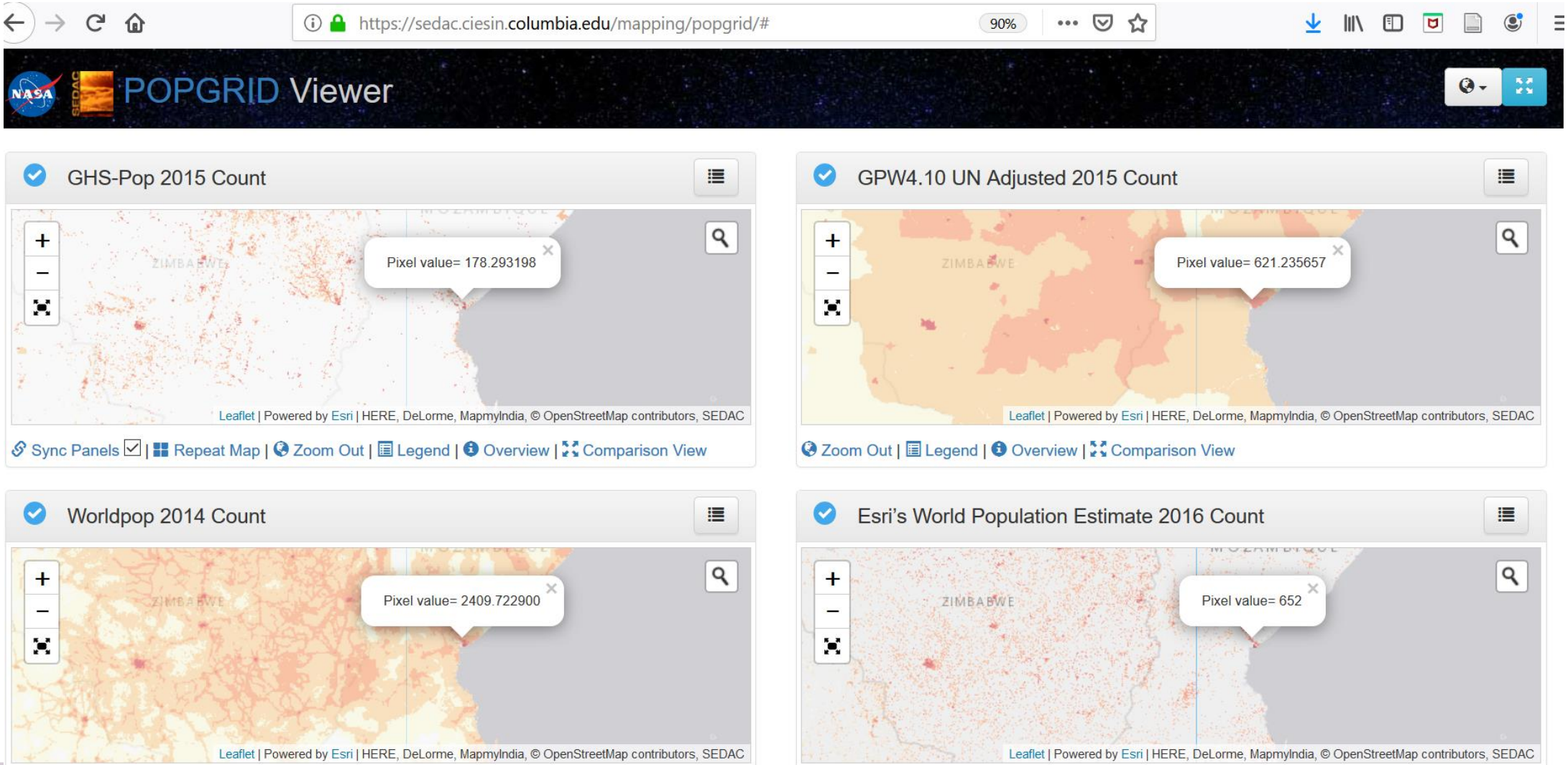
SEDAC Population Estimator (Cont.)



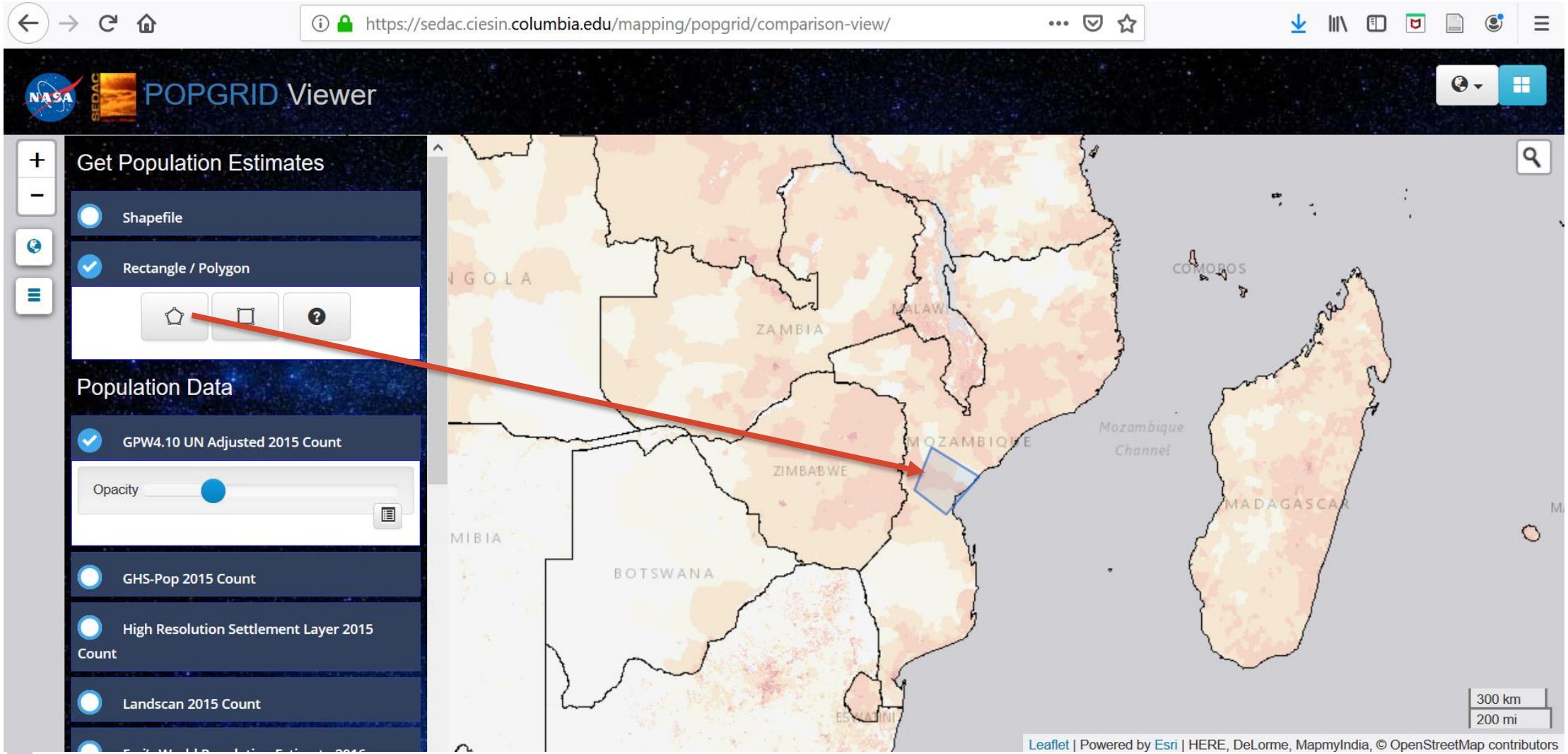
SEDAC Population Estimator (Cont.)



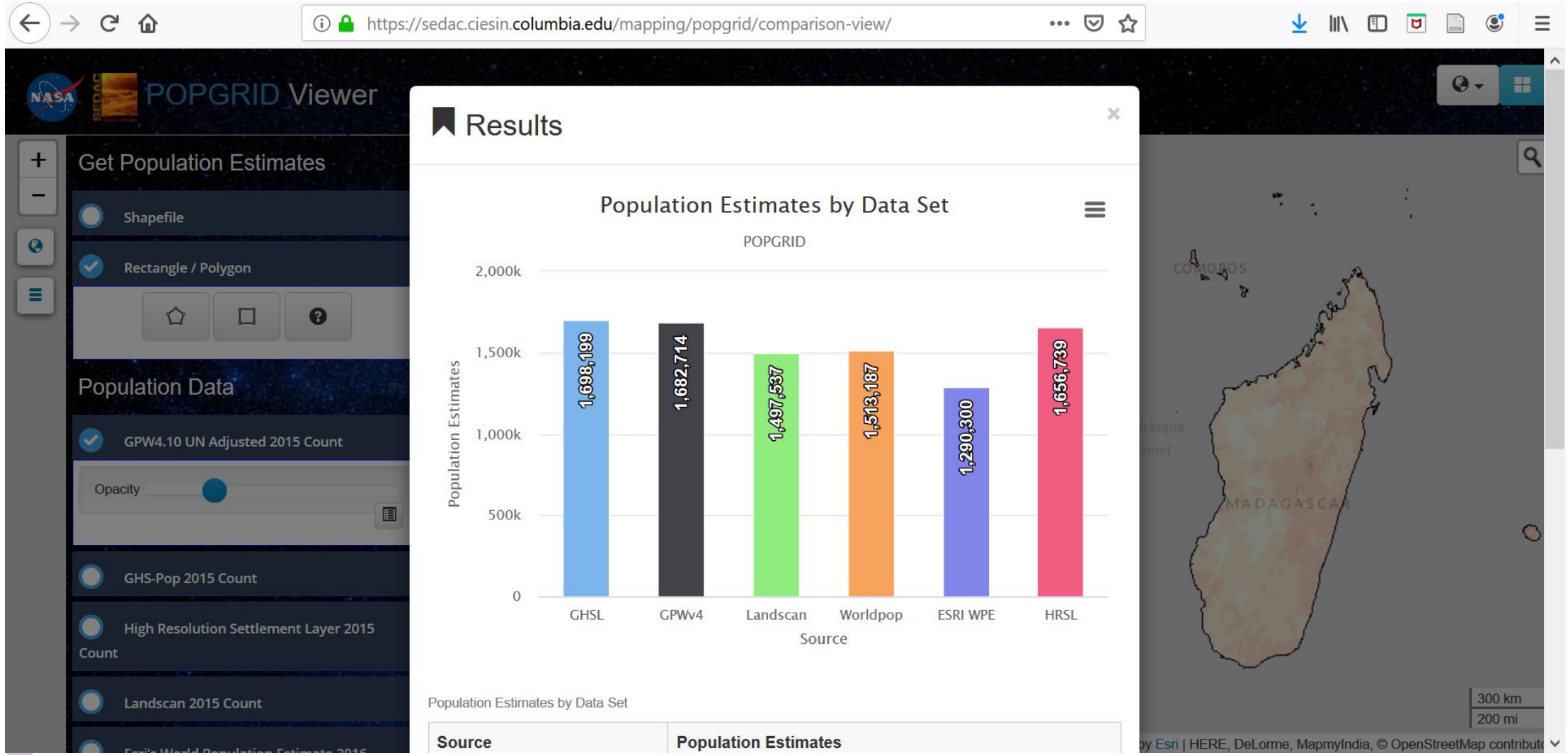
POPGRID Map Viewer: Comparing Population Estimates



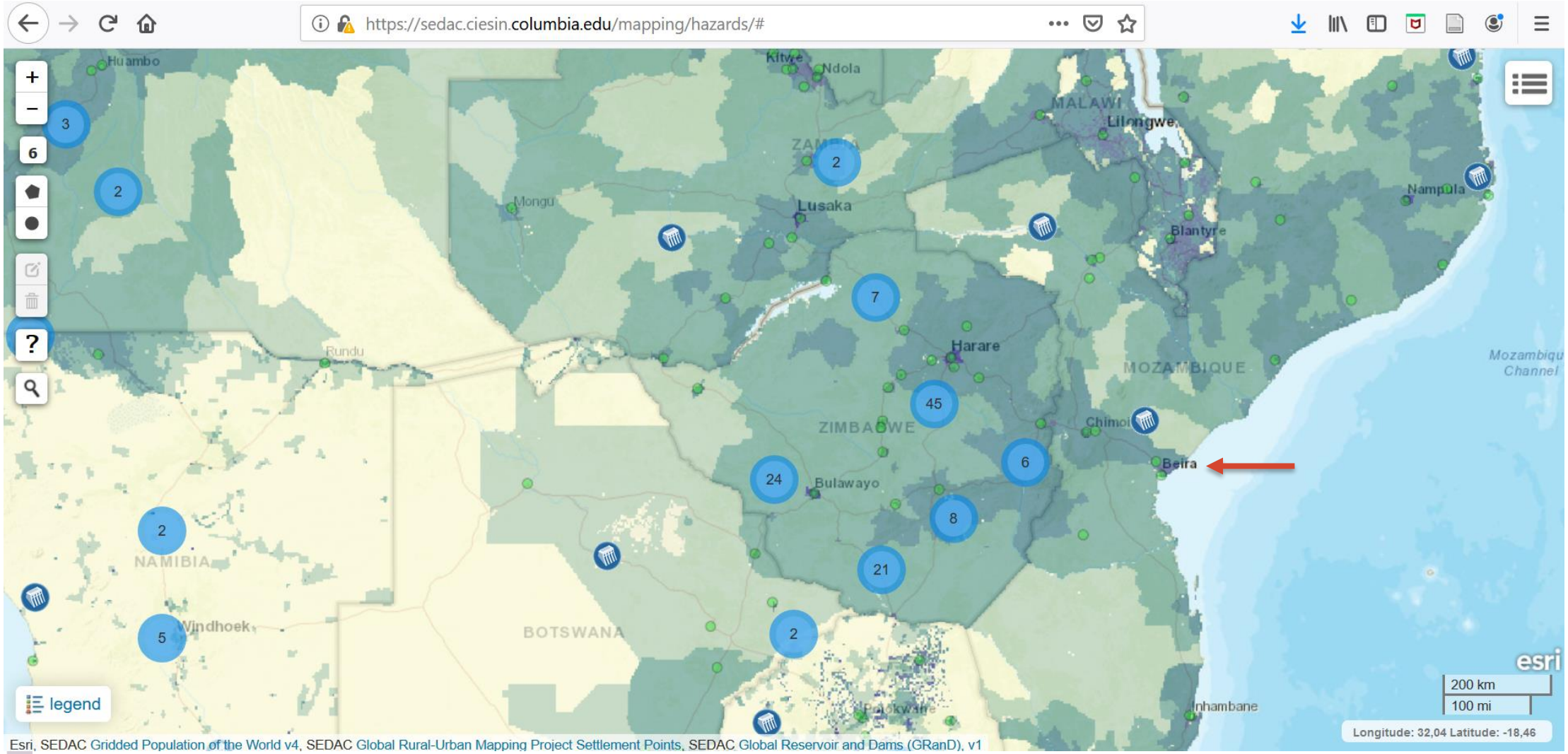
POPGRID Map Viewer: Comparing Population Estimates (Cont.)



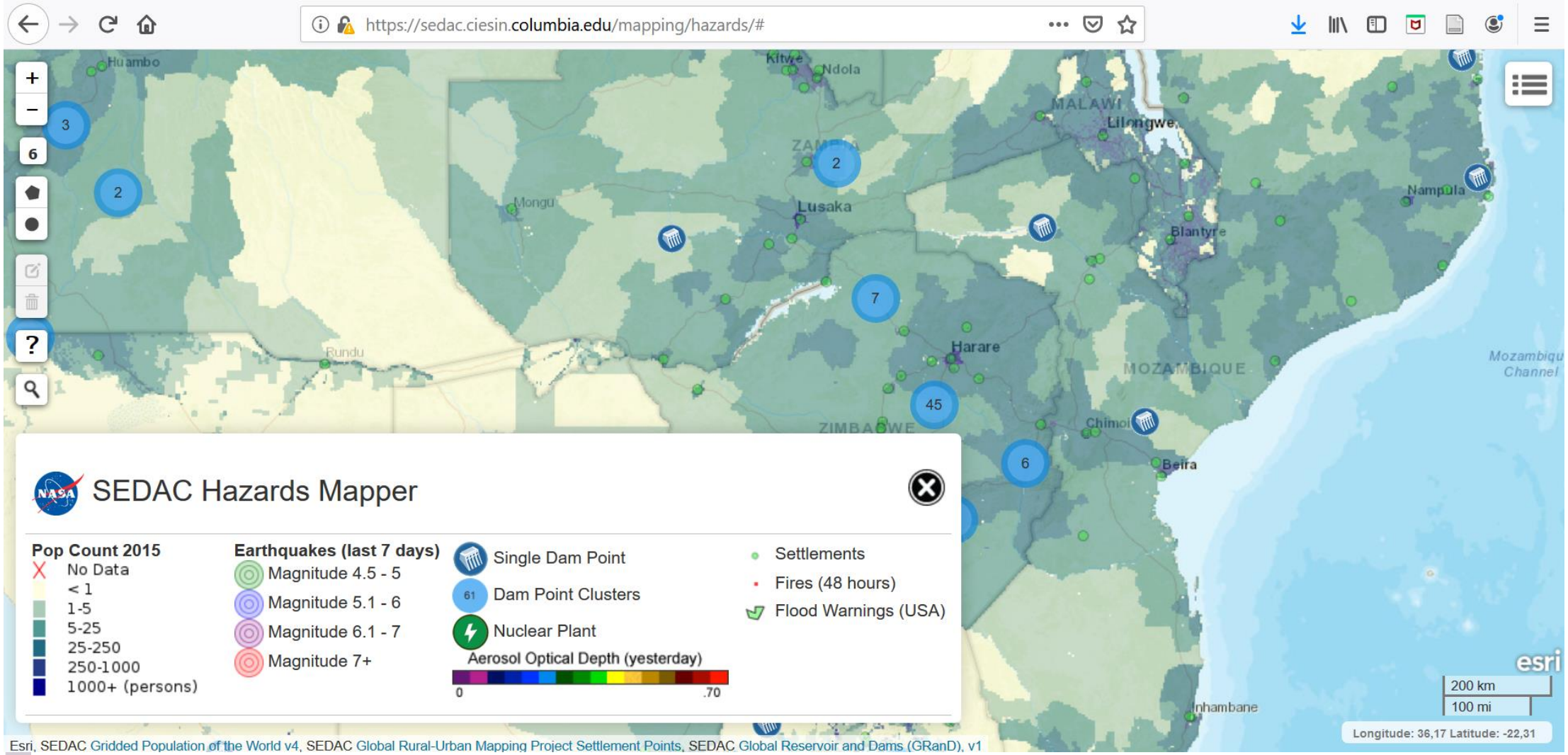
POPGRID Map Viewer: Comparing Population Estimates (Cont.)



SEDAC Hazard Mapper: What is at Risk?



SEDAC Hazard Mapper: What is at Risk?



Links to the Tools

- Population Estimation Service https://sedac.ciesin.columbia.edu/data/collection/gpw-v4/population-estimation-service

- SEDAC Hazard Mapper https://sedac.ciesin.columbia.edu/mapping/hazards/ and Hazards and Population Mapper App (Android version coming soon) https://itunes.apple.com/us/app/hazards-population-mapper/id1092168898?mt=8

- POPGRID viewer https://sedac.ciesin.columbia.edu/mapping/popgrid/

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