

National Aeronautics and Space Administration



CONSERVATION INTERNATIONAL



TRENDS.EARTH
tracking land change



United Nations
Convention to Combat
Desertification



UN-HABITAT

Remote Sensing for Land Degradation and Consumption SDGs

Speakers: Amber McCullum, Dennis Mwaniki, Dr. Alexander Zvoleff, Monica Noon, Dr. Mariano Gonzalez-Roglich

July 23, 2019

Course Structure

- Three, 1.5 hour sessions on July 9, 16, and 23, 2019
- The same content will be presented at two different times each day:
 - Session A: 10:00-11:30 EST (UTC-4)
 - Session B: 18:00-19:30 EST (UTC-4)
 - **Please only sign up for and attend one session per day**
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
 - <https://arset.gsfc.nasa.gov/land/webinars/land-degradation-SDGs19>
- Q&A: Following each lecture and/or by email
 - amberjean.mccullum@nasa.gov
 - juan.l.torresperez@nasa.gov

Homework and Certificates

- Homework
 - One homework assignment
 - Answers must be submitted via Google Forms
- Certificate of Completion:
 - Attend both live webinars
 - Complete the homework assignment by the deadline (access from ARSET website)
 - **HW Deadline: Tuesday August 6th**
 - You will receive certificates approximately two months after the completion of the course from:
marines.martins@ssaihq.com

Homework for Remote Sensing for Land Degradation and Consumption SDGs

This homework includes questions from the lectures and exercises from both sessions of this webinar. Some questions refer to portions of the exercise that can be best answered as you are completing the steps. Thus, it may be best to record your answers on a sheet of paper or elsewhere before submitting them here. You will not be able to save your answers and come back to complete this form at a later time.

To receive a homework by your response
Once you click

* Required

Email address

NASA's Applied Remote Sensing Training Program (ARSET)
presents a certificate of completion to
Amber McCullum
for completing:
Advanced Webinar: Change Detection for Land Cover Mapping
September 28 – October 5, 2018
Trainers: Cindy Schmidt, Amber McCullum

Prerequisites

- Complete [Sessions 1 & 2A of Fundamentals of Remote Sensing](#), or equivalent experience
- [Download and install QGIS](#). QGIS version 2.18.15
 - Use this exercise for help: [Downloading and Installing QGIS](#)
- Download, install, and register the [Trends.Earth](#) software. This is a QGIS plugin that only currently works with the Version 2 iterations of QGIS (not version 3 or higher).
 - Be sure to read the [Before Installing the toolbox](#) page prior to [Installing the toolbox](#).

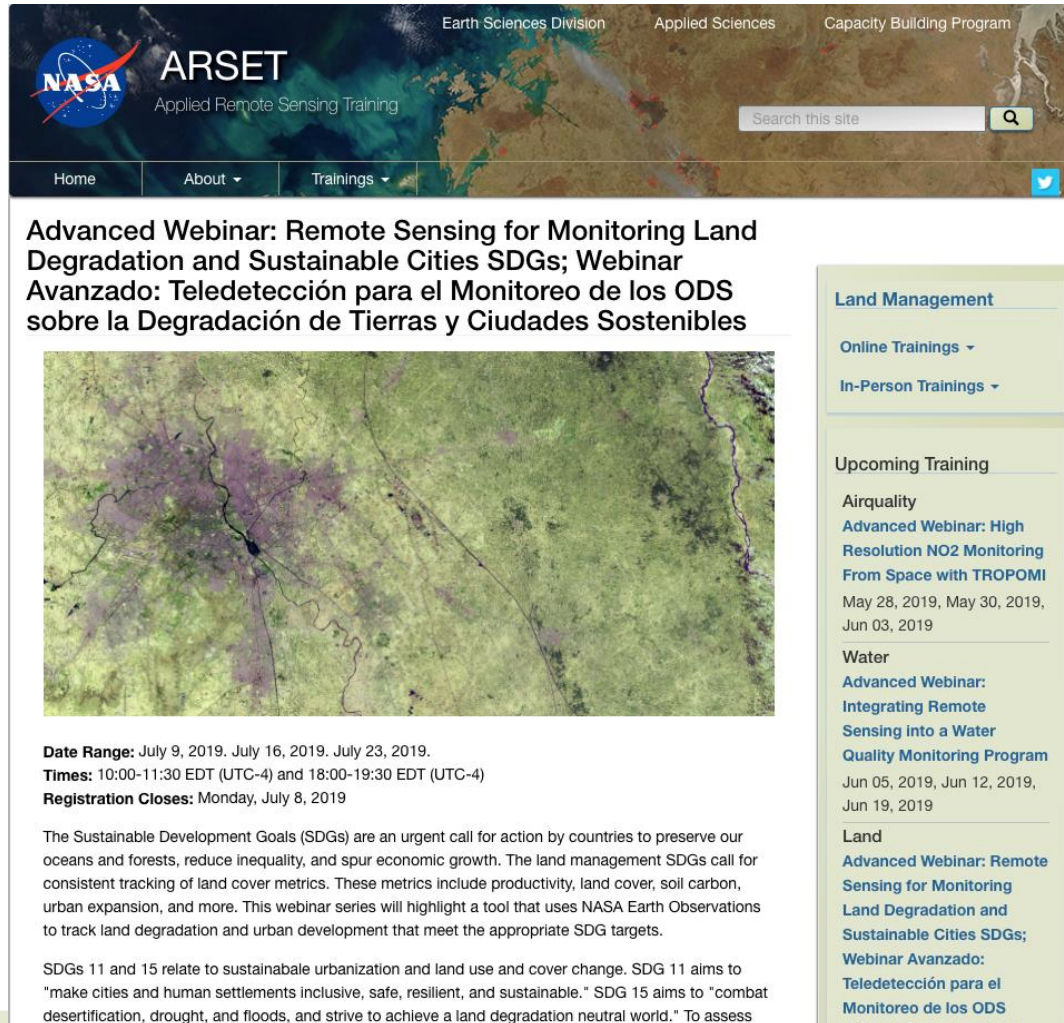


Advanced Webinar: Change Detection for Land Cover Mapping



Accessing Course Materials

<https://arset.gsfc.nasa.gov/land/webinars/land-degradation-SDGs19>



The screenshot shows the ARSET website header with the NASA logo and 'Applied Remote Sensing Training'. Navigation links include Home, About, and Trainings. The main content area features the title 'Advanced Webinar: Remote Sensing for Monitoring Land Degradation and Sustainable Cities SDGs; Webinar Avanzado: Teledetección para el Monitoreo de los ODS sobre la Degradación de Tierras y Ciudades Sostenibles' and a satellite image of a city. A sidebar on the right lists training categories: Land Management, Online Trainings, and In-Person Trainings. Under 'Upcoming Training', it lists 'Airquality' and 'Water' webinars. The 'Land' section highlights the current webinar.

Advanced Webinar: Remote Sensing for Monitoring Land Degradation and Sustainable Cities SDGs; Webinar Avanzado: Teledetección para el Monitoreo de los ODS sobre la Degradación de Tierras y Ciudades Sostenibles

Date Range: July 9, 2019. July 16, 2019. July 23, 2019.
Times: 10:00-11:30 EDT (UTC-4) and 18:00-19:30 EDT (UTC-4)
Registration Closes: Monday, July 8, 2019

The Sustainable Development Goals (SDGs) are an urgent call for action by countries to preserve our oceans and forests, reduce inequality, and spur economic growth. The land management SDGs call for consistent tracking of land cover metrics. These metrics include productivity, land cover, soil carbon, urban expansion, and more. This webinar series will highlight a tool that uses NASA Earth Observations to track land degradation and urban development that meet the appropriate SDG targets.

SDGs 11 and 15 relate to sustainable urbanization and land use and cover change. SDG 11 aims to "make cities and human settlements inclusive, safe, resilient, and sustainable." SDG 15 aims to "combat desertification, drought, and floods, and strive to achieve a land degradation neutral world." To assess

Course Agenda:

[Agenda](#)

Part One

In this webinar, attendees will learn about the SDG framework and global agency coordination; become familiar with SDG 15, Target 15.3, and Indicator 15.3.1; learn about the concept of net primary productivity and how to monitor that metric with remote sensing data; and will learn to view and interpret remote sensing data associated with SDG 15 within a QGIS tool developed by Conservation International called Trends.Earth as a hands-on activity.

- [Presentation Slides »](#)
- [Exercise 1 »](#)
- [Exercise 2 »](#)

Prima Parte

En esta sesión aprenderán acerca del marco de los ODS y la coordinación entre agencias a nivel mundial; se familiarizarán con el ODS 15, Meta 15.3 e Indicador 15.3.1; aprenderán sobre el concepto de la productividad primaria neta y cómo monitorear esa métrica con datos por teledetección; también aprenderemos cómo visualizar e interpretar datos por teledetección asociados con el ODS 15 dentro de una herramienta para QGIS desarrollada por Conservation International llamada Trends.Earth como un ejercicio práctico.

- [Diapositivas de la Presentación »](#)
- [Ejercicio 1 »](#)
- [Ejercicio 2 »](#)

Part Two

In this webinar, attendees will learn about land cover change and soil organic carbon and how to monitor those metrics with remote sensing; learn about country reporting requirements for SDG 15; and view and interpret local remote sensing data associated with SDG 15 within Trends.Earth.

- [Presentation Slides »](#)
- [Exercise 1 »](#)

Segunda Parte

En esta sesión, aprenderán acerca de los cambios en la cobertura terrestre y el carbono orgánico del suelo y cómo monitorear esas métricas mediante la teledetección; aprenderán acerca de los requisitos en cuanto a la presentación de informes para el ODS 15; además, visualizarán e interpretarán datos por teledetección locales asociados con el ODS dentro de Trends.Earth.

- [Diapositivas de la Presentación »](#)
- [Ejercicio 1 »](#)

Course Outline

Session 1: SDG 15

- ARSET and the SDGs
- SDG 15 Overview
- Trends/Earth for 15.3.1
- Exercise (default data)

Session 2: SDG 15

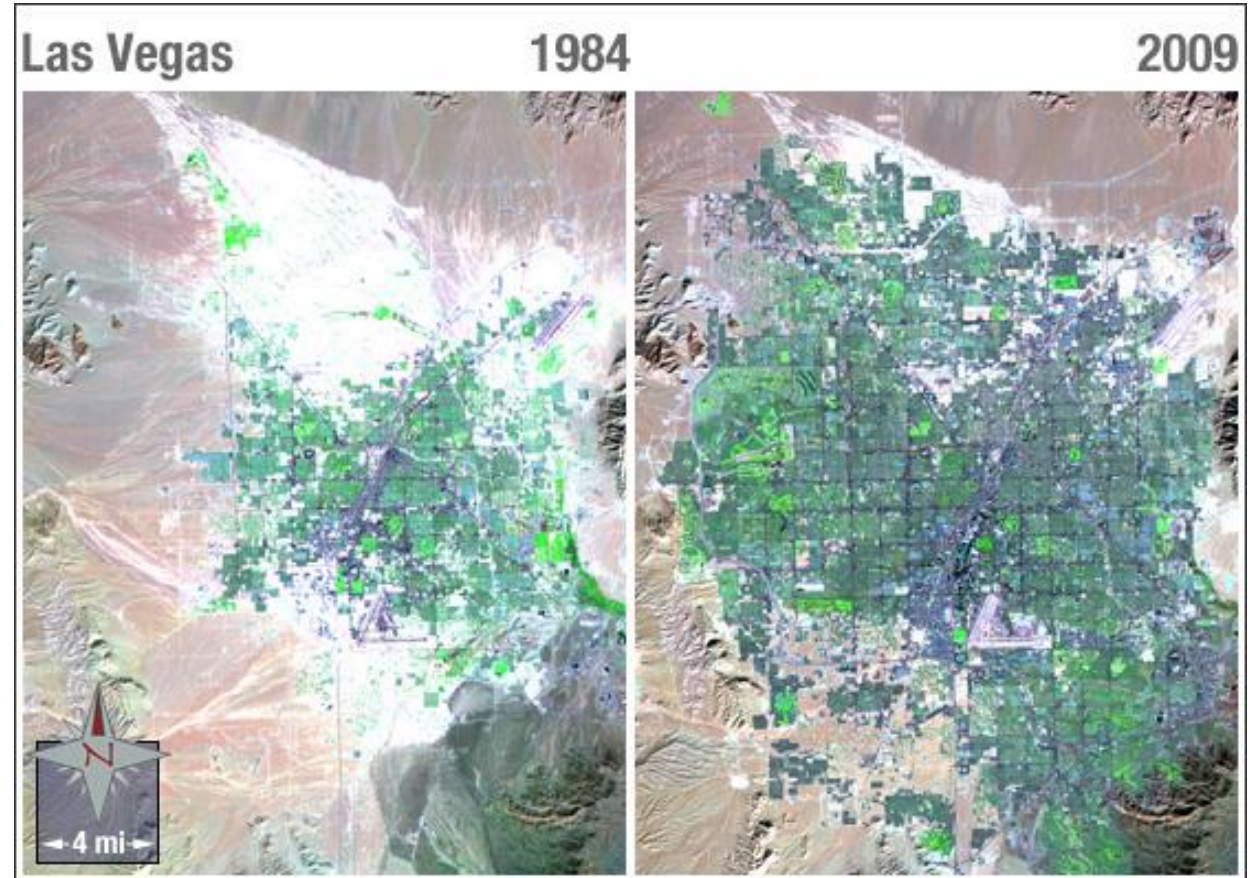
- Global Datasets
- Country/local data example
- Exercise (local data)

Session 3: SDG 11

- SDG 11 Overview
- Trends/Earth for 11.3.1
- Exercise (urban mapping)

Session 3 Agenda

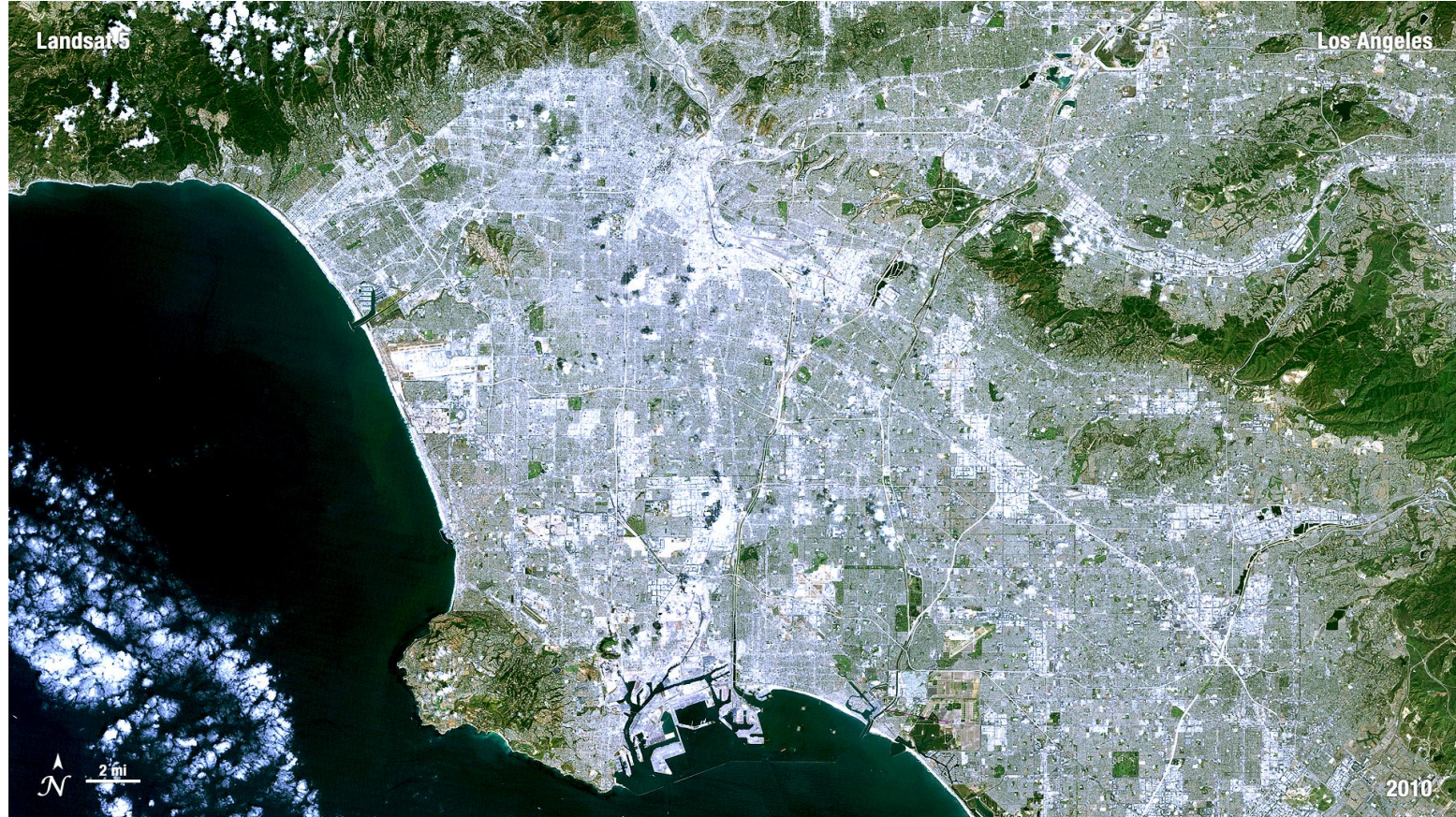
- NASA - Overview of SDG 11
- UN Habitat – Indicator 11.3.1 and data needs
- CI - Presentation on the Trends.Earth tool for SDG 11.3.1
- CI - Exercise using Trends.Earth for urban mapping



Landsat Images of Las Vegas. Image Credit: NASA

SDG 11: Sustainable Cities and Communities

- Make cities and human settlements inclusive, safe, resilient and sustainable



Los Angeles from Landsat. Image Credit: Earth Observatory



SDG: Target 11.3

Supporting Sustainable Cities

- By 2030 enhance inclusive and sustainable urbanization and capacities for participatory, integrated and sustainable human settlement planning and management in all countries
- This target has many aspects, but portions of the indicator 11.3.1 can be monitored via remote sensing



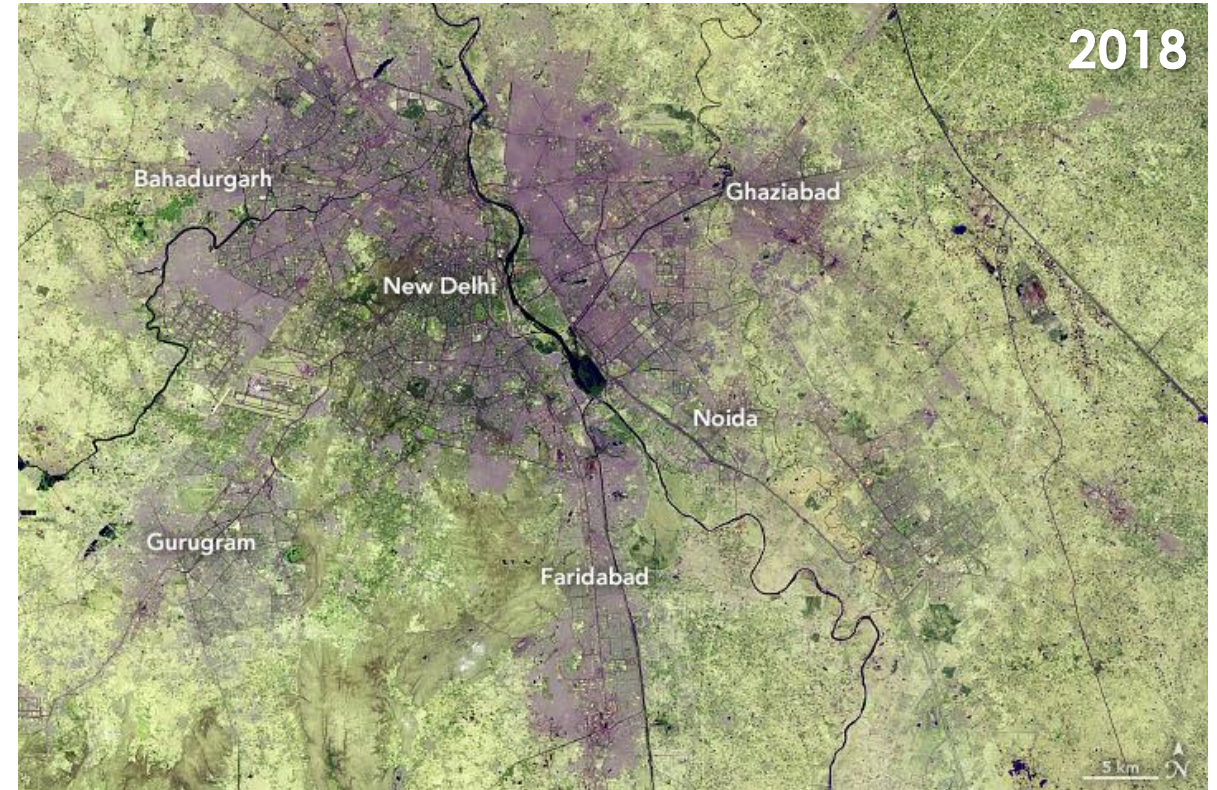
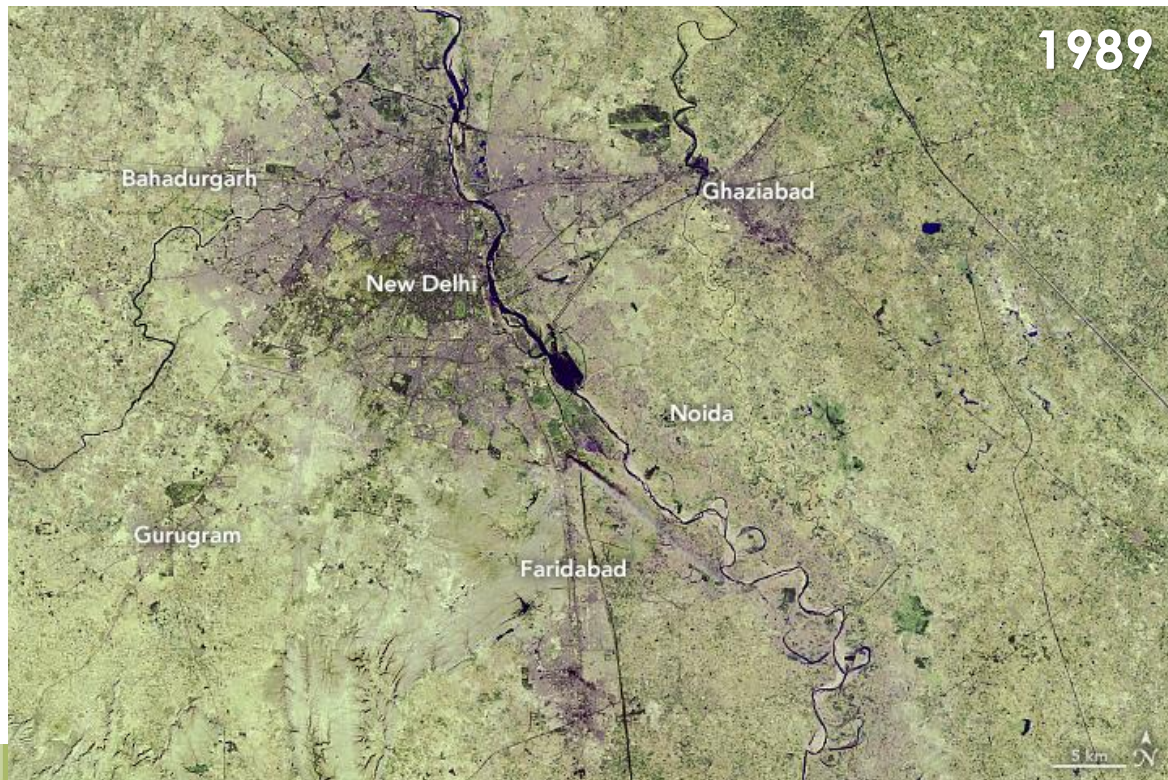
Images: (left) Bombay, India, Image Credit: shilpi siwach; (right) Bombay India from Landsat. Image Credit: Earth Observatory; Credit: Alex Zvoleff



SDG Indicator 11.3.1

Supporting Sustainable Cities

- **Ratio of land consumption rate to population growth rate**
- Landsat data can be used to determine “built up area” over multiple years



SDG 11.3 Data Needs

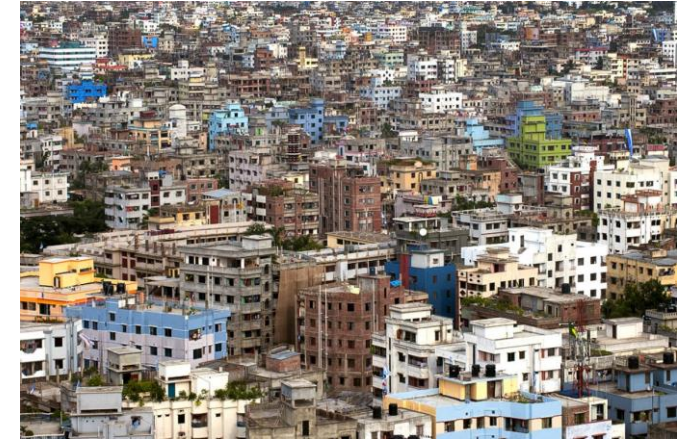
- Satellite images
 - Impervious index
 - Built up area
 - City extent
- City population
- **Good Practice Guidelines**
- **Country reporting**



United Nations Development Programme

<https://www.undp.org>

- Focus on many SDGs including target 11.3 in effort for maintaining and increasing the sustainability of cities



4.2 billion

In 2018, 4.2 billion people, 55 percent of the world's population, lived in cities. By 2050, the urban population is expected to reach 6.5 billion.

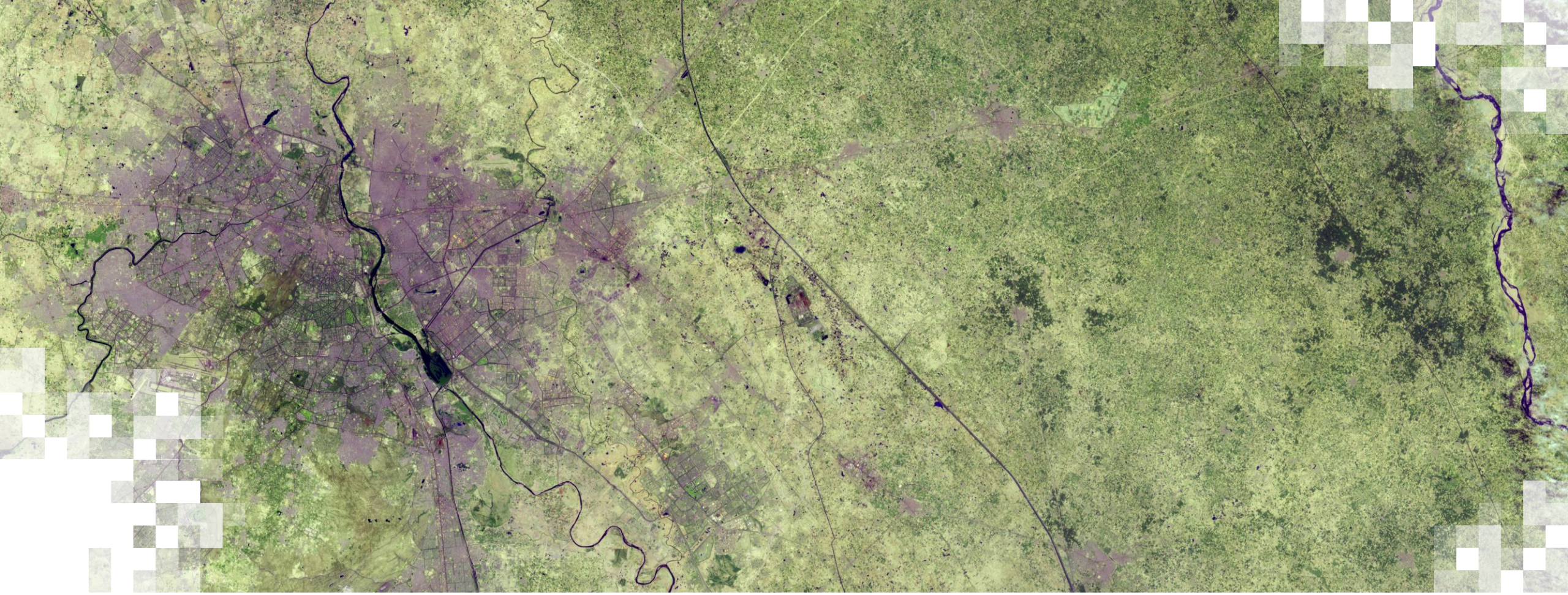
3%

Cities occupy just 3 percent of the Earth's land but account for 60 to 80 percent of energy consumption and at least 70 percent of carbon emissions.

828 million

828 million people are estimated to live in slums, and the number is rising.

Images from UNDP



Guest Speakers:

Dennis Mwaniki (UN Habitat), Dr. Mariano Gonzalez-Roglich (CI), Dr. Alexander Zvoleff (CI), Monica Noon (CI)

TRENDS.EARTH - SDG 11.3.1 and DATA NEEDS



- Like living organisms, cities evolve, transform, adapt, innovate and change with emerging trends
- Four broad ways cities grow: *Infill*, *Extension*, *Leapfrogging*, and *Inclusion*

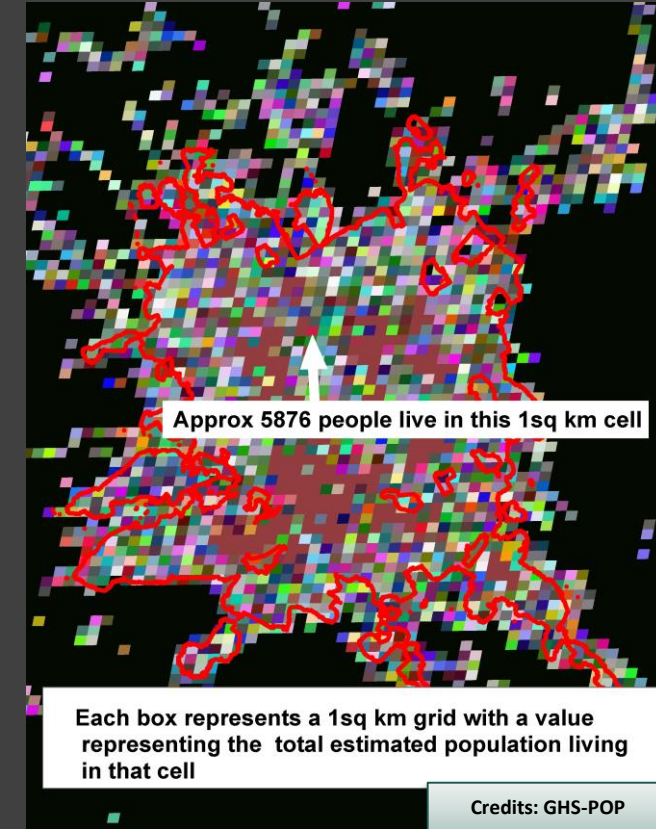
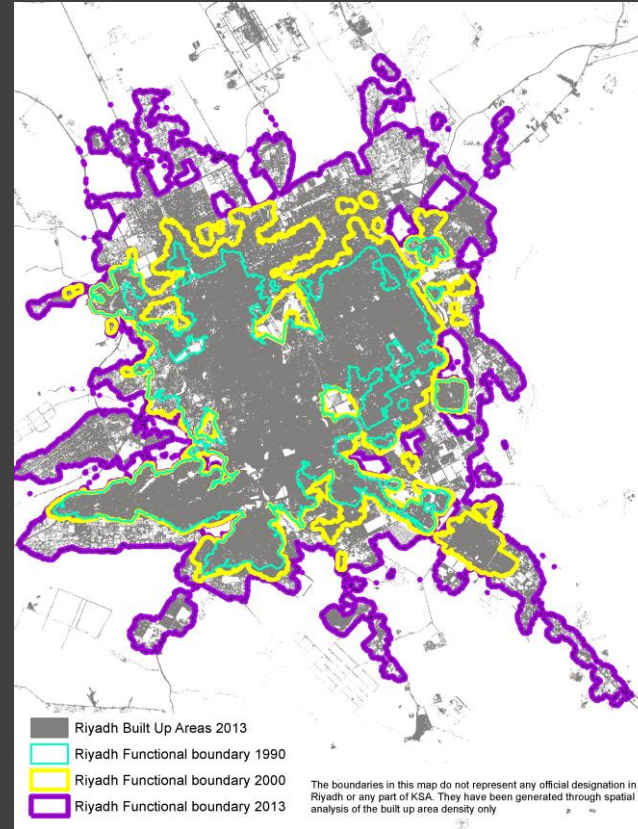
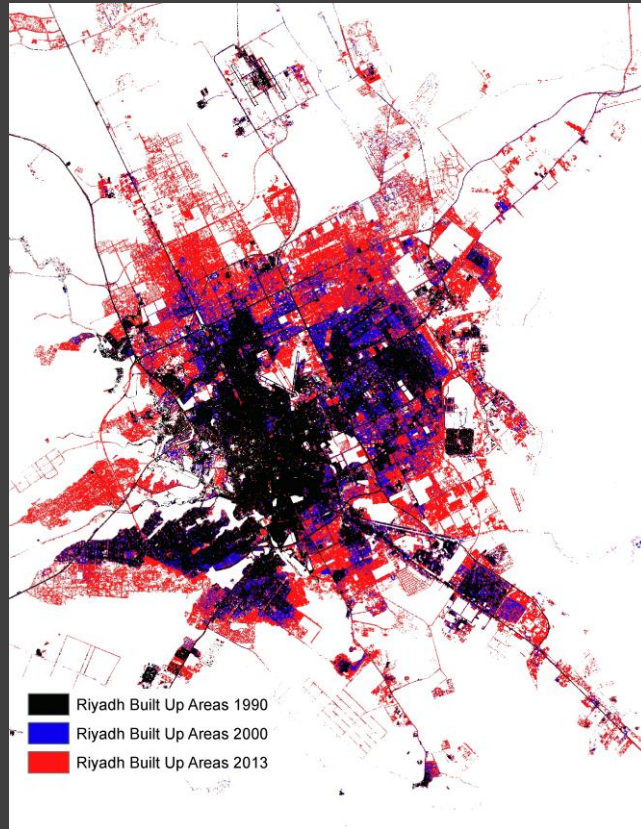
Indicator 11.3.1 measures rate at which cities are expanding spatially versus the rate of their population is growing

– Five year measurement intervals recommended

TRENDS.EARTH - SDG 11.3.1 and DATA NEEDS

Concepts

- Land Consumption Rate
- Population Growth Rate



Data needs/
Indicator inputs

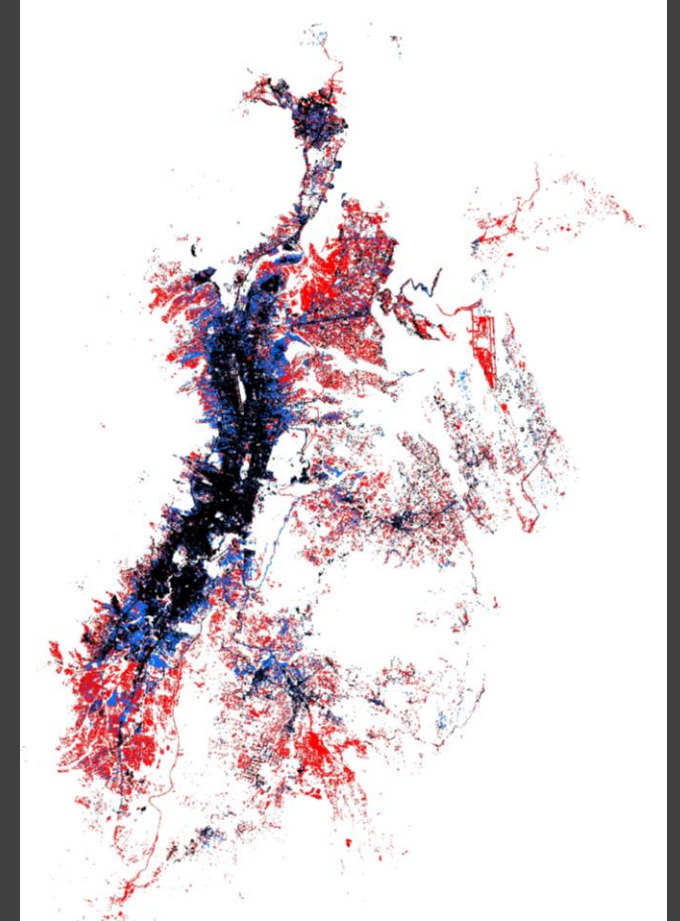
Built up layer

Dynamic & functional city boundaries

Disaggregate population data

Why measure land consumption rate to population growth rate?

- To understand urban transition dynamics
 - Speed of growth for different settlements
 - Direction of growth
 - Type of growth
- Understanding growth can:
 - Help estimate demand for services, direct investments
 - Support development of policies for sustainable urbanization
 - Support vulnerability assessment & disaster preparedness/response



Remote Sensing for monitoring Land Degradation and Sustainable Cities SDGs

Session 3

Presenters: Mariano Gonzalez-Roglich, Alexander Zvoleff, Monica Noon
Conservation International, trends.earth@conservation.org



Updated May 9, 2019



TARGET 11-3

INCLUSIVE AND SUSTAINABLE URBANIZATION

TRENDS.EARTH

SUPPORTING SUSTAINABLE CITIES



TRENDS.EARTH - SDG 11.3.1

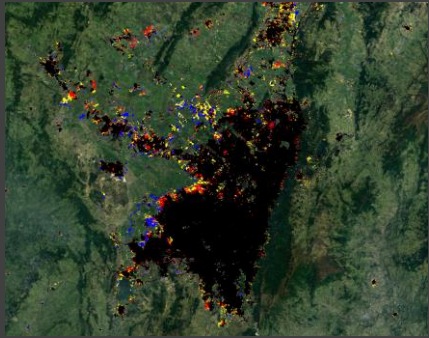


- Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable
 - Target 11.3: By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries
 - Indicator 11.3.1: Ratio of land consumption rate to population growth rate
- Data needs:
 - Urban extent
 - Population data

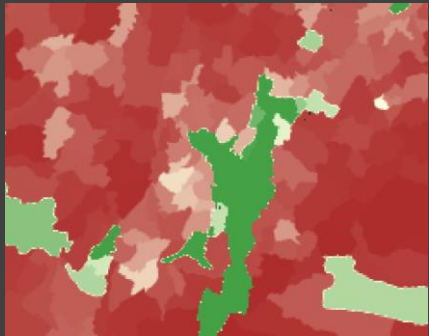
TRENDS.EARTH - SDG 11.3.1



Trends.Earth urban extent series



Gridded Population of the World V4



- Part 1: Estimating the population growth rate
- Part 2: Estimating the land use consumption rate
- Part 3: Estimating SDG 11.3.1

$$PGR = \frac{(\text{LN}(\text{Pop}_{(t+n)} / \text{Pop}_t))}{(y)}$$

$$LCR = \frac{(\text{LN}(\text{Urb}_{(t+n)} / \text{Urb}_t))}{(y)}$$

$$LCRPGR = \frac{(\text{Annual Land Consumption rate})}{(\text{Annual Population growth rate})}$$



Metadata on SDGs Indicator 11.3.1
Indicator category: Tier II

TRENDS.EARTH - COMPUTE SDG 11.3.1



2000



TRENDS.EARTH - COMPUTE SDG 11.3.1



2000

Satellite images

Impervious Index

Built-up area

City extent

City population

SDG 11.3.1

2005

Satellite images

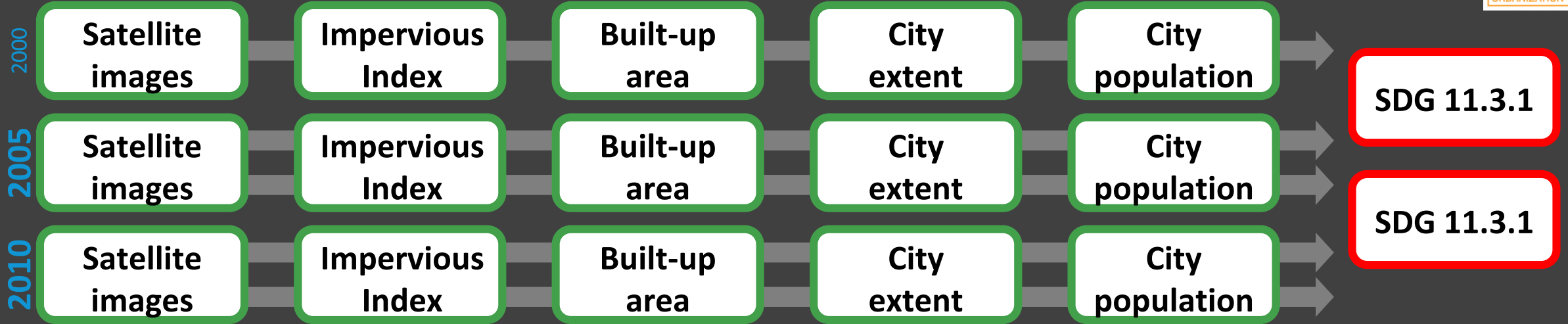
Impervious Index

Built-up area

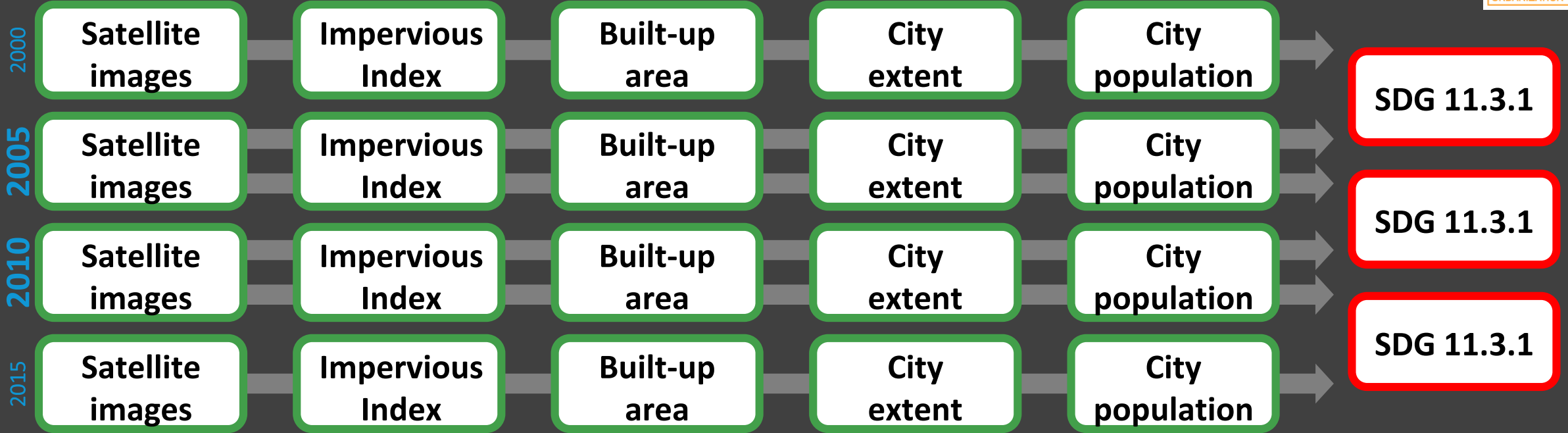
City extent

City population

TRENDS.EARTH - COMPUTE SDG 11.3.1



TRENDS.EARTH - COMPUTE SDG 11.3.1



TRENDS.EARTH - COMPUTE SDG 11.3.1



2000

Satellite images

Impervious Index

Built-up area

City extent

City population

SDG 11.3.1

2005

Satellite images

Impervious Index

Built-up area

City extent

City population

SDG 11.3.1

2010

Satellite images

Impervious Index

Built-up area

City extent

City population

SDG 11.3.1

2015

Satellite images

Impervious Index

Built-up area

City extent

City population

Pre-Computed

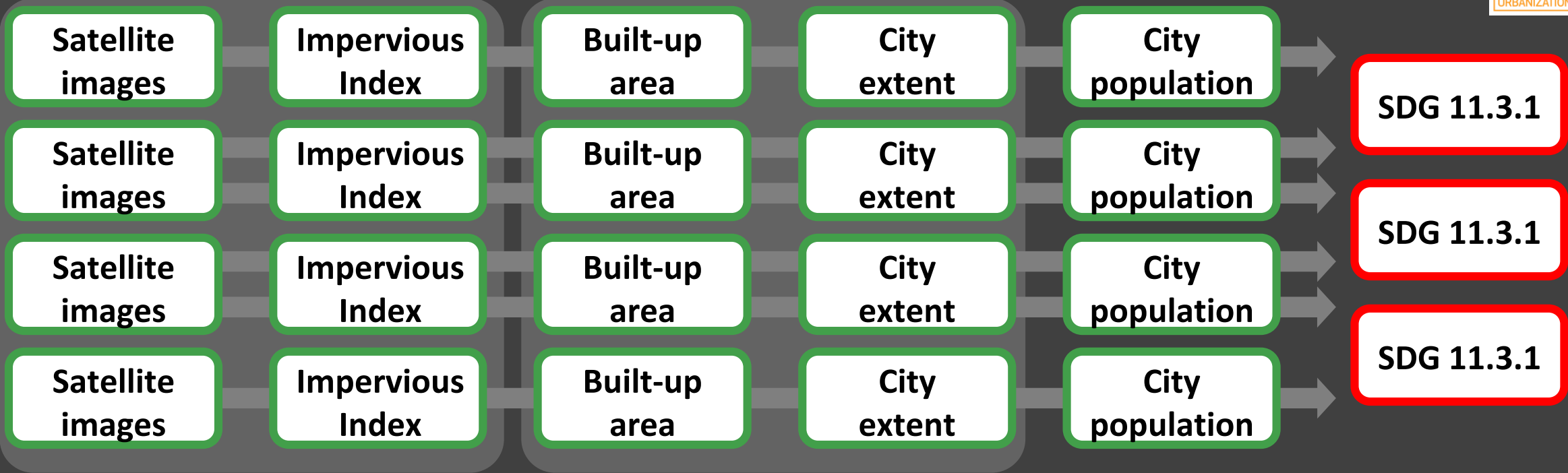
(2.3 M Landsat scenes

1.15 Petabytes of data)

TRENDS.EARTH - COMPUTE SDG 11.3.1



2000
2005
2010
2015



Pre-Computed

(2.3 M Landsat scenes
1.15 Petabytes of data)

User Input

TRENDS.EARTH - COMPUTE SDG 11.3.1



2000

Satellite images

Impervious Index

Built-up area

City extent

City population

SDG 11.3.1

2005

Satellite images

Impervious Index

Built-up area

City extent

City population

SDG 11.3.1

2010

Satellite images

Impervious Index

Built-up area

City extent

City population

SDG 11.3.1

2015

Satellite images

Impervious Index

Built-up area

City extent

City population

Pre-Computed

(2.3 M Landsat scenes
1.15 Petabytes of data)

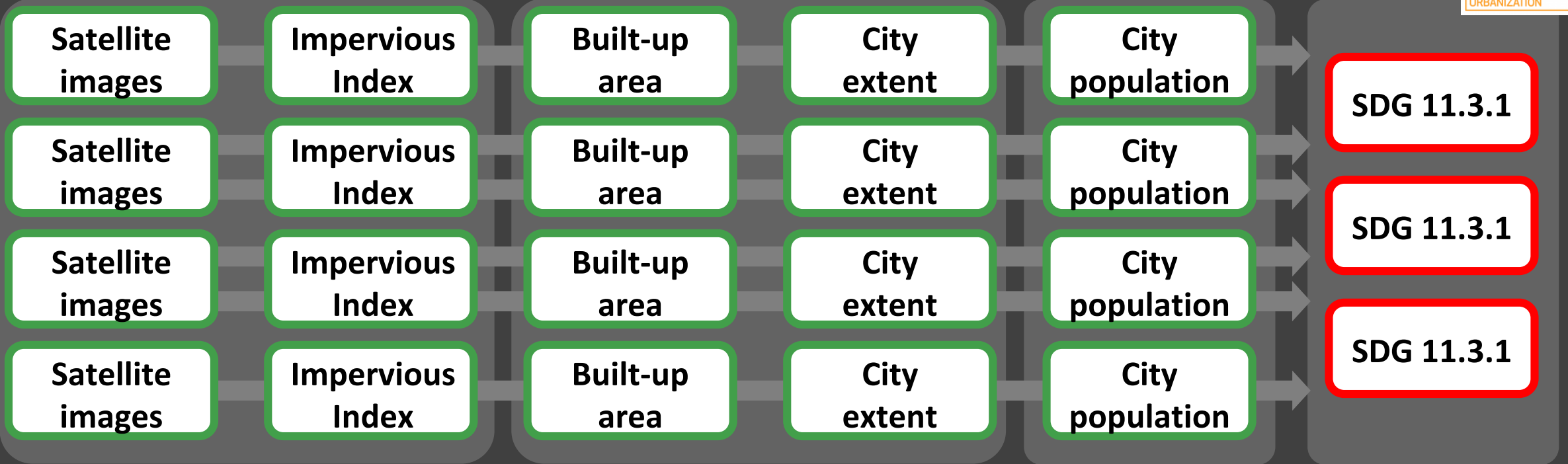
User Input

Global Data

TRENDS.EARTH - COMPUTE SDG 11.3.1



2000
2005
2010
2015



Pre-Computed

(2.3 M Landsat scenes
1.15 Petabytes of data)

User Input

Global Data

**Summary
Maps & Tables**

TRENDS.EARTH - COMPUTE SDG 11.3.1



846 terrestrial ecoregions

<https://doi.org/10.1093/biosci/bix014>

Processing Workflow

Global Man-made Impervious Surface (GMIS)

High quality URBAN
GMIS IS_percentage > 1
GMIS standard_error < 25
ESA CCI land cover = urban

Hi quality NON-URBAN
GMIS IS_percentage = 0
GMIS standard_error = 0
ESA CCI land cover <> urban

Model trained with GMIS 2010 & Landsat derived stack 2010

Models were trained per terrestrial ecoregion (4000 for urban & 4000 for non-urban)

Random Forest (Regression trees)

1998 Landsat derived 24-band stack
2000 Landsat derived 24-band stack
2005 Landsat derived 24-band stack
2010 Landsat derived 24-band stack
2015 Landsat derived 24-band stack
2018 Landsat derived 24-band stack

2000 impervious surface index
2005 impervious surface index
2010 impervious surface index
2015 impervious surface index

TRENDS.EARTH - IMPERVIOUS SURFACE INDEX TO BUILT-UP AREA



Three parameters influence how a map of built-up area is produced from the map of impervious surface index:

Impervious surface index (ISI): higher values reduce built-up area

Night time lights index (NTLI): higher values mean darker areas are excluded from built-up

Water frequency: higher values allow areas with more frequent occurrence of water to be included in the built-up area

TRENDS.EARTH - URBAN MAPPER

TARGET 11-3



INCLUSIVE AND SUSTAINABLE URBANIZATION

Earth Engine Apps Experimental

Trends.Earth Urban Mapper

Layers Map Satellite

Impervious Surface Index (0-100)
(higher values reduce urban area)

Night Time Lights Index (0-100)
(higher values reduce urban area)

Water frequency (0-100)
(higher values increase urban area)

Run analysis

Trends.Earth 30m data-set

- Built-up before 2000
- New built-up by 2005
- New built-up by 2010
- New built-up by 2015
- Water (JRC Global Surface Water)

This is a Conservation International tool developed in collaboration with NASA. It is still under development, so please do not distribute externally. Contact: trends.earth@conservation.org.

Google

Map data ©2018 Google Imagery ©2018 TerraMetrics 2 km

Define built-up area

Calculate Urban Area Change Metrics

Settings | Advanced | Area | Options

Thresholds

See the [Urban Mapper page](#) for assistance choosing these values.

Impervious Surface Index (0-100) (higher values reduce urban area)	20
Night Time Lights Index (0-100) (higher values reduce urban area)	10
Water Frequency (0-100) (higher values increase urban area)	25

Previous | Next

Calculate

TRENDS.EARTH - CONVERTING BUILT-UP AREA TO URBAN EXTENT

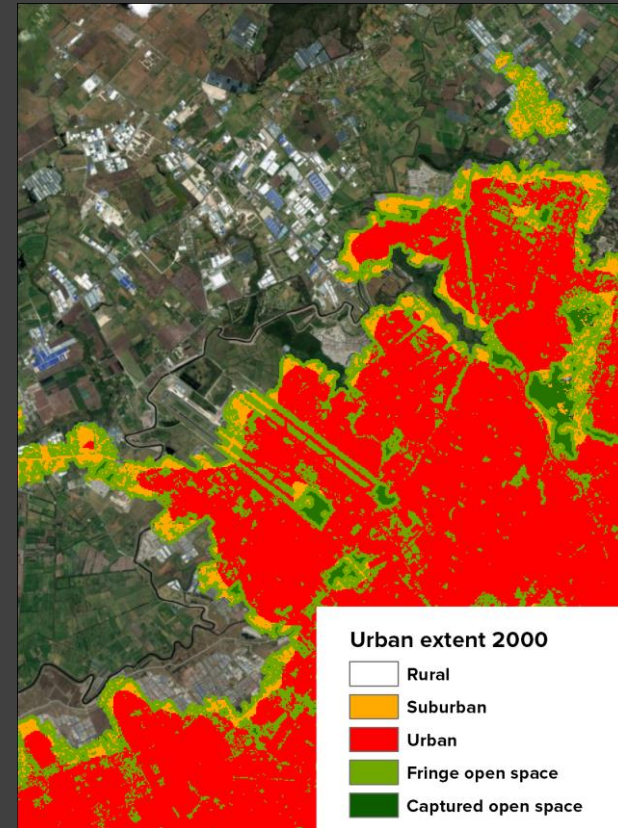


Built-up density within a 500 m radius:

- 1) Urban → > 50%
- 2) Suburban → 25-50%
- 3) Rural → < 25 %

Open space (OS):

- 4) Fringe OS → OS < 100 m from urban and suburban
- 5) Captured OS → OS fully surrounded by fringe OS
- 6) Rural OS → All other OS



Define urban areas (zonation)

Calculate Urban Area Change Metrics

Settings | Advanced | **Area** | Options

Urban definition

Percentage built-up considered suburban
(values below this will be considered rural) 25%

Percentage built-up considered urban
(values below this will be considered suburban) 50%

Open space definition

Area of largest captured open space (hectares)
(contiguous captured open space larger than this area will be considered rural) 200

Population definition (Gridded Population of the World, v4)

Population density consistent with national census and population registers

Population density adjusted to match official UN population estimates

Previous | **Next**

Calculate

Define area of analysis

Calculate Urban Area Change Metrics

Settings | Advanced | Area | Options

Area to run calculations for

Country / Region

First level

Uganda

Second level

Region: All regions

City: Kampala (Kampala)

Disclaimer: The provided boundaries are from [Natural Earth](#), and are in the [public domain](#). The boundaries and names used, and the designations used, in Trends.Earth do not imply official endorsement or acceptance by Conservation International Foundation, or by its partner organizations and contributors.

Area from file

Click "Browse" to choose a file... Browse

Apply a buffer to the chosen area

Buffer size (kilometers): 20.0

Previous Next

Calculate

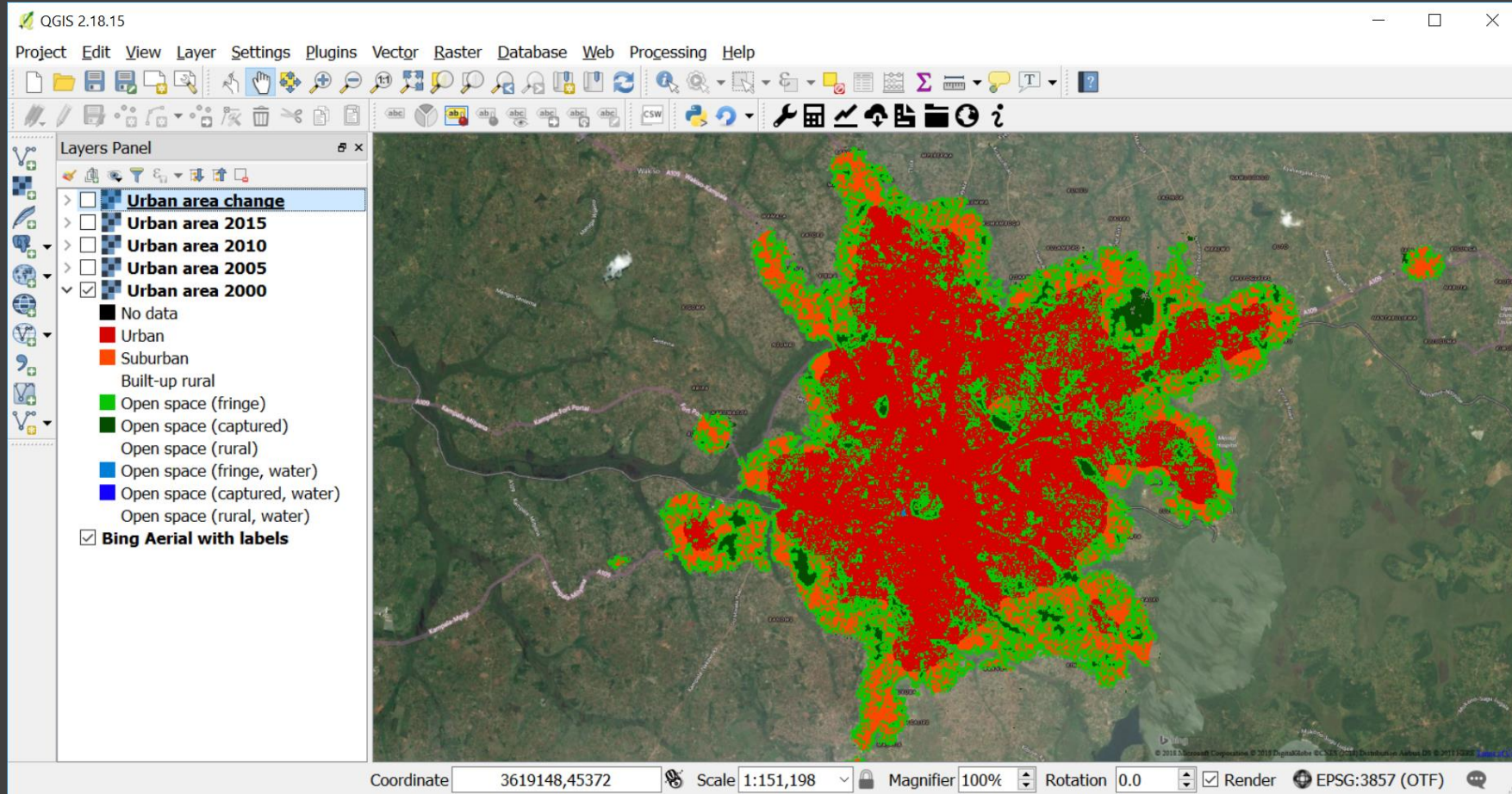
TRENDS.EARTH - QGIS

TARGET 11-3



INCLUSIVE AND SUSTAINABLE URBANIZATION

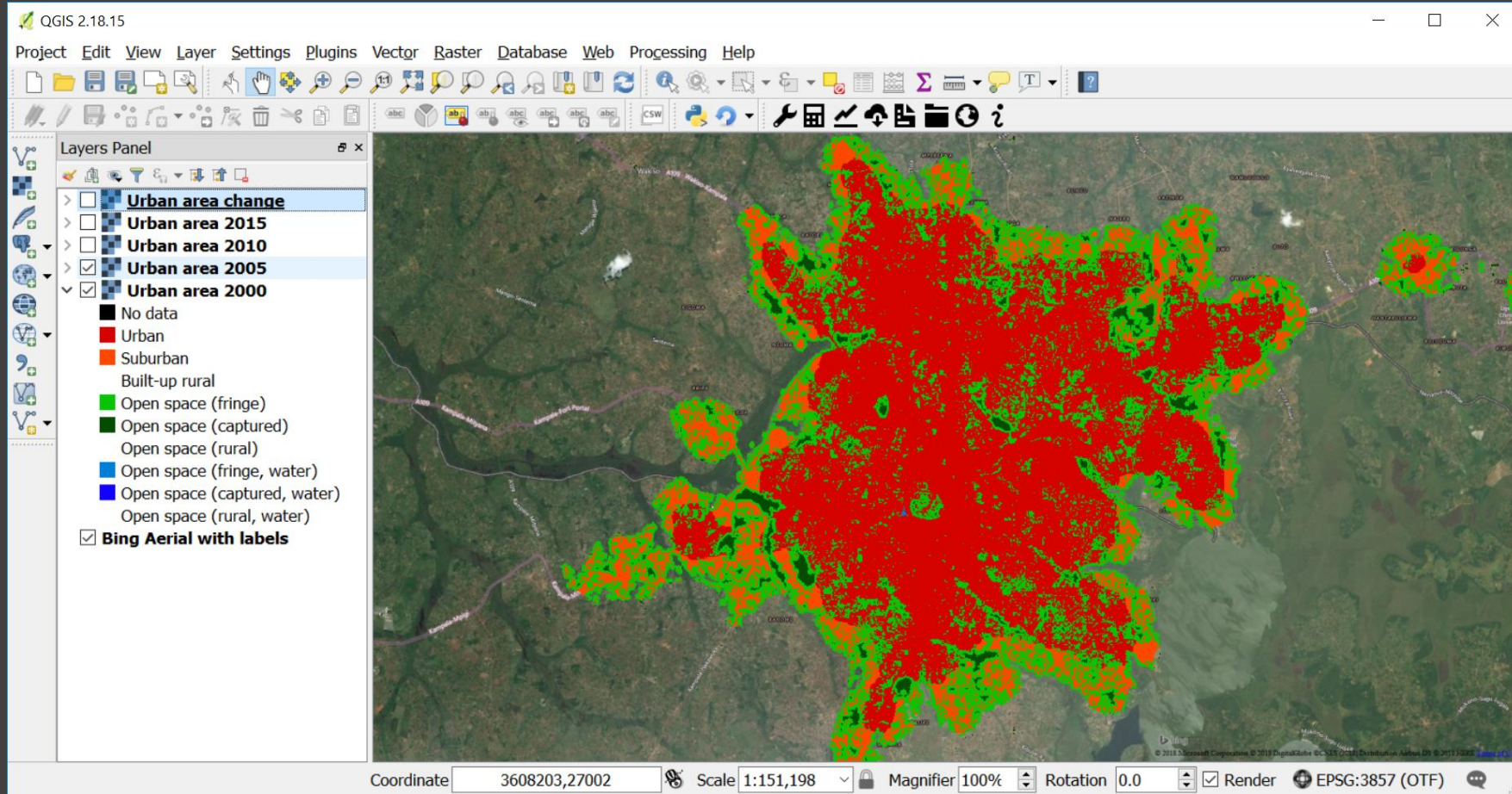
Kampala, Uganda – 2000



TRENDS.EARTH - QGIS



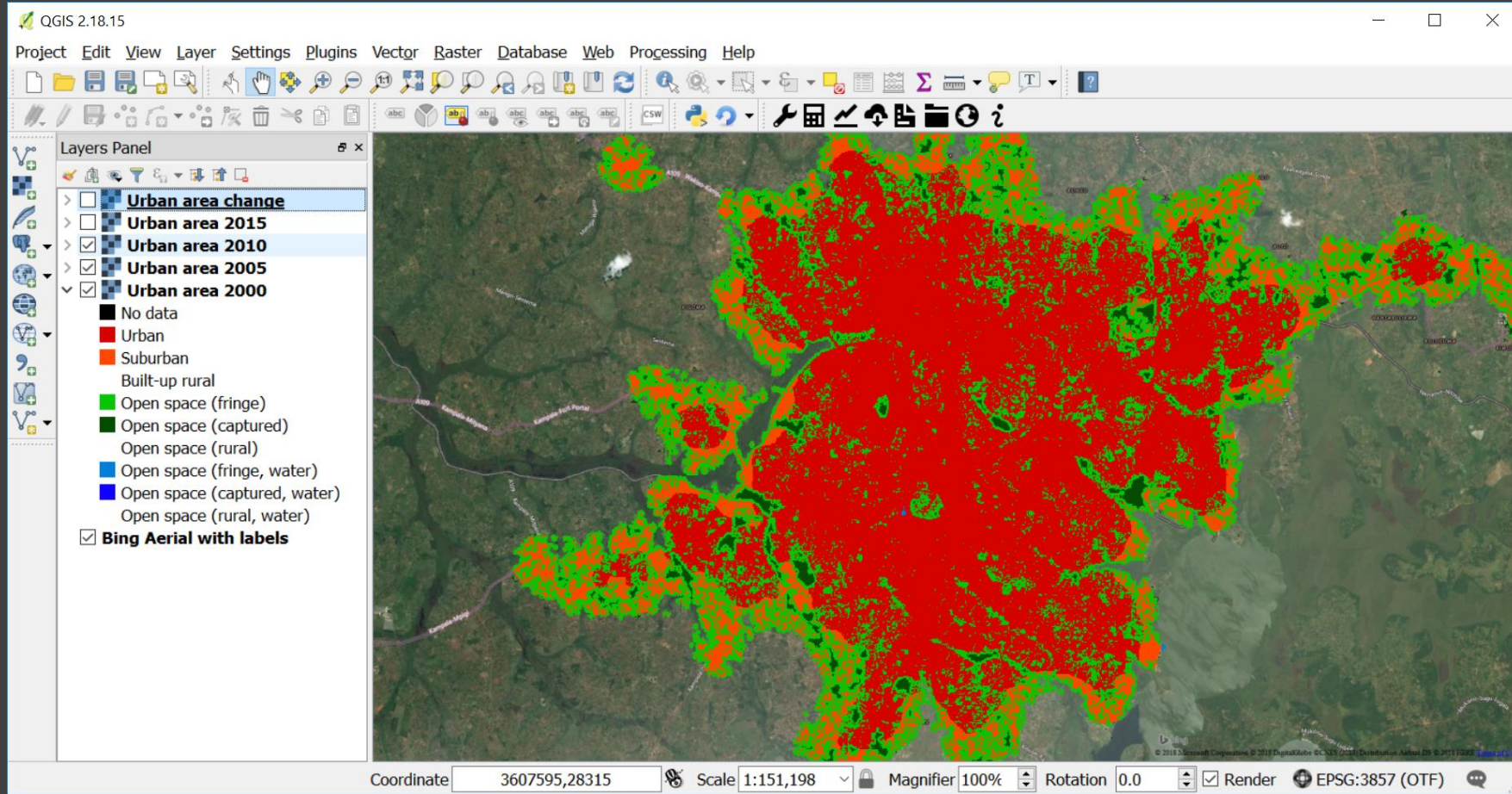
Kampala,
Uganda –
2005



TRENDS.EARTH - QGIS



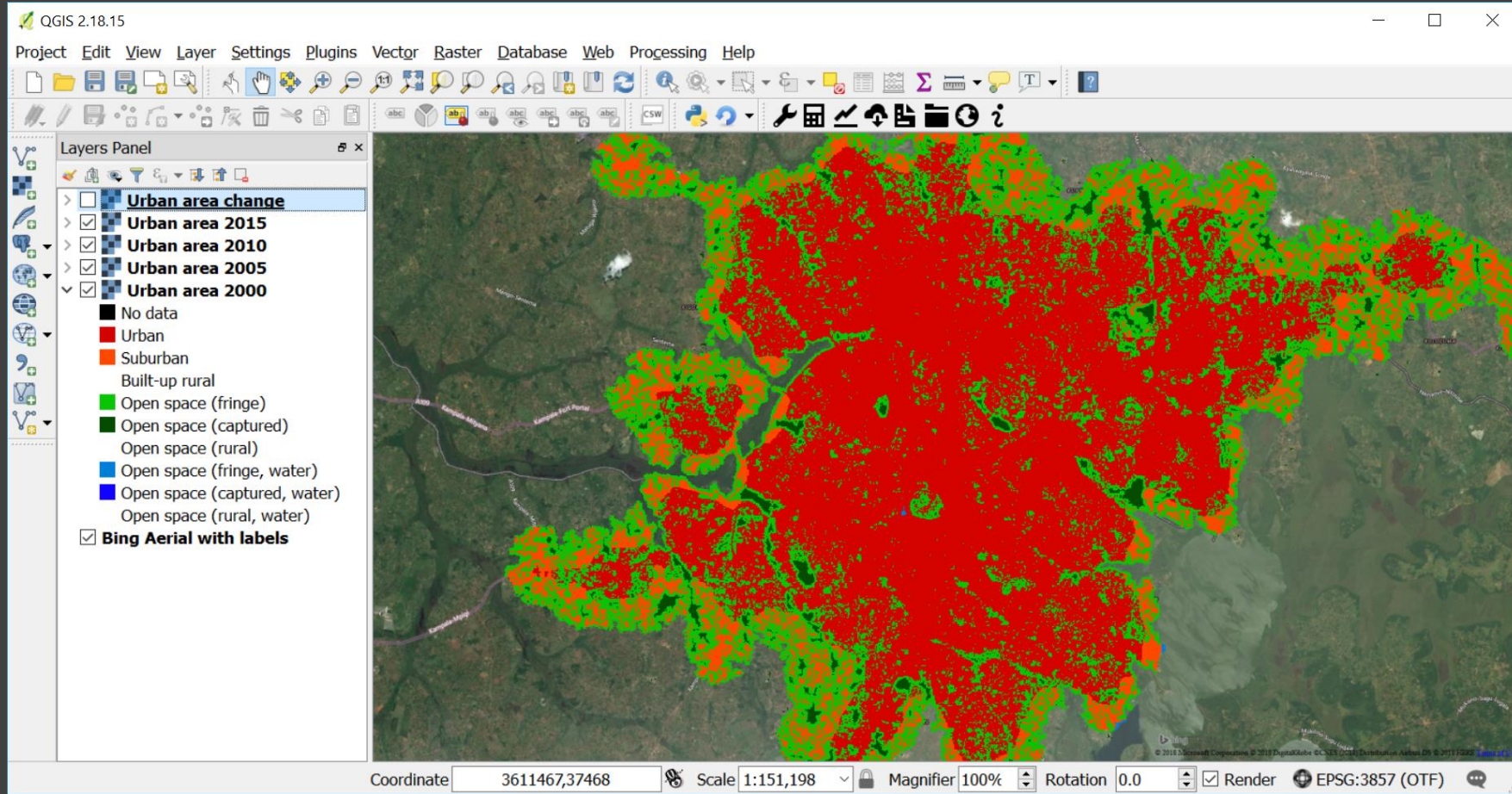
Kampala,
Uganda –
2010



TRENDS.EARTH - QGIS



Kampala,
Uganda –
2015



TRENDS.EARTH - QGIS

Kampala, Uganda – Time series

QGIS 2.18.15

Project Edit View Layer Settings Plugins Vector Raster Database Web P

Layers Panel

- Urban area change
- Urban area 2015
- Urban area 2010
- Urban area 2005
- Urban area 2000
- No data
- Urban
- Suburban
- Built-up rural
- Open space (fringe)
- Open space (captured)
- Open space (rural)
- Open space (fringe, water)
- Open space (captured, water)
- Open space (rural, water)
- Bing Aerial with labels

Coordinate 3611467,37468

kampala_table.xlsx - Rep... Mariano Gonzalez-Roglich

File Home Insert Page Layout Formulas Data Review View Help Tell me Share

A3 Summary of population growth rate and land consumption

Trends.Earth SDG 11.3.1 summary table

Summary of population growth rate and land consumption

Period	City population change	City population growth rate	City area change (sq km)	Land consumption rate	SDG 11.3.1
2000-2005	444,208	0.053964	11,936.41	0.041822	0.775
2005-2010	513,451	0.048330	12,424.12	0.035864	0.742
2010-2015	526,500	0.039791	5,268.17	0.013459	0.338

Urban and land consumption rates

Area (in hectares) of each land class by year

	2000	2005	2010	2015	Consider this class to be part of the city?
Urban	22,585.98	30,219.43	39,896.55	45,869.17	Yes
Suburban	5,014.77	5,264.09	5,434.47	4,986.15	Yes
Built-up rural	1,299.64	1,294.18	789.90	612.27	No
Open space (fringe)	21,677.34	24,663.06	26,428.51	26,342.23	Yes
Open space (captured)	1,888.23	2,924.86	3,726.11	3,547.85	Yes
Open space (rural)	49,088.35	37,188.68	25,278.76	20,196.63	No
Open space					

SDG 11.3.1 Summary Table

Ready 80%

TARGET 11.3

INCLUSIVE AND SUSTAINABLE URBANIZATION

TRENDS.EARTH - REGIONAL TESTING

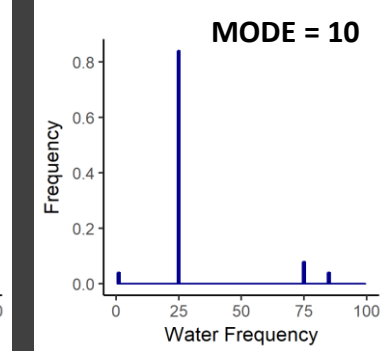
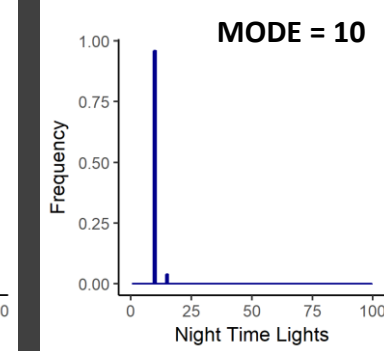
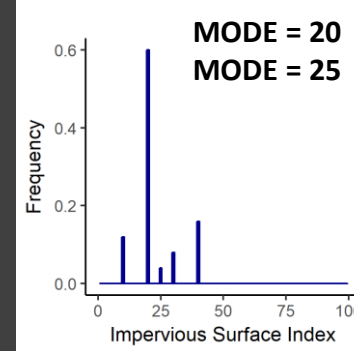


- NASA
- UN-Habitat
- Mexico
- Peru
- Colombia
- USA

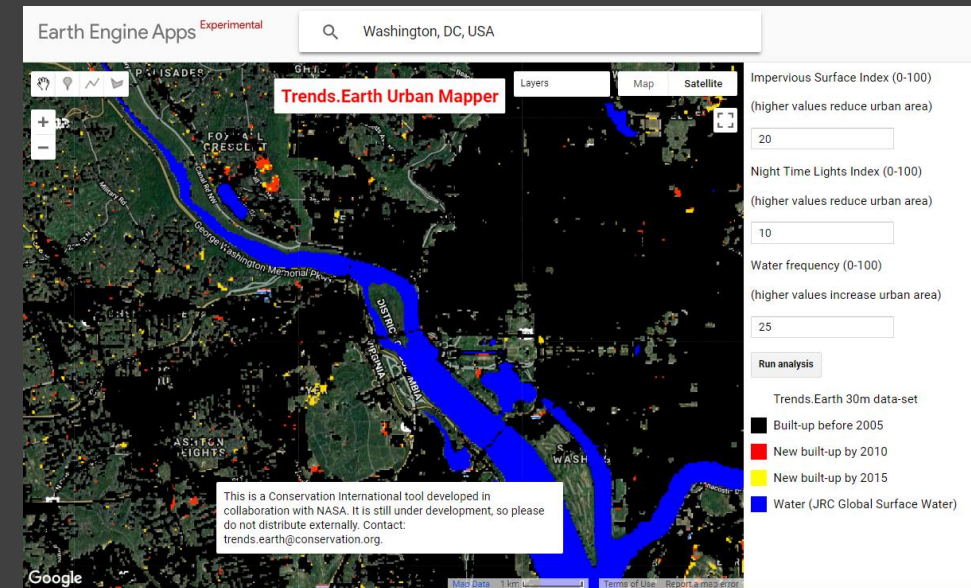
TRENDS.EARTH - REGIONAL TESTING



- | | | |
|------------------|----------------------|-----------------------|
| 1. Atlanta, GA | 10. Indianapolis, IN | 19. Portland, OR |
| 2. Boston, MA | 11. Kansas City, MO | 20. San Diego, CA |
| 3. Chicago, IL | 12. Los Angeles, CA | 21. San Francisco, CA |
| 4. Cleveland, OH | 13. Miami, FL | 22. Seattle, WA |
| 5. Columbus, OH | 14. Minneapolis, MN | 23. St. Louis, MO |
| 6. Dallas, TX | 15. New York, NY | 24. Tampa, FL |
| 7. Denver, CO | 16. Philadelphia, PA | 25. Washington, DC |
| 8. Detroit, MI | 17. Phoenix, AZ | |
| 9. Houston, TX | 18. Pittsburgh, PA | |

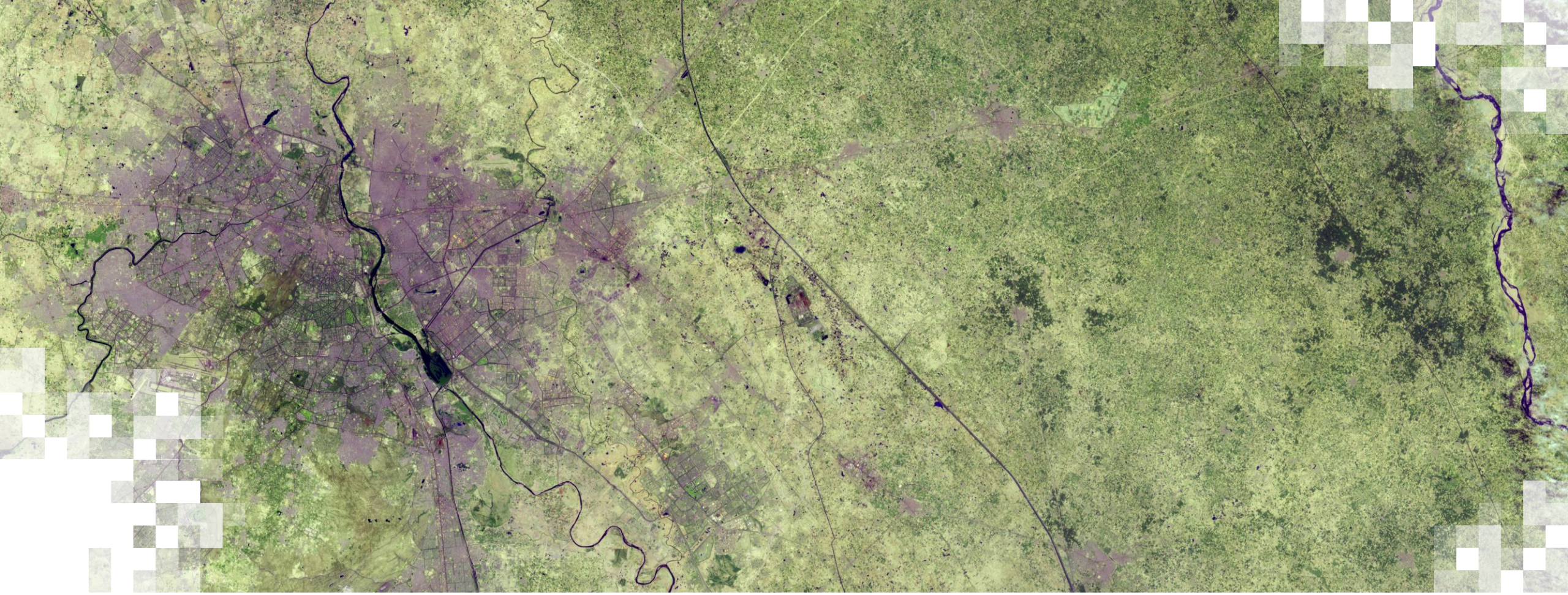


- Continue the verification process to provide regional guidelines.
- Address limitation on hyper arid regions
- Work with gridded population data providers to improve relevance of population data at city level.
- Continue capacity building efforts
 - (ARSET webinar & in person)



TRENDS.EARTH - DEMO

- QGIS Plug in: Trends.Earth
- Website: <http://trends.earth>
- Urban Mapper: <https://geflanddegradation.users.earthengine.app/view/trendsearth-urban-mapper>

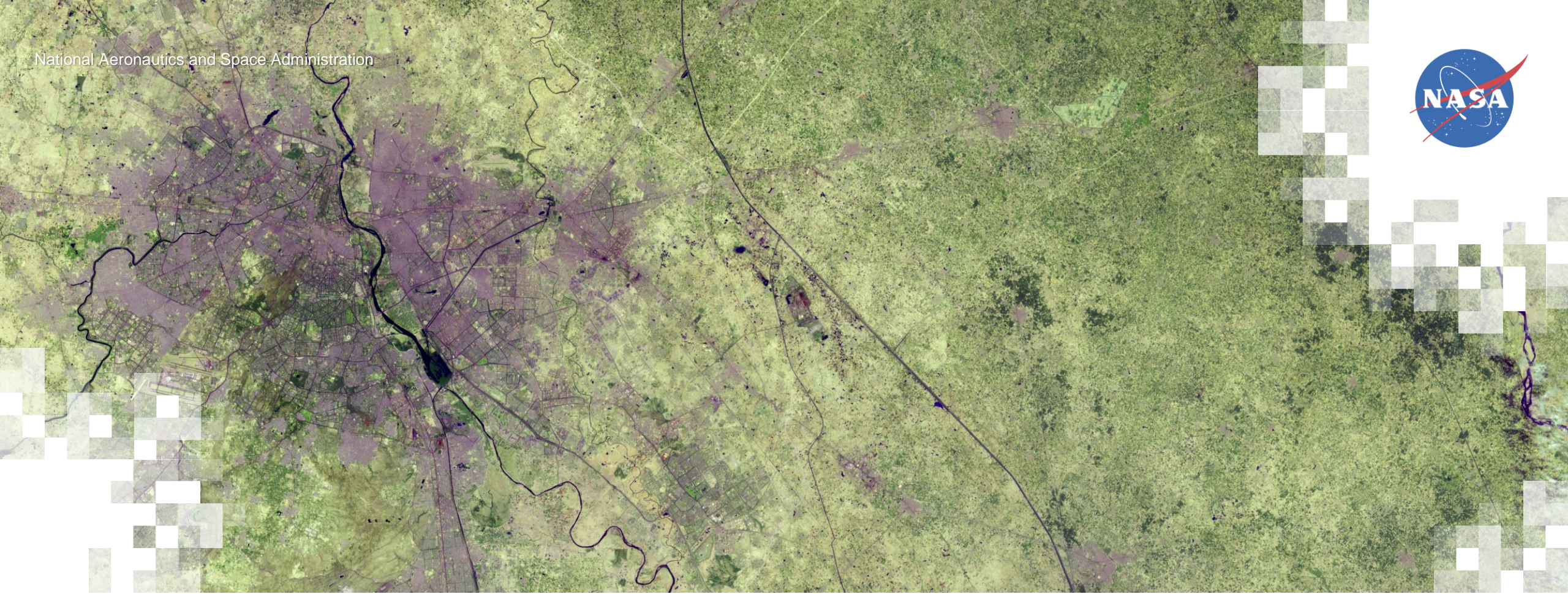


Trends.Earth Exercise

Contacts

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- ARSET Website:
 - <http://arset.gsfc.nasa.gov>

National Aeronautics and Space Administration



CONSERVATION
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TRENDS.EARTH
tracking land change

Thank You

Please complete the homework by August 6th, 2019



United Nations
Convention to Combat
Desertification



7/23/2019