GEO GROUP ON EARTH OBSERVATIONS

CEOS Committee on Earth Observation Satellites

UN HABITAT FOR A BETTER URBAN FUTURE

APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Earth Observations Toolkit for Sustainable Cities and Human Settlements

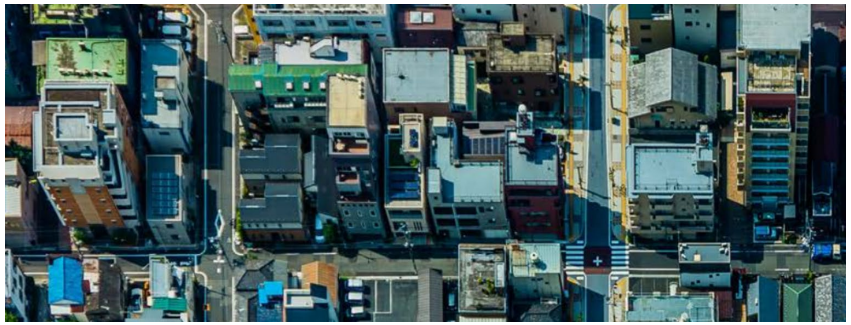
Part 3: Use Cases from the National and City Level

February 10, 2022

Course Information and Prerequisites

- Three 90-minute sessions on January 27, February 3, and 10 from **10:00-11:30 EST (UTC-5)**
- Webinar recordings and PowerPoint presentations can be found on the training webpage: https://appliedsciences.nasa.gov/join-mission/training/english/arset-earth-observations-toolkit-sustainable-cities-and-human

- Fundamentals of Remote Sensing:
  - https://appliedsciences.nasa.gov/join-mission/training/english/arset-fundamentals-remote-sensing



- Introduction to Population Grids and their Integration with Remote Sensing Data for Sustainable Development and Disaster Management:
  - https://appliedsciences.nasa.gov/join-mission/training/english/arset-introduction-population-grids-and-their-integration-remote

Homework and Certificate

- One homework assignment:
  - Answers must be submitted via Google Form accessed from the ARSET website
  - Homework will be made available on February 10, 2021.
  - Due date for homework: February 24, 2022

- A certificate of completion will be awarded to those who:
  - Attend all three live webinars and complete exercise
  - Complete the homework assignment by the deadline
  - You will receive a certificate approximately two months after the completion of the course from: marines.martins@ssaihq.com

Training Objectives

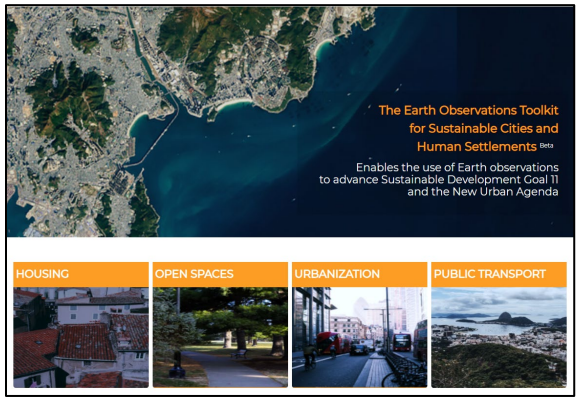
By the end of this training attendees will be able to:

- Understand the value and usefulness of Earth observations to monitor and report on urban Sustainable Development Goal (SDG) indicators and the New Urban Agenda.
- Learn from inspiring examples of cities using Earth observations for SDG 11 (sustainable cities and human settlements) and the New Urban Agenda.
- Understand how to apply Earth observation-based Toolkit resources to enhance urban resilience and improve decisions regarding planning, monitoring, and operational preparedness.

Training Outline

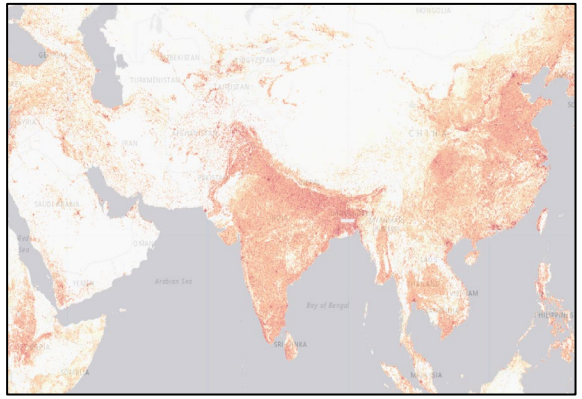
Three 90-minute sessions:

Part 1: January 27, 2022



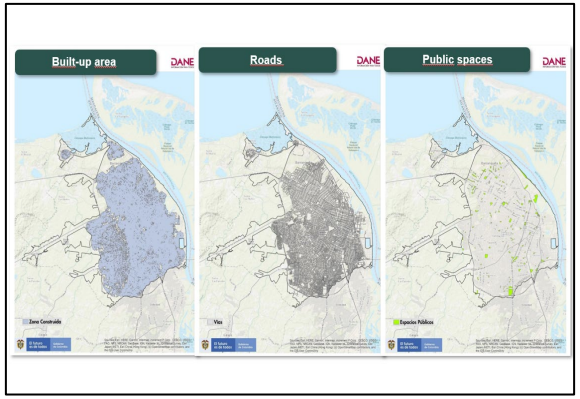
Introduction to Cities and the EO Toolkit for Sustainable Human Settlements

Part 2: February 3, 2022



Applications of the EO Toolkit to Measure and Analyze Sustainable Development Goals

Part 3: February 10, 2022



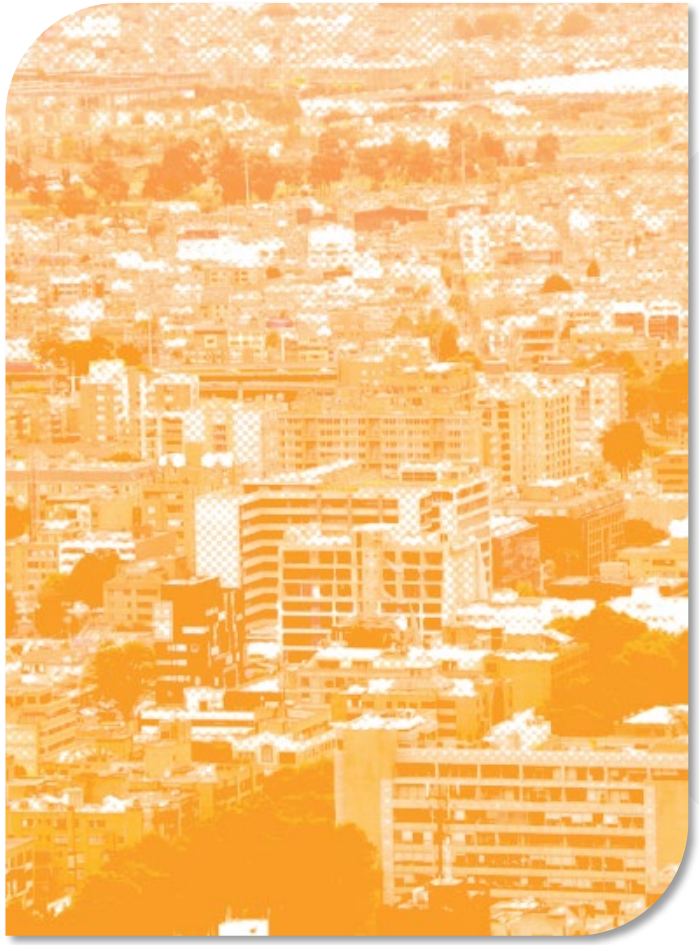
Use Cases from the National and City Level

Using EO To Calculate SDG Indicator 11.7.1 (Open Space) In Colombia

Sandra Liliana Moreno, Technical Director Geostatistics Division, National Administrative Department of Statistics, Colombia

Feb. 10, 2022

Agenda



- Indicator Definition
- Utilizing the EO Toolkit
- Methodology defined by UN-Habitat
- Process developed by DANE
- Results
- Dissemination

Indicator Definition

Goal 11
Make cities and human settlements inclusive, safe, resilient and sustainable

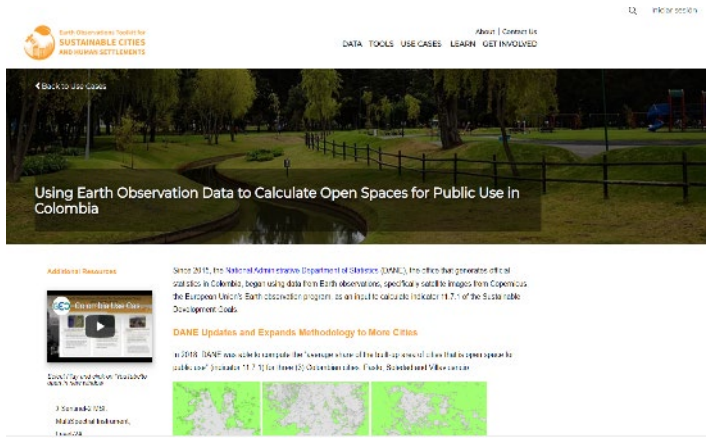
Indicator 11.7
By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

Indicator 11.7.1
Average share of the built-up area of cities that is open space for public use for all, by sex, age, and persons with disabilities

- **UN-Habitat is the custodian agency for the indicator.**
- This indicator is classified at **Level II**, which means that the indicator is conceptually clear, with established international methodology and standards available, but data are not regularly produced by countries.

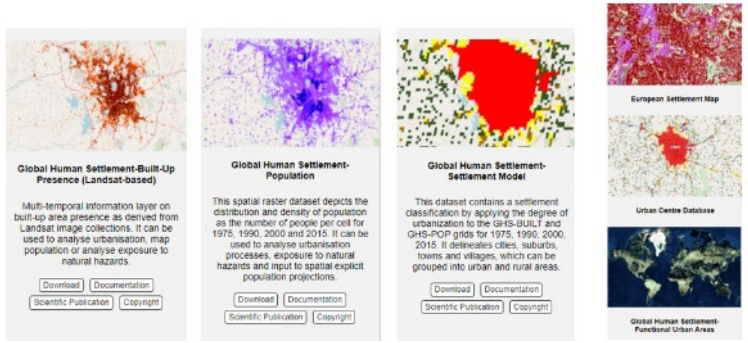
Utilizing the EO Toolkit

1. DANE´s experience is available in the "Use Case" section.



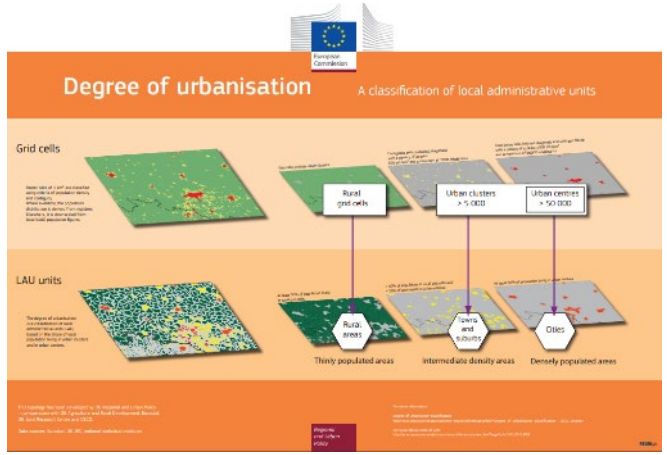
1. Facilitate sharing experiences, definitions and methodologies developed to calculate the SDG indicators.
2. The use of the EO Toolkit, make urban-related EO data and tools easy to find and use
3. Facilitate knowledge sharing, skill-building, and collaboration among local communities, cities, countries, and EO experts.
4. Understand and identify capabilities, common goals, and alliances.

2. GHSL Data in the Toolkit



1. Built-up Area
2. Population Density
3. Degree of Urbanisation DEGURBA
4. Local administrative units classified by the degree of urbanisation LAU

3. DEGURBA Eurostat Methodology



To calculate the SDG indicator 11.7.1, DANE defined cities using the European Commission's Degree of Urbanization (DEGURBA) Eurostat methodology.

Methodology - UN-Habitat Metadata

1. Spatial analysis for delimitation of built-up areas

The objective is to obtain the built-up area through image processing:

1. Acquisition of satellite images.
2. Classify the images into built-up area, public spaces, and water.
3. Perform cluster analysis.
4. Obtaining the final built-up area.

2. Calculation of the area of public open spaces and roads

The objective is to obtain the surface area of public spaces through existing repositories:

1. Consult the national inventory of public spaces (if it exists).
2. Use satellite images for the identification of public spaces.
3. Define roads by their topology and calculate their surface area.

3. Determination of the built-up area of cities that is open space for public use

The objective is to obtain the area of the open spaces:

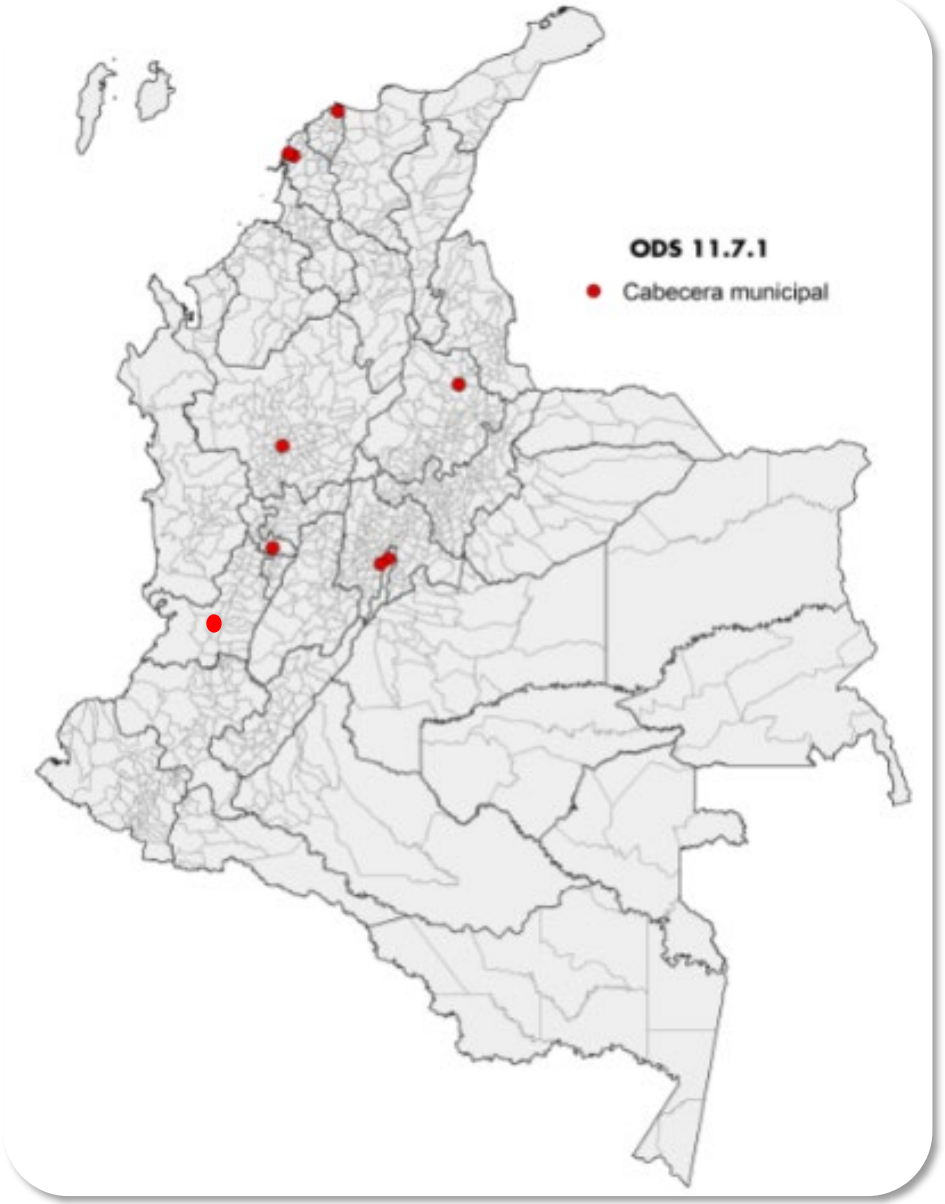
1. Use the limit of the built-up area.
2. Obtain the final total area of public space.
3. Calculate the average proportion of built-up area designed for open space for public use for all.

Process Developed - Sample of Cities

The recommendation of UN-Habitat's Global Urban Observatory (GUO) was applied **to generate a national sample of cities**, based on those defined by the DEGURBA methodology, since this indicator requires additional inputs that are not always available for all cities.

A **sample design proportional to the population size** of the capital cities was determined. Consequently, **a sample of nine (9) cities** was obtained for the calculation of the indicator and the subsequent national estimate.

CITIES
BARRANQUILLA
BOGOTÁ, D,C,
BUCARAMANGA
CALI
CARTAGENA
MEDELLÍN
SOACHA
TURBACO
PEREIRA



Process Developed - Inputs Used

Optical Satellite Images

Sentinel-2

- 9 Bands: RGB, RE-1, RE-2, NIR, SWIR-1, SWIR-2
- Surface reflectance.
- Spatial resolution of 10 meters.

2018

Georeferenced Statistical Information

National Geostatistical Framework – Municipality townships

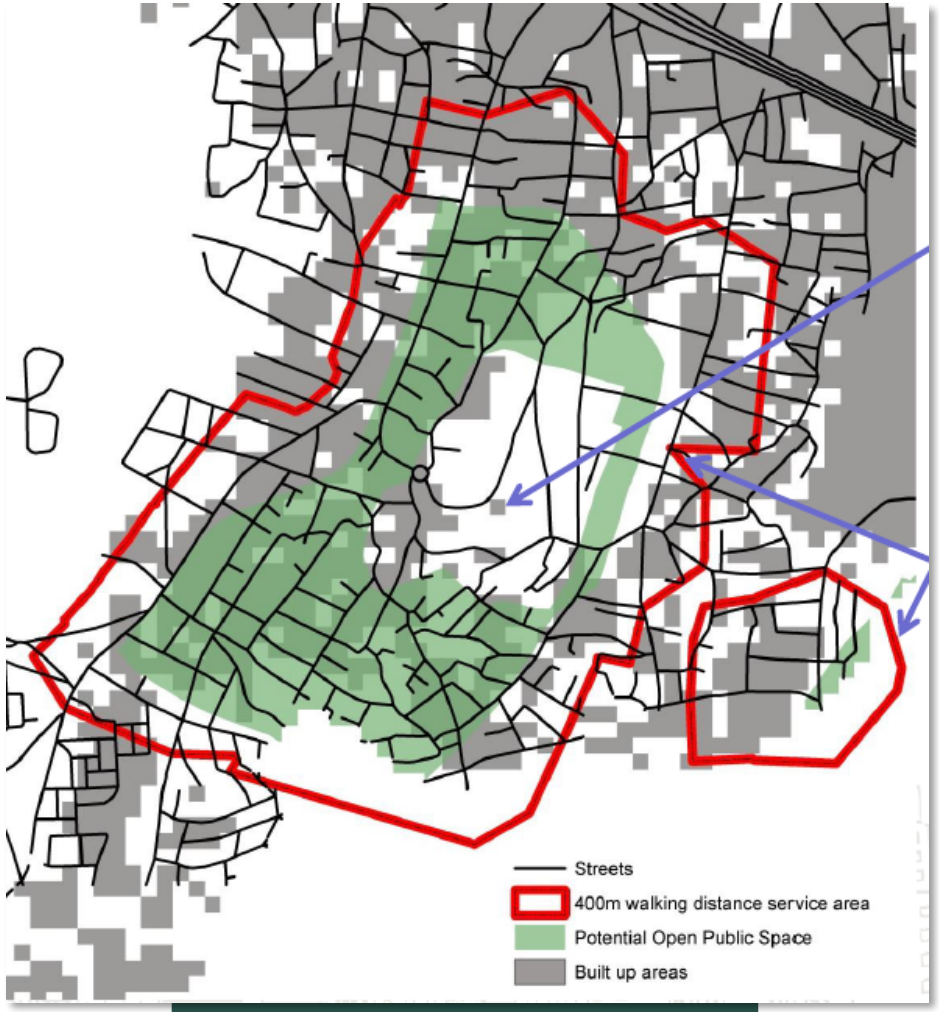
Census units of the CNPV 2018 with information broken down by population groups of interest.

Free Sources

Open Street Map (OSM)

Process Developed - Service Areas

UN-Habitat proposes a methodology to determine access to open space for population groups of interest (**women, children under 14, and people with disabilities**), based on the definition of service areas, and the estimation of the number of people living within these areas.

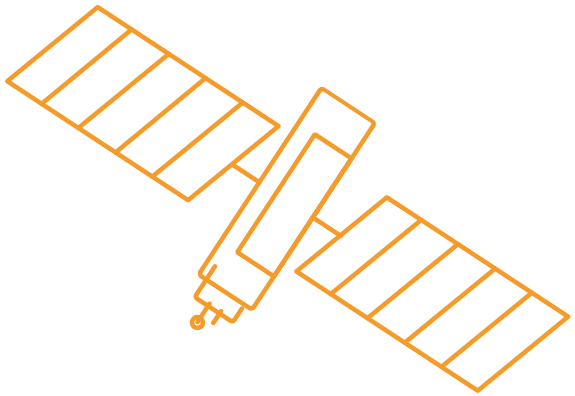


(ONU Hábitat, 2018)

Process Developed - Definition of Stages

Preliminary activities

- The recommendation of the Global Urban Observatory (GUO) was applied or the selection of a statistically representative sample of cities, defined on the basis of the DEGURBA methodology.



Define the urban area of each of the cities

- The selection and classification of Sentinel-2 satellite images of 2018 were performed to identify the built-up areas, using Google Earth Engine.
- The built-up areas were classified to obtain the urban area.

Identify public spaces (DANE´s source)

- Information from the 2018 MGN toponymy and the IGAC land division was used.

Identify public spaces (OSM´s source)

- The information on public spaces was downloaded and cleaned from OSM.

Estimated area for roads

- With the MGN at the block level and the urban area, the area destined for roads was obtained for each city.

Calculate the global indicator

$$11.7.1\ SDG = \frac{public\ space + roads}{\text{Built–up area}} * 100$$

Calculate the indicator disaggregated by children under 14 years, women and persons with disabilities

- The service areas of public spaces were determined and, with the census units of the CNPV, the percentage of the population was calculated:

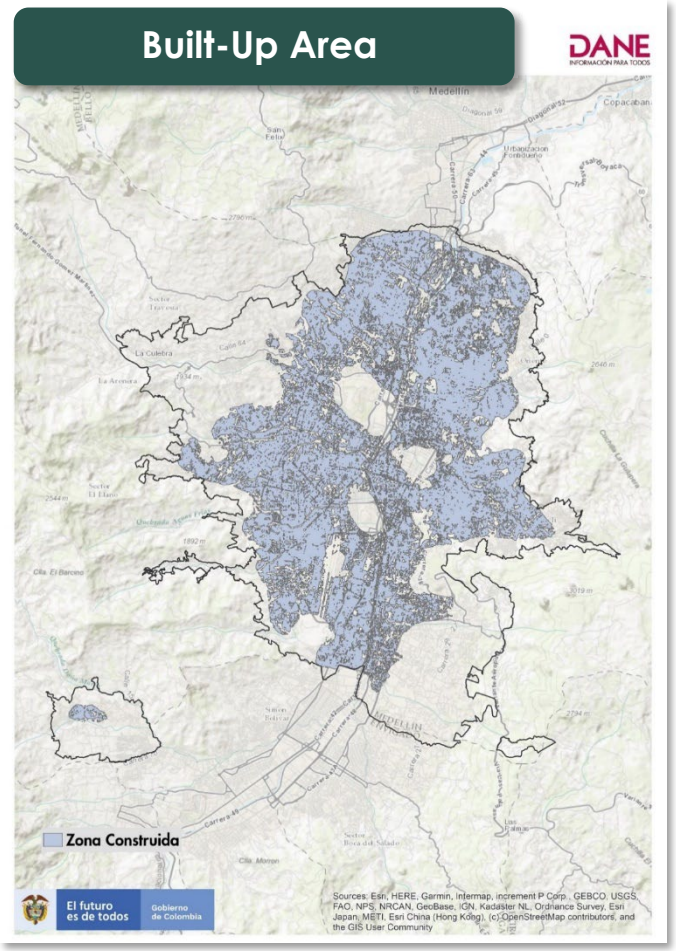
$$Disaggregation = \frac{Total\ number\ of\ people\ of\ the\ population\ group\ in\ service\ area}{Total\ number\ of\ people\ of\ the\ population\ group\ in\ urban\ area} * 100$$

National estimate

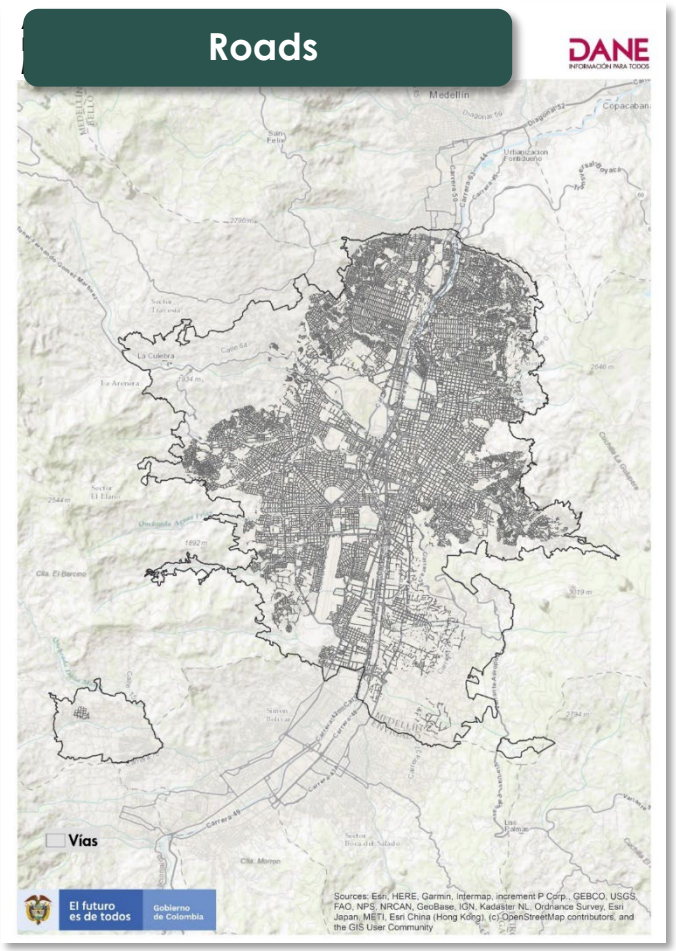
- The estimation was based on the sample of cities, using factors defined by the probability with respect to the population of the cities.

Results - Medellín

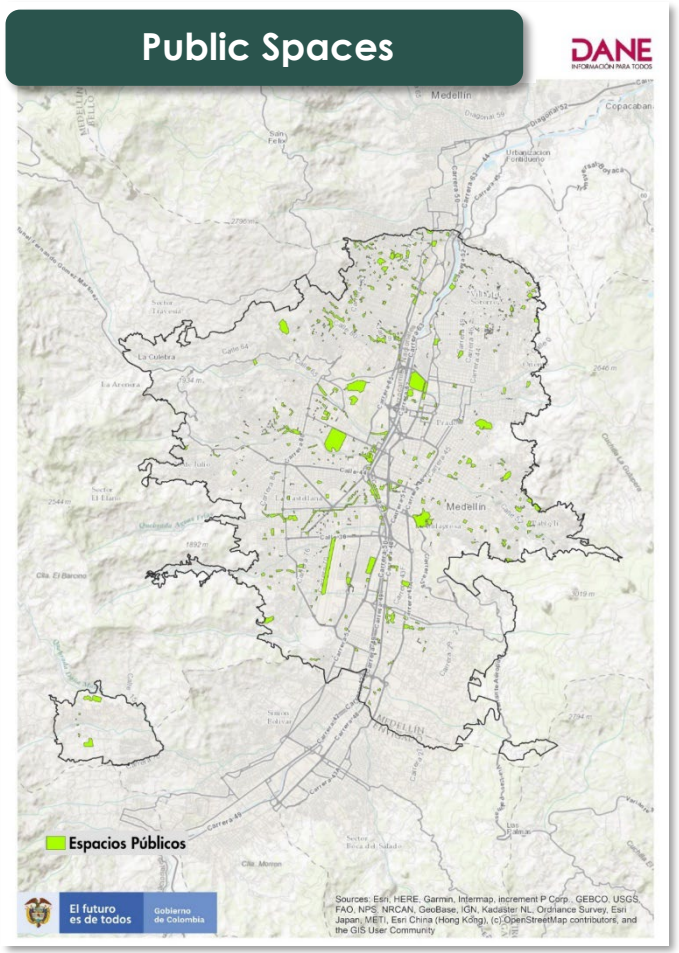
Built-Up Area



Roads

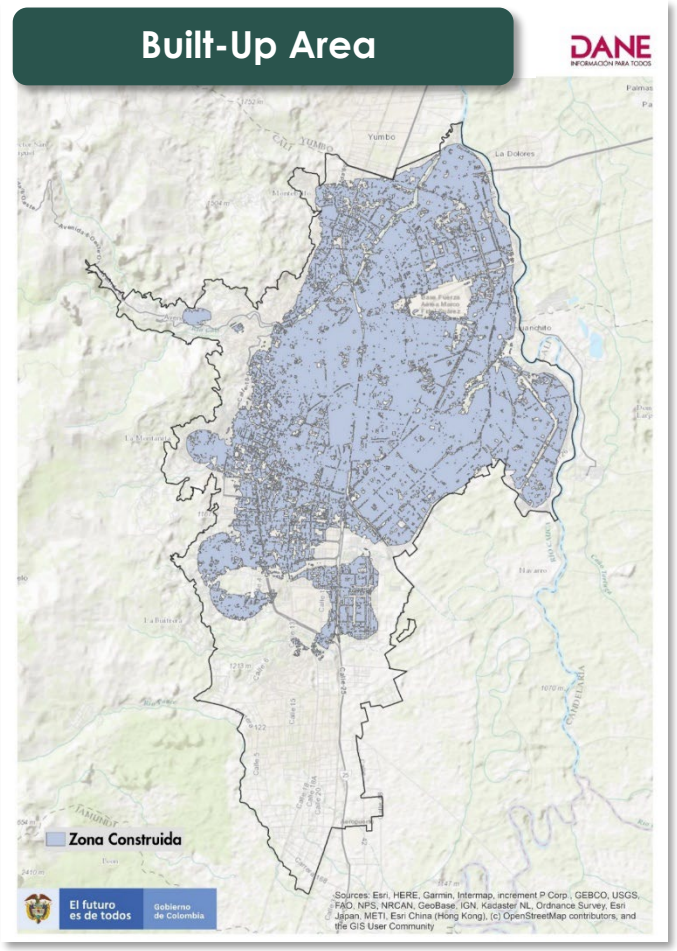


Public Spaces

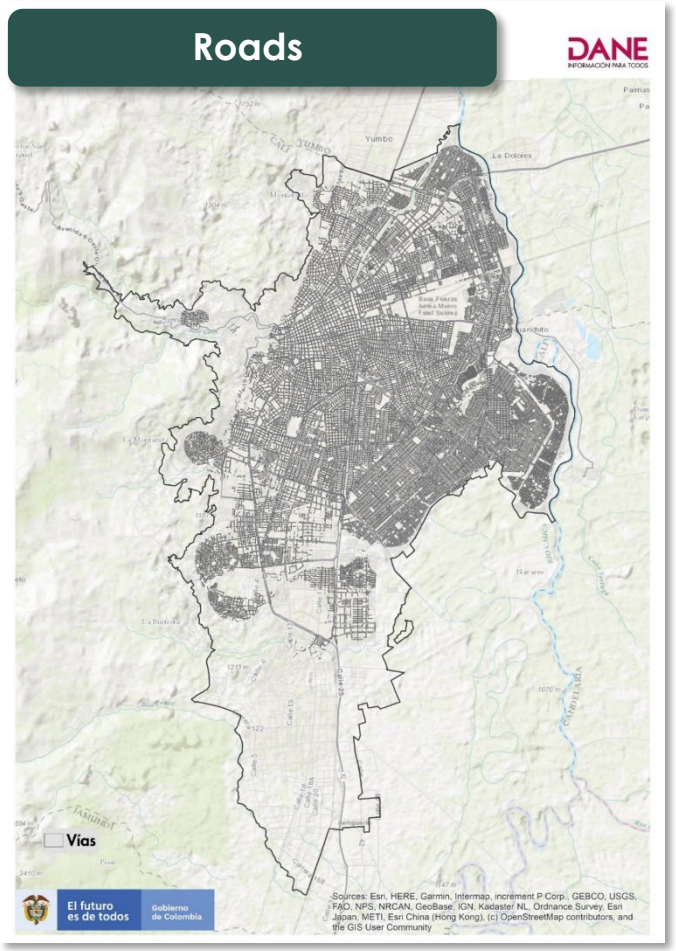


Results - Cali

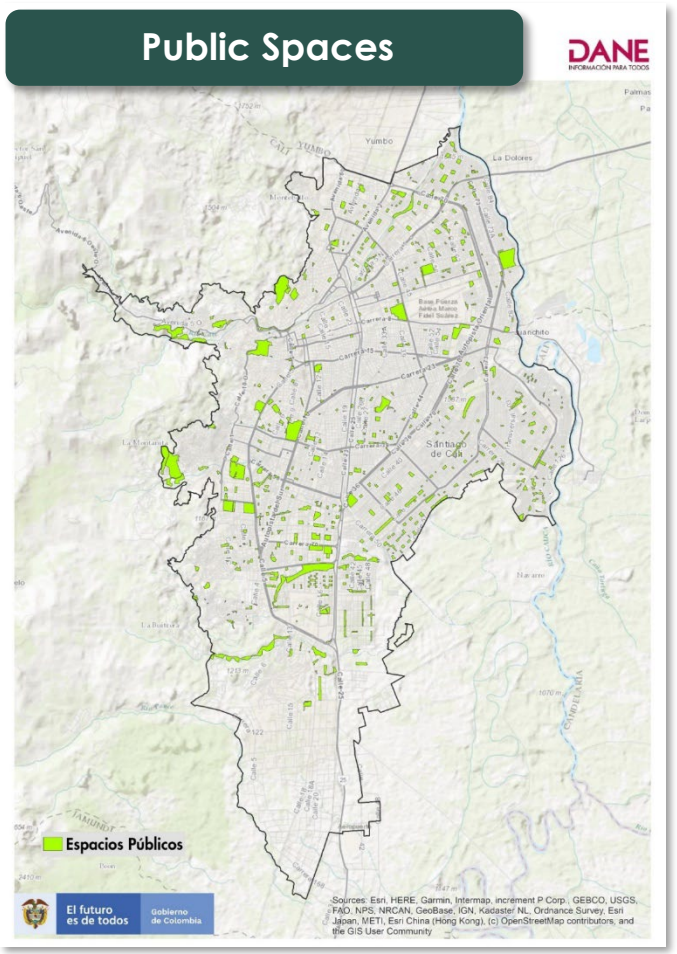
Built-Up Area



Roads

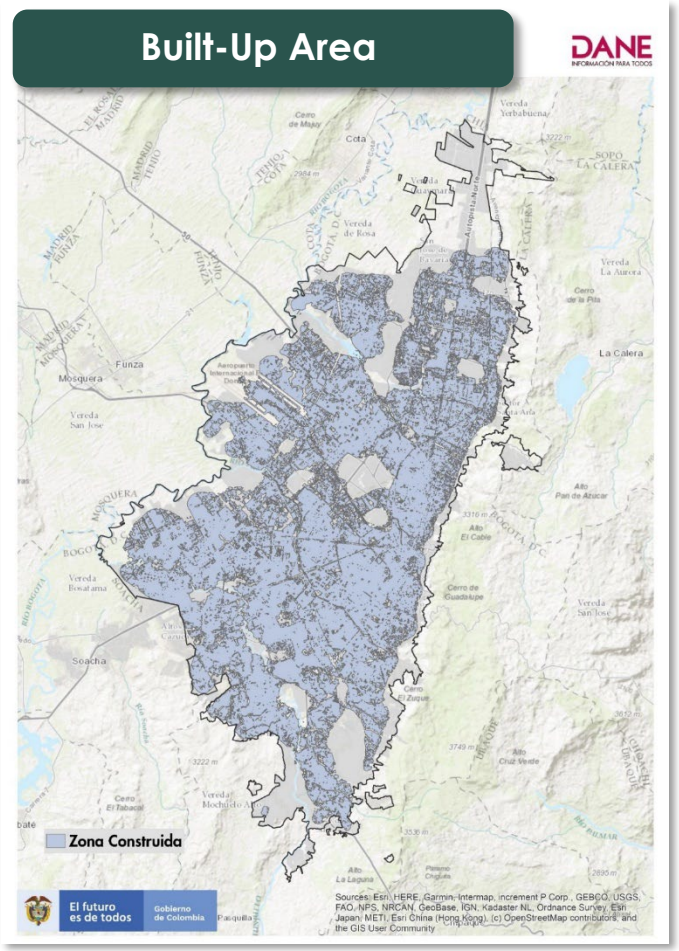


Public Spaces

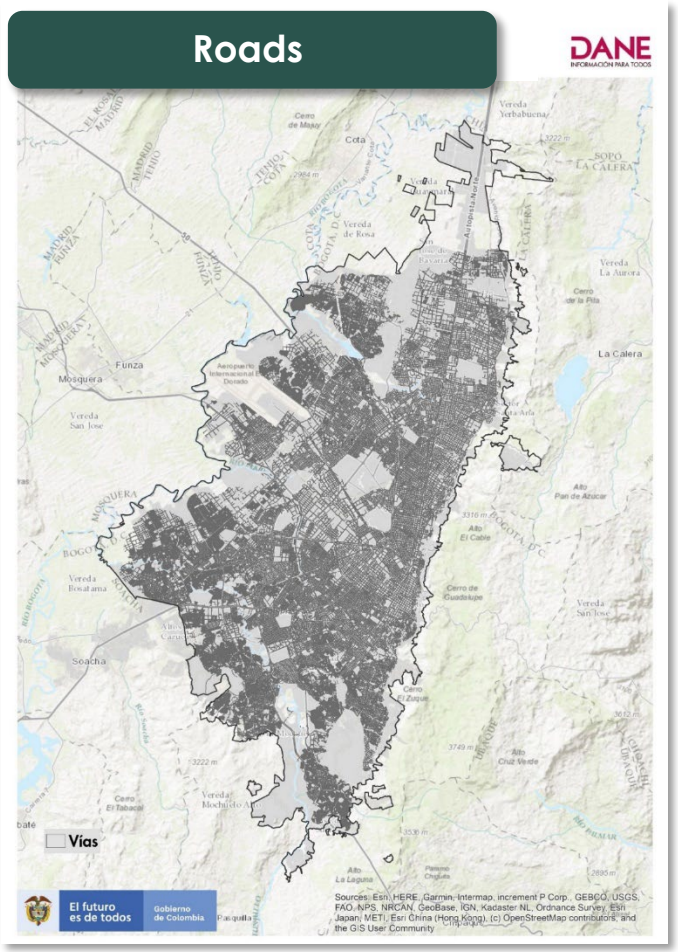


Results - Bogotá

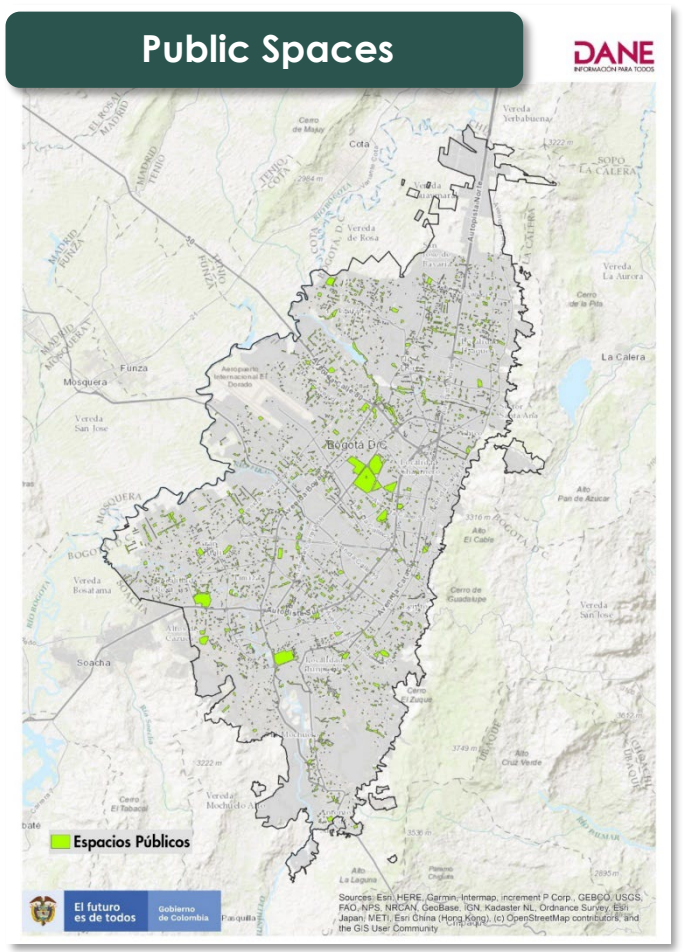
Built-Up Area



Roads

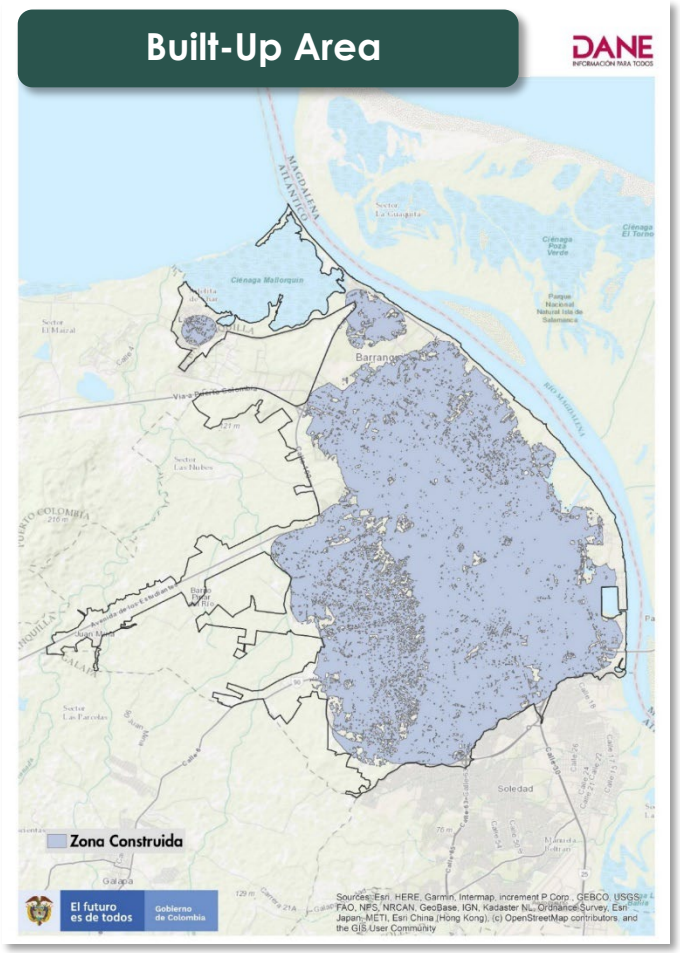


Public Spaces

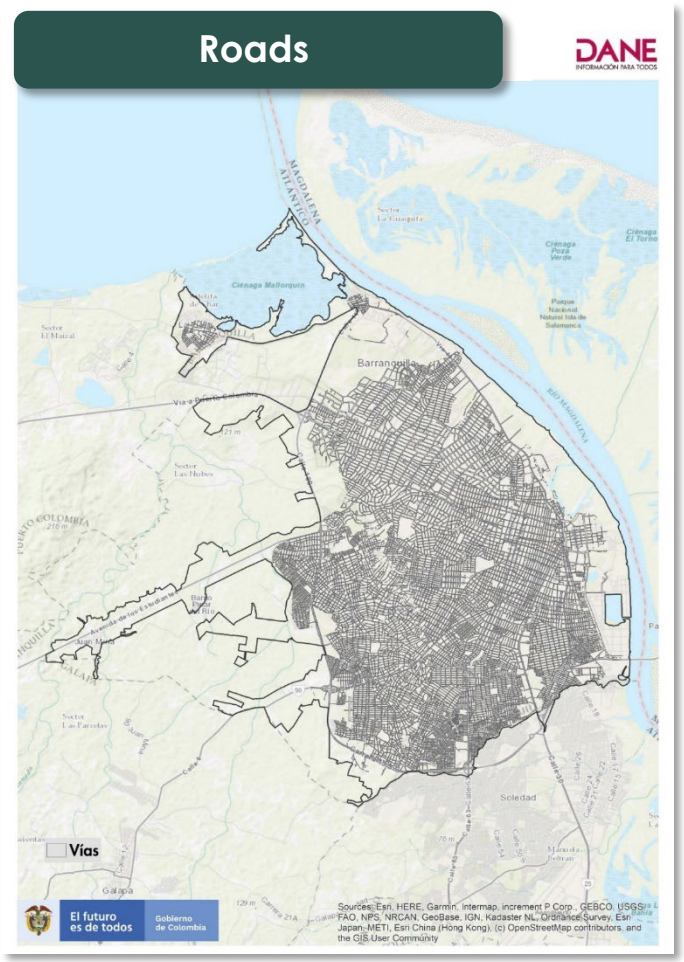


Results - Barranquilla

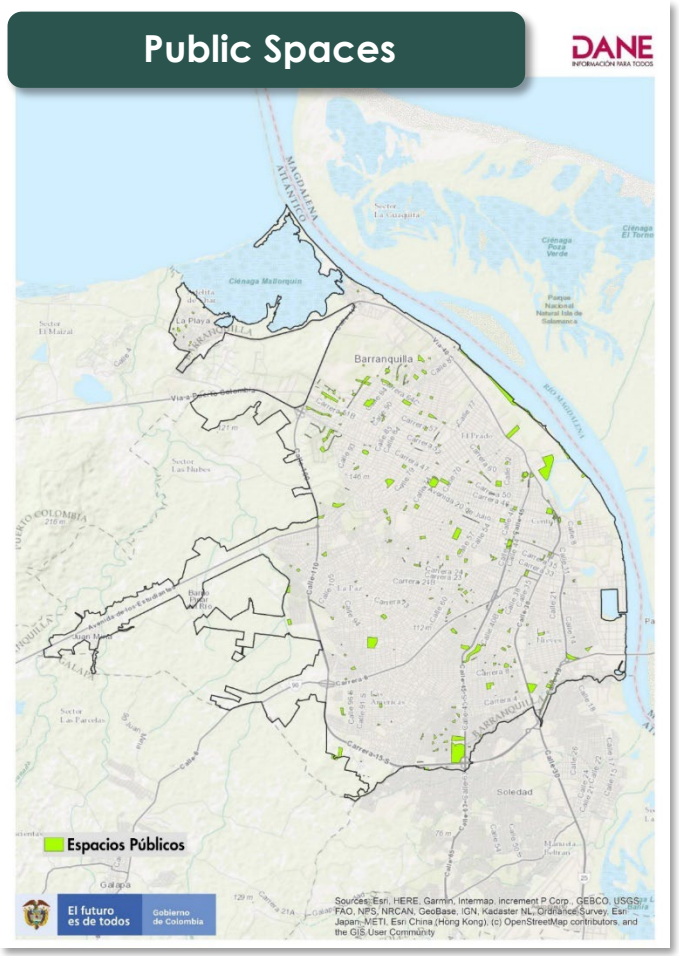
Built-Up Area



Roads



Public Spaces



Results - Calculation of the Global Indicator

Cities	Public Space DANE (m^2)	Public Space OSM (m^2)	Roads (m^2)	Urban Area (m^2)	11.7.1 Global
PEREIRA	1.092.682,5	291.358,6	2.535.681,8	8.677.835,3	**45,2%**
CALI	7.252.746,8	2.127.511,2	22.533.675,2	74.264.818,8	**43%**
MEDELLÍN	2.318.013,1	1.763.211,3	18.436.437,3	53.542.076,6	**42,1%**
BOGOTÁ, D,C,	7.412.246,6	14.436.460,9	72.305.039,4	245.293.914,9	**38,4%**
SOACHA	337.614,9	711.144,1	3.124.883,1	11.728.165,1	**35,6%**
BUCARAMANGA	452.355,3	567.599,7	4.372.632,4	15.436.523,2	**34,9%**
TURBACO	30.812,8	16.619,7	867.664,8	3.136.856,3	**29,2%**
BARRANQUILLA	1.179.951,2	1.048.601,2	17.388.859,6	68.871.089,1	**28,5%**
CARTAGENA	546787,7	347.428,7	9.017.870,3	41.848.557,5	**23,7%**

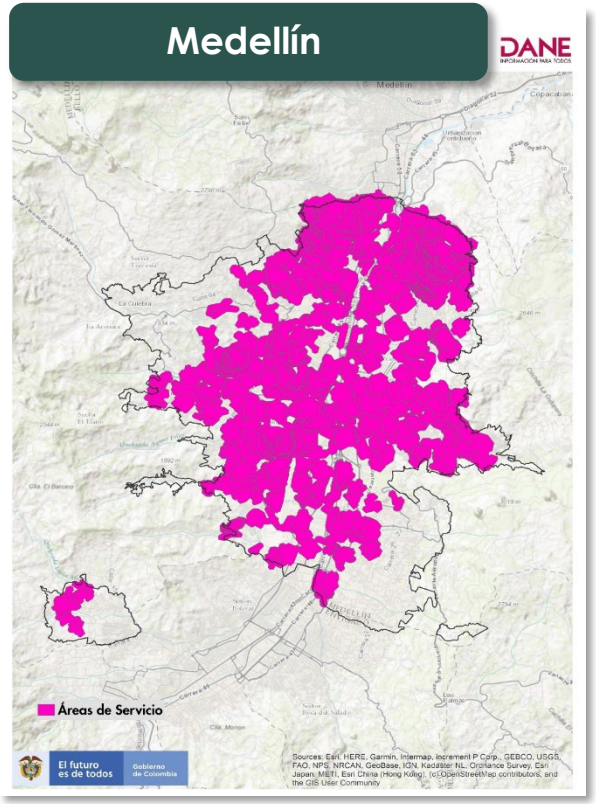
The cities with the highest proportion of open public spaces in relation to their built-up area are **Pereira, Cali, and Medellin.**

The cities with the lowest values are **Cartagena, Barranquilla, and Turbaco**.

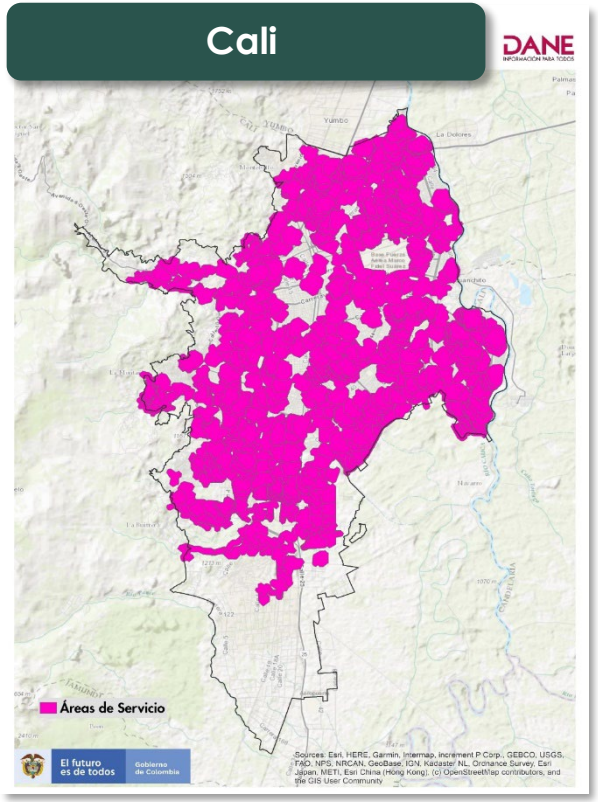
Results - Service Areas

Service areas were generated for each of the public spaces, using network analysis and accessibility functions.

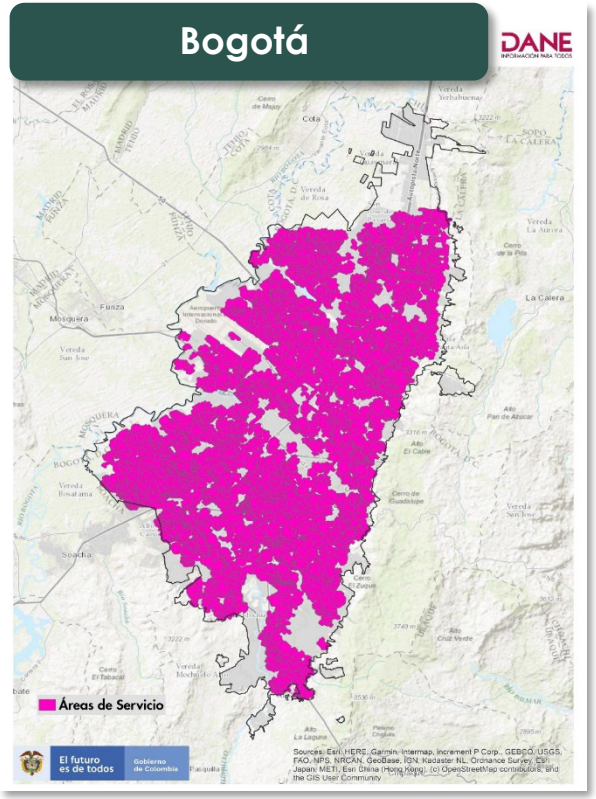
Medellín



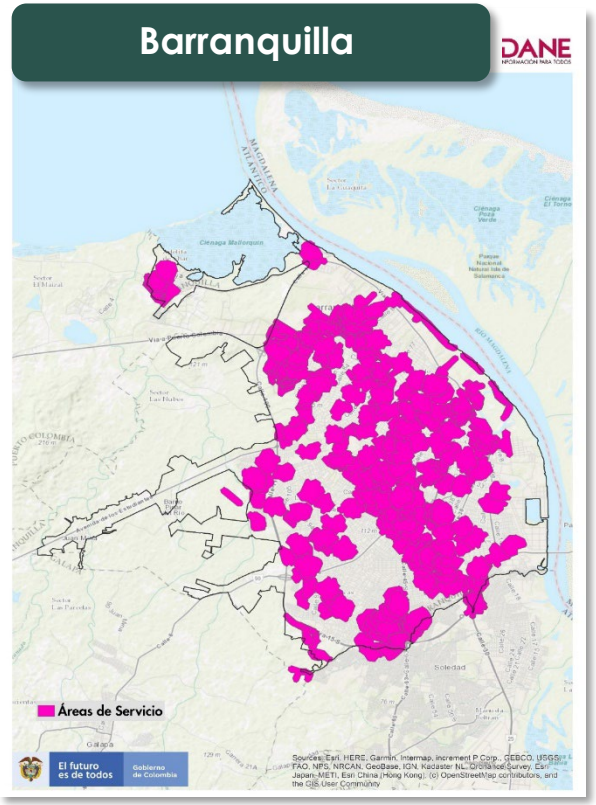
Cali



Bogotá



Barranquilla



Results - Calculation by Population Groups

Cities	Women	Children under 14 Years of Age	Persons with Disabilities
BOGOTÁ, D,C,	97,1%	97,1%	97,5%
PEREIRA	91,1%	90,9%	91,6%
SOACHA	88,7%	87,2%	89,4%
MEDELLÍN	88,2%	88,4%	88,8%
BUCARAMANGA	88,2%	86,6%	88,1%
CALI	86,8%	86,6%	87,0%
TURBACO	67,2%	65,6%	73,9%
BARRANQUILLA	67,1%	63,8%	71,1%
CARTAGENA	60,5%	57,4%	64,1%

Access to public space by the population groups of interest is similar for each of the cities.

However, **Bogotá and Pereira stand out** as cities with percentages above 90%, while **Cartagena** has percentages below 65%.

Results – National Estimate

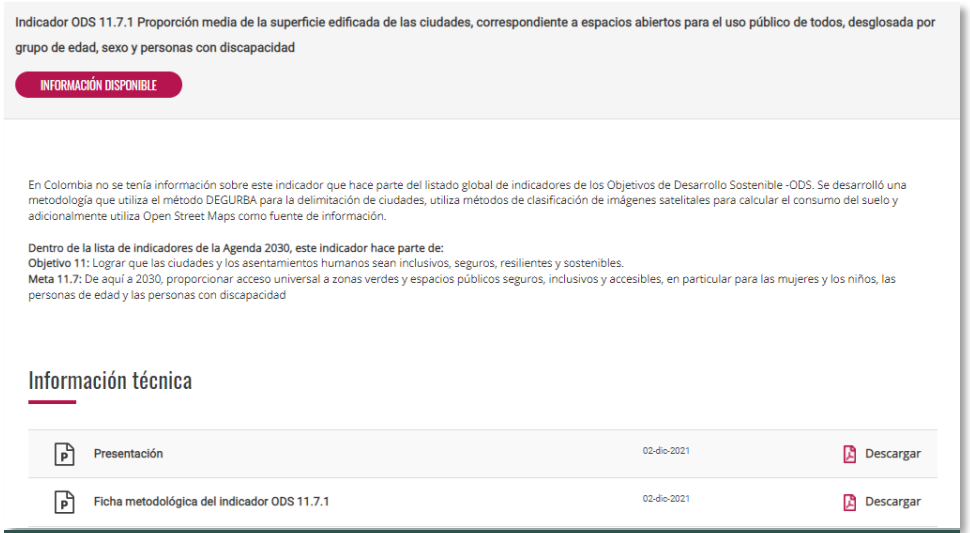
11.7.1 Global	Women	Children under 14 Years of Age	Persons with Disabilities
33,2%	80,8%	77,8%	84,8%

At the national level:

- One-third of the built-up areas correspond to open spaces for public use (green areas + roads).
- The percentage of the population with limited access to open spaces for public use is higher than that of the other two groups of interest.

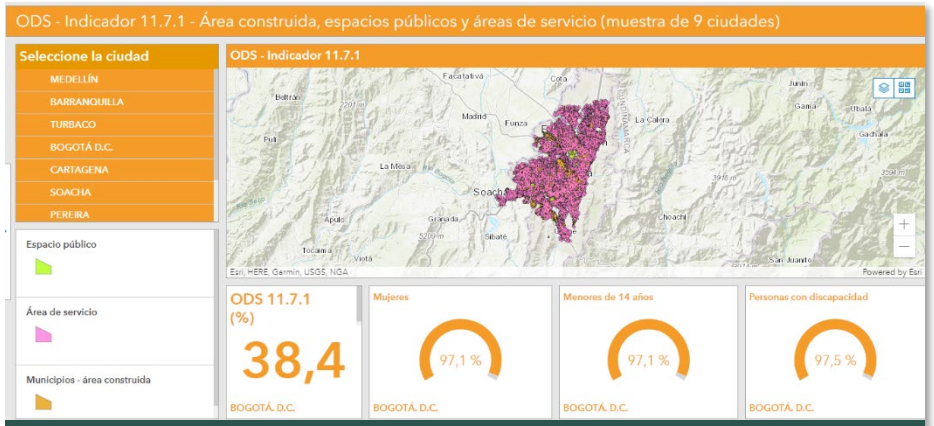
Dissemination - Complementary Products

Experimental statistics section DANE website



https://www.dane.gov.co/index.php/estadisticas-por-tema/estadisticas-experimentales

Geo-viewer



https://www.arcgis.com/apps/dashboards/e9bfd6b6f77447b1af08229c73407fda

DANE ArcGIS Hub for SDG

https://ods-dane.hub.arcgis.com/pages/ods11

Air Quality in Cities: An EO Tool for Monitoring SDG 11.6.2

Evangelos Gerasopoulos & Jennifer Bailey | National Observatory of Athens, Greece

February 10, 2022

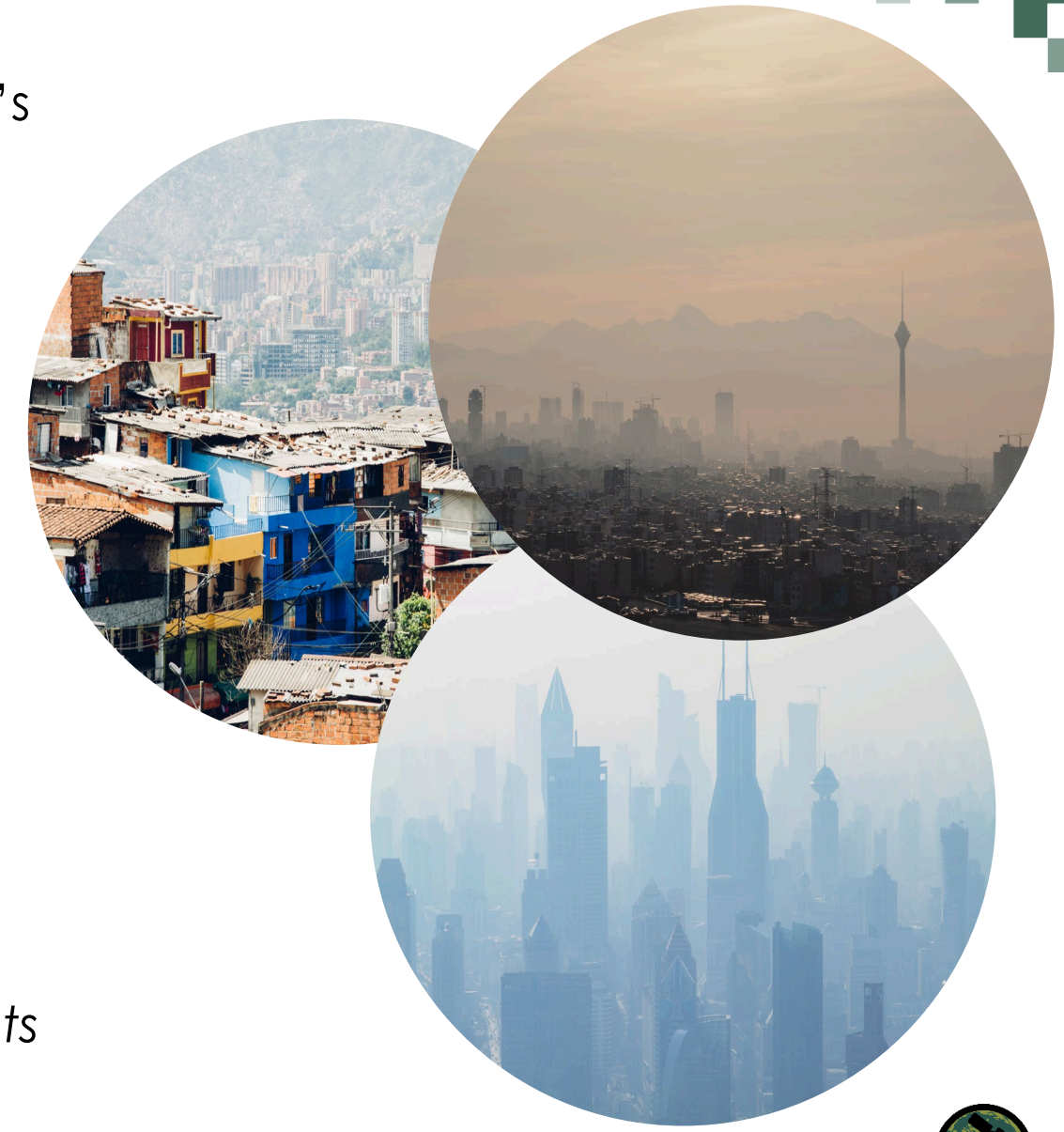
Why cities?

While cities occupy a small proportion of the Earth's surface,

- they are home to more than 50% of the world's population
- consume ¾ + of the world's natural resources &
- generate over 80% of the world's economic production.

Urbanization, combined with overall growth of global population, is projected to add 2.5 billion more people to urban areas by 2050 (68% of people will be living in cities).

2018 Revision of World Urbanization Prospects



Photos by Milo Miloezger (middle), Amir Hosseini (top), Photoholgic (bottom) via Unsplash

Urban Air Quality – $PM_{2.5}$ & Health

"Almost all of the global population (99%) are exposed to air pollution levels that put them at increased risk for diseases including heart disease, stroke, chronic obstructive pulmonary disease, cancer & pneumonia." WHO, 2021

- **$PM_{2.5}$** (particles with a diameter of 2.5 microns or less) - proxy indicator for air pollution
- Strongest evidence for public health concern as fine particles can be inhaled and deeply penetrate lungs – elderly & children particularly vulnerable
- Short-term & chronic impacts → increased mortality & morbidity (cardiovascular & respiratory disease, cancers, etc.)
- No threshold identified below which no damage to health is observed
- WHO estimated that **$PM_{2.5}$ exposure caused 4.2 million premature deaths worldwide** per year in 2016

WHO $PM_{2.5}$ Guideline:
5 µg/m³ annual average

EU $PM_{2.5}$ Standard:
25 µg/m³ annual average

US EPA $PM_{2.5}$ Standard:
12 µg/m³ annual average

Sustainable Development Goal 11

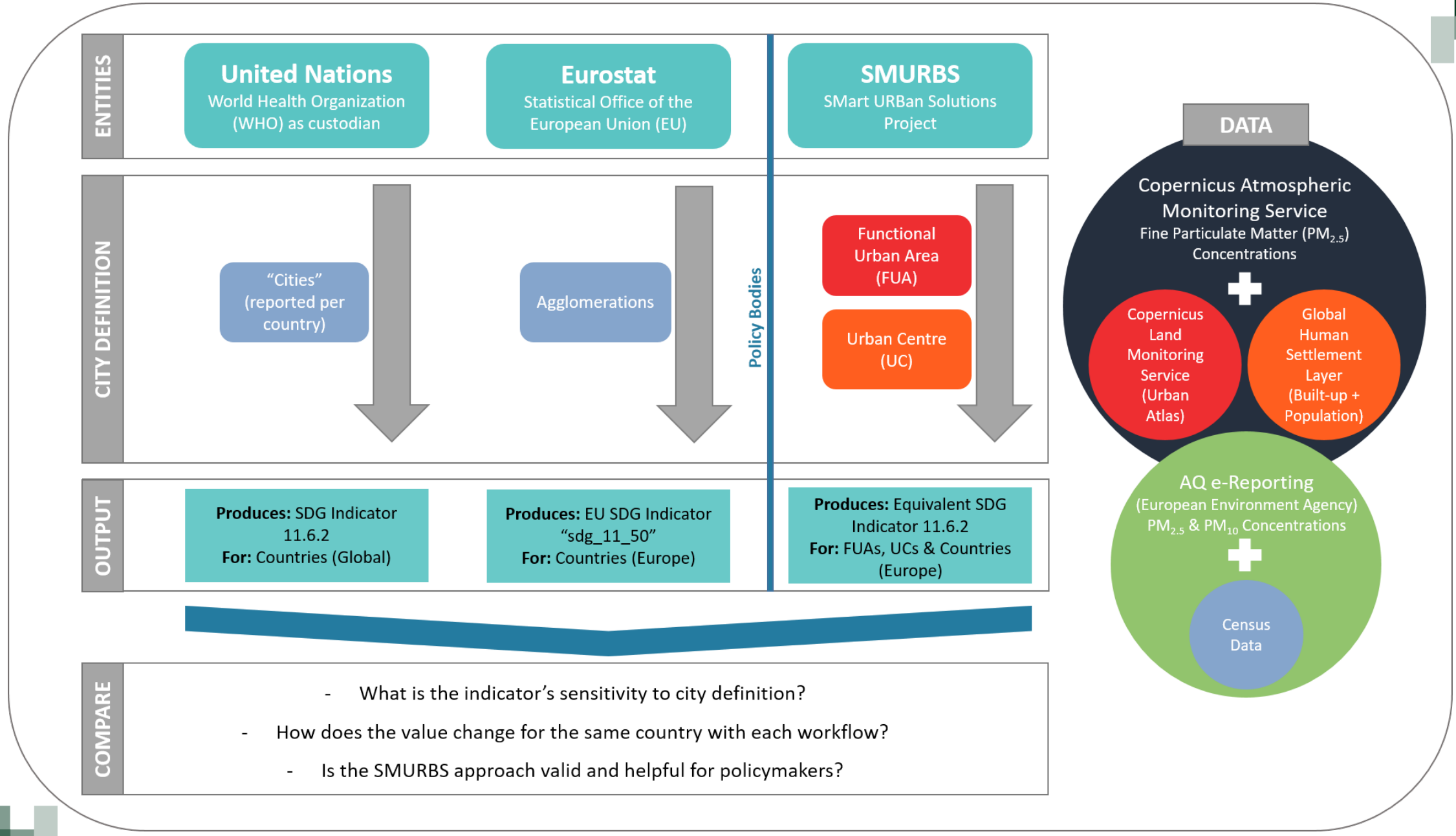
- SDG Indicator 11.6.2 aimed at urban air quality:
  "Annual mean levels of fine particulate matter (e.g., $PM_{2.5}$ and PM_{10}) in cities, population weighted"

But what is a city?

- National definitions vary widely → international incomparability

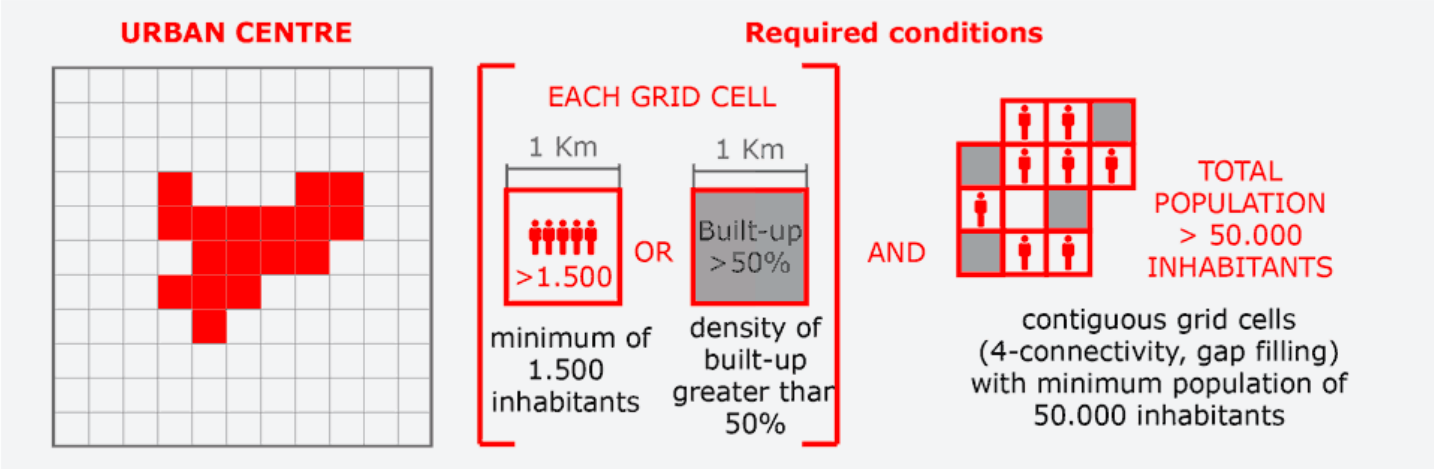
- Habitat III voluntary commitment to develop a "global, people-based definition of cities and settlements" to be presented to the UN Statistical Commission in 2019

- Endorsed by the UN Statistical Commission in 2020, **the Degree of Urbanisation** serves as a methodology for delineation of cities, urban and rural areas



https://www.essoar.org/doi/abs/10.1002/essoar.10502027.1

Urban Centre

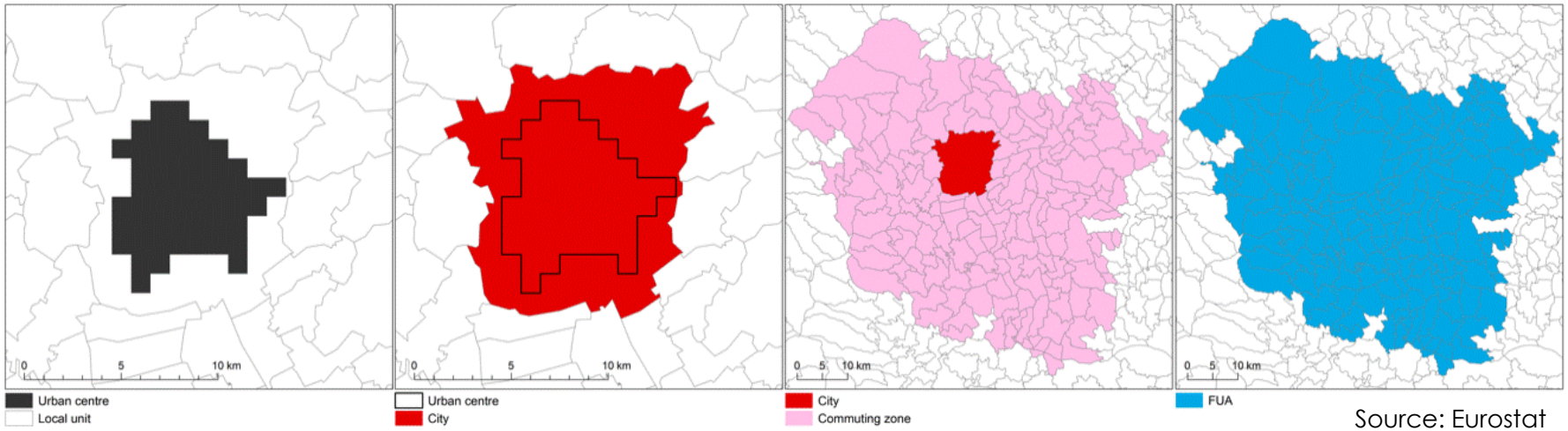


Source: European Commission

Uniform population grid cells of 1km^2 from Global Human Settlement Layer (GHSL) (human settlement information from satellite imagery/modeling & population data from censuses)

Urban Centre (UC) = **contiguous grid cells** w/ 1) **population density** of at least 1,500 inhabitants per km^2 **OR** 2) **density of built-up area** greater than 50% per km^2 AND 3) **at least 50,000 total population**

Functional Urban Area



Source: Eurostat

Functional Urban Area (FUA) definition follows same grid concept, but overlays urban centres with Local Administrative Units (LAUS) to define cities

FUA = a city (at least 50,000 inhabitants) + its commuting zone

Calculating SDG Indicator 11.6.2

Copernicus Atmospheric Monitoring Service

Fine particulate matter concentrations ($PM_{2.5}$)

Global Human Settlement Layer

Built up + population – Urban Centre Database

Copernicus Land Monitoring Service

Urban Atlas – Functional Urban Area

$$National\ annual\ 11.6.2\ values = \frac{(C_{city1}P_{city1} + C_{city2}P_{city2} + \cdots + C_{cityn}P_{cityn})}{P_{total}}$$

City concentrations derived by overlaying & calculating area-weighted average of CAMS regional ensemble reanalysis output (11x11km) masked by city shape files (population is an attribute of the city definition)

SDG 11.6.2 Platform Demo

http://apcg.meteo.noa.gr/sdg1162/

Learn more at https://youtu.be/PIfklOg5XiI

Perspectives

- Horizontal approach for all cities & nations
- Annual averages – city, country, Europe
- Allow for comparison, hot spot identification (i.e., targeted mitigation efforts), city extent delineation
- Disaggregated data as per UN SDG principle & in aid of decision making
- Ability of EO to allow for harmonized reporting
- Further efforts towards advanced usage and integration of EO for smart statistics – exploit multi-source data fusion techniques for use by National Statistical Offices
- Scalability: geographic & supplementary data
  - Socioeconomic and health data → added value of using geospatial lens to identify links between factors & air pollution

Computation of SDG National Indicator 11.3.1: A Case Study of South Africa

Naledzani Mudau

Introduction

- 17 Sustainable Development Goals (SDGs)
  - SDG 11
  - Make cities and human settlements inclusive, safe, resilient and sustainable
    - 10 targets
    - 15 indicators
  - 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 (Tier II*)
    - Ratio of land consumption rate to population growth rate

*Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries

Definition and Computation of SDG Indicator 11.3.1

- SDG indicator 11.3.1 indicates land use efficiency
  - Rate of urban land development and population growth rate
  - Land Consumption < Population Growth

- Computation

- $$LCRPGR = \frac{LN(Urb_{t+n}/Urb_t)}{(y)} / \frac{LN(Pop_{t+n}/Pop_t)}{(y)}$$

Where LN is the natural algorithm value, Urb_t is the urban extent in km^2 for past/initial year, Urb_{t+n} is the urban extent in km^2 for current year, y is the number of years between the two measurement periods, Pop_t is the total population within the urban extent in the past/initial year, and Pop_{t+n} is the total population within the urban extent in the current/final year.

Metadata: https://unhabitat.org/sites/default/files/2020/07/metadata_on_sdg_indicator_11.3.1.pdf

Data Requirements

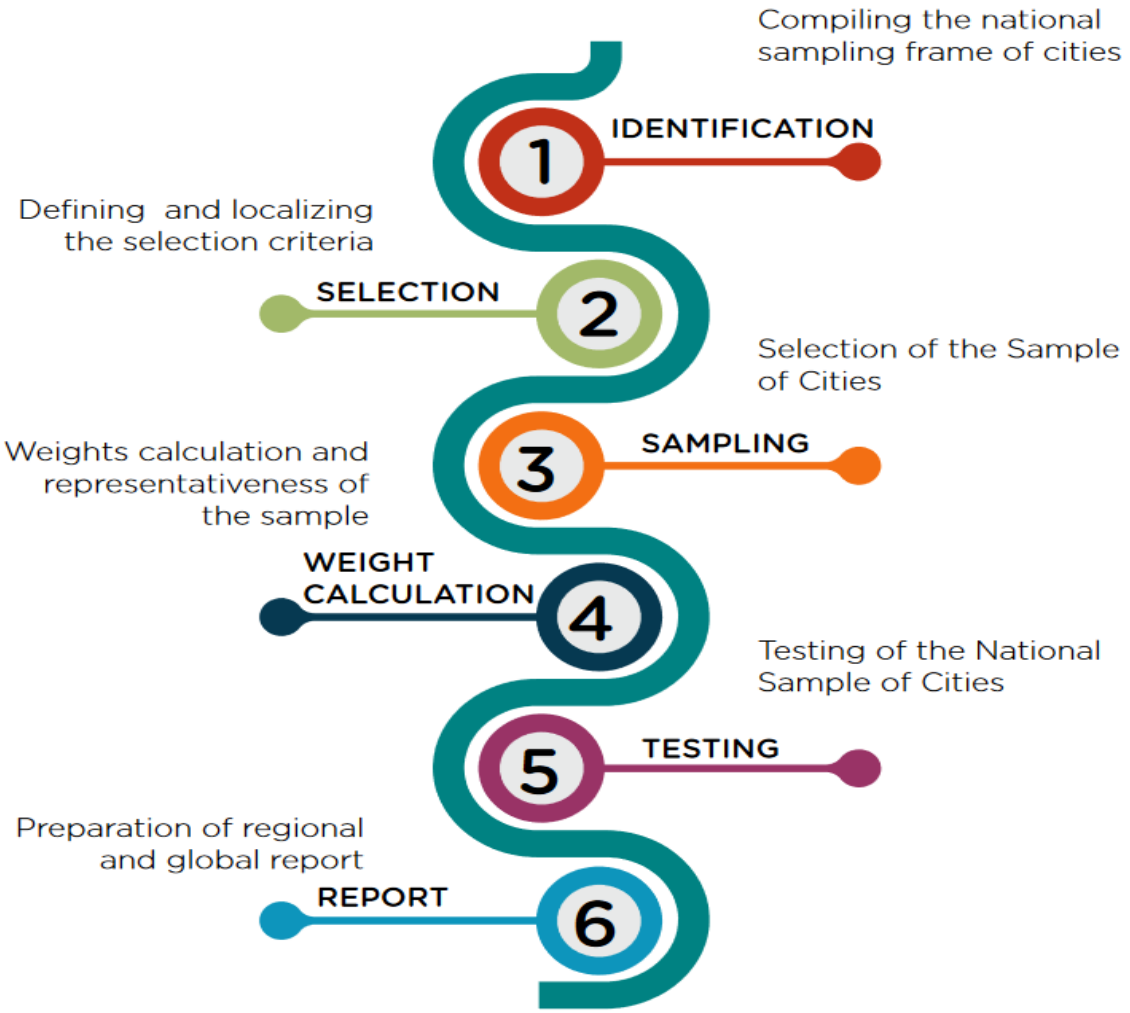
- Population Data
  - National Census Data
  - Gridded Population Data (e.g., WorldPOP, GPW, GHS-POP, High Resolution Settlement Layer [HRSL])
  - Other

- Urban Extent/Boundary
  - Open access satellite images
  - Other satellite data products
    - Global Human Settlement Layer (GHSL)
    - World Settlement Footprint (WSF)
    - Etc.
- Reporting
  - Every 1, 5, & 10 years, depending on the availability and spatial resolution of the input data

SDG Indicator 11.3.1 South Africa Case Study

National Sample of Cities

- The national sample of cities (NSC) is a representative sample of cities that takes into account sub-regional and city specific characteristics.
- It helps to create weighted national averages for indicators.



*https://unhabitat.org/sites/default/files/2020/06/national_sample_of_cities_english.pdf

Cities in South Africa

Cities in South Africa: World Urbanization Prospects

Universe of Cities Population	No. of cities	Total urban population
<100,000	187	6 478 874
100,000-250,000	18	3 078 172
250,001-500,000	7	2 528 437
500,001-1,000,000	3	2 210 003
1,000,001-2,500,000	1	1 763 336
2,500,001-5,000,000	2	6 217 038
5,000,001-9,999,999	1	7 860 781
Total	219	30 136 641

Selection of Cities

Method: National Sample of Cities* (NSC)

Sample of Cities		
Population	No. of cities	Total urban population
<100,000	9	256 590
100,000-250,000	9	1 641 073
250,001-500,000	6	2 236 953
500,001-1,000,000	2	1 604 499
1,000,001-2,500,000	1	1 763 336
2,500,001-5,000,000	2	6 217 038
5,000,001-9,999,999	1	7 860 781
Total	30	21 580 270

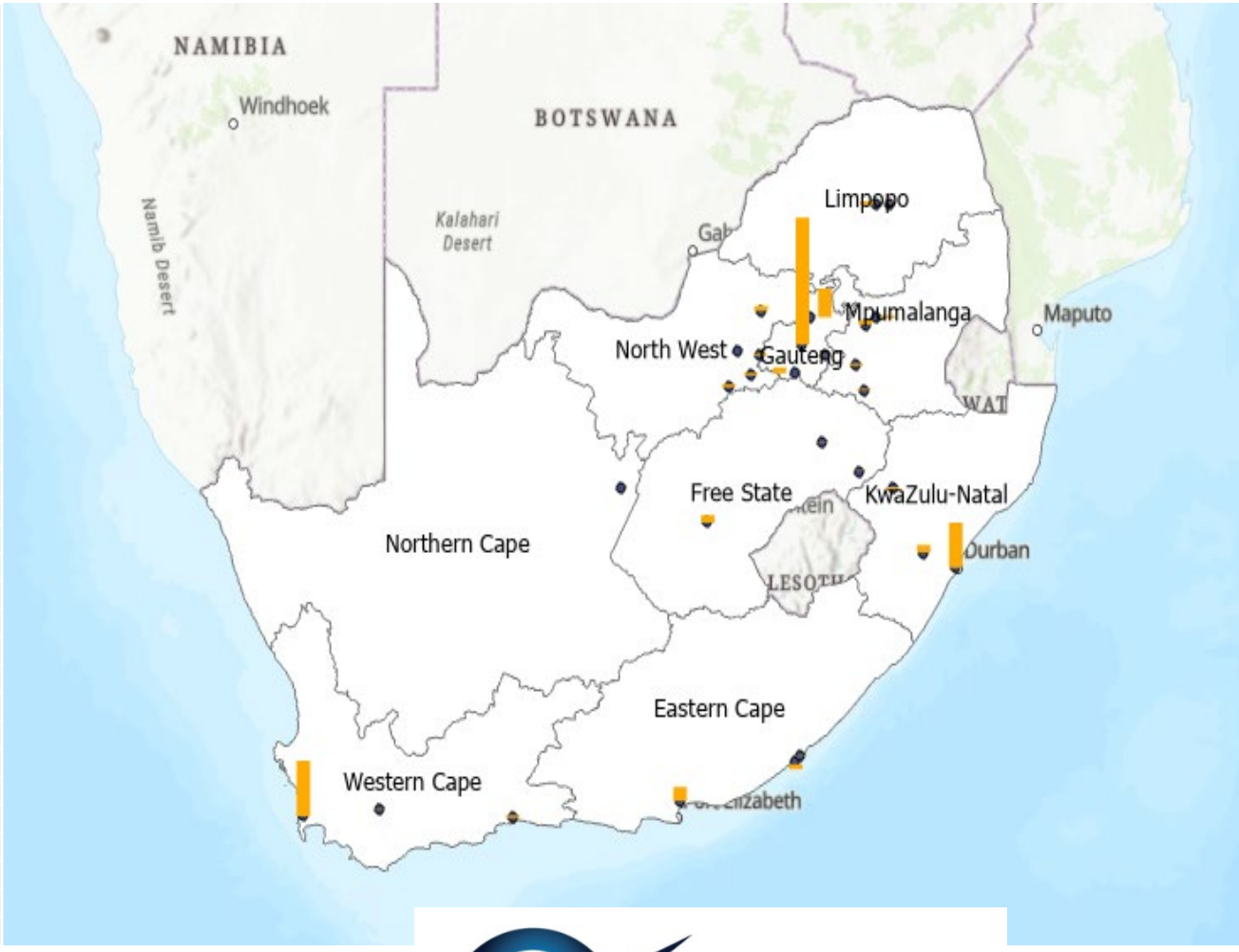
*https://unhabitat.org/sites/default/files/2020/06/national_sample_of_cities_english.pdf

Spatial Distribution and Population

List of Cities

City	Population Category	Population	Province	Number of cities in Box	Number of sampled cities in box	City weight
Gonubie	<100,000	19809	Eastern Cape	21	1	0,095890411
Reitz	<100,000	20183	Free State	29	1	0,132420091
Nigel	<100,000	30276	Gauteng	8	1	0,03652968
Dundee	<100,000	34924	KwaZulu-Natal	27	1	0,123287671
Mankweng	<100,000	41298	Limpopo	18	1	0,082191781
Trichardt	<100,000	44049	Mpumalanga	33	1	0,150684932
Ventersdorp	<100,000	22073	North West	21	1	0,095890411
Barkly West	<100,000	20105	Northern Cape	9	1	0,04109589
Robertson	<100,000	27714	Western Cape	21	1	0,095890411
Uitenhage	100,000-250,000	242924	Eastern Cape	3	1	0,01369863
Welkom	100,000-250,000	211014	Free State	3	1	0,01369863
Carletonville	100,000-250,000	149065	Gauteng	1	1	0,00456621
Ladysmith	100,000-250,000	119726	KwaZulu-Natal	2	1	0,00913242
Polokwane	100,000-250,000	227407	Limpopo	1	1	0,00456621
Embalenhle	100,000-250,000	118889	Mpumalanga	2	1	0,00913242
Klerksdorp	100,000-250,000	189496	North West	2	1	0,00913242
Kimberley	100,000-250,000	225155	Northern Cape	1	1	0,00456621
George	100,000-250,000	157397	Western Cape	3	1	0,01369863
East London	250,001-500,000	295644	Eastern Cape	1	1	0,00456621
Bloemfontein	250,001-500,000	464591	Free State	1	1	0,00456621
Vereeniging	250,001-500,000	377922	Gauteng	1	1	0,00456621
Pietermaritzburg	250,001-500,000	475238	KwaZulu-Natal	2	1	0,00913242
Witbank	250,001-500,000	311657	Mpumalanga	1	1	0,00456621
Rustenburg	250,001-500,000	311901	North West	1	1	0,00456621
Port Elizabeth	500,001-1,000,000	876436	Eastern Cape	1	1	0,00456621
Pretoria	1,000,001-2,500,000	1763336	Gauteng	3	1	0,01369863
Durban	2,500,001-5,000,000	2786046	KwaZulu-Natal	1	1	0,00456621
Cape Town	2,500,001-5,000,000	3430992	Western Cape	1	1	0,00456621
Johannesburg	5,000,001-9,999,999	7860781	Gauteng	1	1	0,00456621

Spatial Distribution of the Cities



Data Sources

- Population

Census 1996, 2007, 2011: Statistics South Africa

- Urban Extent

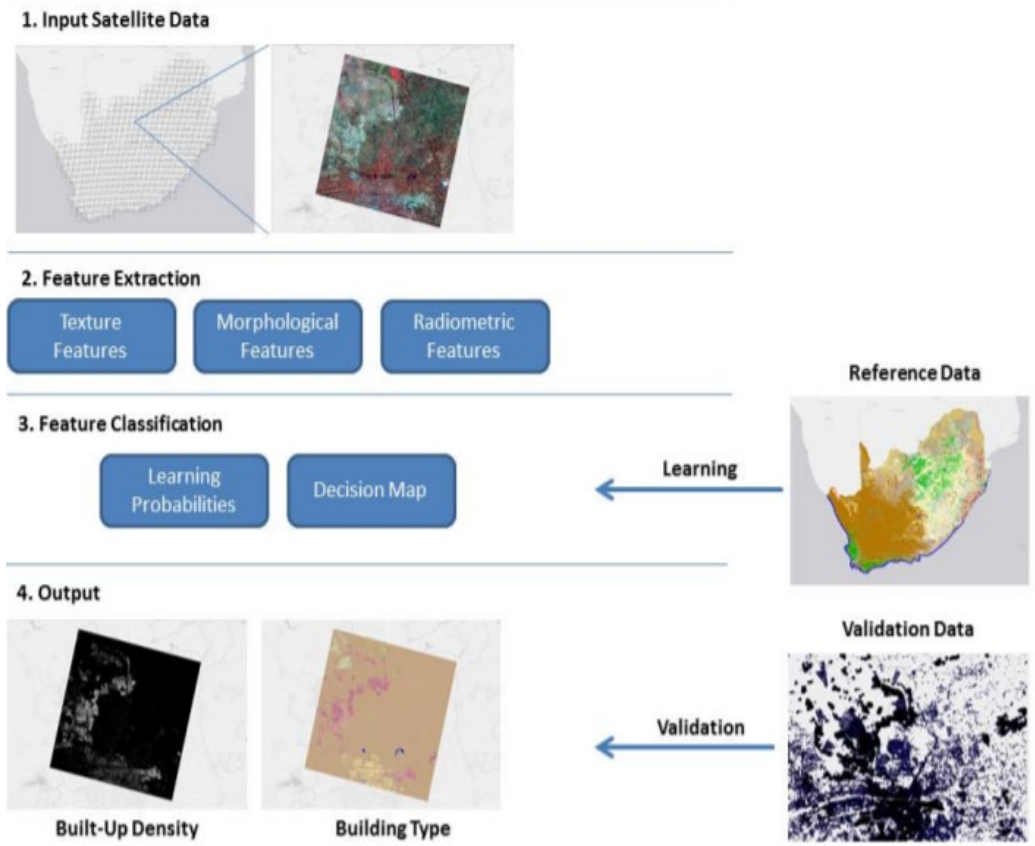
SPOT 5 Satellite Images: 2011

SPOT 2 and 4 Satellite Images: 2001

Landsat 5 Satellite Images: 1996

Built-Up Extraction Methodology

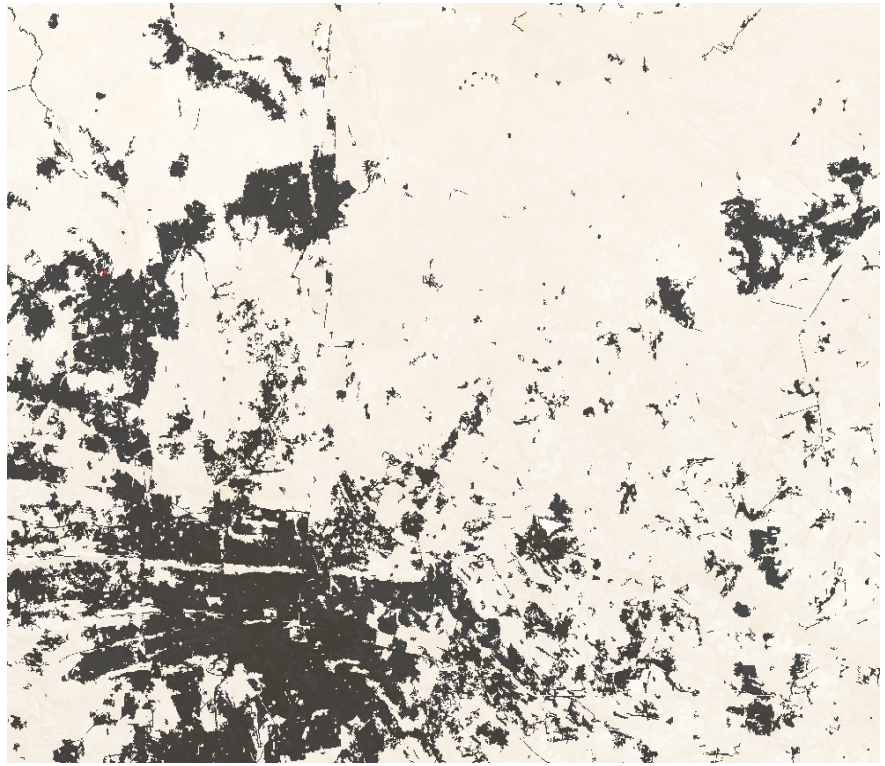
*Built-Up Extraction from SPOT 5 Satellite Images



*https://www.researchgate.net/publication/271823158_Towards_a_country-wide_mapping_monitoring_of_formal_and_informal_settlements_in_South_Africa

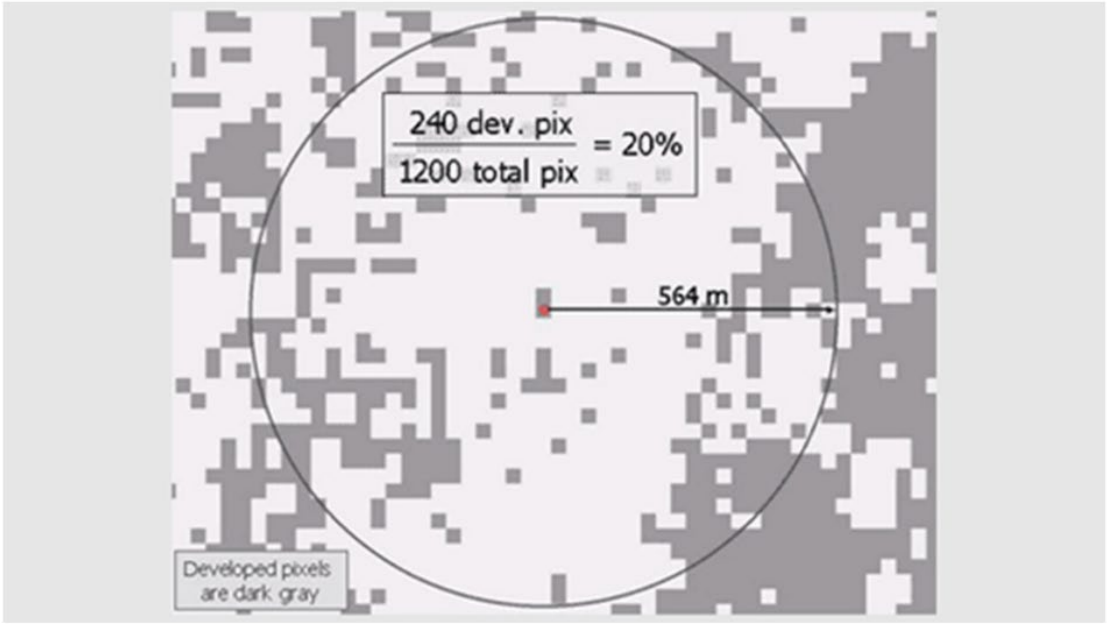
Built-Up Extraction from SPOT 2 and 4, and Landsat 5

Object-Based Image Analysis



Urban Extent Mapping

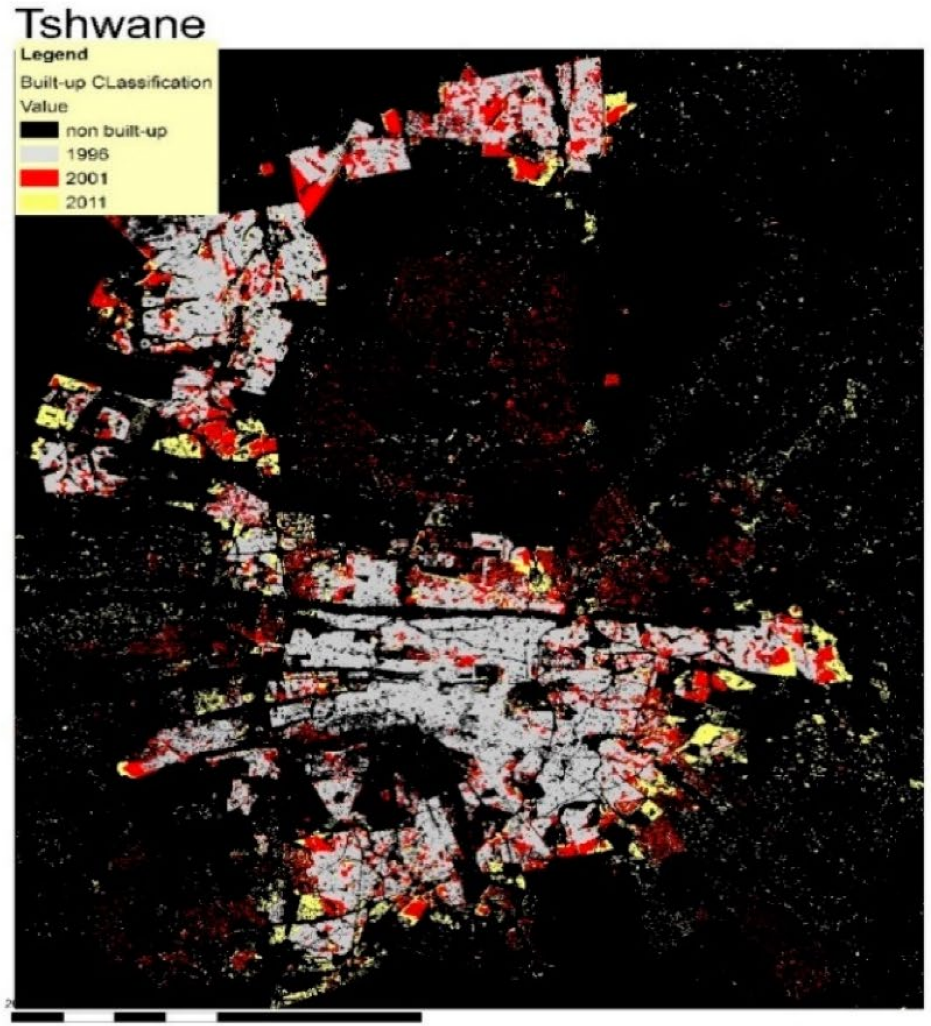
- Urban pixels are all the built-up pixels surrounded by a majority (50% or more) of other built-up pixels in their walking distance circle
- Suburban pixels are all the built-up pixels surrounded by 25–50% of other built-up pixels in their walking distance circle, and
- Rural pixels are all the built-up pixels surrounded by less than 25% of other built-up pixels in their walking distance circle.

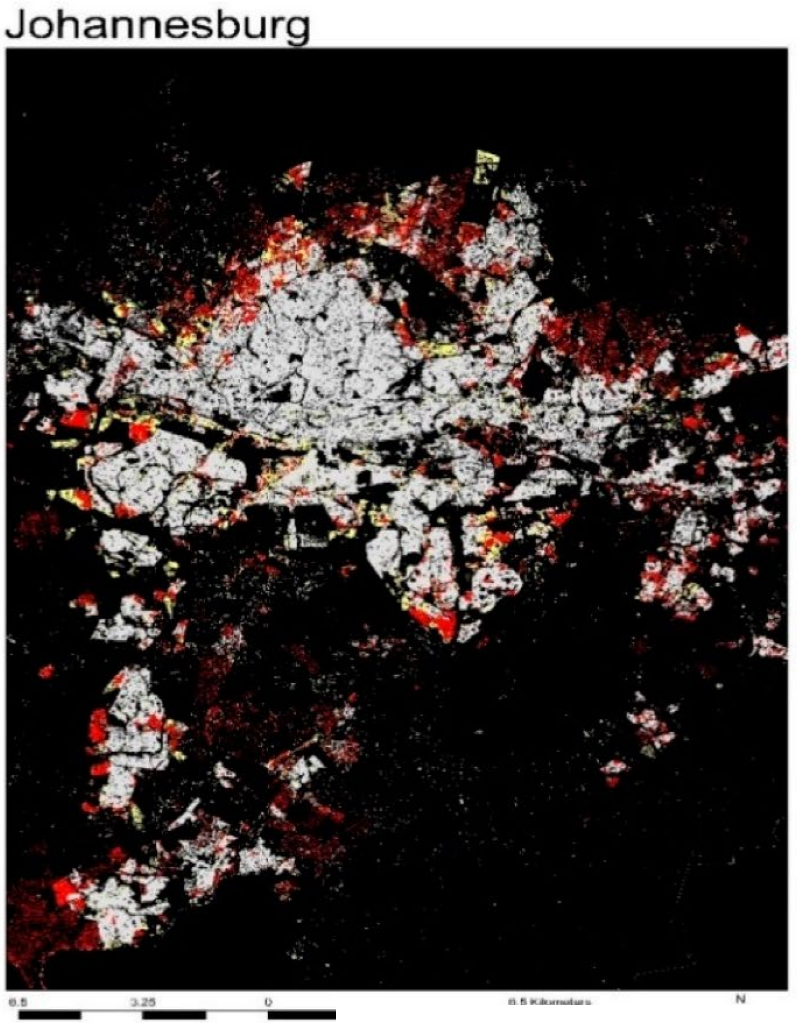


Concept of walking distance circle and determination of urbanness of built-up pixels; Angel et al, 2016

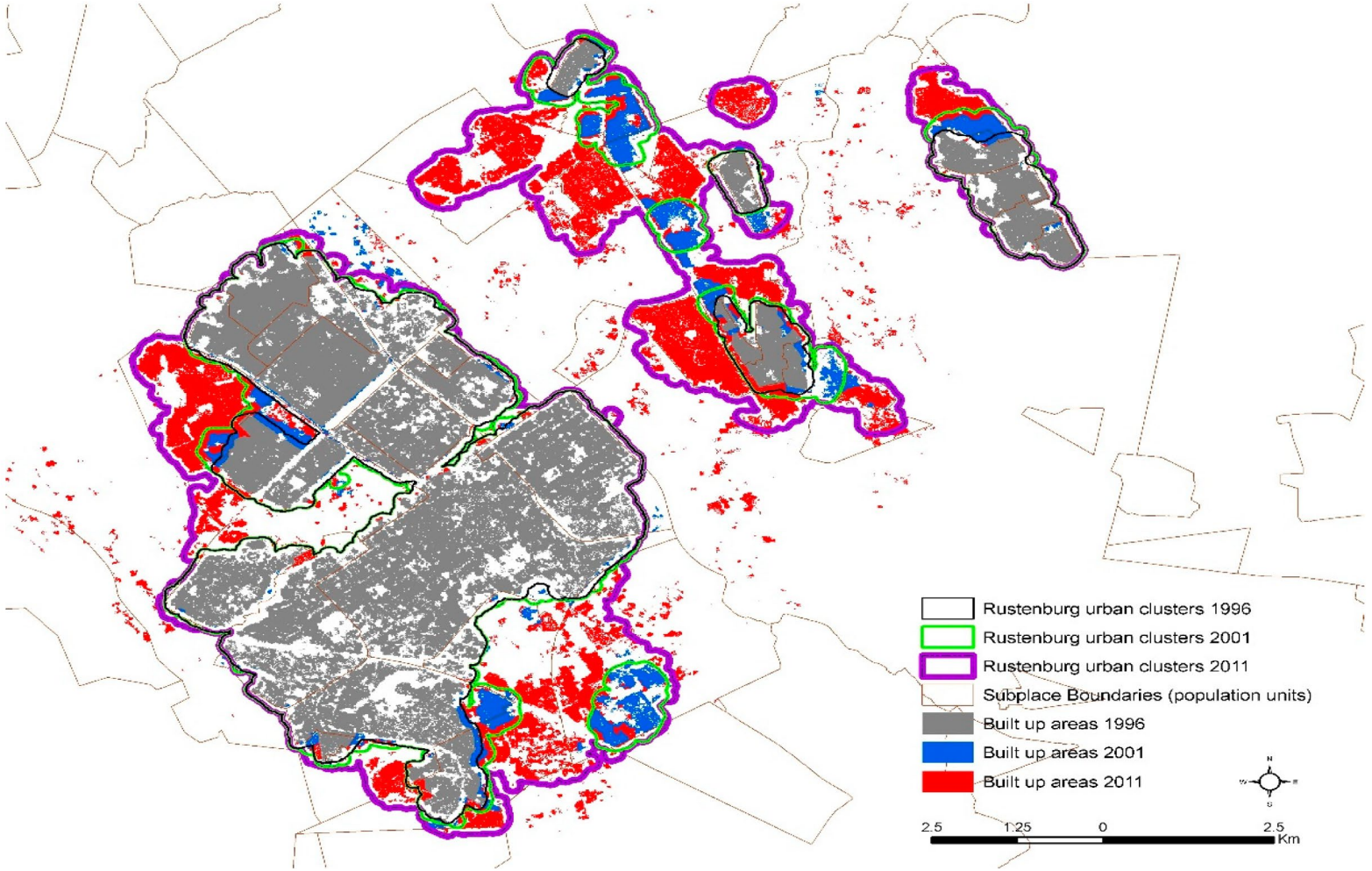
Methodology: Mudau et al, 2020, Assessment of SDG Indicator 11.3.1 and Urban Growth Trends of Major and Small Cities in South Africa, Sustainability

Built-Up Area Mapping Results

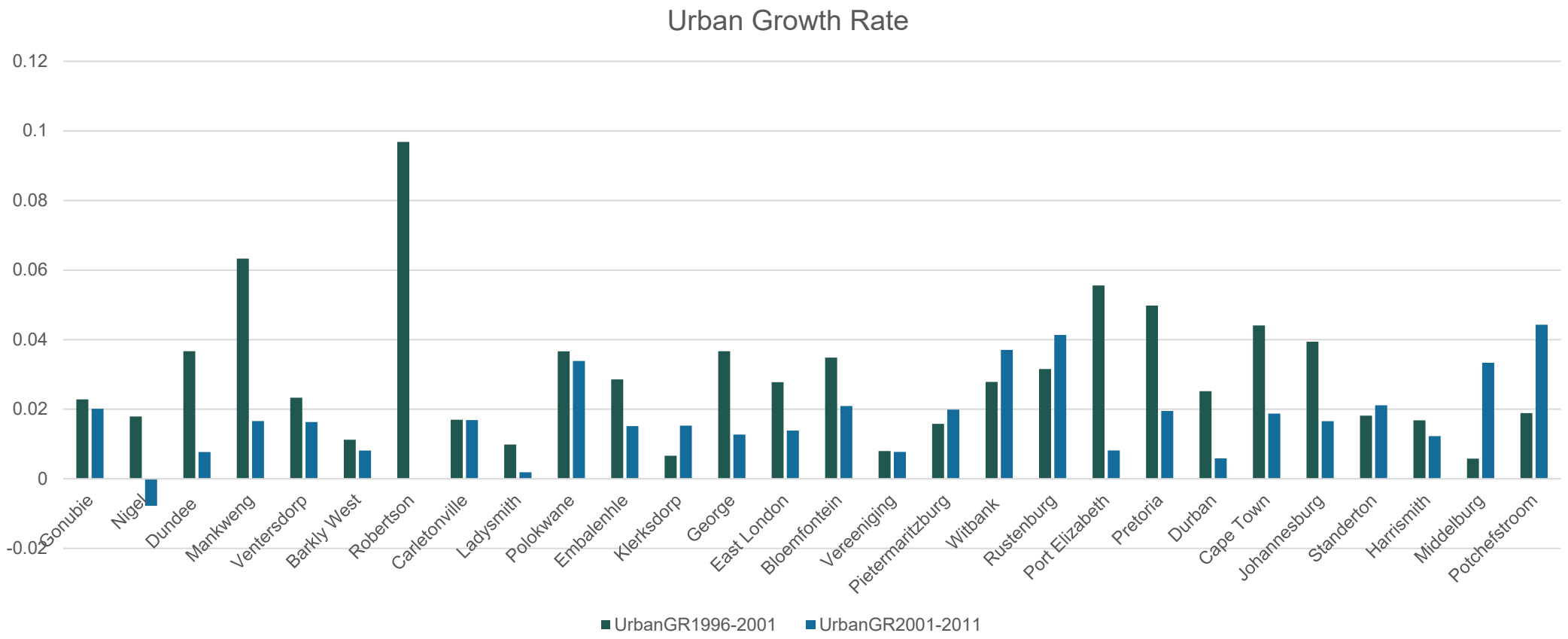




Urban Extent Mapping Results

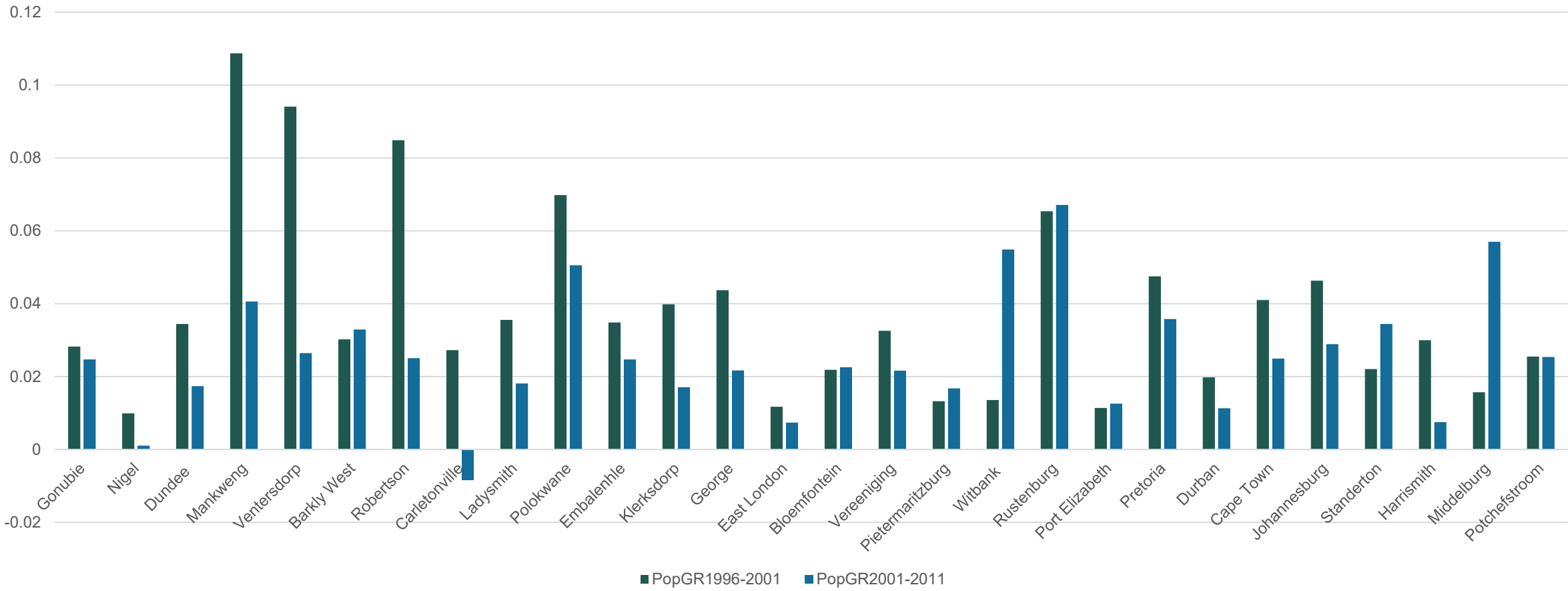


Urban Growth Rate (urbanGR/LCR)



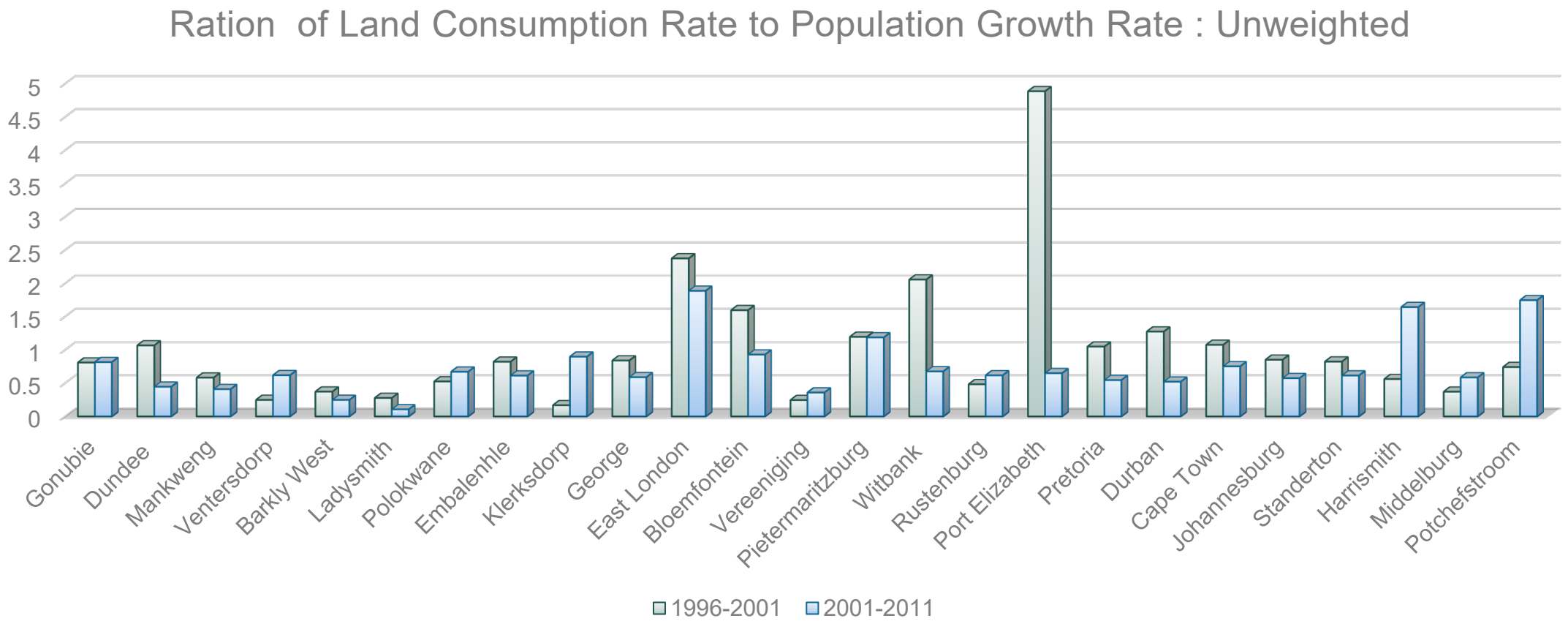
- Metropolitan cities and smaller urban areas experienced higher Land Consumption Rate (LCR) over 1996 and 2001
- Secondary cities (population less than 500 000) experience higher LCR over 2001-2011

Population Growth Rate (PopGR)



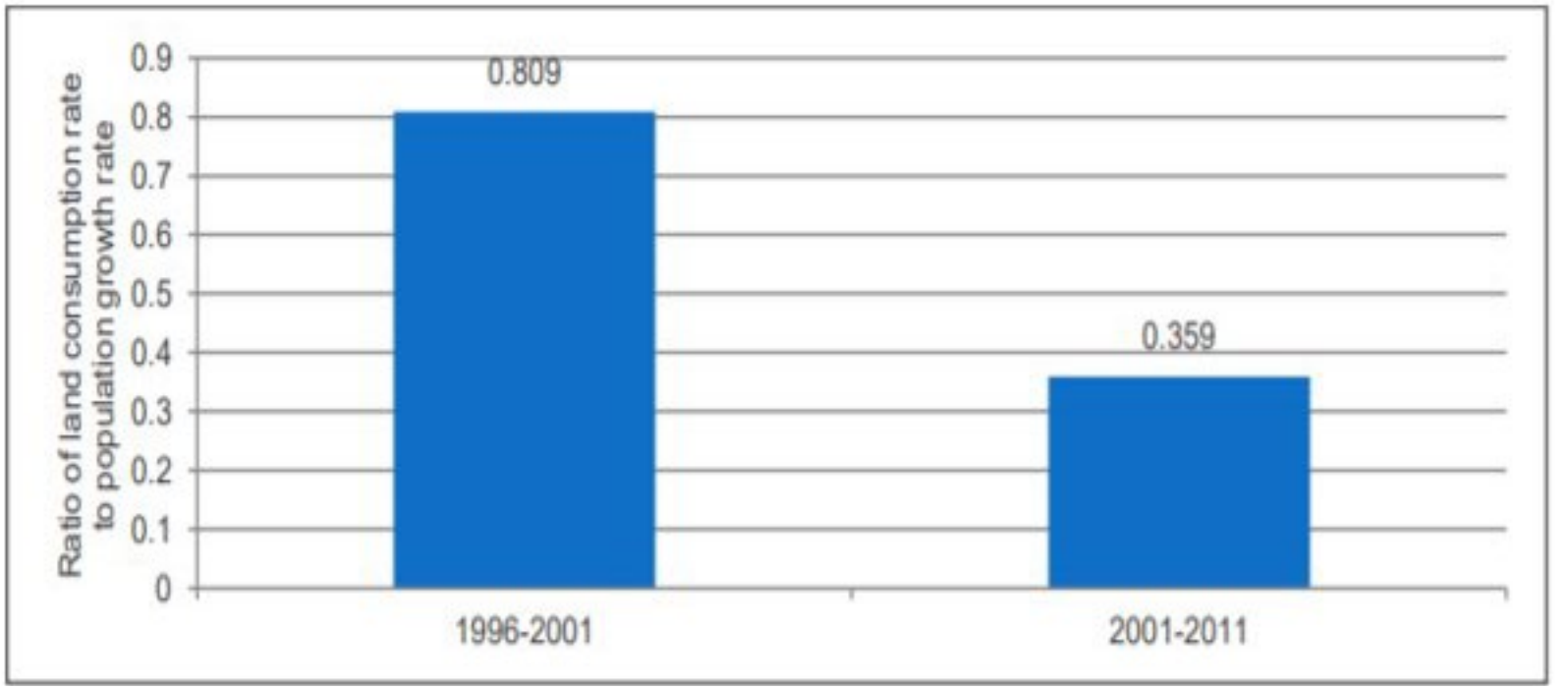
- Urban areas with population of less than 250,000 experience higher population growth rate between 1996 and 2001
- Cities with population of 250,000-500,000 experience higher population growth rate between 2001-2011
- eThekwini experienced the lowest population growth rates compared to other metropolitan cities

SDG 11.3.1: Ratio of LCRPGR



- Most cities had a Ratio of LCRPGR of less than 1.
- Two of the metropolitan cities (i.e., Port Lizabeth and East London) had the highest ratio.
- The ratio declined in many cities over 2001-2011: improved land use efficiency; except for Harrismith and Potchefstroom.

National Ratio of LCRPGR

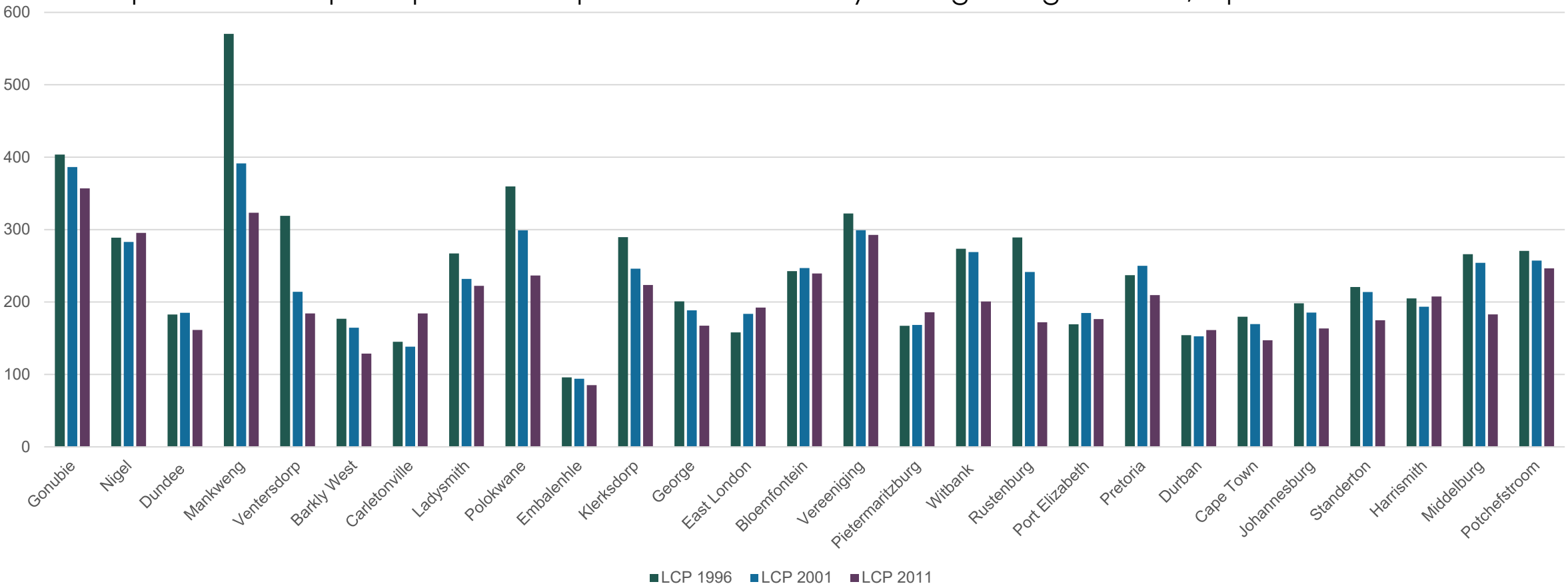


- Weighed ratio of LCRPGR computation shows that the National ratio of LCRPGR improved from 0.809 over 1996-2001 period to 0.359 over 2001-2011 period

Built-Up Area Per Capita (LCP)

Additional Indicator Computed

Built-Up Area Per Capita: Space each person within the city is using at a given time; square meter.



- Almost all the cities experienced a slight decline in built-up area per capita: slight densification of the cities

Conclusions

- The Ratio of LCRPGR was lower over the 2001-2011 compared to 1996-2001
- Smaller cities have experienced higher ratio of LCRPGR compared to major cities
- Indicators such as Land consumption per capita can be used with ratio of LCRPGR
- Additional (sub) indicators such as urban extent and land consumed assessed in the study provides additional information to support management of urban areas
- SDG 11 indicators related to green and public spaces, public transport health and indicators relating to poverty, health, education, energy, inequalities, and climate change may be assessed over sampled cities

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Thank you

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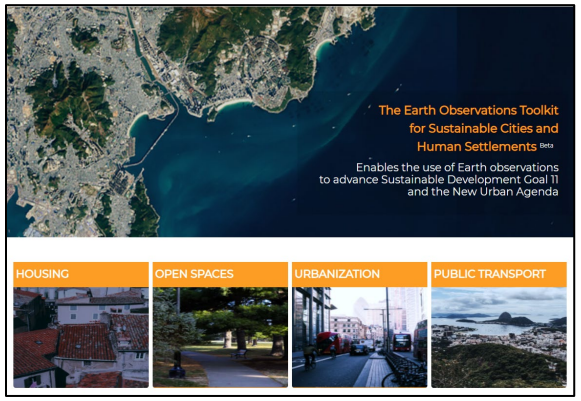
- ARSET Webpage:
  - https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset

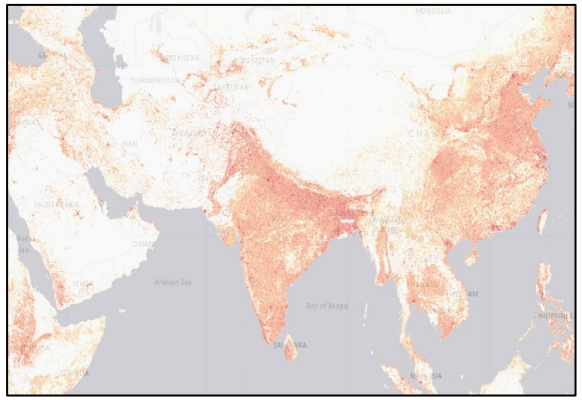
Series Summary

Part 1: January 27, 2022



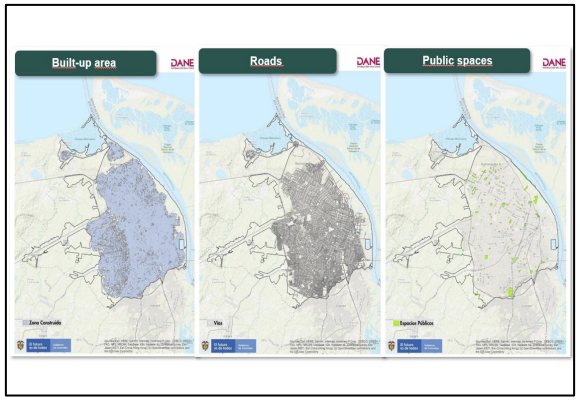
Introduction to Cities and the EO Toolkit for Sustainable Cities Human Settlements

Part 2: February 3, 2022



Applications of the EO Toolkit to Measure and Analyze Sustainable Development Goals

Part 3: February 10, 2022



Use Cases from the National and City Level


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!