→ EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Urban Development

City Academy: Geospatial Data Applications for Urban Development, Sao Paulo 16.-17.09.2019

Improving urban livelihoods: how can satellite data assist to reach this goal

Tomas Soukup, GISAT

urban development eo4sd

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Agenda and Speaker

Improving urban livelihoods: how can satellite data assist to reach this goal

Speaker

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Senior Remote Sensing
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Outline of the Presentation

- Why does it matter?
- Definitions: Urban Green Areas, Public Spaces
- Definitions of Open & Green Areas (OGA) as a proxy
- EO4SD-Urban Urban Greenery products at glance
- Methodology of EO-based OGA products for WBG UrbanScapes
- Examples of derived analytical products
- Quality and Utility

PUBLIC SPACES MATTER

- benefit our health
- help to build a sense of community, civic identity and culture
- have the ability to drive economic growth
- can transform wasted space and became part of NBS
- if utilized and designed well can give a city character and enhance its diversity, livability, inclusiveness, safety and overall city attractivity

Public Spaces

- Public urban spaces such as streets, open spaces, green areas, parks, and public buildings are a big part of cities that are still often overlooked
- Inadequate, poorly designed, or privatized public spaces often generate exclusion and marginalization and degrades the livability of the city
- Importance of green areas and open public spaces are now embedded within the Sustainable Development Goals (SDGs), particularly in Goal 11.7: "By 2030, provide universal access to safe, inclusive and accessible, green and public spaces"

Starting point

How far we can go remotely ?

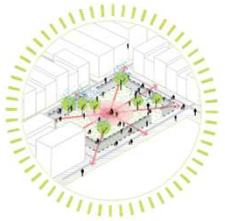
URBANSCAPES
INCLUSIVE, LIVABLE, URBAN SPACES AND PLACES

Service: Identification, quantification and characterization of potential public spaces (using EO)

Coherent with SDG 11.7 implementation (UN-HABITAT)

Urban Spaces:

- Open and Green Spaces
- Streets
- Building



Public (open / green) spaces definitions

- **UN-HABITAT (2015)**:

  - "**Public open space**" is defined as the sum of the areas of the built-up areas of cities devoted to **streets and boulevards** (including walkways, sidewalks, and bicycle lanes) and the areas devoted **to public parks, squares, recreational green areas, public playgrounds** and **open areas of public facilities**.

  - Not included: **areas devoted to public facilities**—e.g. schools, stadiums, hospitals, airports, waterworks, or military bases - that are not open to the general public. It also does not include open spaces that are in private ownership or vacant lands in private ownership

Public (open / green) spaces definitions

- For mapping of Urban Greenery in Europe (in frame of EU Copernicus Land Monitoring services) and in frame of EO4SD-Urban **Urban Atlas (2012)** nomenclature is used as de-facto standard for class specifications.
- It reflects interpretability of land use by means of remote sensing.

Public (open / green) spaces definitions

EU Urban Atlas (2012):

- **ARTIFICIAL NON-AGRICULTURAL VEGETATED AREAS**
  - Vegetation planted and regularly worked by humans; strongly human-influenced. Sporting facilities as functional units independent of being non-sealed, sealed or built-up.
  - **GREEN URBAN AREAS (1.4.1)**
    - Public green areas for **predominantly recreational use** such **as gardens, zoos, parks, castle parks and cemeteries**. Suburban natural areas that have become and are managed as urban parks (Forests or green areas extending from the surroundings into urban areas are mapped as green urban areas when at least two sides are bordered by urban areas and structures, and **traces of recreational use are visible**.)
    - *Not included:* Private gardens within housing areas, buildings within parks (such as museums, governmental areas), patches of natural vegetation or agricultural enclosed by built-up areas without being managed as green urban areas
  - **SPORTS AND LEISURE FACILITIES (1.4.2)**
    - All **sports and leisure facilities** including associated land, ***whether public or commercially managed***, public arenas for any kind of sports including associated green areas, parking places, etc.

Public (open / green) spaces from EO

Missing peaces in **Urban Atlas** with respect to UN-HABITAT definitions

- Urban Atlas does not include living streets, open spaces, squares
- Term 'public' is applied and required in less strict meaning

- Main caveats of application of remote sensing for OGA mapping:
  - Actual ground-use can be different from remote image interpretation
  - Public use / accessibility of the space cannot be interpreted (just guessed)
  - Polygons delineated by remote sensing shall be understood as *potential / candidate* spaces that need to be confirmed by ground truthing
  - Main function of the multi-use space can be difficult to determine
  - Classification rule-sets and signatures might need to be adapted across different cities

Public (open / green) spaces from EO
Monitoring and interventions

- The importance of open and green spaces is embedded within the SDG Goal‘s 11 Target **11.7**: *aiming at making green and public spaces accessible, safe and inclusive*

- Global/regional scale
  - **SDG Indicator 11.7.1**
    - **Average share of the built-up areas of cities in open space in public ownership and use.**
  - **Additional city indicators** (e.g. WB‘s **Global City Indicators**) and **diagnostics**
    - **Green areas per 100,000 inhabitants, Citizens access to nearby green areas, …**

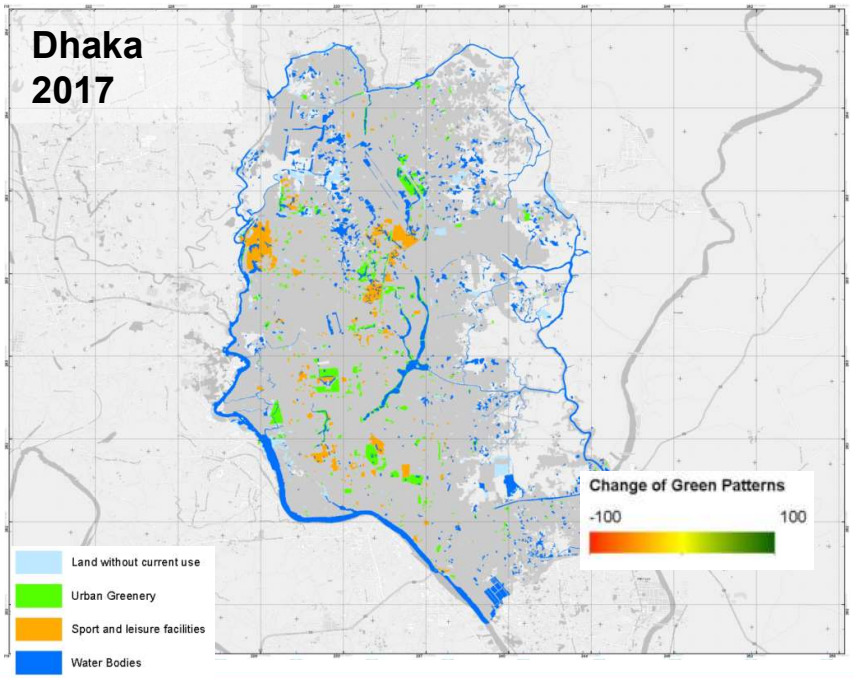
City-wide scale improving city liveability

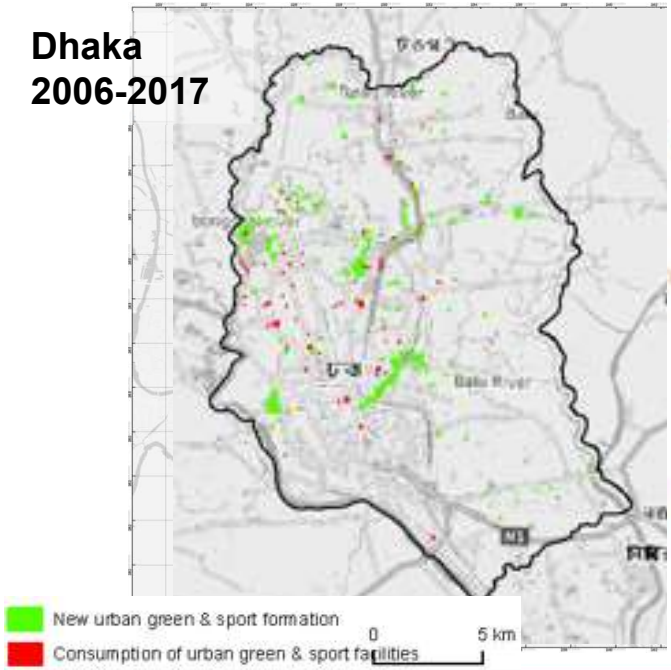
- Inadequate existent local inventories about locations and characteristics
- Prioritization of interventions
- Scaling up from pilot study to the city-wide level

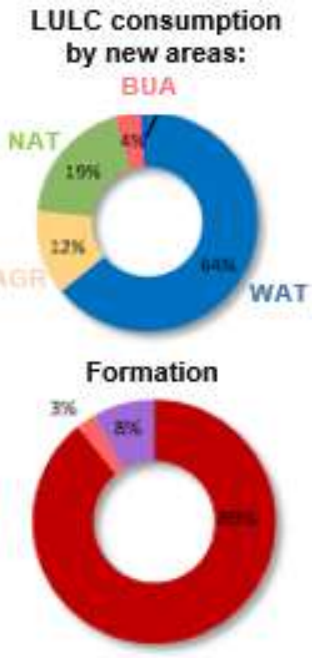
Artificial green areas extent and change
EO4SD-Urban standard product

Distribution of Green Areas
- Derived directly from LULC product
- Basic nomenclature based on Urban Atlas (classes 1.4.1, 1.4.2)

Distribution + structure of changes
- Green extension / uptake
- Gross / Net increase / decrease
- Structure of consumption and formation







Collaboration Steps

GISAT/WBG UrbanScapes collaboration on potential public space consists of

Step I. Identifying public spaces

- **Definition of scope**
- **6 criteria rule-based classification based on standard EO4SD Urban portfolio products**
- **Methodology, GIS layers**

Step II. Spatial analysis on public space network

- **Various indicator analyses at block, neighborhood and city levels**
- **Maps, Graphics and Stats**

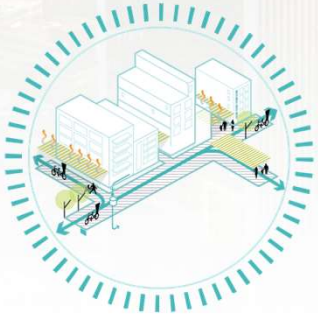
Step III. Quality & Reality check

- **Cross check with other satellite imagery**
- **Ground truthing and local surveys**
- **Quality and Utility Check, Analytics,**
- **Report and Roll-out**

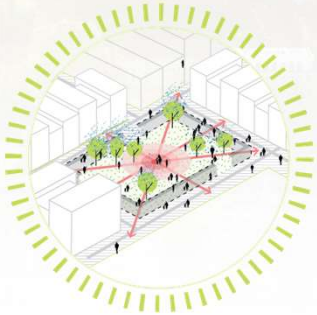
Step I: Setting the scope

- **Publicness:**
  - This project aims to identify **potential public urban spaces** that might contribute to enhancing livability and quality of life across a city
- **3 elements *of Public Spaces*:**
  - Open and Green spaces
  - Streets
  - Building

ACTIVE BUILDINGS



COMFORTABLE STREETS



NATURAL OPEN SPACES

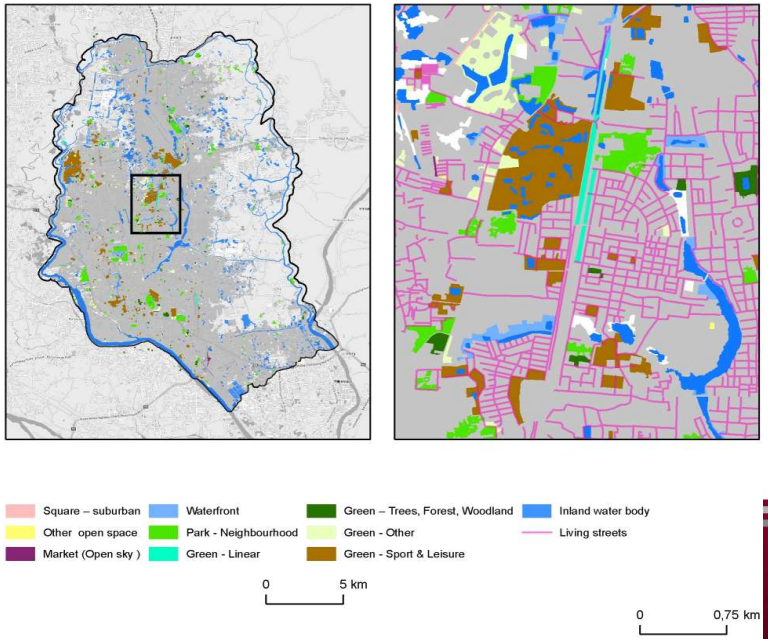
Step I: Methodology
Indentification of seed OGA elements

- **Identification of potential GOA**
  - Seed areas from standard LULC products
  - Object-based image segmentation and analysis
  - Machine Learning components

VHR EO imagery (HR EO imagery)

  - Open data mining (transport network -> street network, POIs & labels)

OSM



Step I: Methodology
OGA Characteristics

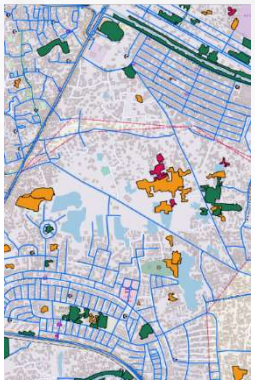
- For each *candidate* OGA object (polygon) several indicators are derived by OBIA and GIS
- Indicators build for 6 base OGA criteria

to classify public spaces

Indicator group	*Indicator*
Distance and accessibility	Distance to roads, ammenities
	Distance to water
Patterns	Shape linearity, size, compactness
	Vegetation typology (high,low, bare)
	Park probability indicator
	LULC patterns and proportions
Contextual	Built-up proportions and adjacency
	LULC adjacency

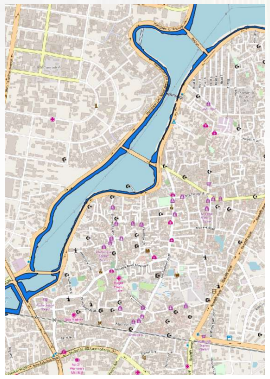
Characteristics

C1. Distance to nearest Road?



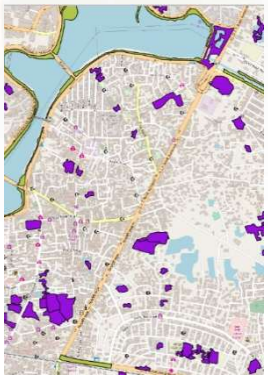
Very accessible (<10m)
Accessible (<100m)
Inaccessible (>100m)

C2. Adjacent to Water



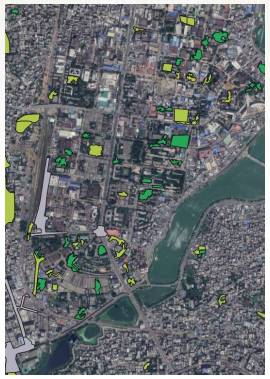
Waterfront

C3. Compactness: Linear or not



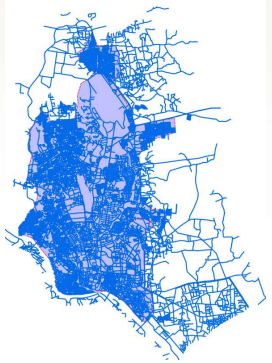
Linear
General

C4. Patterns



High vegetation
High built up and open
Horticultural management

C5. Location (Urban Mask)



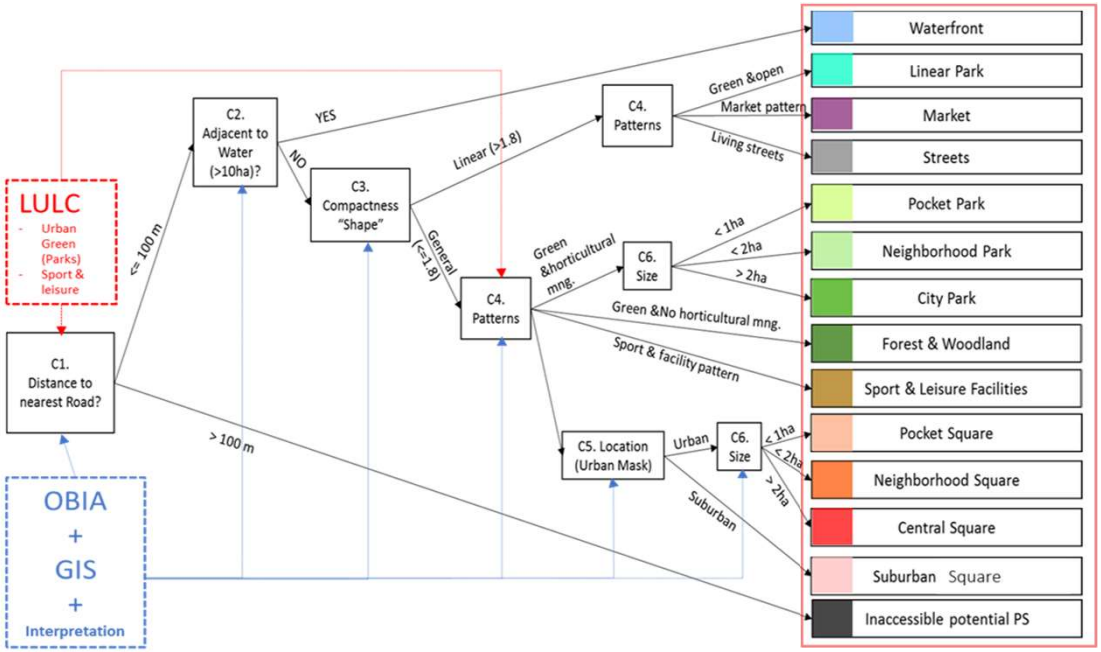
Urban **Vs suburban**

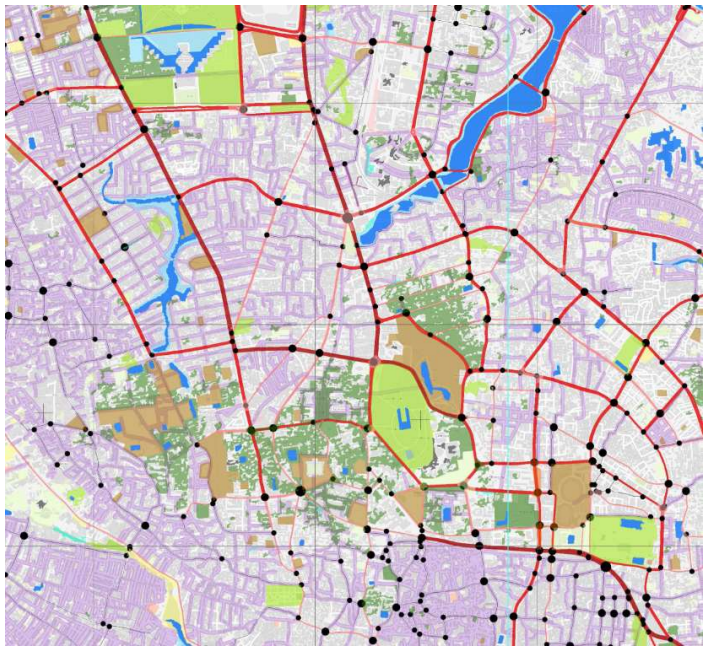
C6. Size

Pocket(1ha)
Neighborhood(<2ha)
City

Rule-based OGA typology

In order to better understand multi-faceted characteristics of public spaces, a rule-based typology has been developed and applied in case cities





* Additional "public" building stocks based on OSM and local knowledge introduced. Full list includes cinema, college, courthouse, department_store, hospital, library, memorial, monument, museum, park, picnic_site, playground, post_office, public_building, school, sports_centre, stadium, supermarket, swimming_pool, theatre, university, viewpoint, zoo, station, bus stop

Step II: City-wide Assessment
Testing Analytics

Spatial Analysis describing public space network

Availability: share of public spaces out of a unit area

Accessibility: distance from a public space to nearest roads

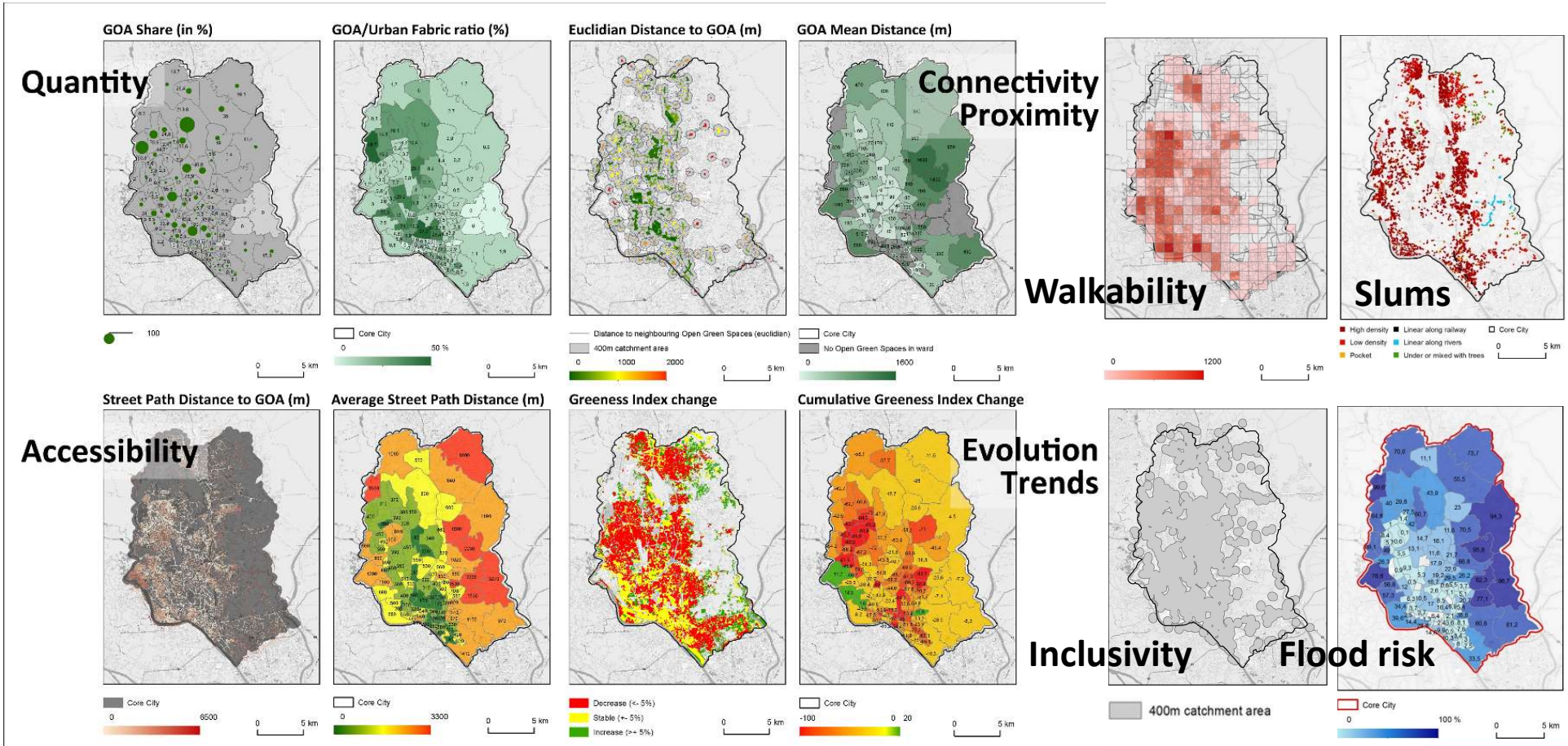
Connectivity: distance from a public space to neighboring public spaces

Inclusivity: share of population living within 400m catchment area

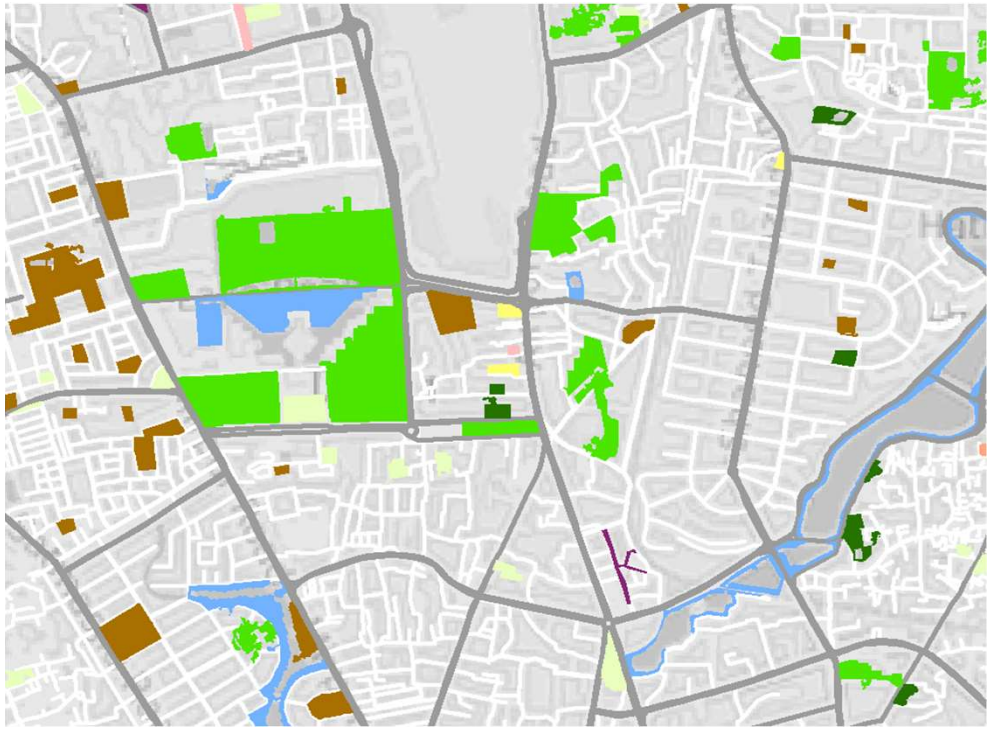
..and more

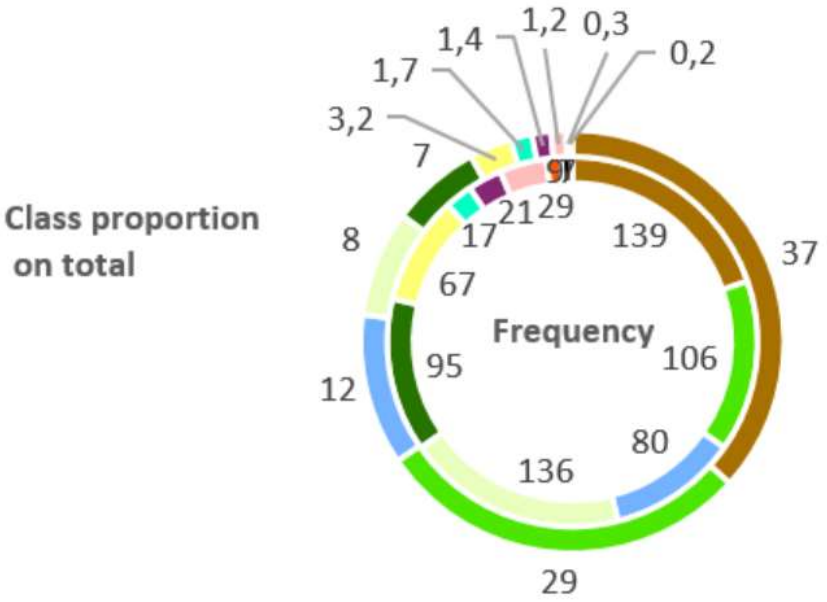
Step II: City-wide Assessment
Testing Analytics

Spatial Analysis describing public space network



Step II: City-wide Assessment
Testing Analytics – Types proportions



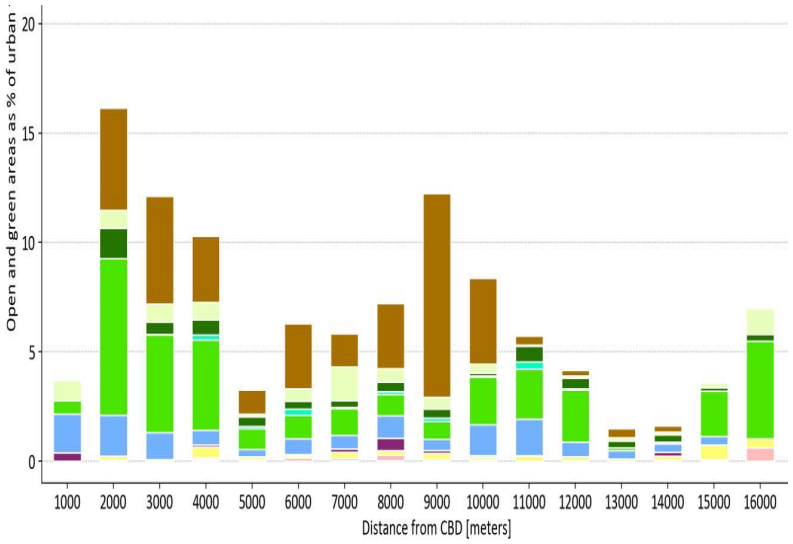


- Square- Neighbourhood
- Square - Pocket
- Square - suburban
- Other open space
- Market (Open Sky)
- Waterfront
- Park - Neighbourhood
- Park - Pocket
- Green - Linear
- Green - Trees, Forest, Woodland
- Green - Other
- Cemetery
- Green - Sport & Leisure
- Inaccessible potential PS

Step II: City-wide Assessment
Testing Analytics: Distribution - Diversity

OGA typology profiles

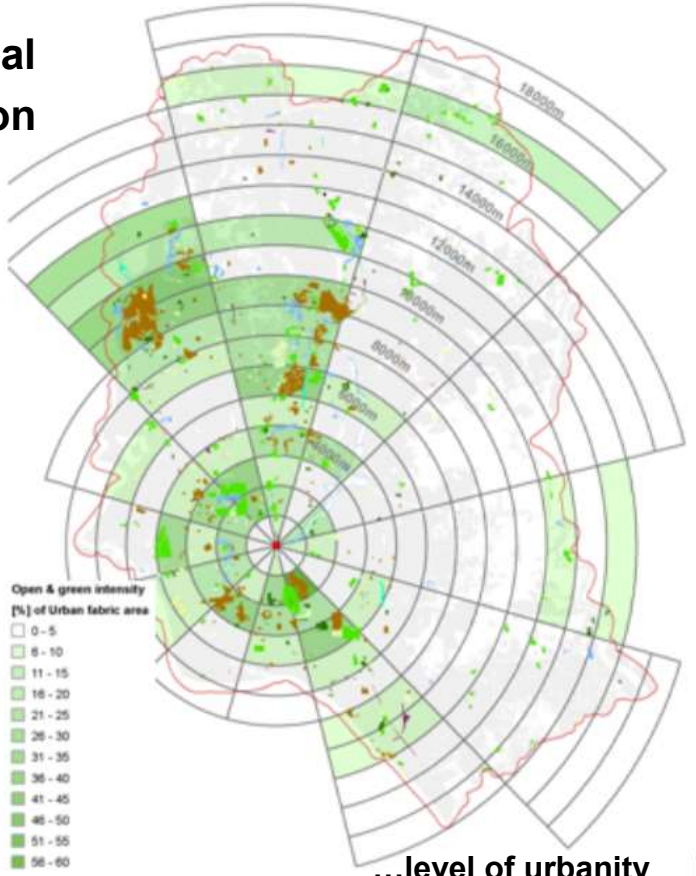
…OGA share (%) on urban fabric

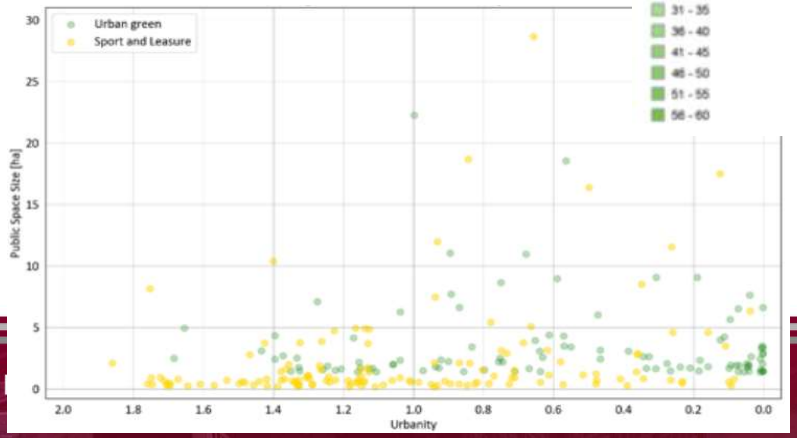


…distance to CBD (m) by 1000

- Square- Neighbourhood
- Square - Pocket
- Square - suburban
- Other open space
- Market (Open Sky)
- Waterfront
- Park - Neighbourhood
- Park - Pocket
- Green - Linear
- Green - Trees, Forest, Woodland
- Green - Other
- Cemetery
- Green - Sport & Leisure
- Inaccessible potential PS

…directional distribution



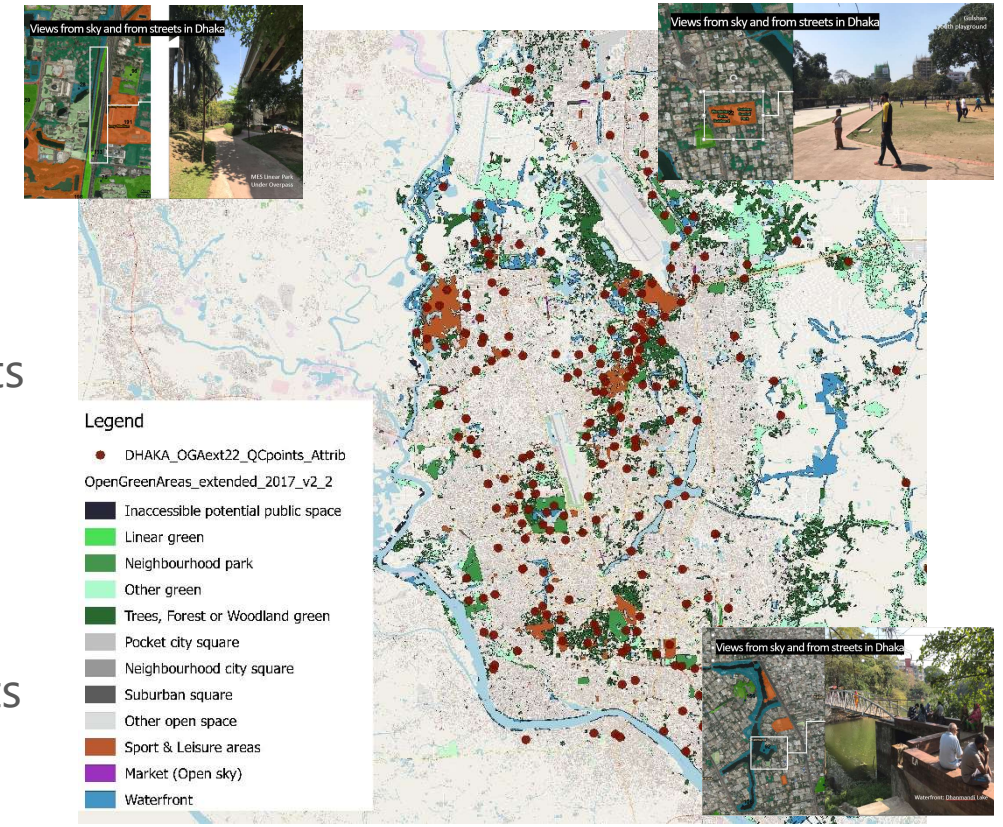


…level of urbanity

Step III: Reality Check
Validation

Reality Check

- Total 224 points have been randomly selected for ground-truthing
- WBG Dhaka Task team visited 50 points in Feb, 2019, local university scale this up to all 244 points.
- In result, the accuracy rate was satisfiable at 85%.
- The main reason of the inaccurate parts was hidden figures (e.g. squatters, markets) under high vegetations in Dhaka

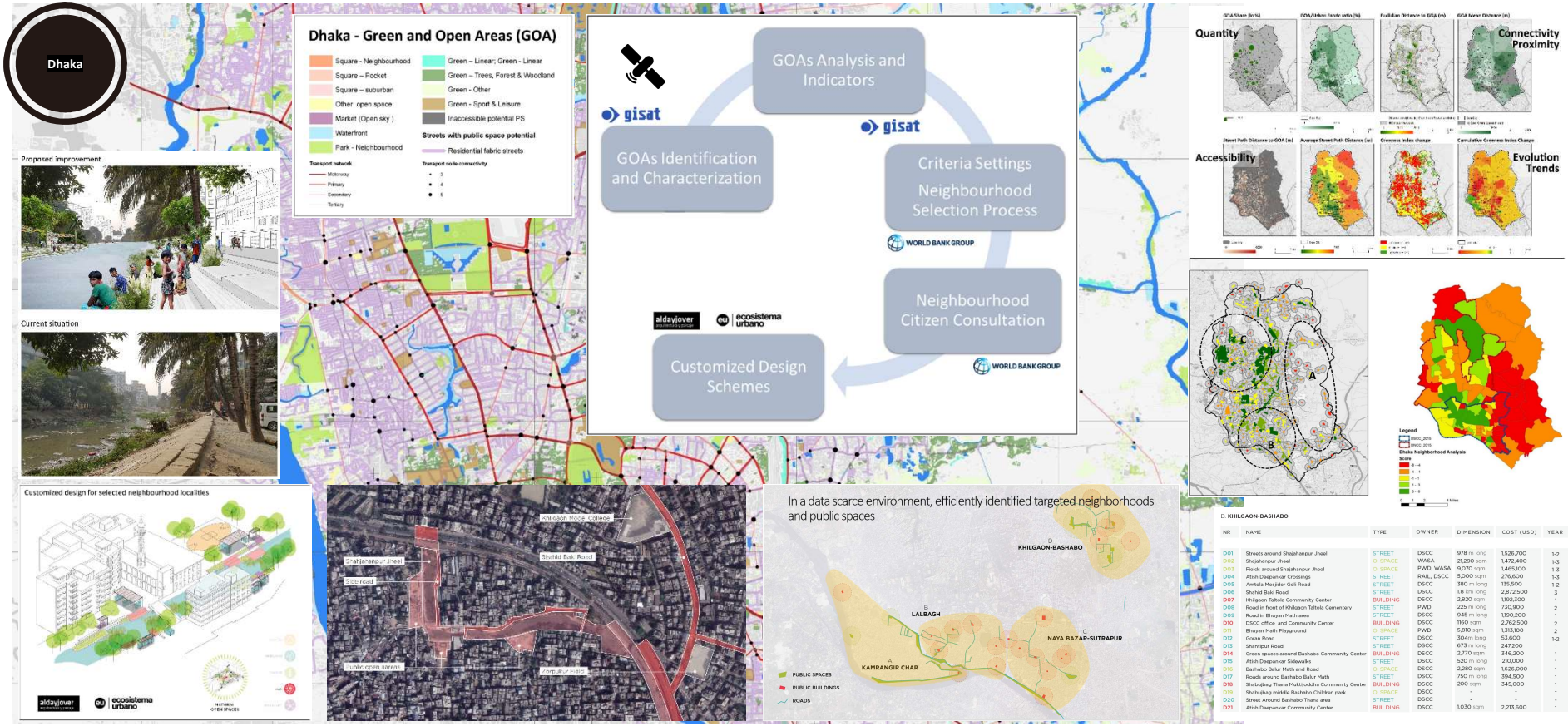


Dhaka city neighborhood upgrading project (DCNUP)

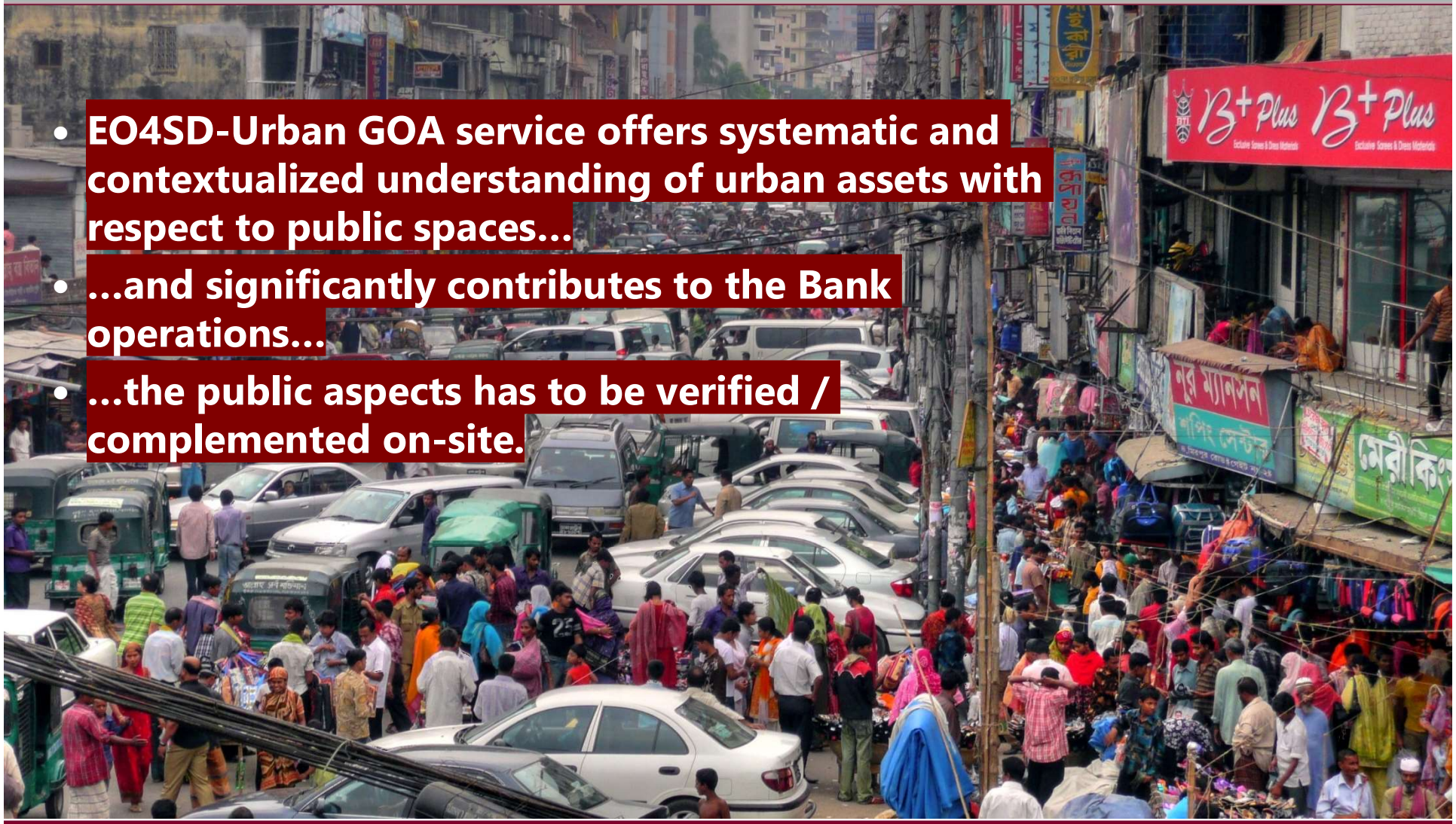
- Seeks to enhance public space and improve urban services in selected neighborhoods in Dhaka
- Bank Loan of $100 million, prepared in less than a year
- Focused on public rights of way; green/open spaces; public buildings, facilities and amenities owned by the city government
- Leverage on neighborhoods communities: discrete, bounded, built up area in Dhaka City covering an area of ~2 sqkm

Step III: Operation
Utility testing

EO as part of the Full Planning Cycle



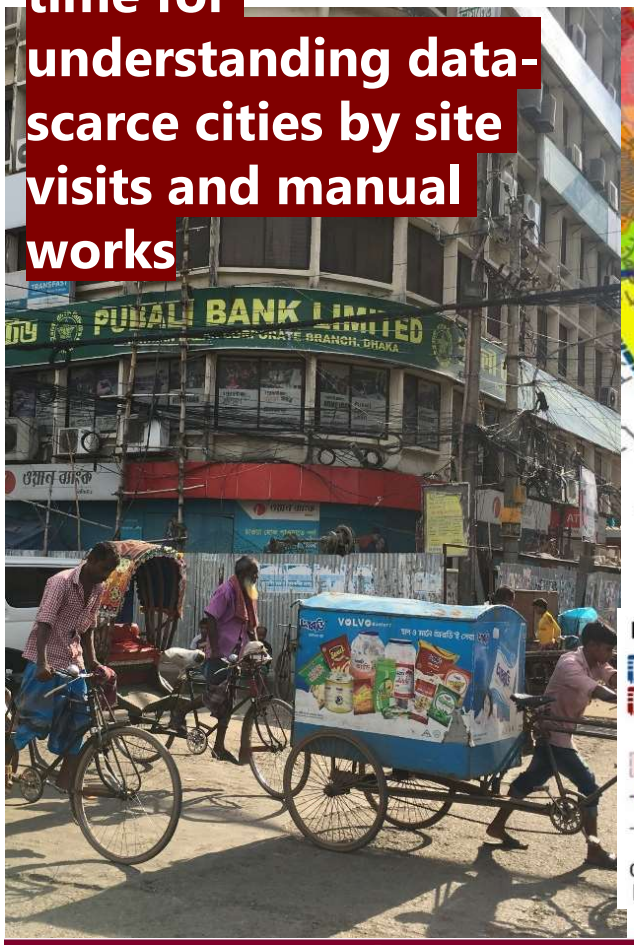
Step III: Operation
Positive Feedback



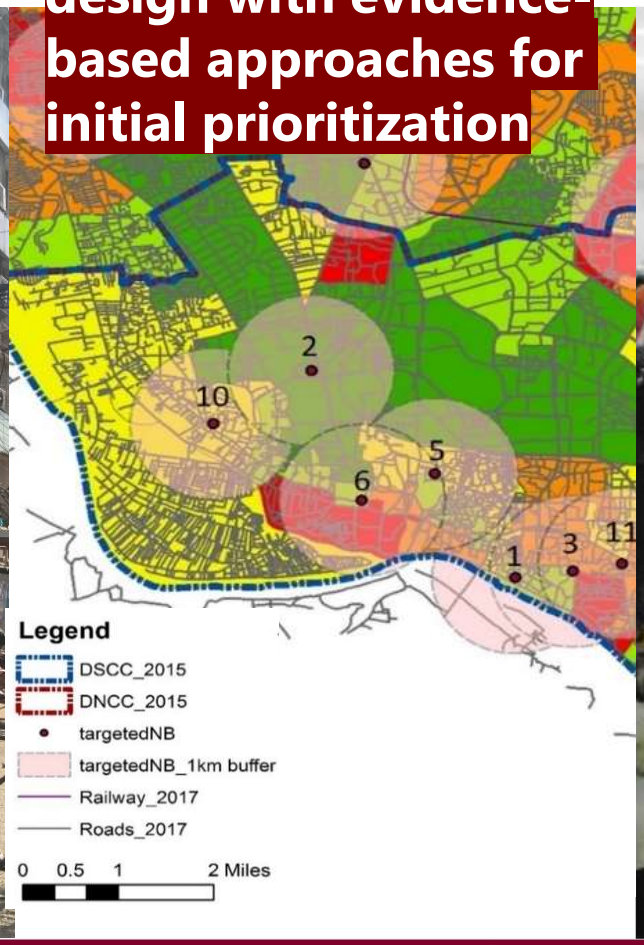
- **EO4SD-Urban GOA service offers systematic and contextualized understanding of urban assets with respect to public spaces…**
- **…and significantly contributes to the Bank operations…**
- **…the public aspects has to be verified / complemented on-site.**

Step III: Operation
Positive Feedback

❶ Reduced costs and time for understanding data-scarce cities by site visits and manual works



❷ Improved project design with evidence-based approaches for initial prioritization

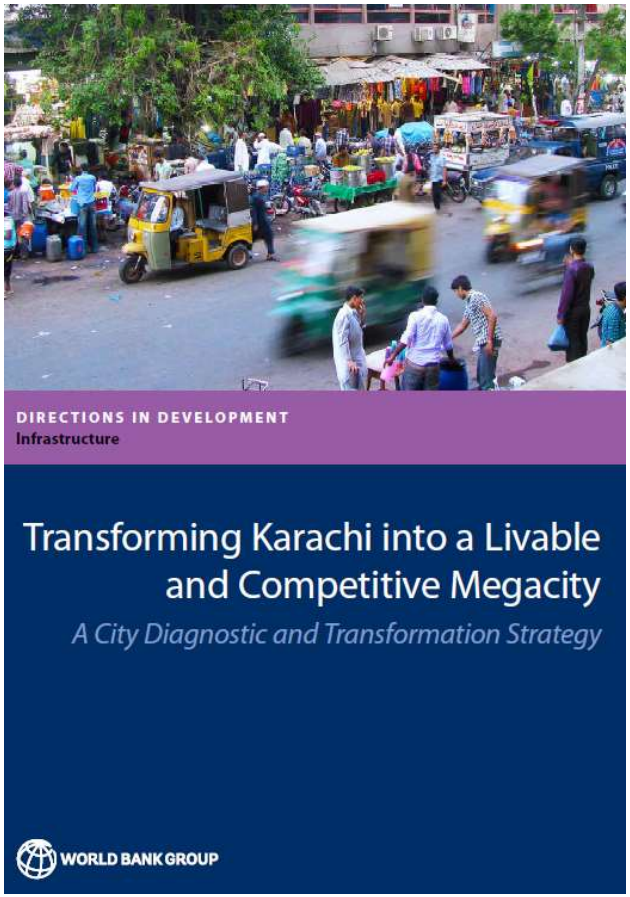


❸ Better communication with local partners

Step III: Operation
Positive Feedback

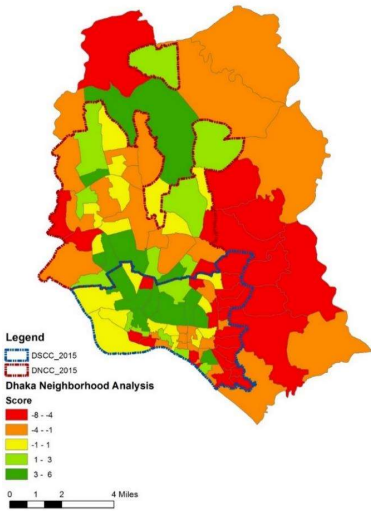
❶ Reduced costs and time for the preparations

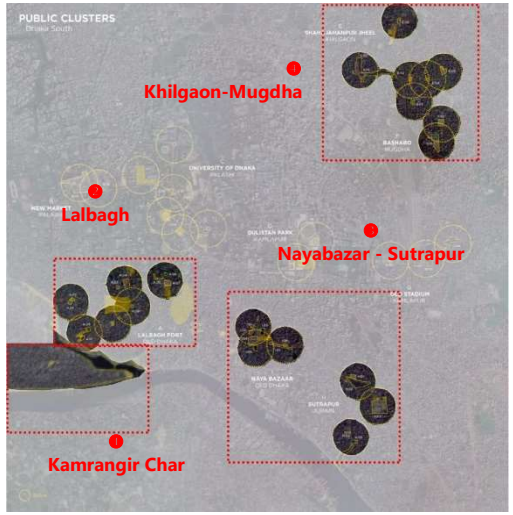
- TA: Transforming Karachi into a Livable and Competitive Megacity: *A City Diagnostic and Transformation Strategy* *(KCD)*
- KCD is the first phase of a long-term city transformation strategy
  - benefiting from remote sensing and spatial analysis, and contributed to improving efficiency of the preparations of KNIP



Step III: Operation
Positive Feedback

❷ Improved project design with evidence-based approaches





Neighborhood Information			Raw data				Score card (Above/Below Average)			
#	Name	Key landmark	# of road junctions/sqkm	# of public facilities in NB	sqm of open green space per	% of slum of total area	Well-connected road network	Accessibility to public facilities	open green space	Slum domination
1	Kotwali	Ahsan Manzil	267.99	2.00	0.43	2.76	Below	Above	Below	Below
2	Philkana	New Market	291.69	6.00	4.13	0.00	Below	Above	Above	Below
3	Sadarghat	Bahadur Shah Park	267.99	2.00	0.43	2.76	Below	Above	Below	Below
4	Jurain	Jurain Rail Station	149.38	0.00	0.62	23.75	Below	Below	Below	Above
5	Bangshal	Old Central Jail	2294.98	1.00	0.05	2.59	Above	Above	Below	Below
6	Lalbagh	Fort Museum	299.80	1.00	0.00	46.05	Below	Above	Below	Above
7	Malibagh	Shahid Baki Road	170.42	0.00	0.21	5.36	Below	Below	Below	Below
8	Farmgate		152.71	8.00	5.74	1.10	Below	Above	Above	Below
9	Mohammadpur	Sahkhertek Road	208.21	0.00	0.09	22.01	Below	Below	Below	Above
10	Hazaribag		416.46	1.00	1.62	14.93	Above	Above	Below	Above
11	Luxmibazar	Truck Stand	156.53	0.00	2.90	7.05	Below	Below	Above	Below
Dhaka Average			326.13	1.45	2.52	8.53				

- Based on the results of the EO4SD-U analytics, the task teams created a neighborhood selection criteria to address spatial and political inclusion
  - Measure Demonstration & Deprivation factors across Dhaka:
  - Proxy indicators: Road connectivity, Open green space, Slum proximity, Public amenity concentration
  - Wards according to deprivations
    - Red = more deprived
    - Green = less deprived

Step III: Operation
Positive Feedback

❷ Improved project design with evidence-based approaches

In a data scarce environment, efficiently identified targeted neighborhoods and public spaces

DCNUP Potential Neighborhoods

Step III: Operation
Positive Feedback

❷ Improved project design with evidence-based approaches

- **Reflecting local needs identified from the analytics to Concept Designs for neighborhoods**

Step III: Operation
Positive Feedback

❸ Better communication with local partners

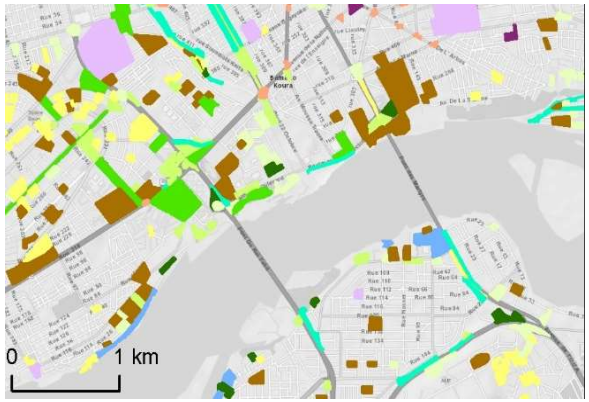
- Initial prioritization combined with local knowledge, developing a comprehensive inventory of public urban
- assets and plan for improvement activities

NR	NAME	TYPE	OWNER	DIMENSION	COST (USD)	YEAR
D01	Streets around Shajahanpur Jheel	STREET	DSCC	978 m long	1,526,700	1-2
D02	Shajahanpur Jheel	O. SPACE	WASA	21,290 sqm	1,472,400	1-3
D03	Fields around Shajahanpur Jheel	O. SPACE	PWD, WASA	9,070 sqm	1,465,100	1-3
D04	Atish Deepankar Crossings	STREET	RAIL, DSCC	5,000 sqm	276,600	1-3
D05	Amtola Mosjider Goli Road	STREET	DSCC	380 m long	135,500	1-2
D06	Shahid Baki Road	STREET	DSCC	1.8 km long	2,872,500	3
D07	Khilgaon Taltola Community Center	BUILDING	DSCC	2,820 sqm	1,192,300	1
D08	Road in front of Khilgaon Taltola Cementery	STREET	PWD	225 m long	730,900	2
D09	Road in Bhuyan Math area	STREET	DSCC	945 m long	1,190,200	1
D10	DSCC office and Community Center	BUILDING	DSCC	1160 sqm	2,762,500	2
D11	Bhuyan Math Playground	O. SPACE	PWD	5,810 sqm	1,313,100	2
D12	Goran Road	STREET	DSCC	304m long	53,600	1-2
D13	Shantipur Road	STREET	DSCC	673 m long	247,200	1
D14	Green spaces around Bashabo Community Center	BUILDING	DSCC	2,770 sqm	346,200	1
D15	Atish Deepankar Sidewalks	STREET	DSCC	520 m long	210,000	1
D16	Bashabo Balur Math and Road	O. SPACE	DSCC	2,280 sqm	1,626,000	1
D17	Roads around Bashabo Balur Math	STREET	DSCC	750 m long	394,500	1
D18	Shabujbag Thana Muktijoddha Community Center	BUILDING	DSCC	200 sqm	345,000	1
D19	Shabujbag middle Bashabo Children park	O. SPACE	DSCC	-	-	-
D20	Street Around Bashabo Thana area	STREET	DSCC	-	-	-
D21	Atish Deepankar Community Center	BUILDING	DSCC	1,030 sqm	2,213,600	1

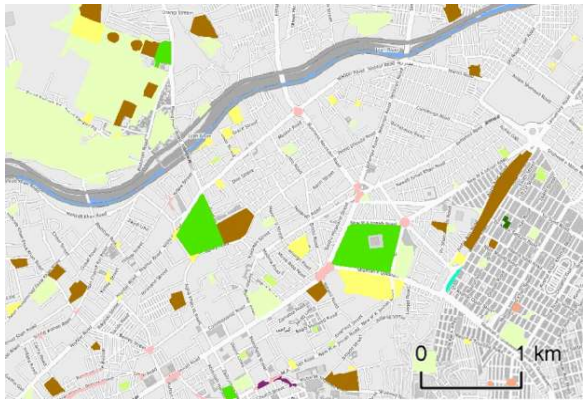
Global Analysis

Global Analysis
Roll-out to additional cities

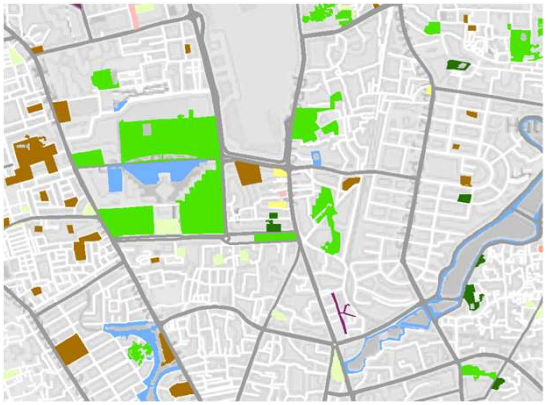
Bamako 2018



Karachi 2015



Dhaka 2017



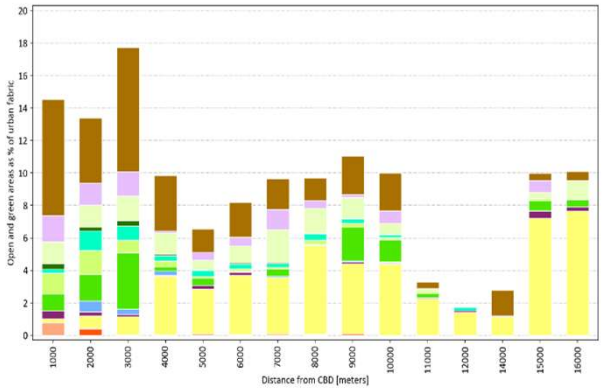
Fallujah 2017

Ramadi 2017

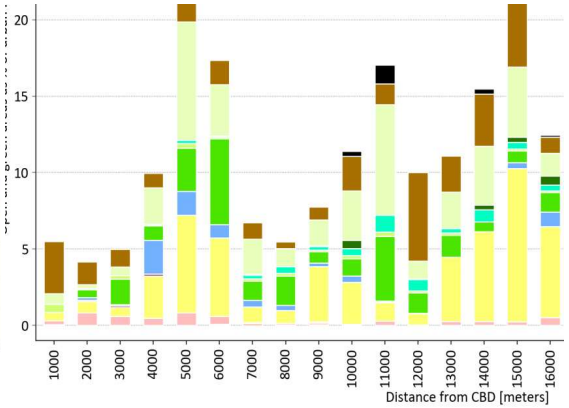
Lima 2018

Global Analysis
Roll-out to additional cities

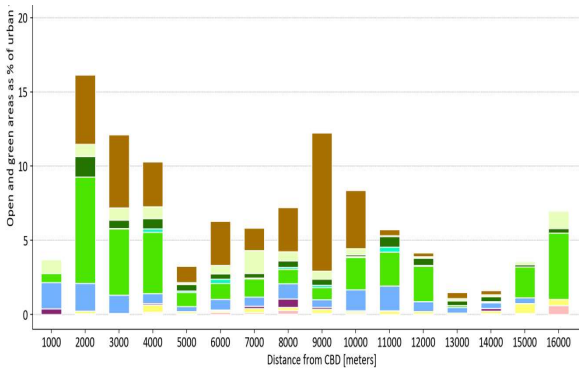
Bamako 2018



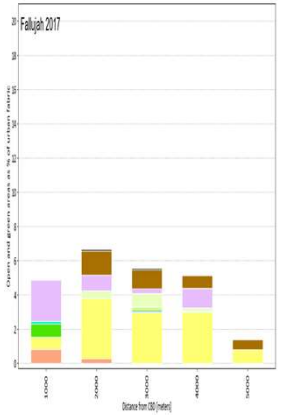
Karachi 2015



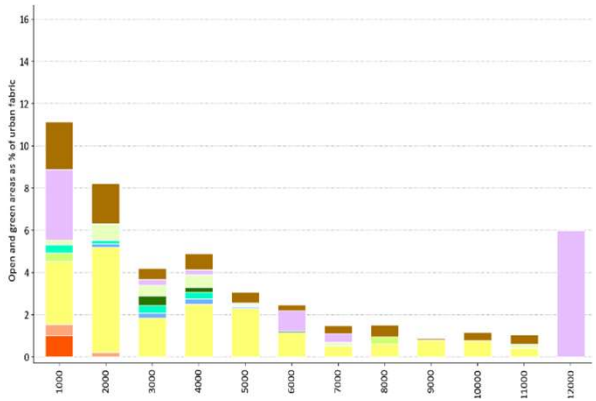
Dhaka 2017



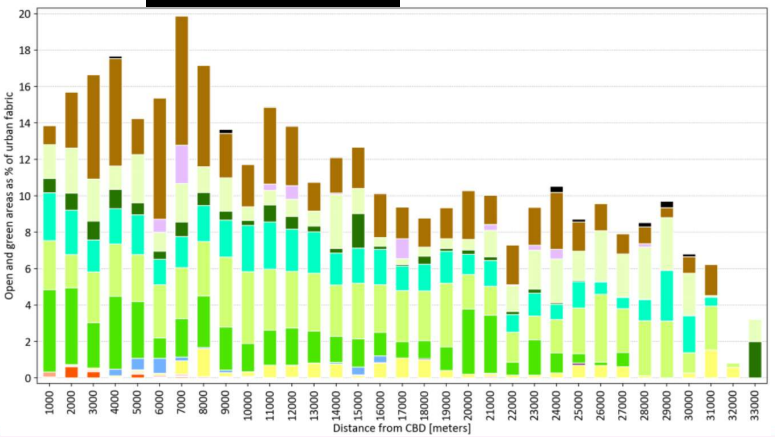
Fallujah 2017



Ramadi 2017



Lima 2018



Global Analysis
Roll-out to additional cities

Bamako 2018

Karachi 2015

Dhaka 2017

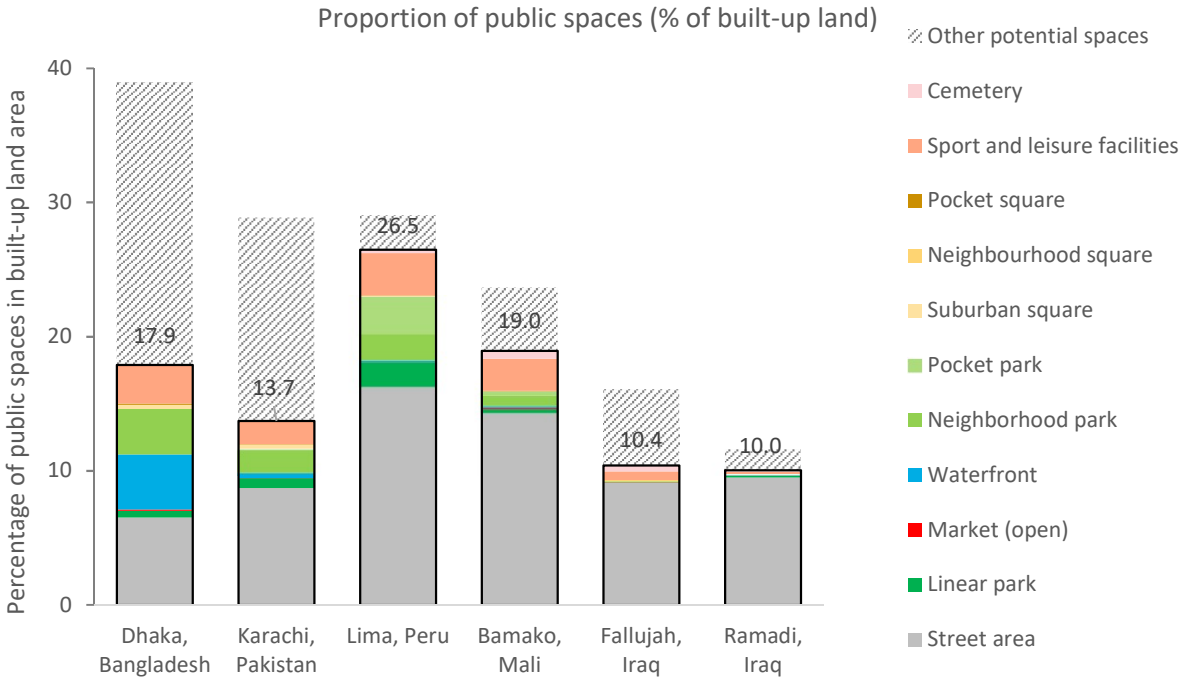
Fallujah 2017

Ramadi 2017

» **Lima 2018**

Accessibility to *potential* public spaces [average (Euclidean) distance from road]

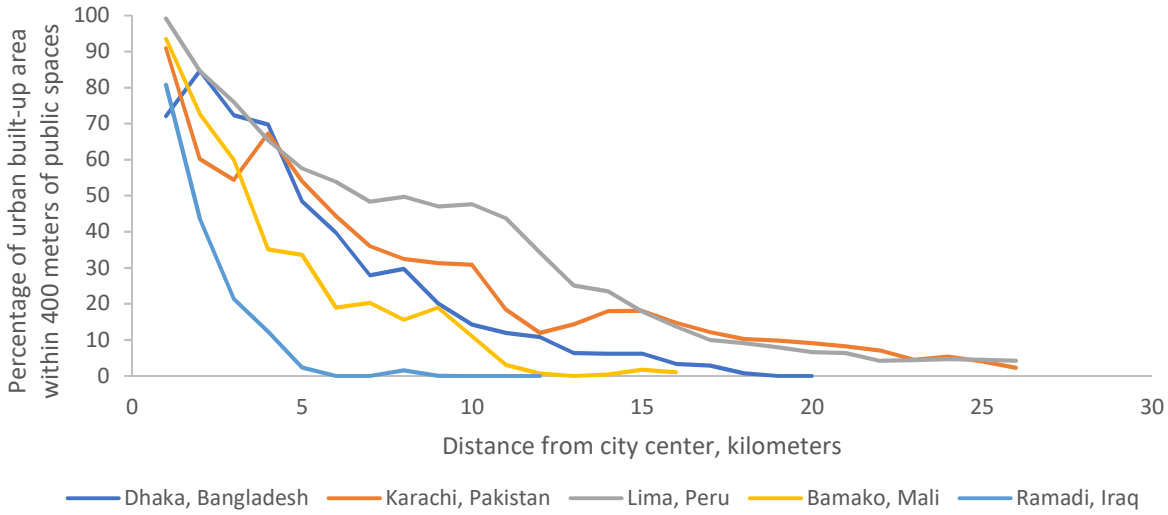
Global Analysis
Roll-out to additional cities



Source: World Bank, based on EO4SD-Urban data http://www.eo4sd-urban.info/.
Note: "Other potential spaces" include vacant areas, residual green areas, forest and dense trees, and inaccessible areas. This list of public-space types is not exhaustive. For detailed definitions of each category, see appendix B. EO4SD = Earth Observation for Sustainable Development, a joint project between the World Bank and the European Space Agency.

Global Analysis
Roll-out to additional cities

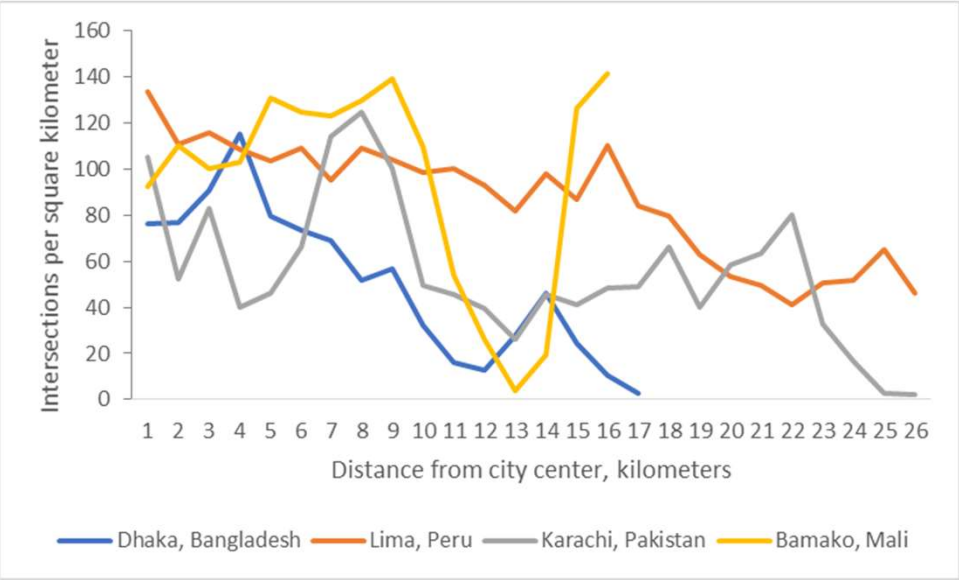
Inclusivity



Source: World Bank, based on 2019 EO4SD-Urban data) http://www.eo4sd-urban.info/.
Note: "Near" refers to a distance of 400 meters or less. The definition and locations of city centers are explained in each case study later this chapter; and the public spaces included in this analysis are parks, waterfronts, squares, and markets, excluding streets. EO4SD = Earth Observation for Sustainable Development, a project of the European Space Agency. Due to data availability, Lima and Bamako refers to data in 2018

Global Analysis
Roll-out to additional cities

Walkability



- **100 intersections per km² as a reference of an ideally walkable and prosperous city (UN-Habitat)**

	Intersections (total in AOI)	Intersections (per km² in urban artifical area)	Road length (total km in AOI)	Road length (km per km² in urban artifical area)
Dhaka	14 857	69	2 718	13
Karachi	20 277	72	3 743	13
Ramadi	5 522	74	1 357	18
Fallujah	4 403	122	768	21
Bamako*	*30 420*	*170*	*4 251*	*24*
Lima*	*26 811*	*154*	*4 197*	*24*

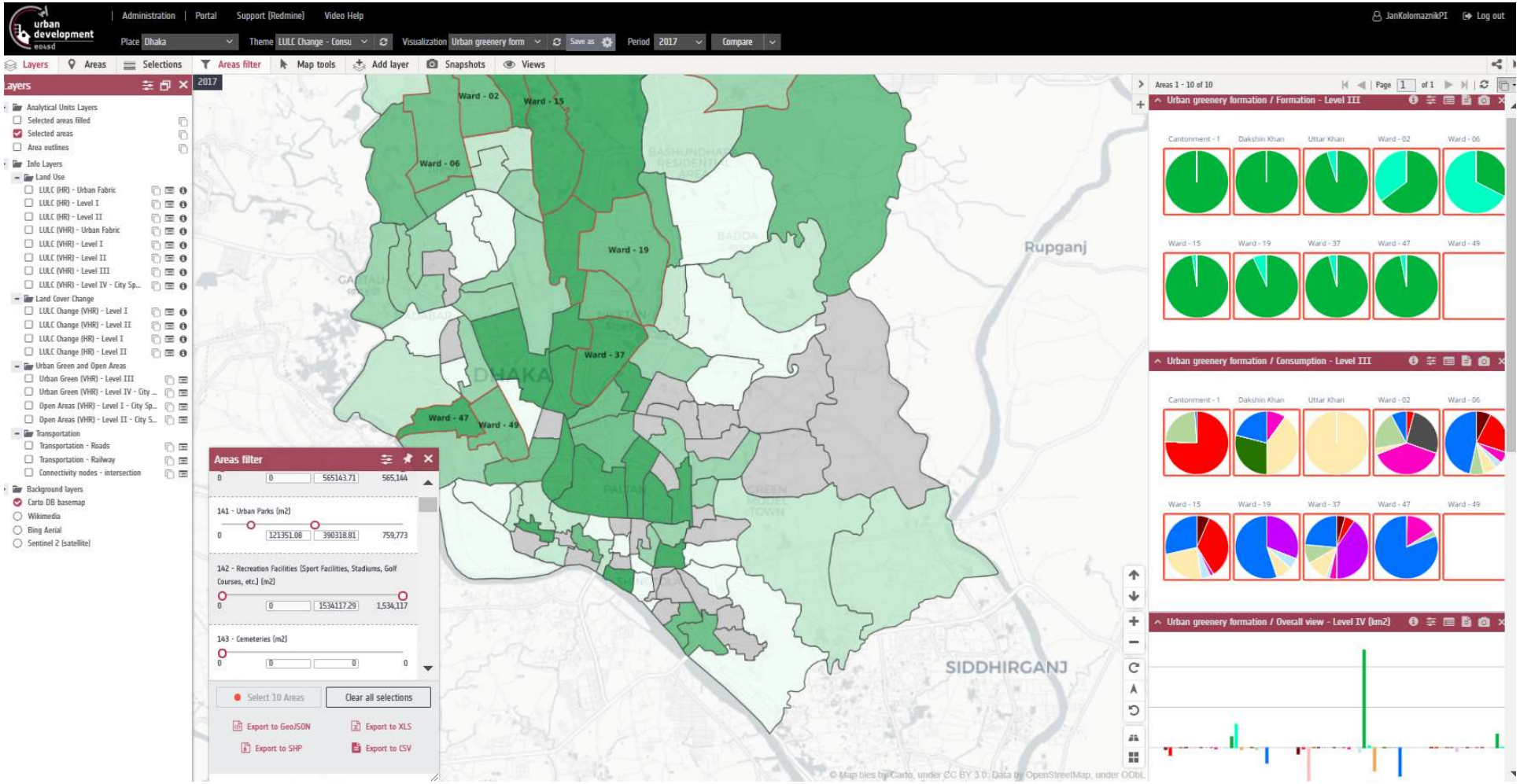
** part of the city*

based on Open Street Map (© Contributors OpenStreetMap)

Source: World Bank, based on 2019 EO4SD-Urban data, http://www.eo4sd-urban.info/.

Note: The total area is defined by administrative boundaries of the cities. EO4SD = Earth Observation for Sustainable Development, a project of the European Space Agency

UTEP Implementation + Publication
Selected results shared



Thank you for your attention!

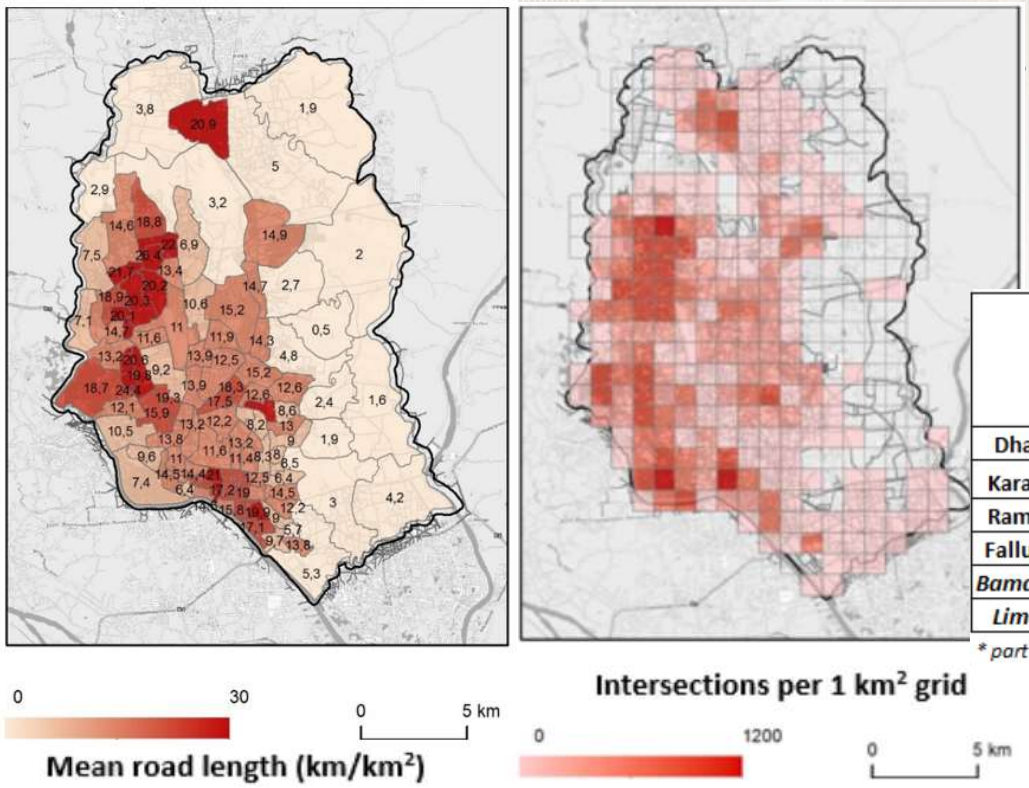
Backup slides

Transport network patterns

- **Transport network density (Dhaka)**

from analysis and augmentation of OpenStreetMap layers

Dhaka 2017



Transport network across cities

100 intersections per km² as a reference of an ideally walkable and prosperous city (UN-Habitat)

	Intersections (total in AOI)	Intersections (per km² in urban artifical area)	Road length (total km in AOI)	Road length (km per km² in urban artifical area)
Dhaka	14 857	69	2 718	13
Karachi	20 277	72	3 743	13
Ramadi	5 522	74	1 357	18
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*Bamako**	*30 420*	*170*	*4 251*	*24*
*Lima**	*26 811*	*154*	*4 197*	*24*

** part of the city*

based on Open Street Map (© Contributors OpenStreetMap)

Land use status and growth patterns

from VHR imagery

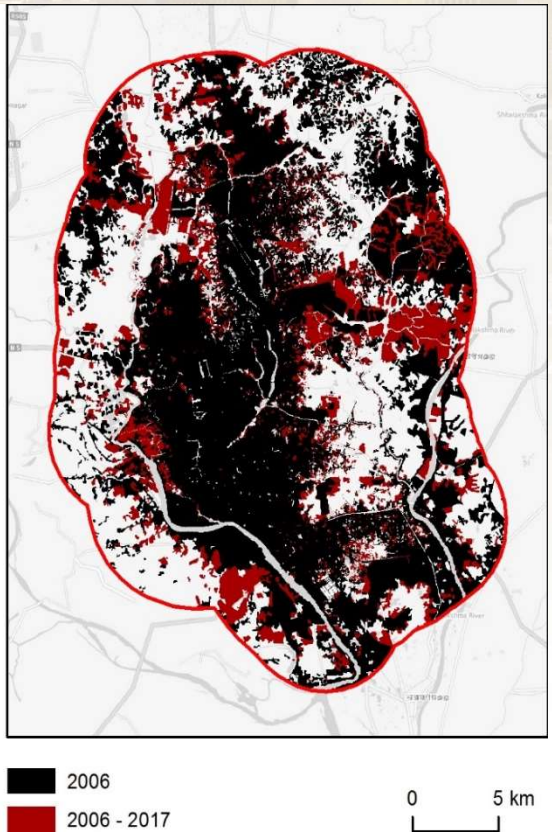
Dhaka 2006-2017

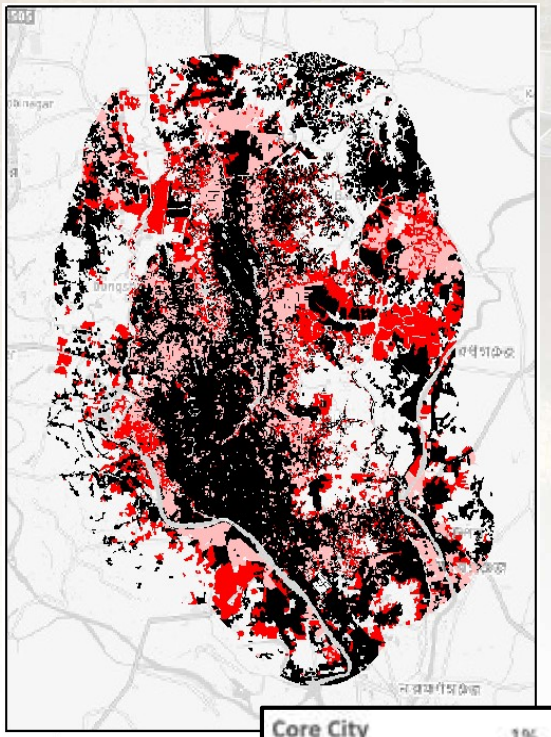
Urban extent growth (land consumption)

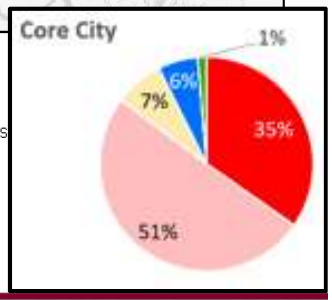
23.6% increase of urban form extent

1.9% avg. annual growth rate

Densification (infilling, vertical growth)







Land use status and growth patterns

Dhaka 2006-2017

Urban extent growth (land consumption)

- **23.6%** increase of urban form extent
- **1.9%** avg. annual growth rate

Densification (infilling, vertical growth)

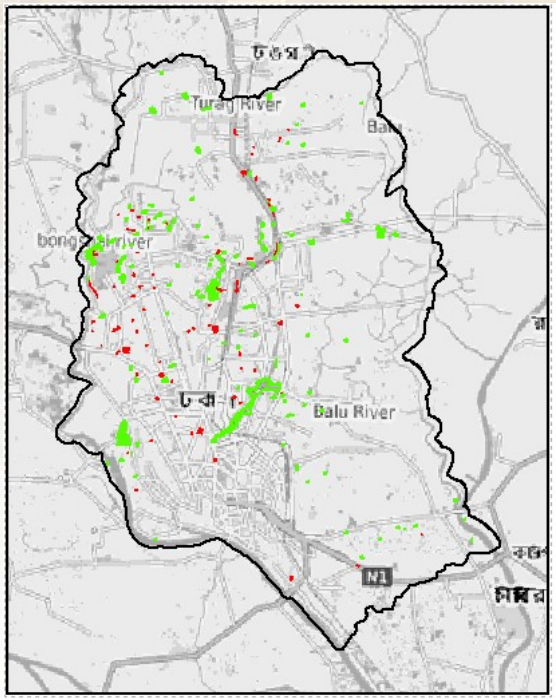
Green areas , sport & leisure fac.
(LULC – according to UA2012)

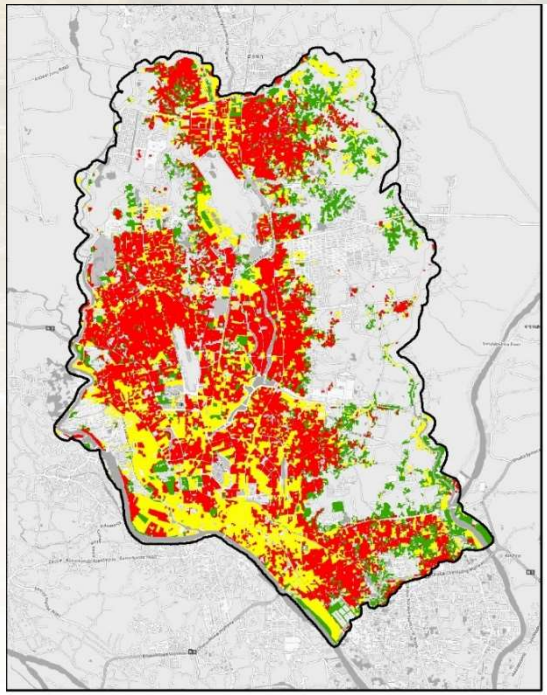
- Number: **462** → **484 (+4.8%)**
- Extent: **12 .5** → **13.6 km²** **(+9.2%, 0.8% avg. annual growth rate)**
- **Gross/Net change (balance):**

+ 1.8 km²

- 0.66 km²

from VHR imagery



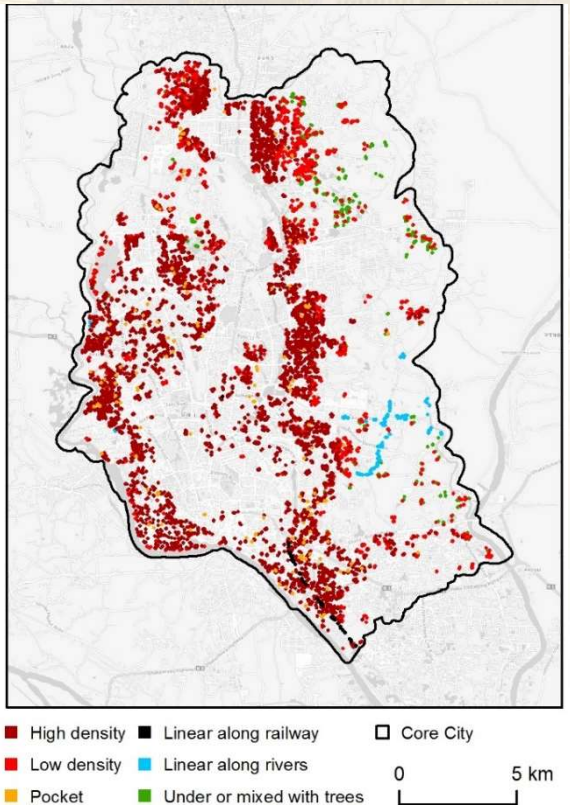


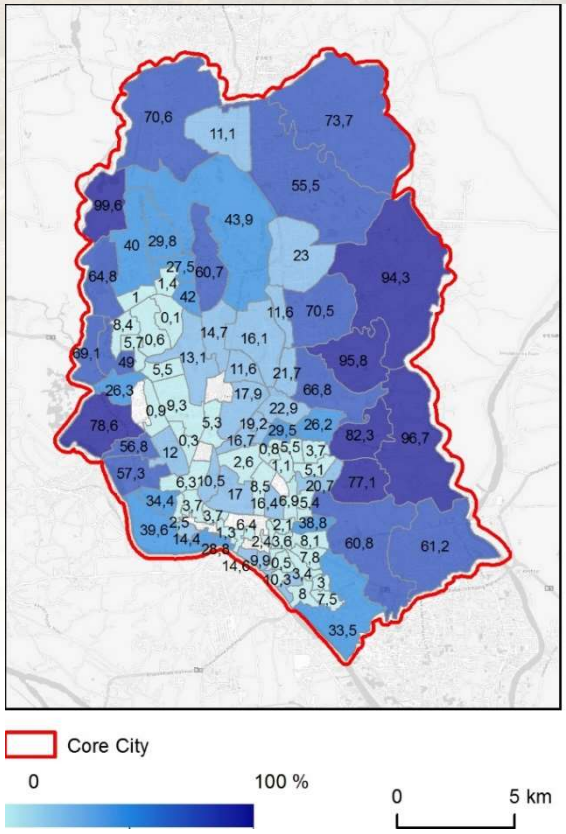
Decrease of **share of "greenness" in urban fabric blocks**:

- **Increase in 21% blocks**
- **Decrease in 48% blocks**

Informal settlements and distribution of flood vulnerability

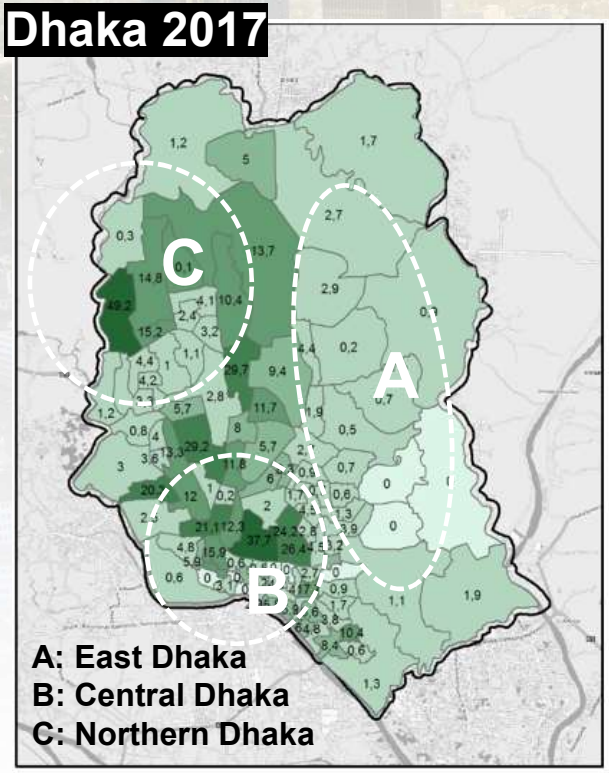
- **1650 informal settlement patches detected**
  - Distinct pattern of spatial distribution
  - Various characteristics derived
- **Flooding risk**
  - From archived satellite imagery
  - Higher risks at urban fringe

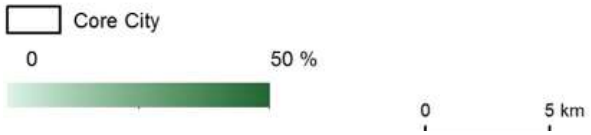




Indicators of sustainable public space network

Dhaka 2017

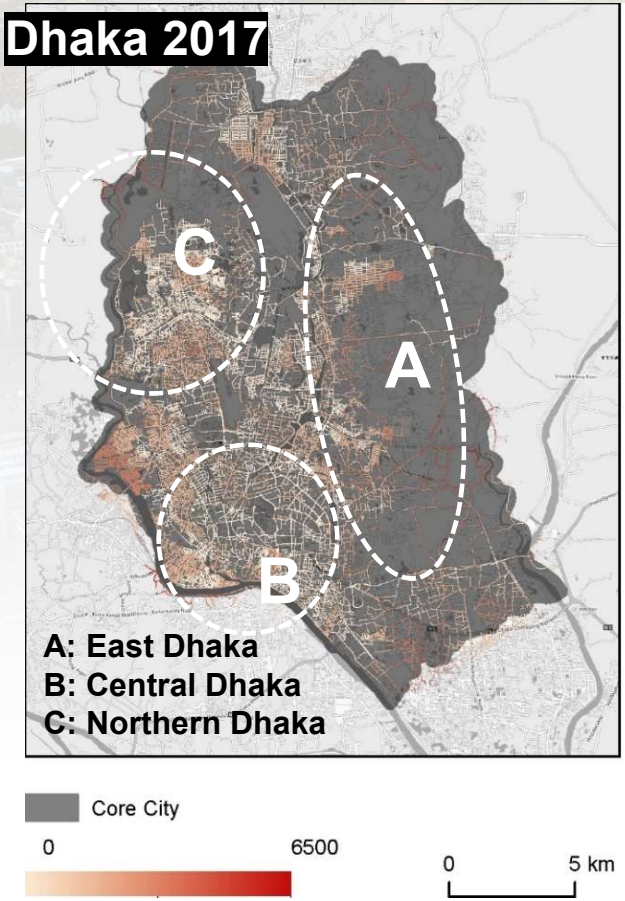




Share of OGA spaces on urban fabric (%)

- ***Share of public spaces*** out of total (urban fabric) area :
  - **7.9%**

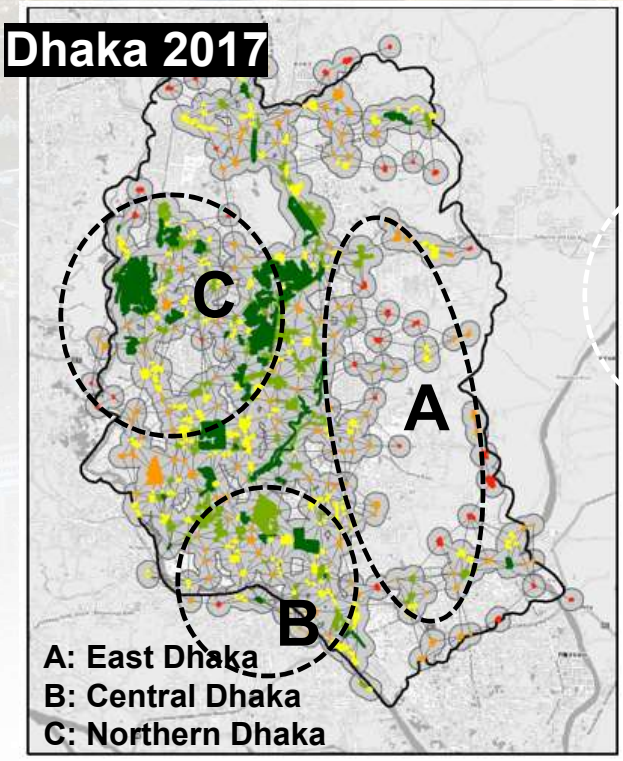
Indicators of sustainable public space network



Street path distance to the nearest Open Green Space (m)

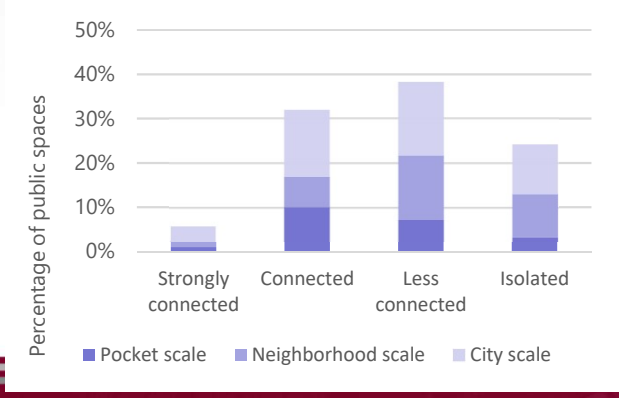
- ***Share of public spaces*** out of total (urban fabric) area :
  - **7.9%**
- ***Accessibility*****:** mean distance from a public space to the nearest roads
  - Median: 1 m; Mean: 90 m

Indicators of sustainable public space network

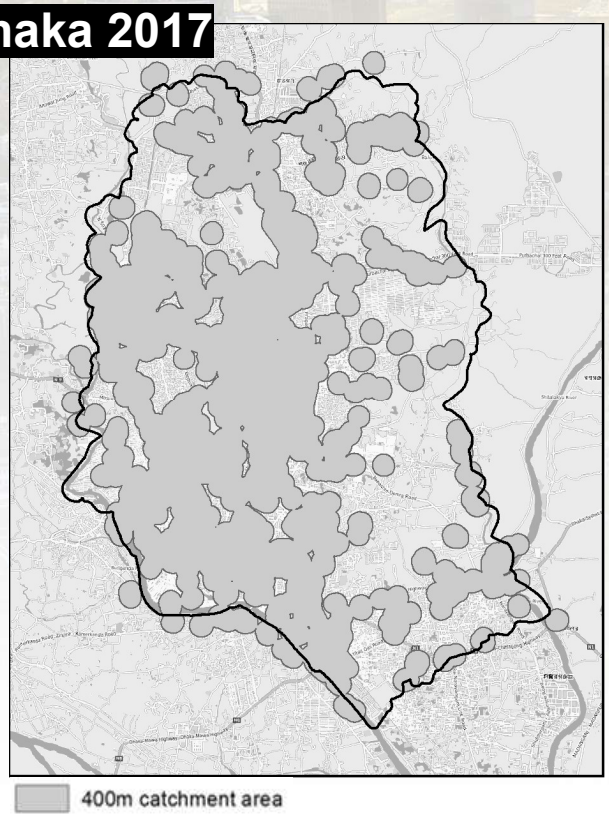


Distance from park to the nearest neighbouring park (m)

- ***Share of public spaces*** out of total (urban fabric) area :
  - **7.9%**
- ***Accessibility***: mean distance from a public space to nearest roads
  - Median: 1 m; Mean: 90 m
- ***Connectivity***: mean distance from a public space to neighbouring public spaces
  - Median: 83m; Mean: 156 m



Indicators of sustainable public space network



400 m catchment areas around all OGA spaces

- ***Share of public spaces*** out of total (urban fabric) area :
  - **7.9%**
- ***Accessibility***: mean distance from a public space to nearest roads
  - Median: 1 m; Mean: 90 m
- ***Connectivity***: mean distance from a public space to neighbouring public spaces
  - Median: 83m; Mean: 156 m
- ***Inclusivity***: share of population living within 400m catchment area
  - 74% of population *(aggregated for AOI, from GPWv4 population grid)*