

# Earth Observation for Sustainable Development to Support Land Use Planning in Urban Areas

Thomas Häusler, Sharon Gomez, Fabian Enssle GAF AG

Land and Poverty Conference 2018: Using Satellite Imagery for Urban Change Detection  
March 19-23, 2018  
Washington, DC

Lead:



Partners:



Financed by:





The project “Earth Observation for Sustainable Development-Urban” (EO4SD-Urban) was initiated in May 2016 and is supported by the European Space Agency (ESA).

The main objectives are:

- To improve understanding of EO applications for urban development with the Multi-Lateral Development Banks and developing countries.
- To mainstream EO applications in an operational manner into development programmes.

Phase 1 was completed successfully by end of 2017.

Phase 2 now continues with new Cities and Stakeholders.

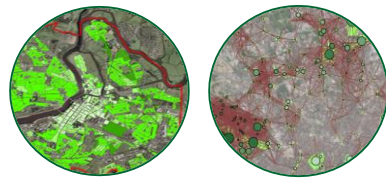




# EO Products for Urban Development



Green Areas/Networks



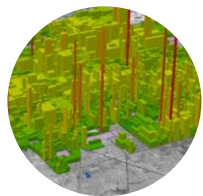
Urban Extent and Change



Building Footprint



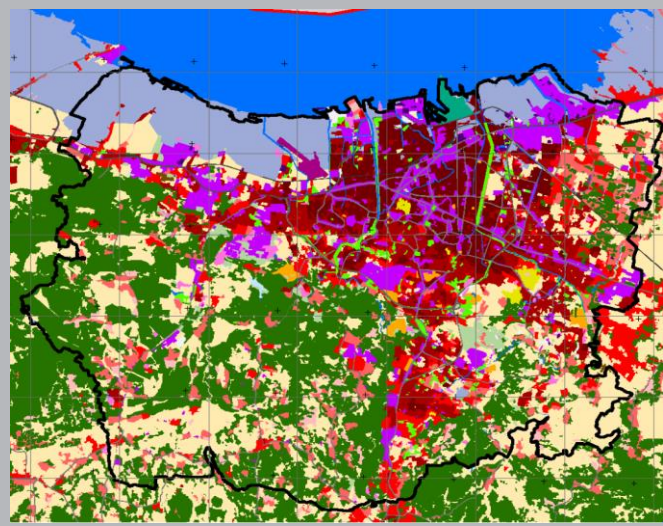
Population Density



Waste Sites



Baseline Products  
Urban and Peri-Urban LU /LC



Detailed



Change



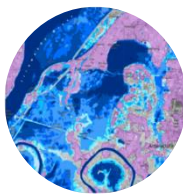
Transport Infrastructure



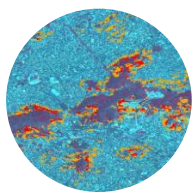
Informal Settlements



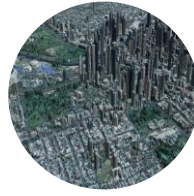
Flood Risk



Landslide Risk



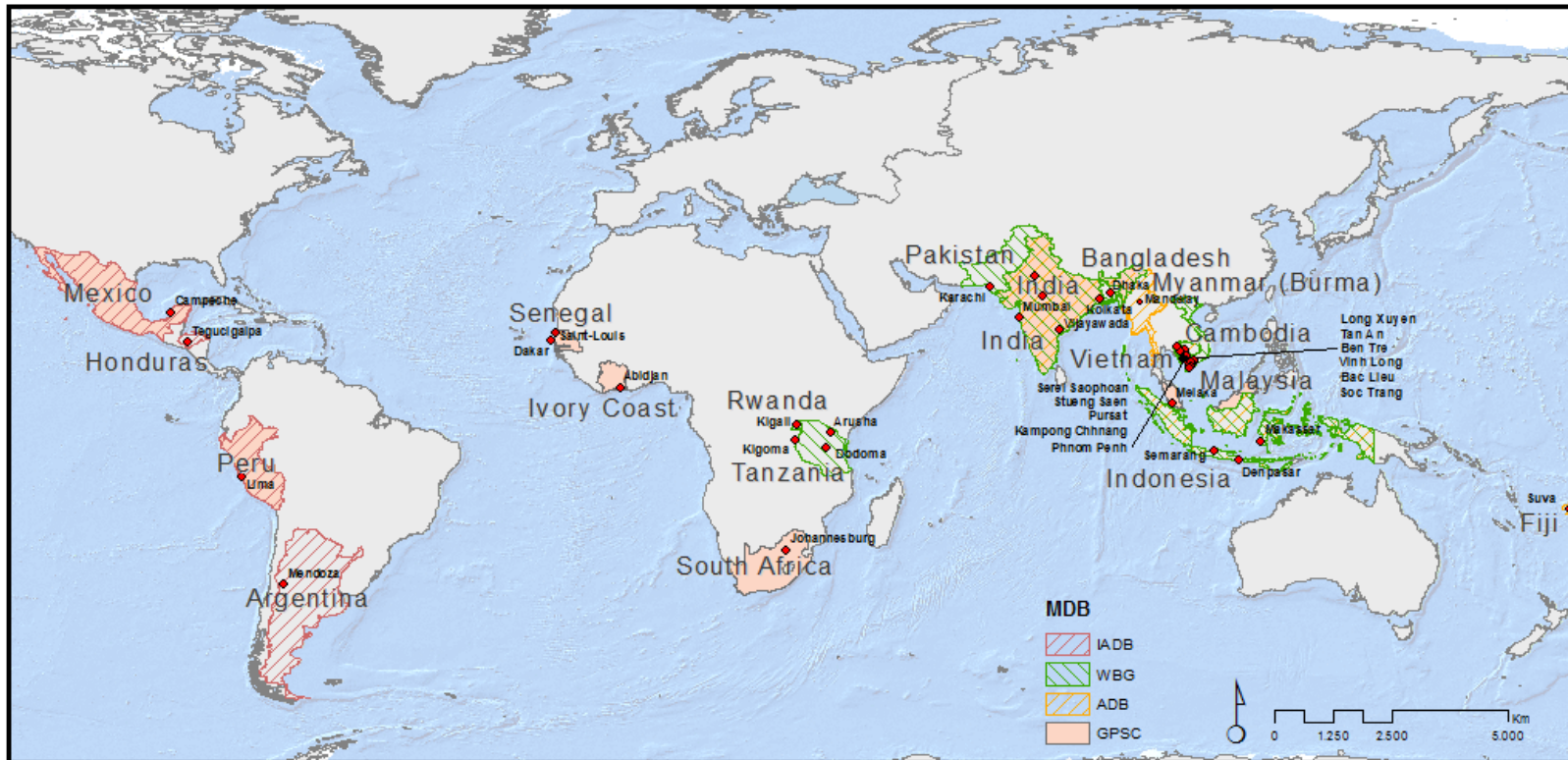
Terrain Motion



# Geographic Spread of EO4SD-Urban Cities



About 40 cities have been identified and stakeholder engagement initiated.



- Distributed globally.
- Include mega-cities and small to medium sized cities.
- Cover a multitude of urban planning/development issues.

# Phase 1 Cities



- 16 cities in 9 countries and 3 continents received 204 EO4SD-Urban products; (57 Baseline Products, 147 Special Products)
- 3 MDBs: Worldbank, Inter-American Development Bank, Asian Development Bank





# Geographic Spread of EO4SD-Urban Cities

---



## **Rwanda:**

Kigali

## **Cambodia:**

Phnom Phen  
Kampong Chhnang  
Stueng Saen  
Pursat  
Serei Saophoan

## **India:**

Kolkata

## **Indonesia:**

Denpasar  
Semarang

## **Myanmar:**

Mandalay

## **Pakistan:**

Karachi

## **Argentina:**

Mendoza

## **Tanzania:**

Arusha  
Kigoma  
Dodoma

## **Bangladesh:**

Dhaka

# Achievements of EO4SD-Urban Phase 1

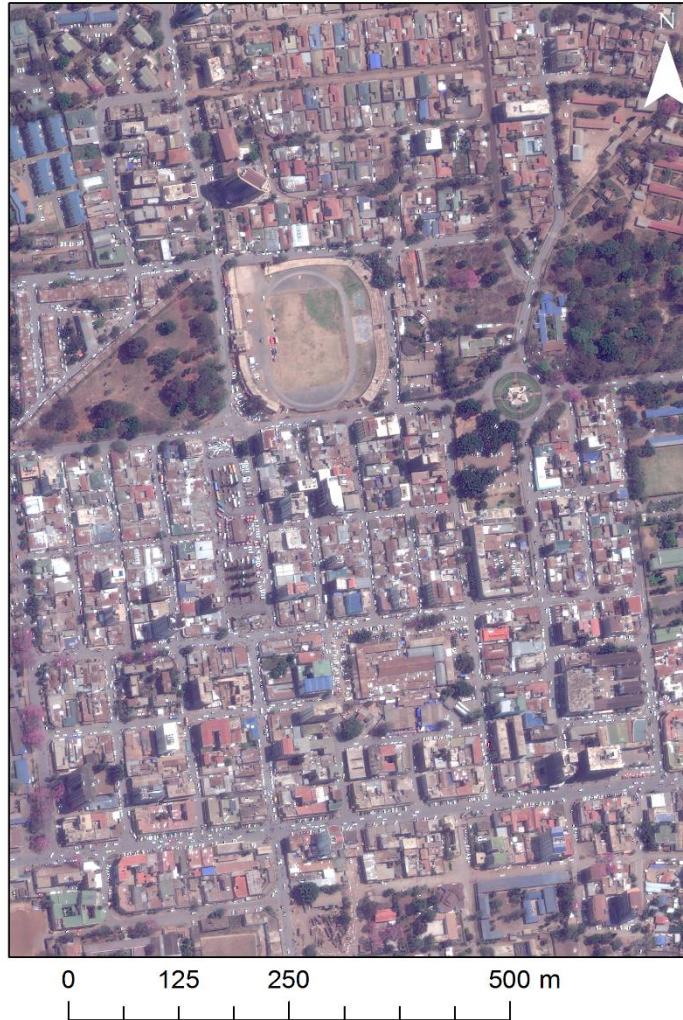
---



- Baseline LU/LC and Derived Products Products for 2 points in time: 15 Cities
- LU/LC data for 4 points in time: 2 Cities
- Flood Risk Products: 6 Cities,
- Terrain Motion Product: 1 City (Semarang),
- Building Height data: 1 City (Kigali),
- Urban Extent/Imperviousness products: 16 Cities for 2 points in time, 6 Cities for 4 points in time.

# EO Data: VHR Example

## – Worldview 2 & GeoEye 1



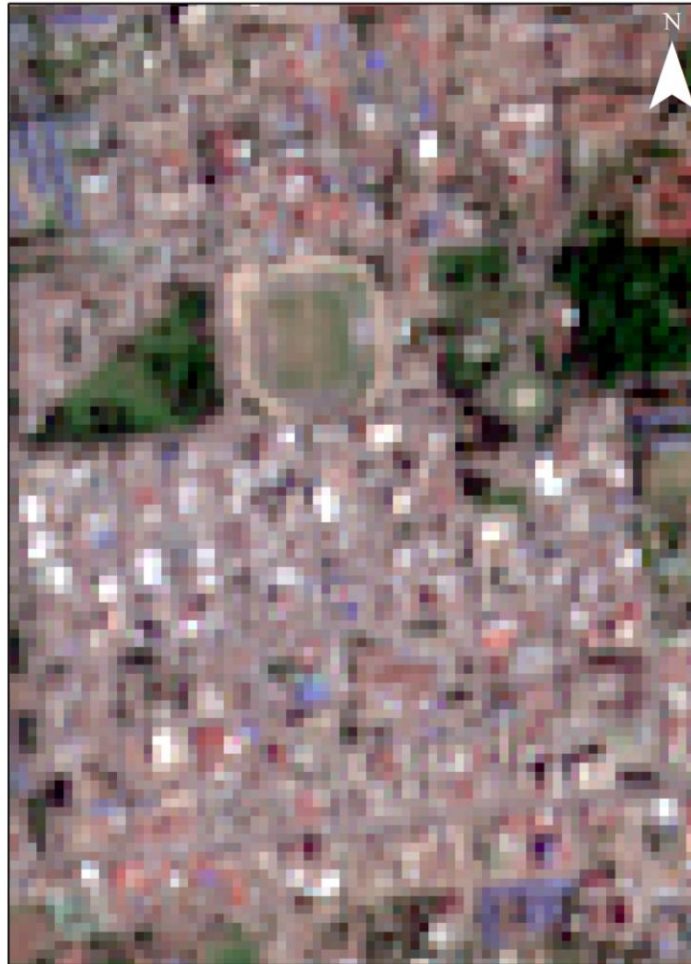
- Images from:  
17.09.2016  
30.12.2015  
04.01.2015
- Spatial Resolution:  
0.5 m
- Natural Composite Band  
Combination:  
Red, Green, Blue  
(3, 2, 1)



# EO Data: HR Example – Sentinel 2



0 500 1.000 2.000 m

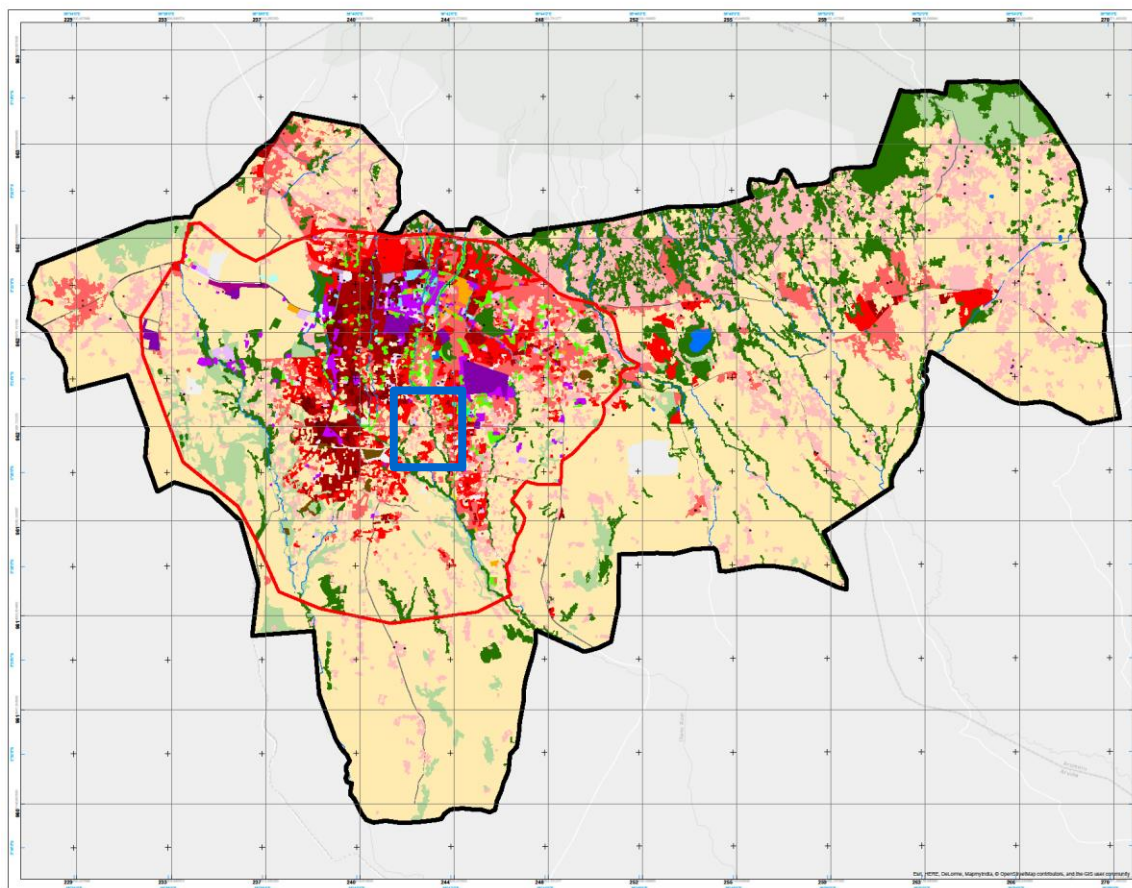


0 125 250 500 m



- Images from: 04.02.2016
- Spatial Resolution: 10 m
- Natural Composite Band Combination: Red, Green, Blue (4, 3, 2)

# Arusha – Tanzania: Land Use/Land Cover 2015

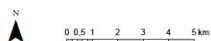


Coordinate System: WGS 1984 UTM Zone 37S  
Projection: Transverse Mercator  
Datum: WGS 1984  
False Easting: 500000.0  
False Northing: 10000000.0  
Central Meridian: 39.000  
Scale Factor: 0.9996  
Latitude of Origin: 0.00  
Units: Meter

Printed on: 11.09.2017  
Version: 1.0

## LAND USE MAP OF ARUSHA, TANZANIA

Status 2015



EO4SD-Urban:  
Earth Observation for Sustainable Development - Urban Project

Map Producer: GAF AG

**Interpretation:**  
The map displays precise Land Use / Land Cover (LULC) information (delivered in vector format) over Arusha (Tanzania). This product contains spatial explicit information about the different LULC categories for the year 2015.

The LULC information within the core urban area was derived from Very High Resolution (VHR) EO data and has a detailed nomenclature whereas the peri-urban area was mapped with High Resolution (HR) EO data with an aggregated nomenclature.

**Image Data:**  
Worldview 2 © Digital Globe, Inc. (2016), (acquired on 17/09/2016, GSD 0.5 m),  
Sentinel-2A (2016) (acquired on 04/02/2016, GSD 10 m) provided by the European Space Agency.

**Vector Data:** © OSM (2015), Toponyms © GoogleMaps (2015).

**Background Map:** © 2017 Esri

### Land Use / Land Cover



Third Party Data was used to avoid classification process only and did not undergo a Quality Assurance procedures. Commitment and spatial accuracy are unknown.

EO4SD-Urban is an ESA project aimed at deriving key geo-information products from Earth Observation data in support of urban development programmes.

More information available under: <http://www.eo4sd-urban.info/>

Map produced by: **GAFAG**

Map produced for: **WORLD BANK GROUP**

Project implemented by a Consortium lead by:

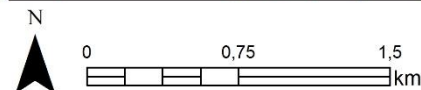
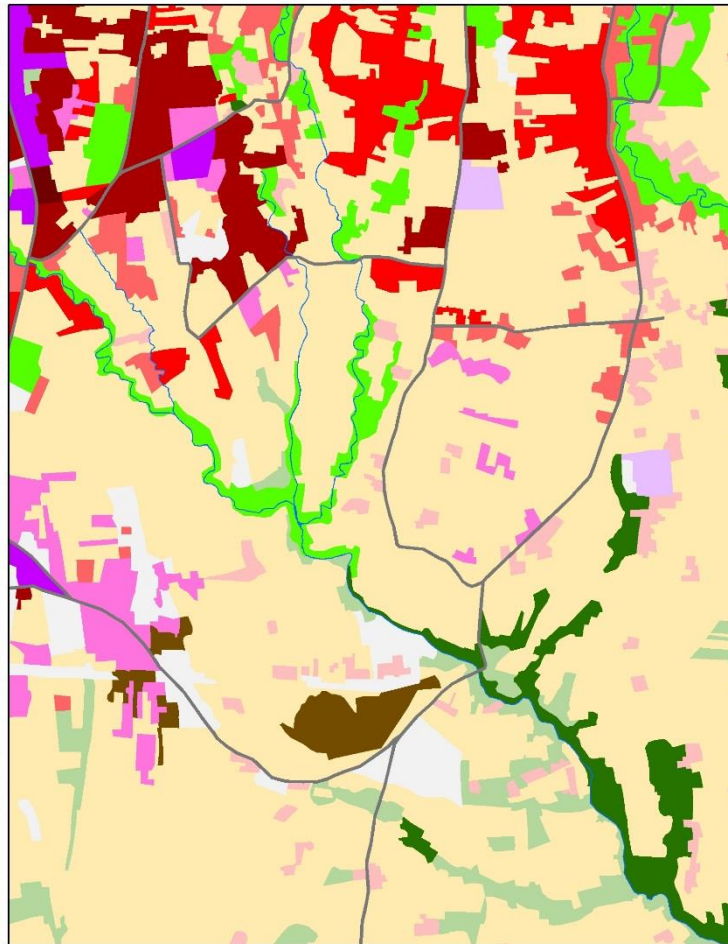
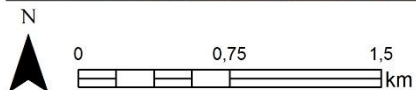
Project funded by:





# Arusha – Tanzania: Land Use/Land Cover 2005

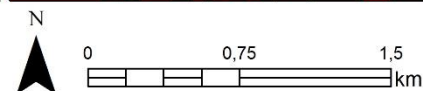
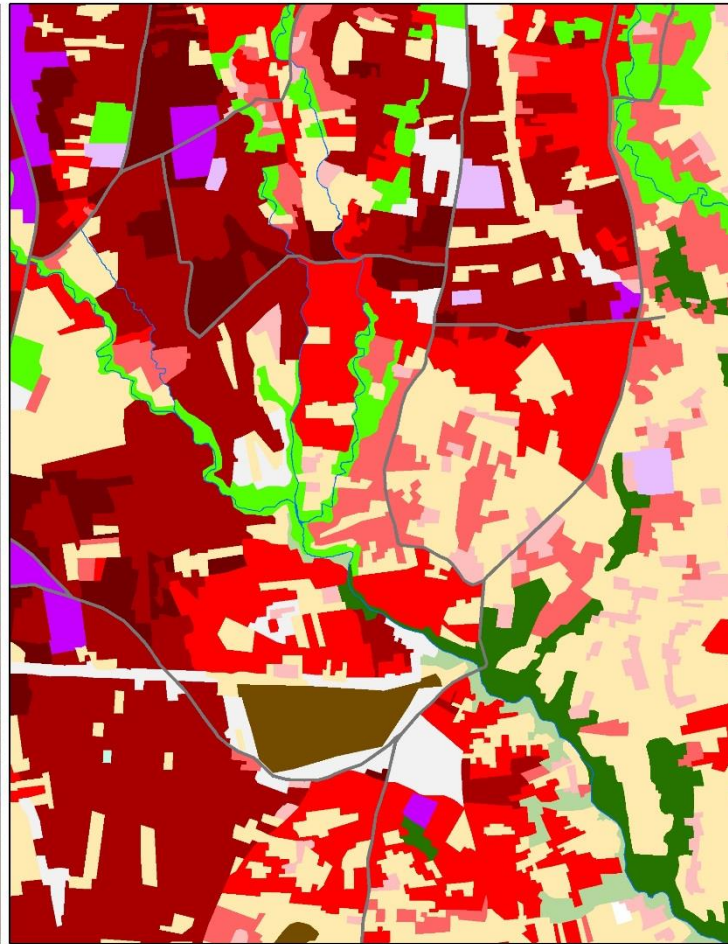
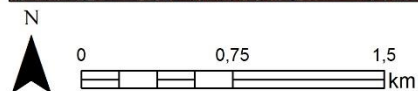
## Subset





# Arusha – Tanzania: Land Use/Land Cover 2015

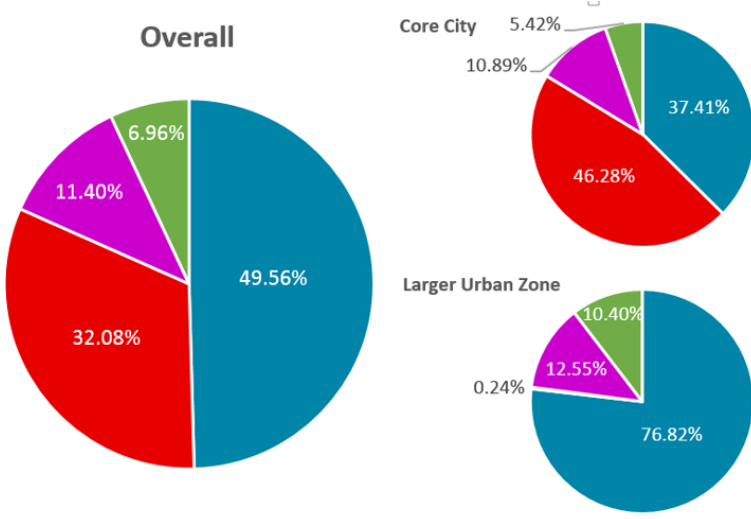
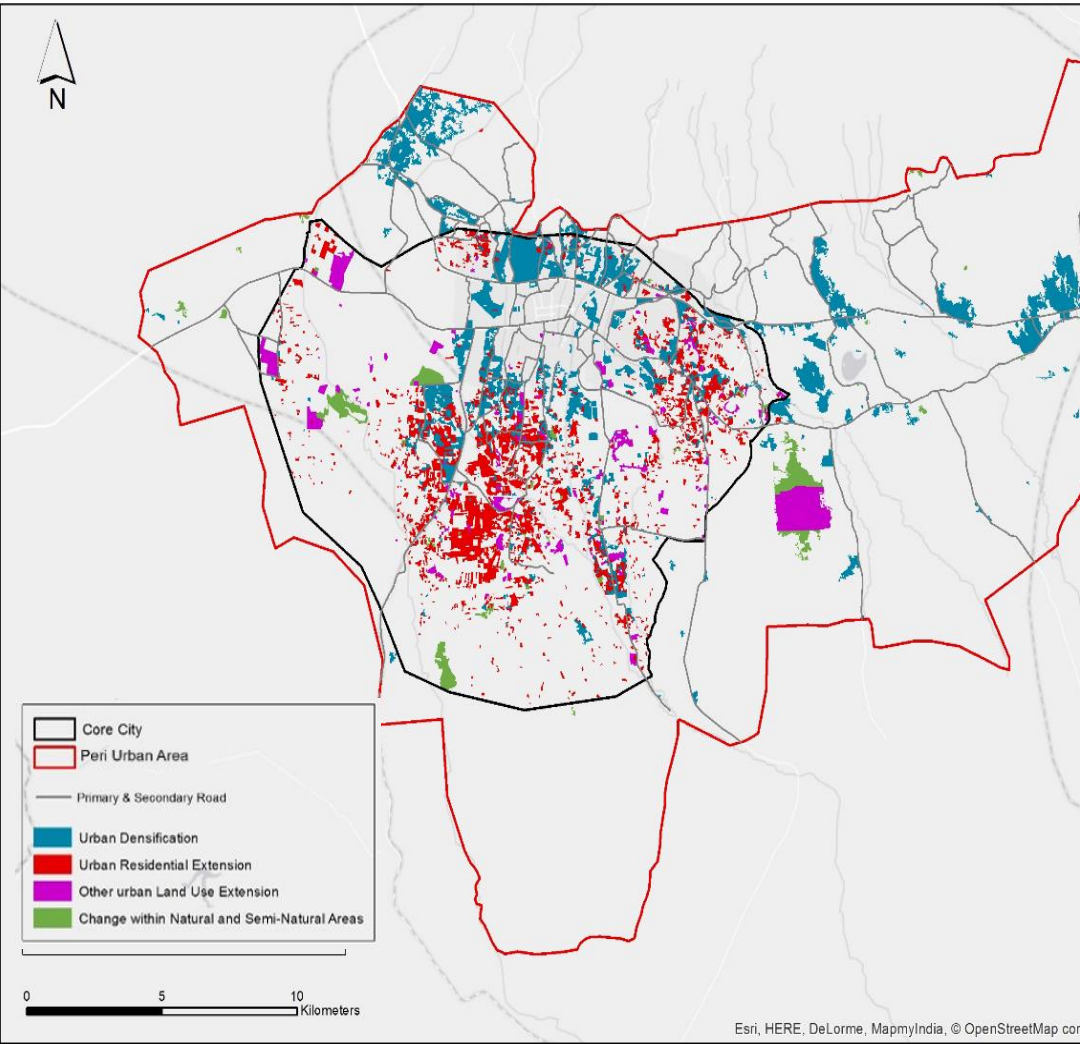
## Subset



- Agricultural Area
- Airport
- Arterial Line
- Bare Soil
- Cemeteries
- Collector Line
- Commercial Area,
- Construction Site
- Forest and Shrublands
- Government
- Hospitals
- Industrial Area
- Land Without Current Use
- Military
- Mining/Quarry Areas/DumpSites
- Natural areas (non-forested)
- Public Buildings
- Railway
- Recreation Facilities
- Residential, 0 - 10% Sealed
- Residential, 10 - 30% Sealed
- Residential, 30 - 50% Sealed
- Residential, 50 - 80% Sealed
- Residential, 80 - 100% Sealed
- Schools
- University
- Urban Parks
- Water
- Wetlands



# Arusha - Land Use Land Cover Change



- Residential densification is more dominant in Peri-urban zone
- Residential extension is more dominant in Core Urban zone



# Arusha – Unplanned vs planned Settlements 2005 - 2015



**Unplanned areas continue to expand (more than planned areas) in Core Area**

15/09/2005, GSD 0.6 m);  
Worldview 2 © Digital Globe, Inc. (2016), (acquired on 17/09/2016, GSD 0.6 m).  
Vector Data: © OSM (2015), Toponyms © GoogleMaps (2015).  
Background Map: © 2017 Esri

- Unplanned to planned settlements
- Decrease of unplanned settlements
- Expansion of unplanned settlements
- Expansion of planned settlements
- No change in unplanned settlements
- No change in planned settlements

More information available under: <http://www.eo4sd-urban.info/>

Map produced by: **GAFAG**

Map produced for: **WORLD BANK GROUP**

Project implemented by a Consortium lead by:

Project funded by:



**SETTLEMENT TYPES IN ARUSHA, TANZANIA**

**Change Map 2005 to 2015**

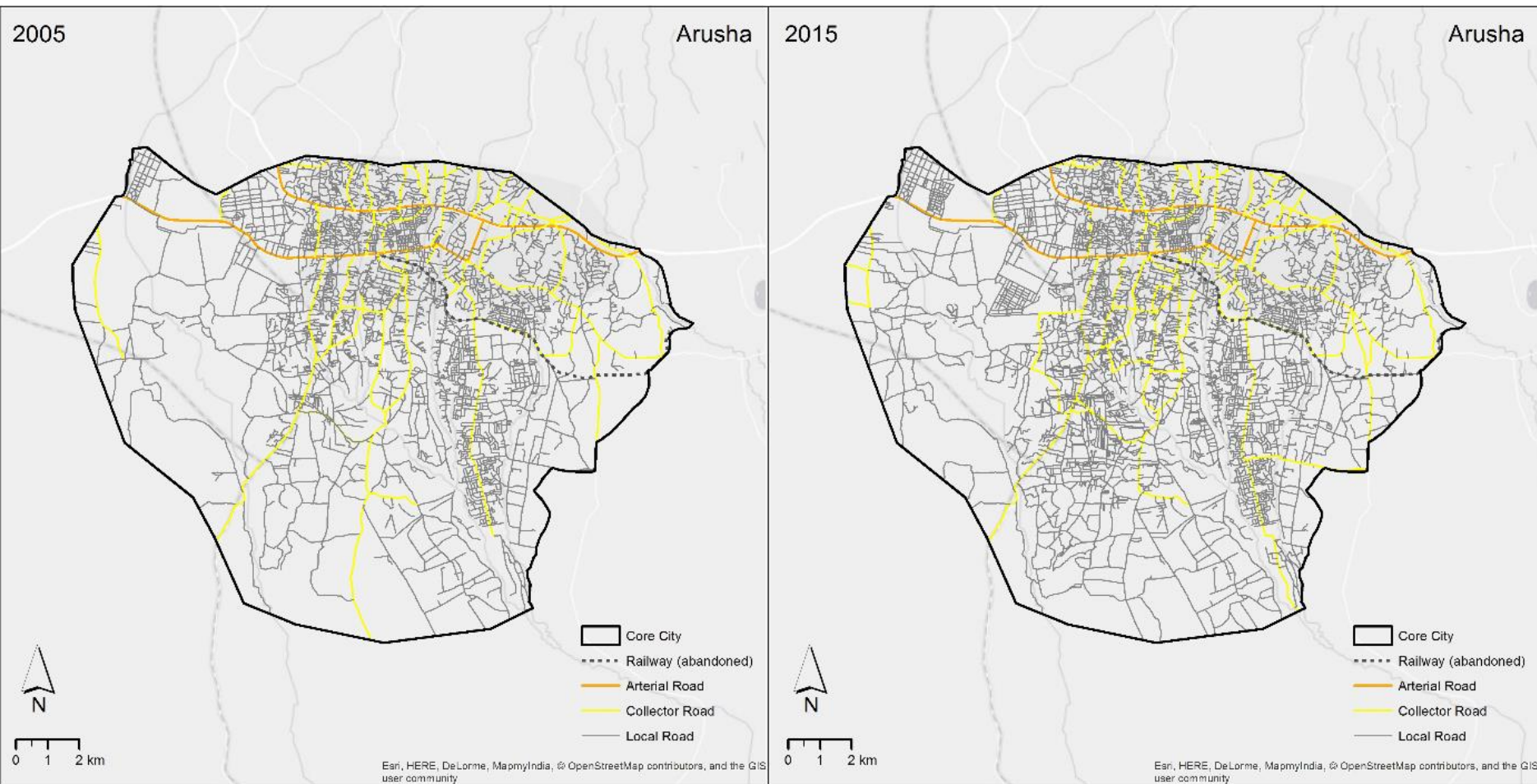


Coordinate System: WGS 1984 UTM Zone 37S  
Projection: Transverse Mercator  
Datum: WGS 1984  
False Easting: 500000.0  
False Northing: 1000000.0  
Central Meridian: 39.000  
Scale Factor: 0.9996  
Latitude of Origin: 0.00  
Units: Meter

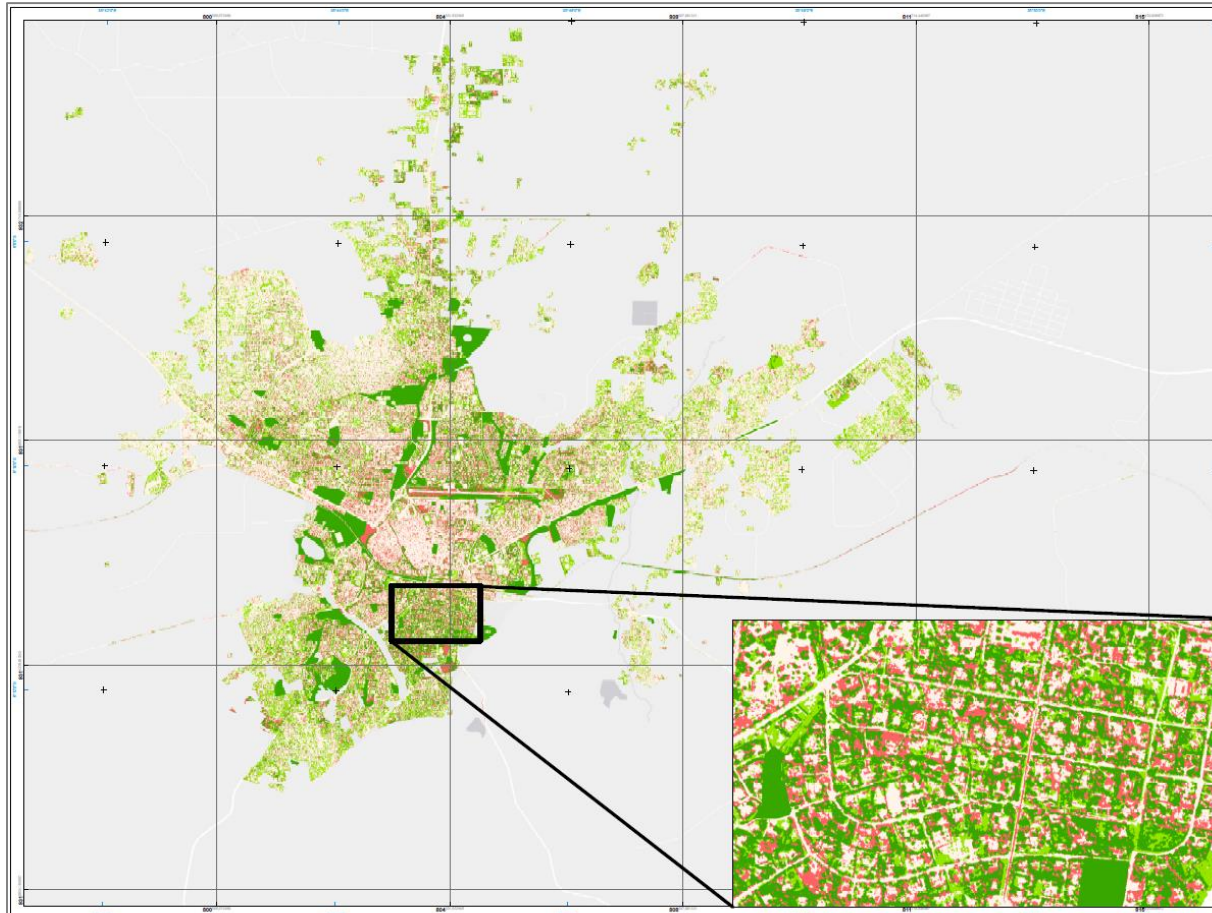
Printed on: 13.10.2017  
Version: 1.0



# Transport Network of Arusha in 2005 and 2015



# Changes of Urban Green Areas - Dodoma



## URBAN GREEN AREAS IN DODOMA, TANZANIA

Change Map 2006 to 2016

Coordinate System: WGS 1984 UTM Zone 36S  
Projection: Transverse Mercator  
Datum: WGS 1984  
False Easting: 500,000.0000  
False Northing: 10,000,000.0000  
Centre Meridian: 33.0000  
Scale Factor: 0.9996  
Latitude Of Origin: 5.0000  
Units: Meter

Printed on: 13.02.2018  
Version: 1.0



0 1.25 2.5 5 km



E04SD-Urban:  
Earth Observation for Sustainable Development - Urban Project

Map Producer: GAF AG

**Interpretation:**  
The map displays precise Urban Green Area information (delivered in vector format) over Dodoma (Tanzania). This product contains spatial explicit information about permanent, new and loss of urban green area between 2006 and 2016.

The Urban Green Area information was derived from Very High Resolution (VHR) EO data and shows the change in urban green areas with a 1 m spatial resolution.

**Image Data:**  
Quickbird © Digital Globe, Inc. (2006, 2009) (acquired on 13/09/2006, 15/05/2009 and 03/03/2009, GSD 0.6m);  
Pleiades-1B © CNES (2016), distributed by Airbus DS (acquired on 30/05/2016 and 13/06/2016, GSD 0.5 m).

Vector Data: © OSM (n.a.), Toponyms © GoogleMaps (2015);

Background Map: © 2017 Esri

### Urban Green Areas

#### Change Status

- Non-Urban Green Area
- Permanent Urban Green Area
- Loss of Urban Green Area
- New Urban Green Area

E04SD-Urban is an ESA project aimed at deriving key geo-information products from Earth Observation data in support of urban development programmes.

More information available under: <http://www.e04sd-urban.info/>

Map produced by: **GAFAG**

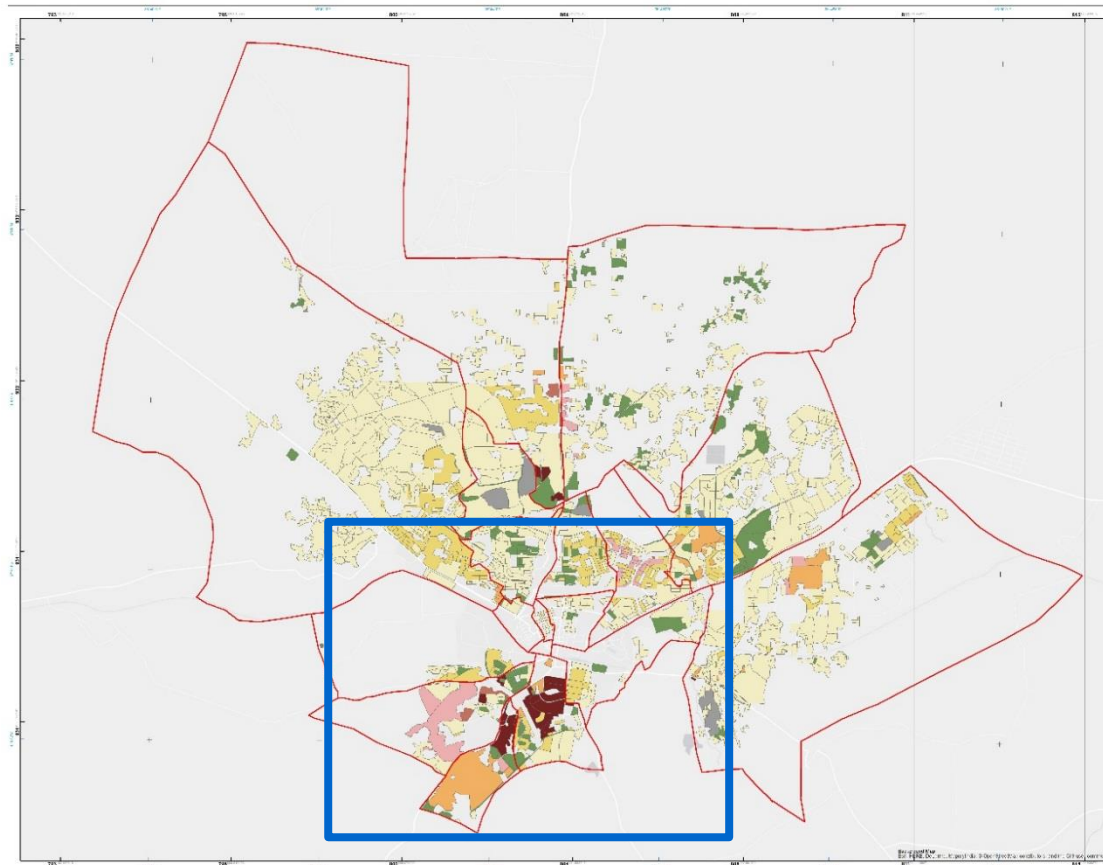
Map produced for: **WORLD BANK GROUP**

Project implemented by a Consortium lead by:

Project funded by:



# Dodoma – Tanzania: Population Distribution Change Map



Coordinate System: WGS 1984 UTM Zone 36S  
Projection: Transverse Mercator  
Datum: WGS 1984  
False Easting: 500,000.0000  
False Northing: 10,000,000.0000  
Central Meridian: 35.0000  
Scale Factor: 0.9996  
Latitude Of Origin: 0.0000  
Units: Meter

Printed: 01.10.10.2017  
Version: 1.0

## POPULATION DISTRIBUTION IN DODOMA, TANZANIA

### Change Map 2005 to 2015



E04SD-Urban:  
Earth Observation for Sustainable Development - Urban Project

Map Producer: GAF AG

**Interpretation:**  
This map displays precise information about changes in the population distribution (derived in vector format) for Dodoma (Tanzania). Eight different change classes were identified based on a frequency distribution analysis of the changes that occur. This product contains spatially explicit information about unchanged population distribution, decrease and increase (at a certain percentage level) in the population distribution between the years 2005 and 2015.

The population distribution map was derived from a model, based on WorldPop data (2015) with a spatial resolution of 100m, official population census data and soil sealing engine.

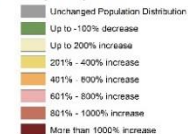
**Image Data:**  
WorldPop Data (2015) (acquired on 04/03/2017, GSD 100 m);

**Vector Data:** © Global Administrative Areas (2015), Toponyms © GoogleMaps (2015)

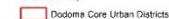
**Background Map:** © 2017 Esri

## Population Distribution

### Changes in Population Distribution



### Overview Map



E04SD-Urban is an ESA project aimed at deriving key geo-information products from Earth Observation data in support of urban development programmes.

More information available under: <http://www.e04sd-urban.info/>

Map produced by: **GAFAG**

Map produced for: **WORLD BANK GROUP**

Project implemented by a Consortium lead by:

**GAFAG**

Project funded by:

**esa**

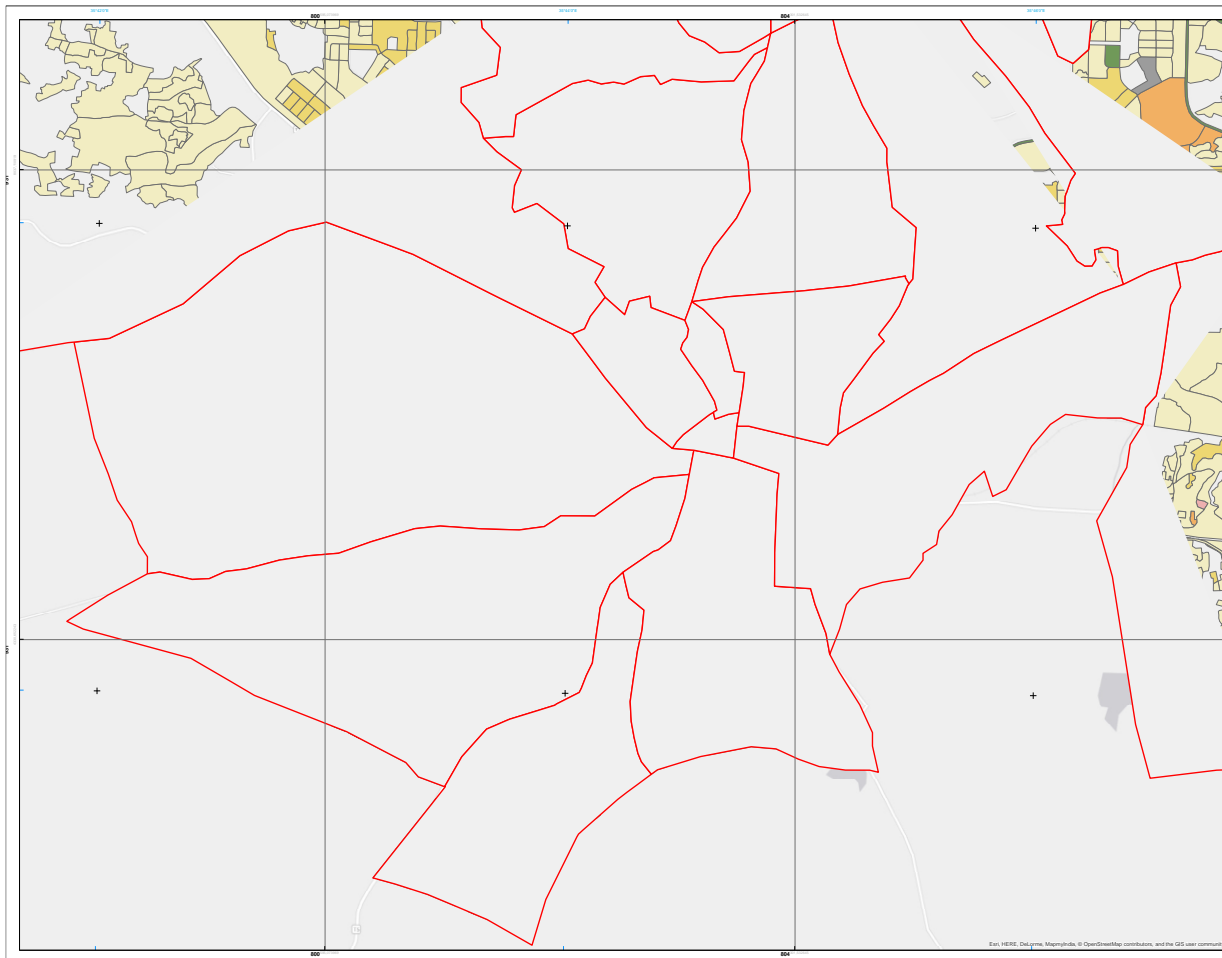




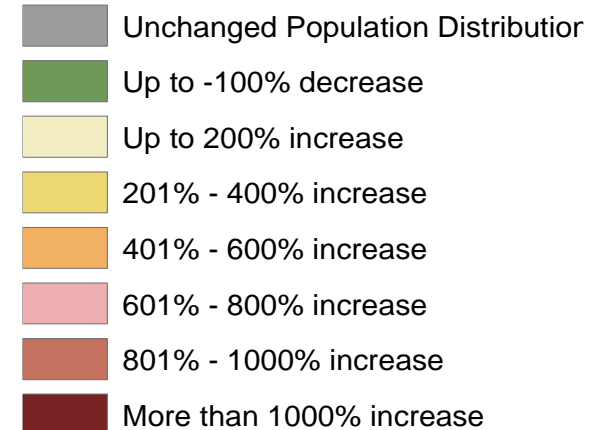
# Dodoma – Tanzania: Population Distribution Change Map



## Subset



### Changes in Population Distribution



### Overview Map

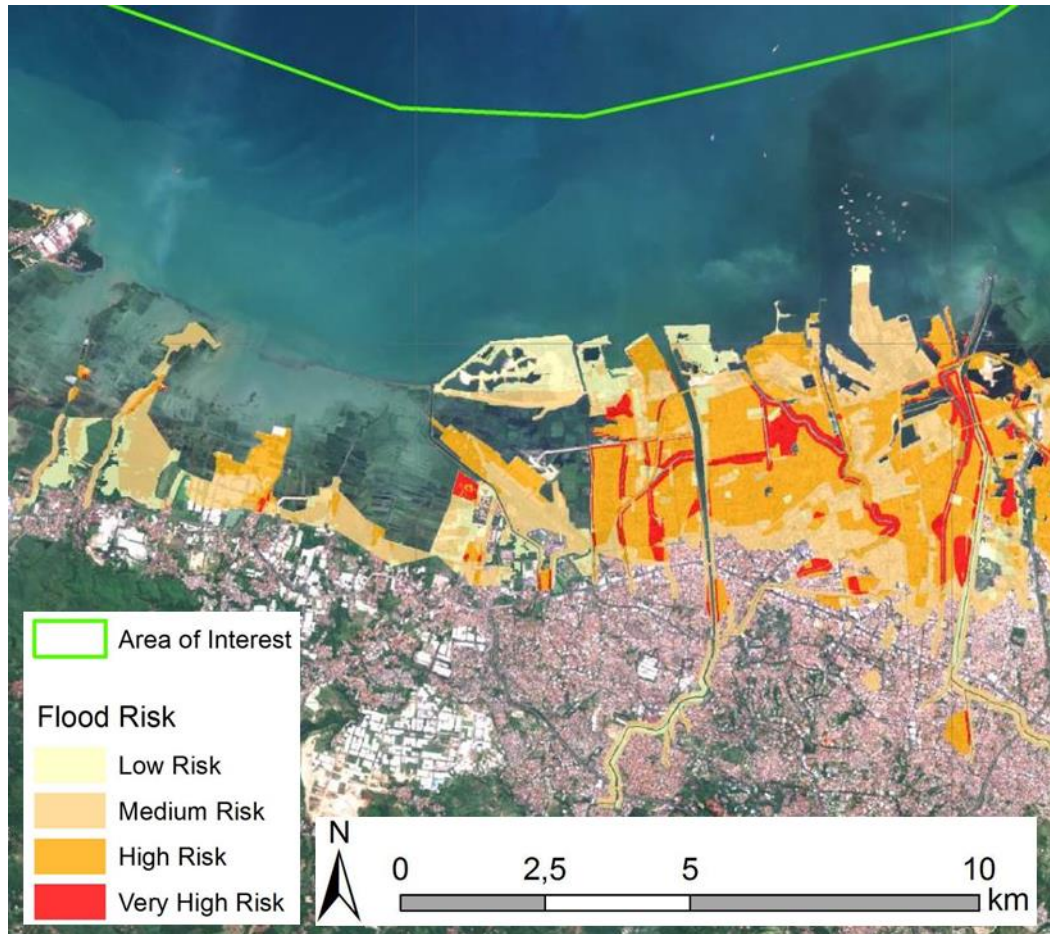


# Semarang – Indonesia: Flood Risk Map

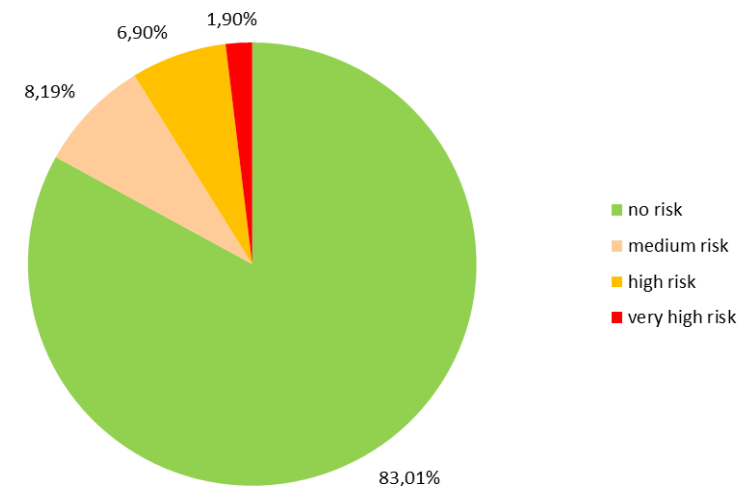


## Requires

- precise DTM modelling
- adequate EO archive data coverage

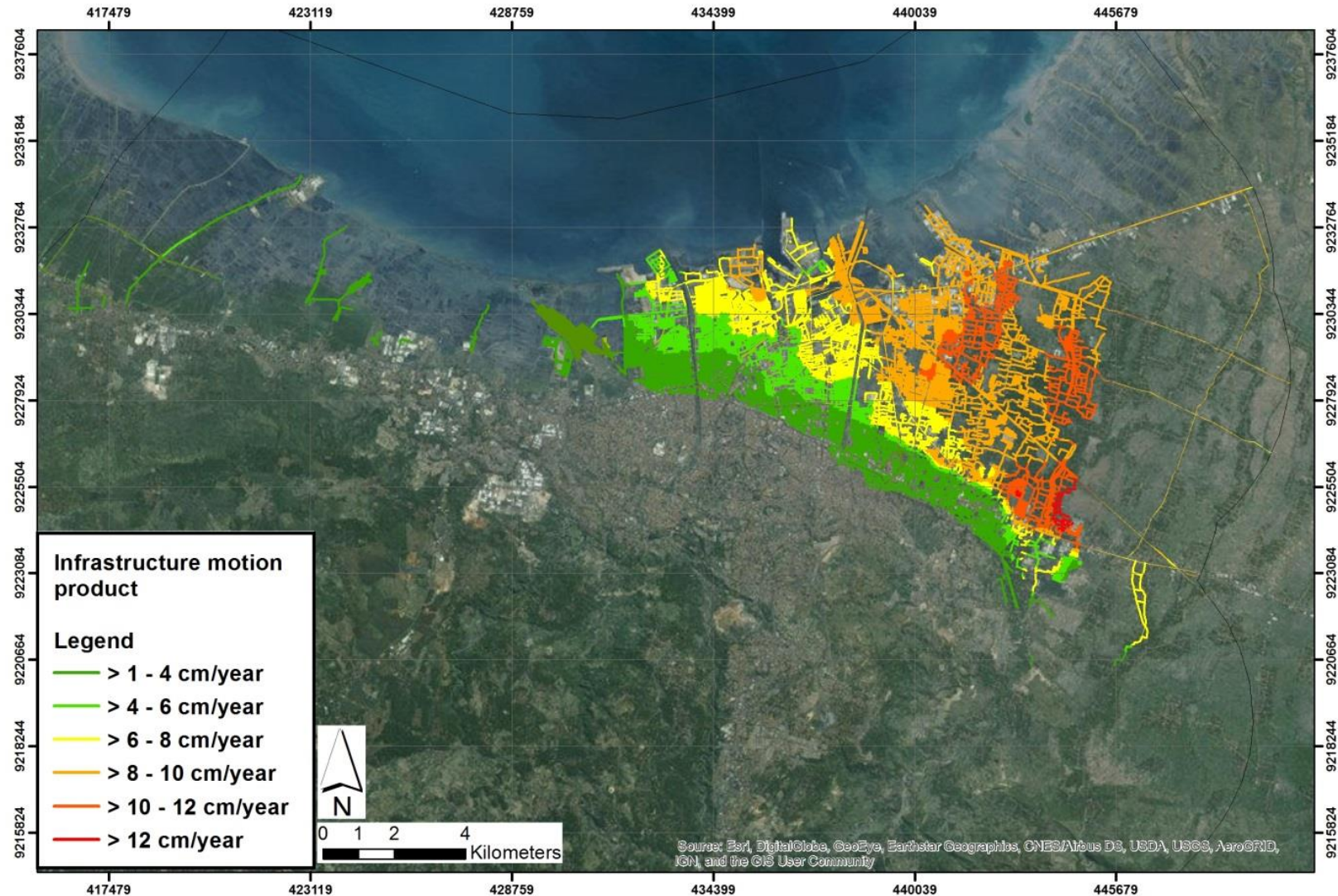


Residential and Public Urban Fabric in Flood Risk Zones





# Semarang – Indonesia: Terrain and Infrastructure Motion





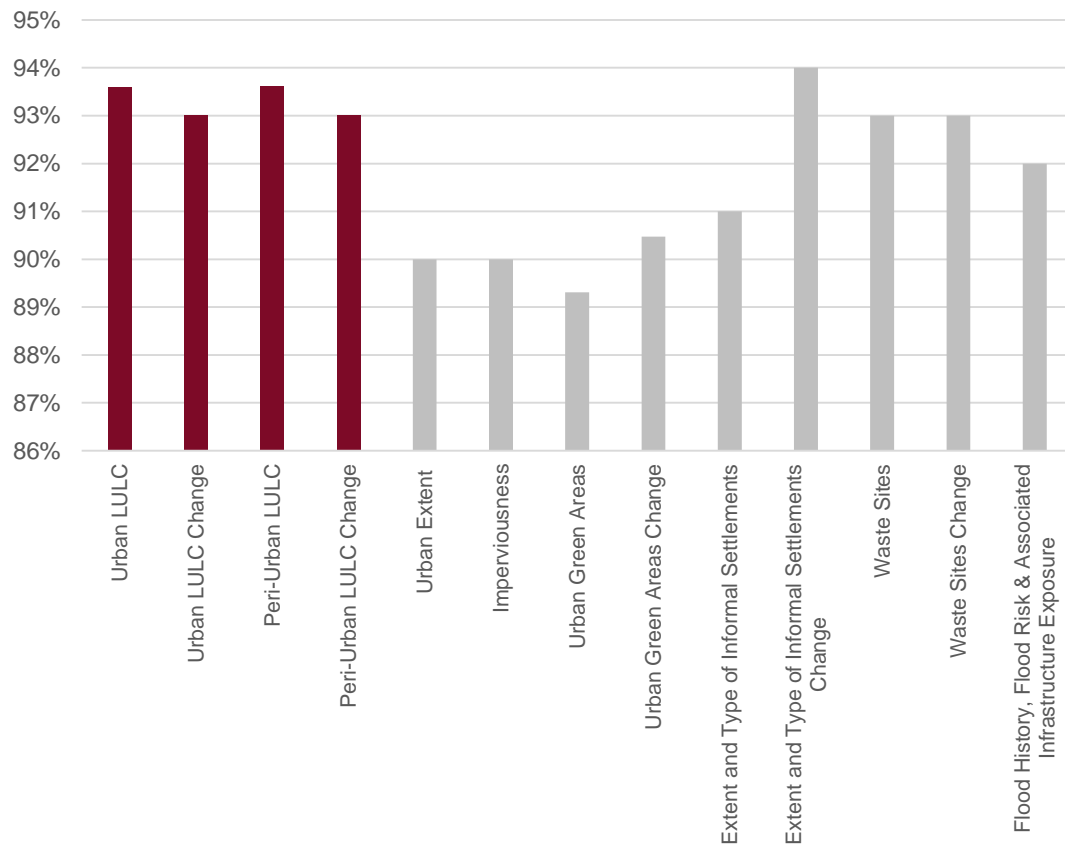
# Accuracy Assessment



## Statistically & Scientifically Sound Sampling Design

- **Stratified Random Sampling**
  - Number of samples per strata
  - Expected accuracy, acceptable error, 95% C.L.
- **Response Design**
  - Independent re-interpretation
- **Analysis Design**
  - Error matrix
  - Metrics (overall, user's, producer's acc.)

### LULC, Green Areas, Planned and Un-planned Settlements



# Transparent Methods - Quality - Accuracy Service Operations Report for each City



**Earth Observation for Sustainable Development**

**urban development road4d**

**Service Operations Report - Dhaka**

ESA Ref: AOI-ES40145-ND  
Doc. No: ES40145-ND  
Date: 18.09.2017

GAFAG GIS4G GIS4G GIS4G GIS4G GIS4G GIS4G GIS4G GIS4G GIS4G

## Requirements

Product Name (Name assigned from DO)	Specific requirements (Overall standard product specifications in DO)	Provider
Urban & Peri-Urban Land Use / Land Cover (LULC)	None	GISAT
Urban & Peri-Urban Land Use / Land Cover Change (LUCC)	None	GISAT
Open Green Areas	Land use changes and identification of green areas and public spaces Typology of public / green / open space Characterize and describe such appropriate indicators, how urban spaces are physically organized and structured within cities vis-a-vis land use, housing, commercial, industry, distribution, infrastructure, transportation, spending etc. Where possible, provide some quantitative and/or qualitative measures of the quality of urban spaces in selected cities (e.g. presence of green spaces, urban areas that are susceptible to floods etc.)	GISAT, GISATX
Informal Settlements	Density of housing in order to support population density estimation Create spatially-defined typology classes (relevant to product data density as response variable using satellite imagery) Informal settlements (typology) locations, topography and morphology and growth patterns, including time of emergence, spread and density of population Location: in the heart of city, old city, slums, in path of development (along roads, express, along railway, in residential centres, at fringe, in suburban industrial areas) Pattern shape, internal character (use of transportation, heterogeneity, building size, height & spacing, density (< population) etc.) growth: increase / decrease, dating Level of vulnerability to disaster and climate change and water scarcity, storms, floods and earthquakes, etc., depending on: Location: natural hazards (flood, landslide, localized seismicity, industrial, road/railroad accident, plane crash) Housing structural typology: material (concrete, brick, concrete/brick, density) Accessibility: road density, and distance to main roads	GISAT, GISATX
Transport Network	None	GISAT
Urban Forest	None	ISAR
Imperviousness	None	ISAR
Food History, Hazard & Risk	None	NOI

## Area of Interest

### 2.2 Service Area Specification

The Service Area or Area of Interest (AOI) has been divided in two parts:

- Core Urban Area which corresponds to the most populated areas including the historic city centre
- Peri-Urban Area which covers the surrounding of the city

This AOI geospatial division has been set up for offering products specifically relevant for artificial areas only and which require the use of Very High Resolution satellite imagery (less than 4 m spatial resolution).



Figure 1: Dhaka, Bangladesh - Core City (green), Service Area (red).

## Products Specifications

### 2.3 Product List and Product Specifications

The following Table lists the products which have been produced within the ES40145-Urban project for the production site in Dhaka.

Table 2: Product list

Product Name	Class and Definition	Resolution	Temporal Period
Land Use / Land Cover (LULC)	Land Use / Land Cover (LULC)	1000m	2006-2017
Urban & Peri-Urban Land Use / Land Cover Change (LUCC)	Urban & Peri-Urban Land Use / Land Cover Change (LUCC)	1000m	2006-2017
Open Green Areas	Open Green Areas	1000m	2006-2017
Informal Settlements	Informal Settlements	1000m	2006-2017
Transport Network	Transport Network	1000m	2006-2017
Urban Forest	Urban Forest	1000m	2006-2017
Imperviousness	Imperviousness	1000m	2006-2017
Food History, Hazard & Risk	Food History, Hazard & Risk	1000m	2006-2017

Product Name	Class and Definition	Resolution	Temporal Period
Land Use / Land Cover (LULC)	Land Use / Land Cover (LULC)	1000m	2006-2017
Urban & Peri-Urban Land Use / Land Cover Change (LUCC)	Urban & Peri-Urban Land Use / Land Cover Change (LUCC)	1000m	2006-2017
Open Green Areas	Open Green Areas	1000m	2006-2017
Informal Settlements	Informal Settlements	1000m	2006-2017
Transport Network	Transport Network	1000m	2006-2017
Urban Forest	Urban Forest	1000m	2006-2017
Imperviousness	Imperviousness	1000m	2006-2017
Food History, Hazard & Risk	Food History, Hazard & Risk	1000m	2006-2017

## Description of: • Methodology • Accuracy Assessment • Quality Control Sheets

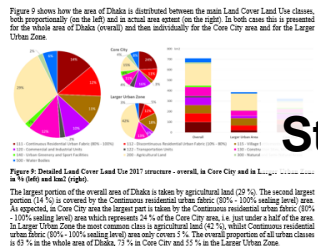


Figure 9: Donut chart showing the area of Dhaka is distributed between the main Land Use classes, both proportionally (on the left) and in actual area extent (on the right). In both cases this is presented for the whole area of Dhaka (overall) and then individually for the Core City area and for the Larger Urban Zone.

Figure 10 displays the proportion of each Land Use Class in each district. Given the large number of districts the graph was divided into three parts.

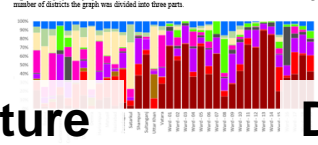


Figure 10: Detailed Land Use Class 2017 structure - overall, in Core City and in Larger Urban Zone.

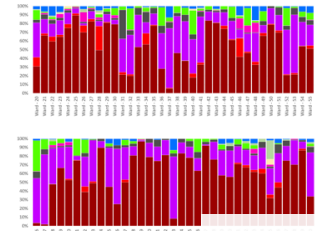


Figure 10: Detailed Land Use Class 2017 structure in % per district.

### 4.4 Informal Settlements - Status and Trends

Figure 16 shows spatial distribution of slums in Core city of Dhaka and their classification into several types regarding location and density.

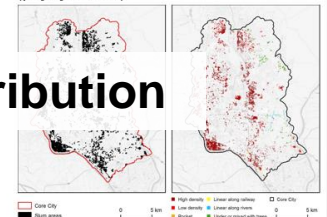


Figure 16: Informal Settlements/Slum Areas (left) and Slum Areas Types (right) - Spatial Distribution 2017.

From Figure 16 it can be seen that slums are not just as well as in the very core city, but mainly on the edges. Most of them are high density slums.

The next figure shows the proportion of each informal settlement slum area within each district located at either flood prone areas (high, medium, low risk of flooding) or in the risk of flooding areas. Considering the high number of districts the graph is divided into two parts. Only districts where informal settlements slum areas are situated are displayed.

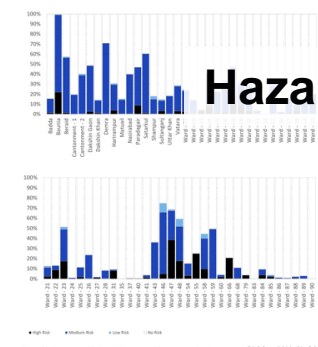


Figure 17: Proportion of Informal Settlements/Slum Areas in flood prone areas (high/low risk) in % of slum area per district - overall 2017.



Figure 18: Flood risk within AOI of peri-urban (top) and core urban areas (bottom) based on flooding events from 2007-2017.

## Statistics

## Evolution

## Integration with..



# Quality Control and Assurance



- **Documentation of QC checks**
  - EO & ancillary data, interim & final products
  - Accuracy, consistency, completeness
- **Formalisation and consolidation into QC Sheets**

North Macedonia for Sustainable Development - Urban Project

Earth Observation for Sustainable Development - Urban

Quality Assurance and Quality Control Sheets

These QA/QC Templates were prepared by GAF AG compliant with ISO 9001:2008 Quality Management System standards and can only be used by Partners in the current E045D Urban Project.

Project Title: E045D-Urban

Project Leader: GAF AG

Service Provider: GAF AG

Client: WB

Editor: AB, DK, LV, FE

Date: 27.07.2017

QA/QC Sheets developed by GAF AG

Overview of QC Sheets and Processing Steps

Sheet used

Sheet filled in

**Requirements**

0.1 Requirements

Expected Specifications of Input Data

1.1 List of EO Data

1.2 List of In-Situ Data

1.3 List of Ancillary Data

**Data Quality Checks**

2.1 EO Data Quality

2.2 In-Situ Data Quality

2.3 Ancillary Data Quality

**Pre-Processing of EO Data**

3.1 Geometric Correction

3.1.1 Data Fusion

3.2 Data Processing

**Thematic Processing**

4.1 Classification

4.2 Intermediate Quality Control of Land Use Data

**Accuracy Assessment**

5.1 Thematic Accuracy

5.2 Error Matrix and Accuracy Statistics

**Delivery Checks / Delivery**

7.1 Completeness

7.2 Compliance

Glossary (Index numbers in the QA/QC tables refer to the glossary at the end of this document)

Further QC relevant Documents:

© 2017 GAF AG All Rights Reserved. Unless otherwise indicated, the contents of these QA/QC pages are copyrighted by GAF AG. No part of these pages, either text or image may be used for any purpose other than use in the E045D Urban Project. Therefore, reproduction, modification, storage in a retrieval system or redistribution, in any form or by any means, electronic, mechanical or otherwise, for reasons other than personal use, is strictly prohibited without prior written permission.

2.3 Ancillary Data Quality												
Dataset 1 (4%)	LU Map											
File Name (e.g. yymmdd_ tbd...)		Readability (4)	Check-Header / Metadata (3)	Data Coverage / Metadata Service Area (5)	Projection / Spheroid / EPSG (4a)	Spatial Resolution and unit (e.g. m, km) (4b)	Data Format (4c)	Bit Depth (4d)	Completeness (Vector Attribute Table: Raster: Thematic Values)	Geom. Misalignment	Dropped Lines / Artefacts (ISO table only) (7)	Utility for Current Project
Landuse_Map_Of_2014		<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Complete (INSPIRE/ISO19115) <input type="checkbox"/> Incomplete <input type="checkbox"/> Not available	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If no: xx%	R Correct <input type="checkbox"/> Incorrect <input type="checkbox"/> Unknown EPSG: 32749	0.5  1 2	* sh R	1.8	<input type="checkbox"/> Complete <input type="checkbox"/> Incomplete	<input type="checkbox"/> No <input type="checkbox"/> Yes <input type="checkbox"/> Unknown If yes: XX m	<input type="checkbox"/> No <input type="checkbox"/> Yes <input type="checkbox"/> 0.5 If yes: xx%	<input type="checkbox"/> None <input type="checkbox"/> Partial <input type="checkbox"/> Full
Comments:		43 undetected classes, Map has gaps and overlaps, Definition of residential area 1 and 2 is unknown, class definitions are missing, especially for difficult classes like mixed garden.										

3.1 Geometric Correction														
Sensors #		Sentinel 2, Landsat 5, QB 2, PLK	Processing Date	Aerial Extant, City / Region / Country	Projection / Spheroid <a href="#">4a</a>	No. & RMS (m) of GCPs <a href="#">4b</a>	No. & RMS (m) of TPS <a href="#">4c</a>	No. & RMS (m) of CPs <a href="#">4d</a>	Digital Elevation Model (DEM)	Model / Algorithm <a href="#">4e</a>	Resampling Method <a href="#">4f</a>	Validation Reports	Acceptance Status	Output File Name (e.g. <a href="#">yymmdd_tbd...J</a> )
N o.	File Name (e.g. <a href="#">yymmdd_tbd...J</a> )													
Sentinel 2														
1.	S2A_OPER_MSI_L1C_TL_SGS_20160325T115331_A003947_T49MDN	10.04.2017	<a href="#">Sentinel 2A</a> IDN	UTM49S / WGS84	N/A	N/A	N/A							S2A_OPER_MSI_L1C_TL_SGS_20160325T115331_A003947_T49MDN
2.	S2A_OPER_MSI_L1C_TL_SGS_20160524T080330_A004805_T49MDN	10.04.2017	<a href="#">Sentinel 2A</a> IDN	UTM49S / WGS84	N/A	N/A	N/A							S2A_OPER_MSI_L1C_TL_SGS_20160524T080330_A004805_T49MDN
Landsat-5														
3.	LTS12006520072398KT00	10.04.2017	<a href="#">Sentinel 2A</a> IDN	UTM48N / WGS84	N/A	N/A	N/A							LTS12006520072398KT00_MTL_top
Plešades 1B														
4.	DIM_PHR1B_MS_2015090606304179_SIN_2226855301-002_top_PSH	10.04.2017	<a href="#">Sentinel 2A</a> IDN	UTM49S / WGS84	N/A	1.7, RMSE x0.10; y 0.46	N/A	SRTM 30	<a href="#">Actin, 1<sup>st</sup> order polynomial</a>	OC	Yes	Yes		oDIM_PHR1B_MS_2015090606304179_SIN_2226855301-002_top_PSH
5.	DIM_PHR1B_MS_2015090606304533_SIN_2226851101-002_top_PSH	10.04.2017	<a href="#">Sentinel 2A</a> IDN	UTM49S / WGS84	N/A	1.7, RMSE x0.10; y 0.46	N/A	SRTM 30	<a href="#">Actin, 1<sup>st</sup> order polynomial</a>	OC	Yes	Yes		oDIM_PHR1B_MS_2015090606304533_SIN_2226851101-002_top_PSH

# Value of EO4SD-Urban Services

---



## Product generation is based on:

- Verified user requirements
- Harmonised and standardised state-of-the-art methodologies
- Comprehensive and transparent documentation
- Application of statistically sound accuracy assessment
- Stringent Quality Control and transparent documentation
- User feedback to improve the services

**Geospatial products can be used to monitor SDG 11 Indicators**





# SDG Indicators which can use EO

**11** SUSTAINABLE CITIES  
AND COMMUNITIES



## Indicators:

Target 11.1: Housing and slums	11.1.1: Proportion of urban population living in slums, informal settlements or inadequate housing
Target 11.2: Transport	11.2.1: Proportion of the population that has convenient access to public transport by sex, age and persons with disabilities
Target 11.3: Planning	11.3.1: Ratio of land consumption rate to population growth rate
Target 11.7: Public space	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

# Spatial Data for Monitoring SDG 11 – Indicator 11.2.1



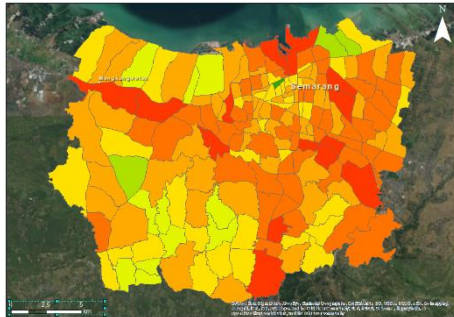
## Target 11.2: Transport

**11.2.1:** Proportion of the population that has convenient access to public transport by sex, age and persons with disabilities

% with access to Public transport  
$$= 100 \times \frac{\text{population with convenient access to Public transport}}{\text{(City Population)}}$$

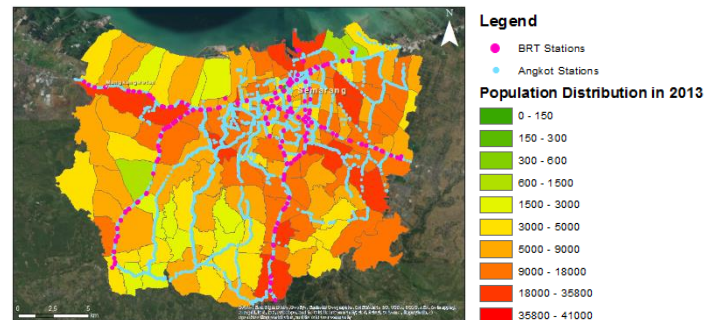
### Input Data:

EO4SD-Urban Population Product  
Census Data per Ward Level for 2013

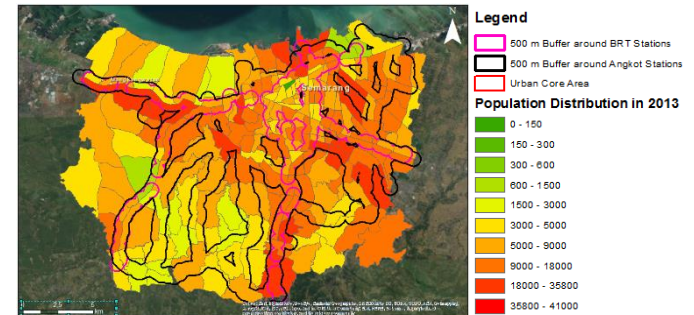


### Other Spatial Data:

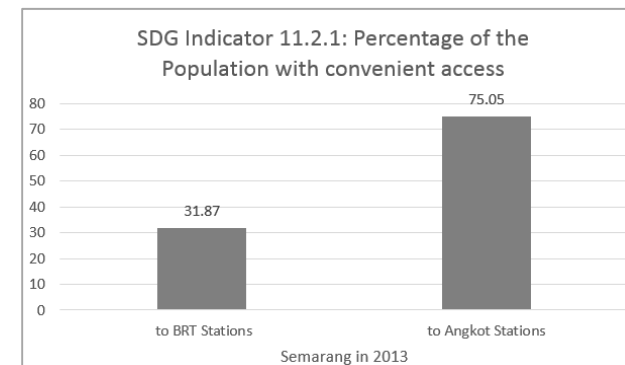
Public Transport Stations (BRT, Angkot)  
Census Data per Ward Level for 2013



### Buffer Analysis:



### Results:





# Spatial Data for Monitoring SDG 11 – Indicator 11.3.1



## Target 11.3: Planning

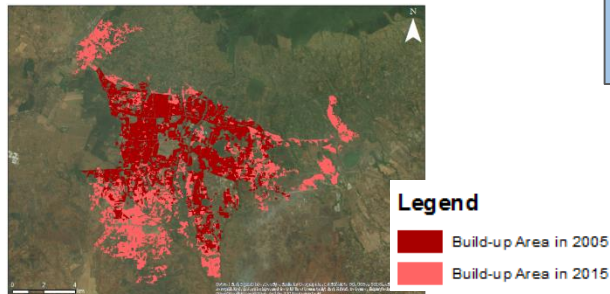
**11.3.1: Ratio of land consumption rate to population growth rate**

**Ratio of land consumption rate to population growth rate (LCRPGR)**

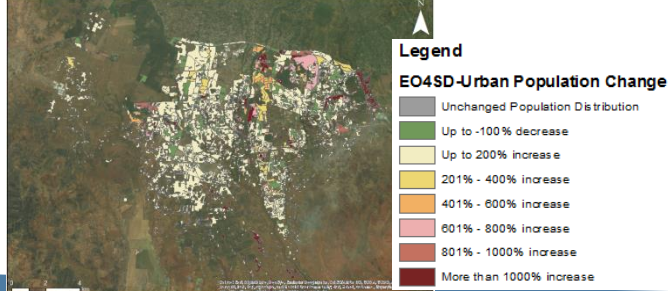
$$= \frac{\text{Land consumption rate}}{\text{Annual population growth rate}}$$

### Input Data:

EO4SD Build-up Area Arusha



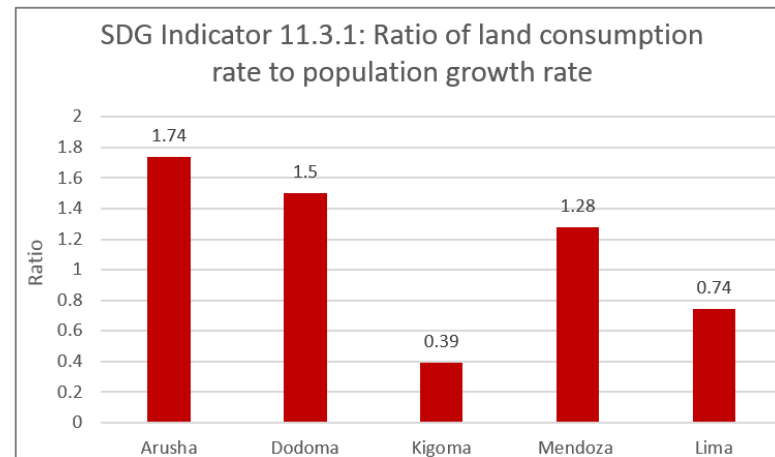
EO4SD Population Distribution Arusha



### Other Spatial Data:

World Population Grid from the Global Human Settlements Layer (GHSL)

### Results:





# Conclusions

---

- **Positive feedback from the different stakeholders of the MDB programmes.**
  - **The importance of rigorous QC, documentation of methods and results cannot be overstated as it has a direct impact on issues of**
    - transparency,
    - repeatability,
    - completeness and
    - validity of the products.
  - **Phase 2: processing of geo-spatial products for additional Urban Projects in the different geographical regions will continue.**
  - **Emphasis will be given on spatial analytics for urban planning.**
  - **Stakeholder feedback at the end of the Project will provide an overview of the of the utility of the geo-spatial products for urban planning.**
- ➡ This should support mainstreaming EO into urban programmes.**



# Thank you for your attention

[www.eo4sd-urban.info](http://www.eo4sd-urban.info)

GAF AG

Dr. Thomas Haeusler (Co-ordinator)

Dr. Sharon Gomez

Arnulfstr.199, 80609 Munich -  
GERMANY

[www.gaf.de](http://www.gaf.de)

[thomas.haeusler@gaf.de](mailto:thomas.haeusler@gaf.de)

[sharon.gomez@gaf.de](mailto:sharon.gomez@gaf.de)



Lead:

Partners:

Financed by:

