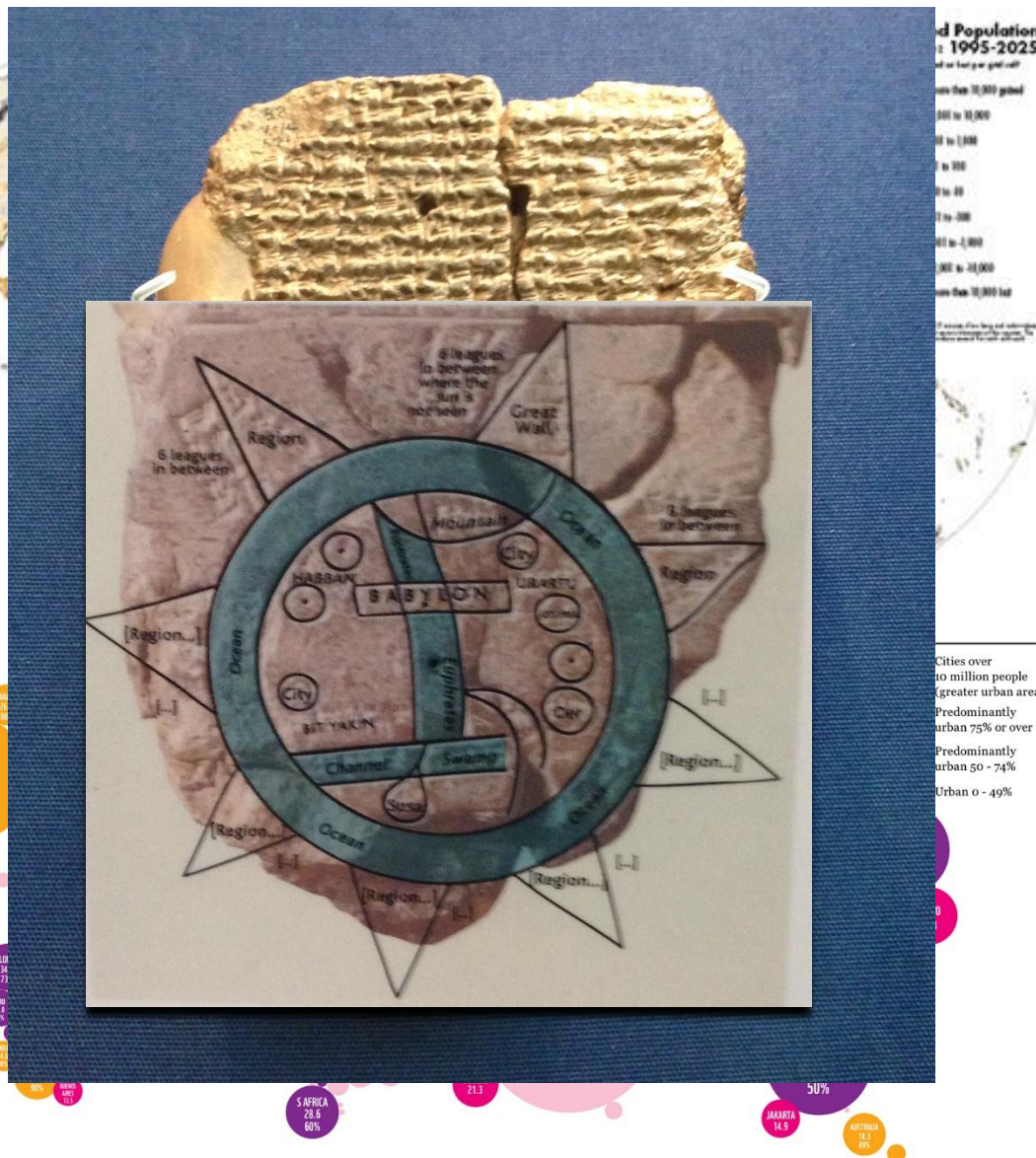


A GIS tool to create human population distribution layers

Michele Vittorio

June 29, 2016

Importance of high resolution population estimates



Monitor population

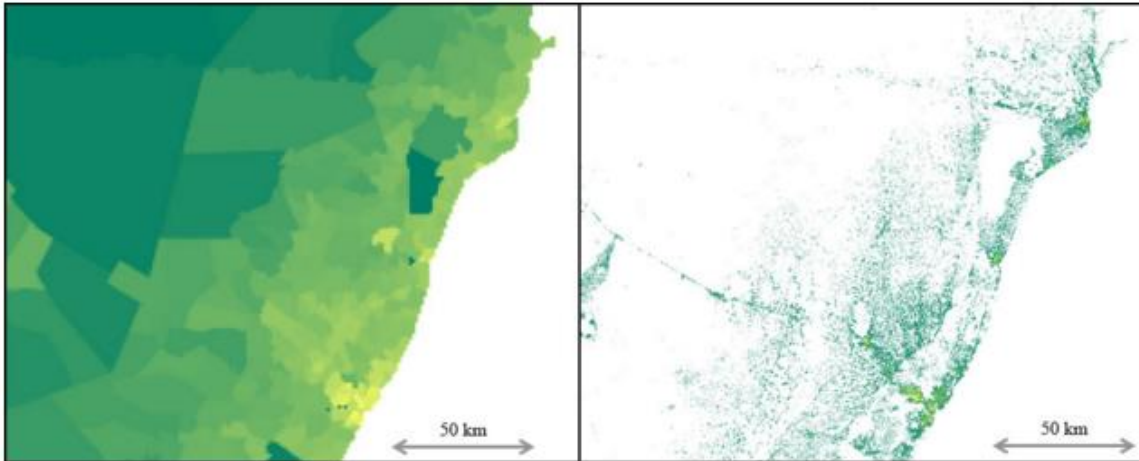
Emergency planning

Resources allocation

Scenario analysis

Availability of population data

- Coarse resolution datasets.
- Aggregate data significantly different than the data provided. by the census.
- Local data only partially covering the whole country.
- Static data.



Left, 2015 estimates of population density of a coastal region in Kenya from CIESIN's Gridded Population of the World, version 4 (GPWv4), which is based on census data. Right, new Facebook estimates of population density in the same coastal region in Kenya. This allocation, which is derived from processing of third party satellite imagery and incorporates GPWv4, provides a higher resolution map of population distribution.

d) Model 2



Different options for creating a population map

Choropleth maps

- A total number is assigned to each polygon (census blocks if available or districts/regions)



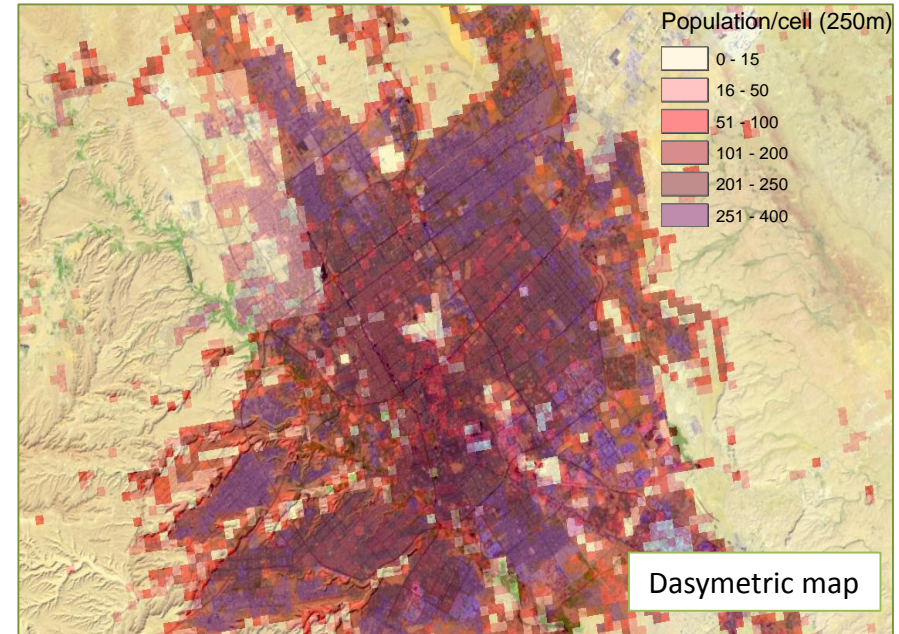
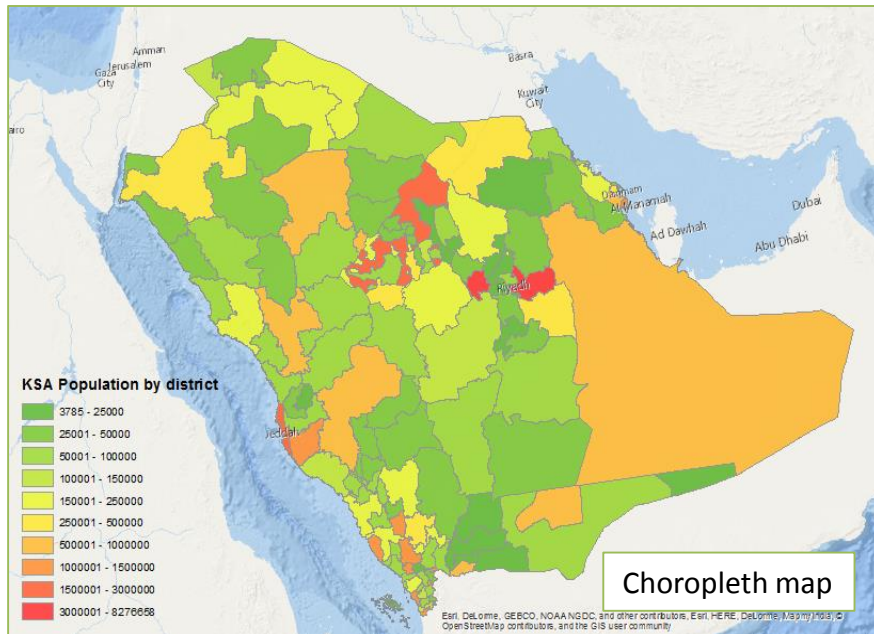
Isopleth maps

- A total number is assigned to each polygon (census blocks if available or districts/regions)



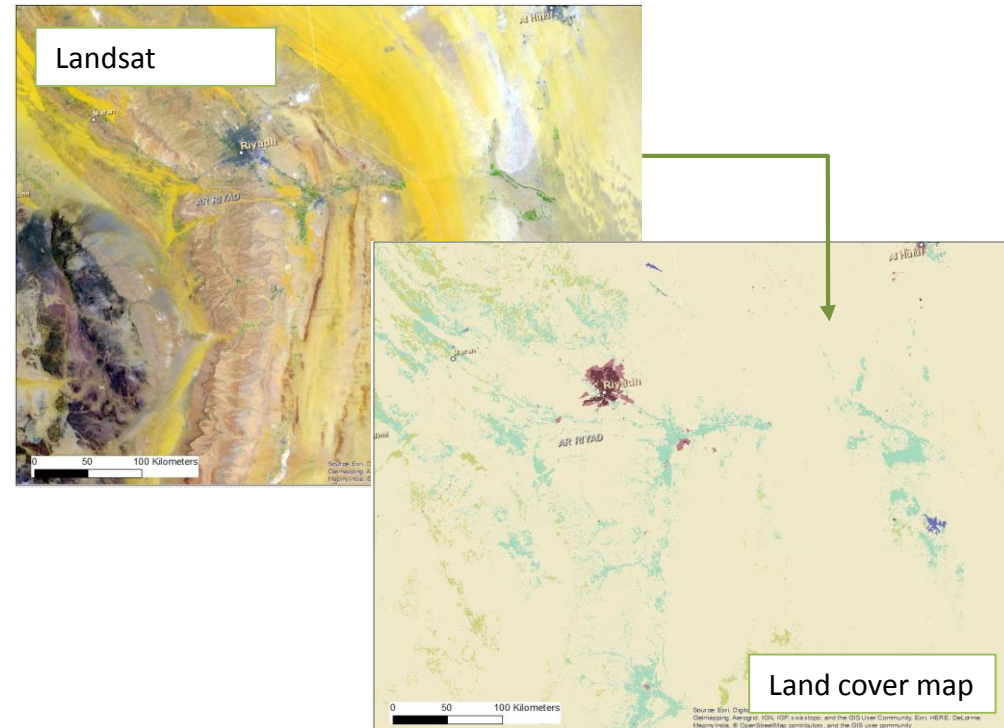
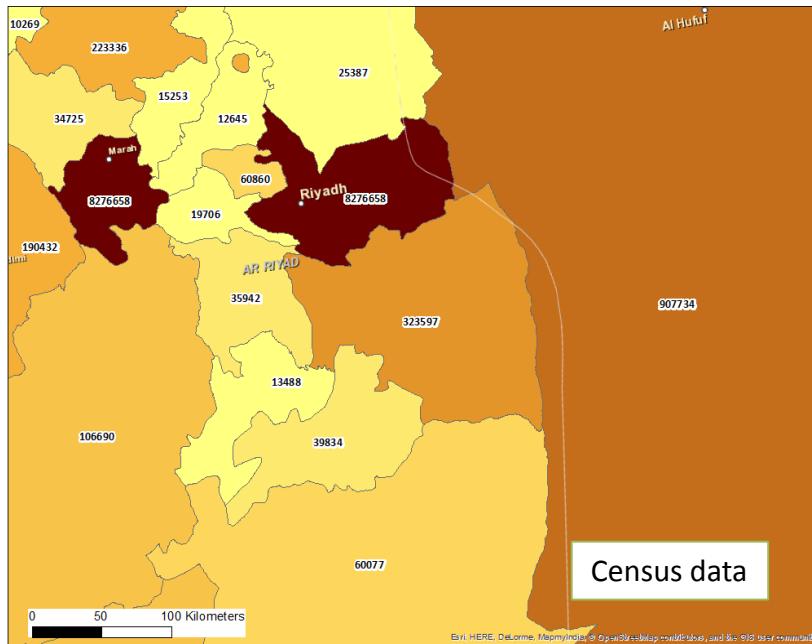
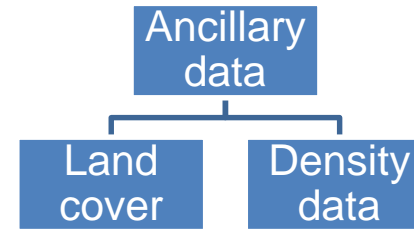
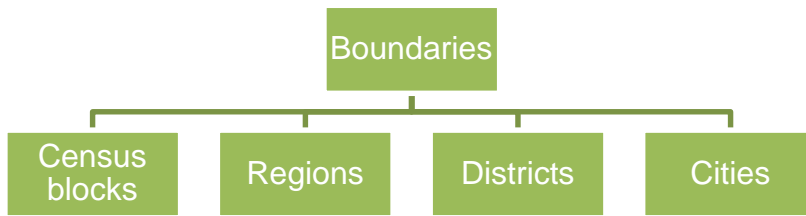
Dasymetric map

- Interpolation of data where ancillary information is used ("intelligent" dasymetric mapping)

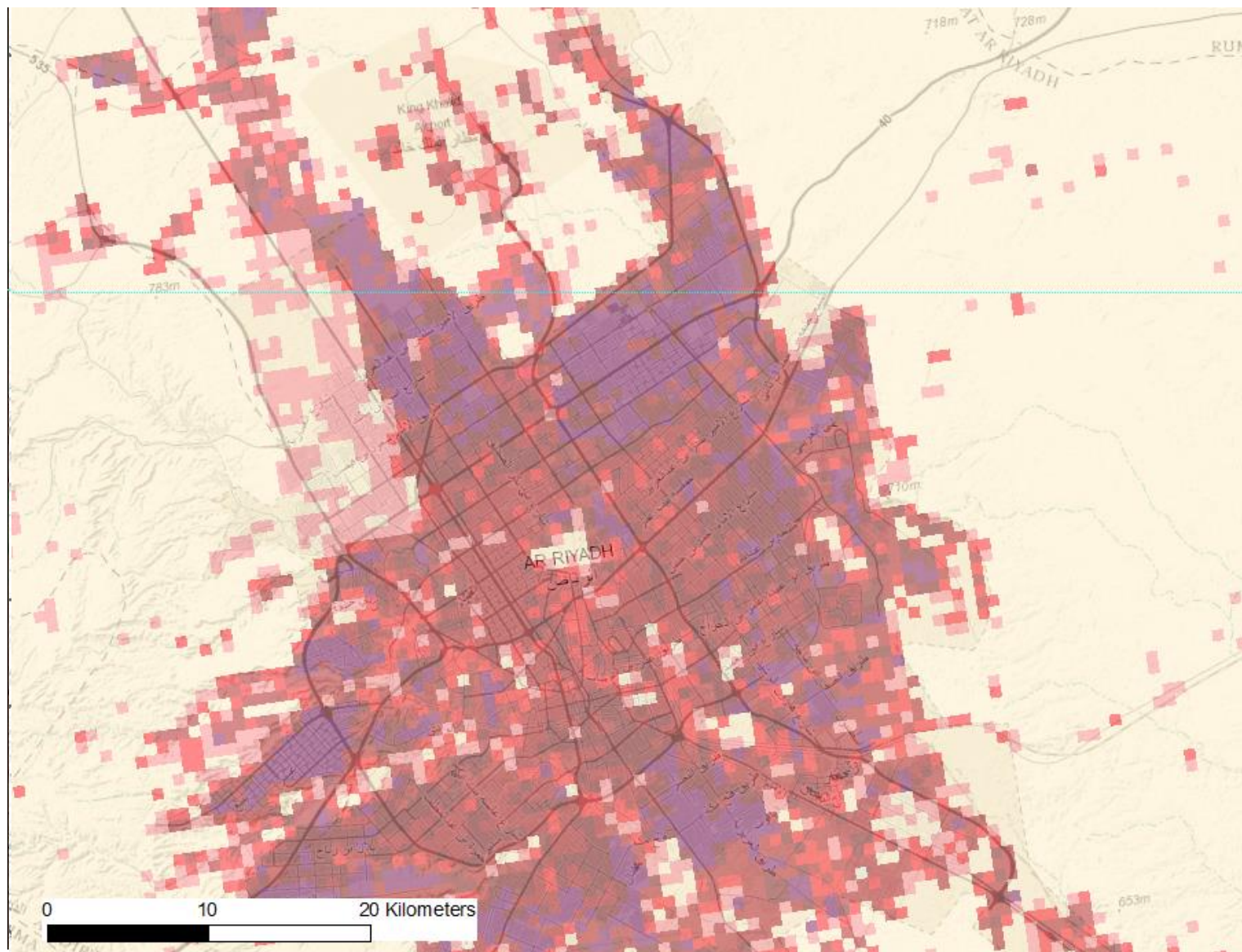


Dasymetric map

Dasymetric mapping is a geospatial technique that uses additional information types to more accurately distribute data that has been assigned to arbitrary boundaries.



Dasymetric map workflow



Satellite images



Land cover



Density map



Census data



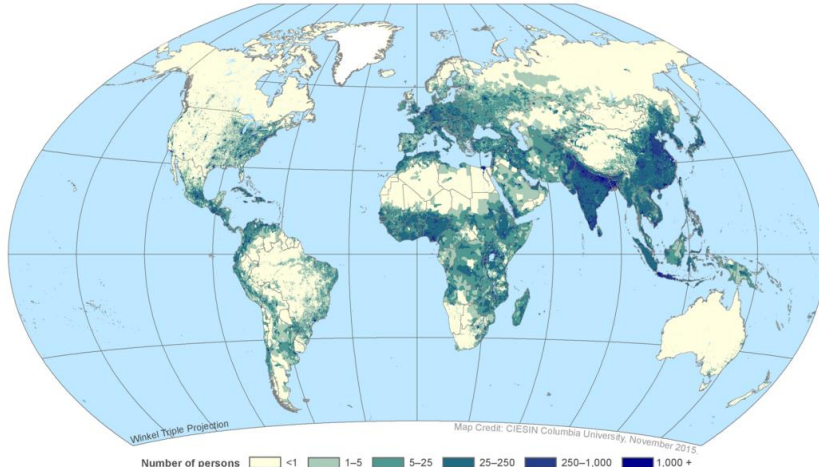
Population map

Ancillary data

- WorldLand cover BaseVue 2013 and World Land Cover ESA 2010
- Landsat 8
- Global Total Population CIESIN, ESRI World Population Estimate, Oak Ridge LandScan™.

UN-Adjusted Population Count, 2015: Global

Gridded Population of the World, Version 4 (GPWv4)



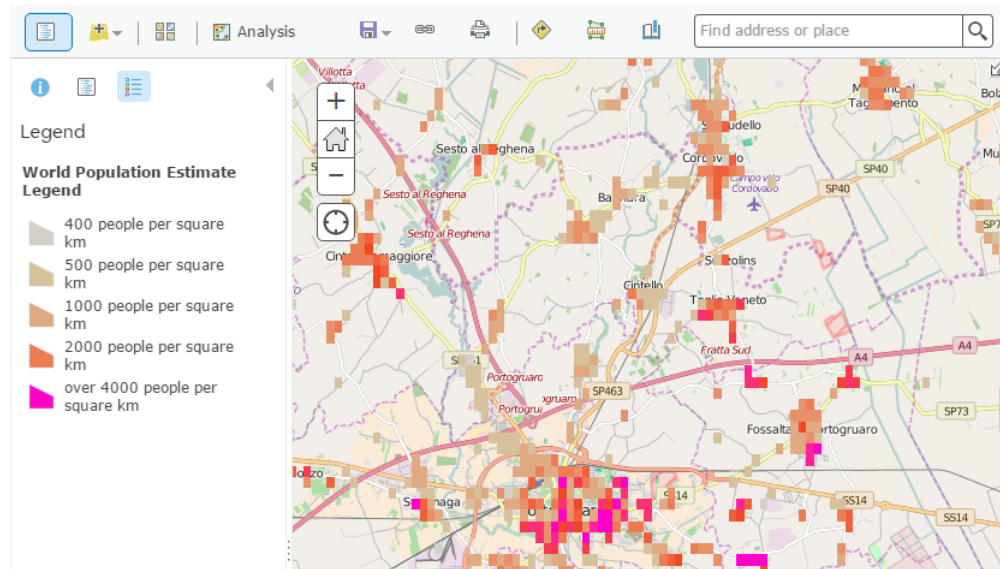
Gridded Population of the World, Version 4 (GPWv4) Population Count Adjusted to Match 2015 Revision of UN WPP Country Totals consists of estimates of human population consistent with national censuses and population registers with respect to relative spatial distribution, but adjusted to match the 2015 Revision of UN World Population Prospects country totals for the years 2000, 2005, 2010, 2015, and 2020. A proportional allocation gridding algorithm, utilizing approximately 12.5 million national and sub-national administrative units, is used to assign population values to 30 arc-second (~1 km) grid cells. The grids contain estimates of the number of persons per grid cell.

Data Source: Center for International Earth Science Information Network - CIESIN - Columbia University, 2015. Gridded Population of the World, Version 4 (GPWv4): Population Count Adjusted to Match 2015 Revision of UN WPP Country Totals. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). <http://dx.doi.org/10.7927/H4PR75X1>.

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Home ▾ World Population Estimate

New Map ▾ Michele ▾

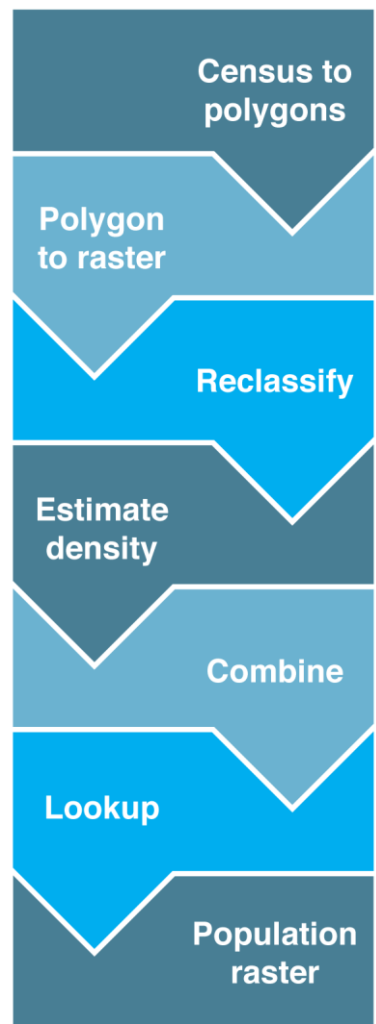
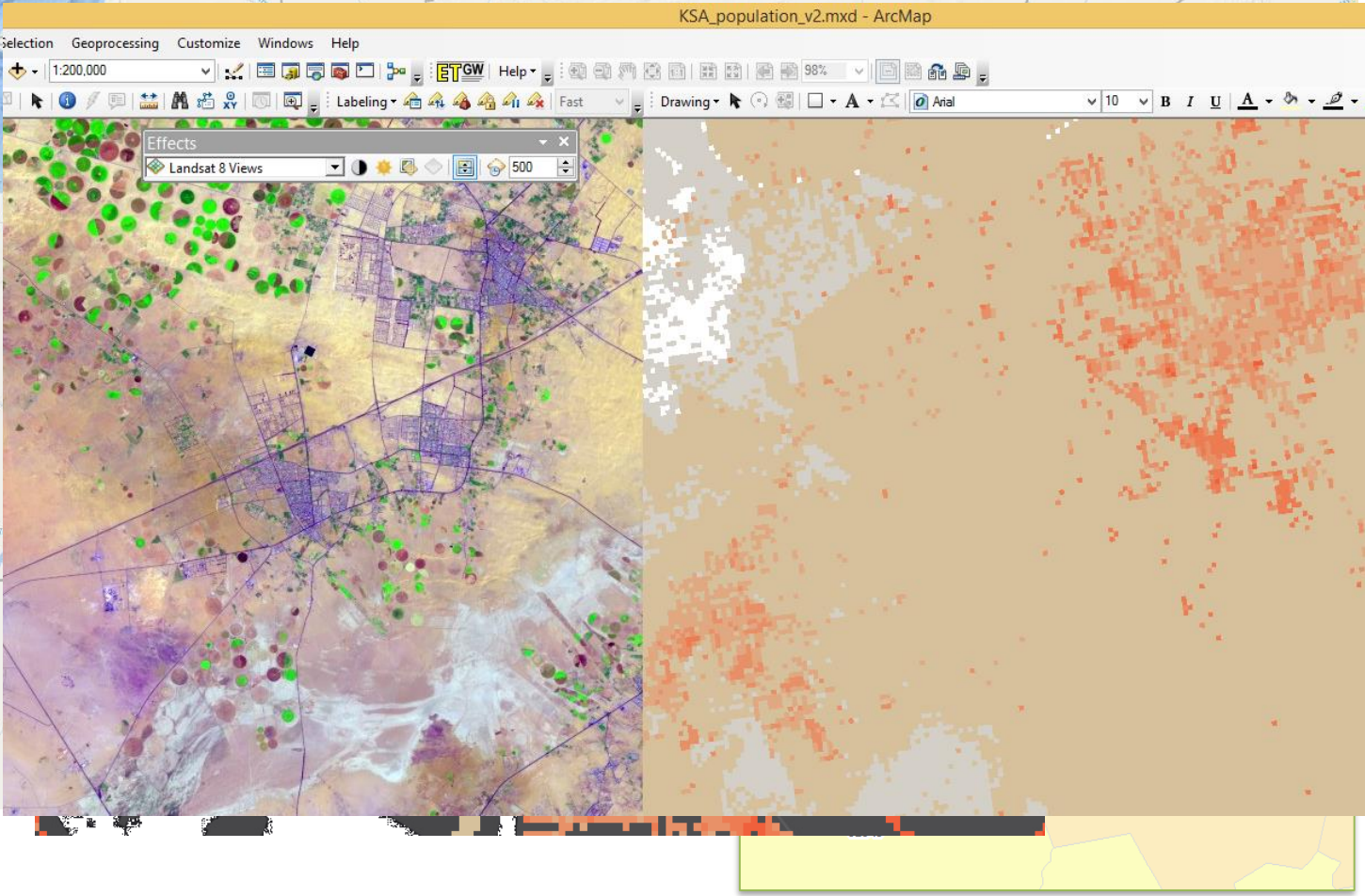


This world-wide dynamic image service provides access to Landsat 8 Operational Land Imager (OLI) scenes at 30m. Landsat 8 collects new multispectral scenes for each location on Earth every 16 days, assuming limited cloud coverage. Newest and near cloud-free scenes are displayed by default on top. Attributes include acquisition date and estimated cloud cover percentage. Most scenes collected since 1st January 2015 are included as well as approximately 5 scenes for each path/row from 2013 and 2014. The service provides access to all multispectral OLI bands as follows:

spectral analysis of consistently
orthorectified Landsat Thematic Mapper (TM) imagery.

Estimate the expected population density in the different land use classes according to the census data. Create the population raster using several iterations the dasymetric calculation.

THE POPULATION RASTER



The interpolation model is derived by the EnviroAtlas model published by EPA and (Mennis, J. and Hultgren, T., 2006. Intelligent dasymetric mapping and its application to areal interpolation. Cartography and Geographic Information Science, 33(3): 179-194.)

THE MODEL

A table listing the population density classes is created. Optionally the expected density values can be manually inserted, including the classes with density = 0.

For each census polygon, calculate the number of populated and not populated cells.

For each census polygon the model selects a representative population density class, according to the parameters (minimum number of cells, overlapping cells).

The population density for the classes are calculated: $\text{Pop density} = \frac{\text{sum of pop of polygons represented by the same class}}{\text{sum of populated cells}}$.

For each class, calculate a first population estimate multiplying the population density by the number of cells.

For each census polygon sum all of the population estimates and compare the results to the census population, and distribute the remaining population by area to the remaining classes.

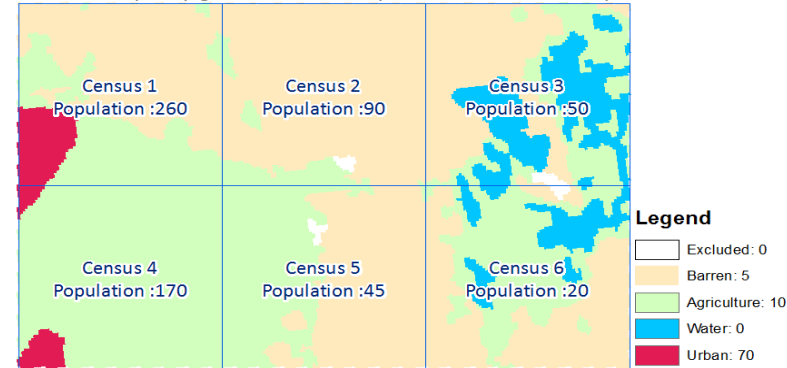
Recalculate the population estimate by multiplying all population densities by the number of cells.

Recalculate population densities for all of the unselected classes = $\frac{\text{sum of estimated population for the class}}{\text{total class number of cells}}$.

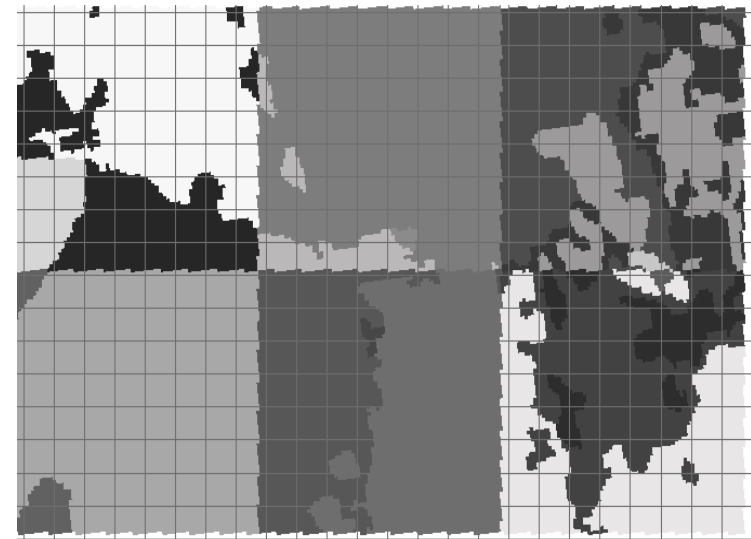
Calculate a correction ratio = $\frac{\text{population estimate}}{\text{total estimated population for the specified polygon}}$.

Calculate the final population estimate as the initial population of the polygon multiplied by the correction ratio.

Census polygons and Population density classes

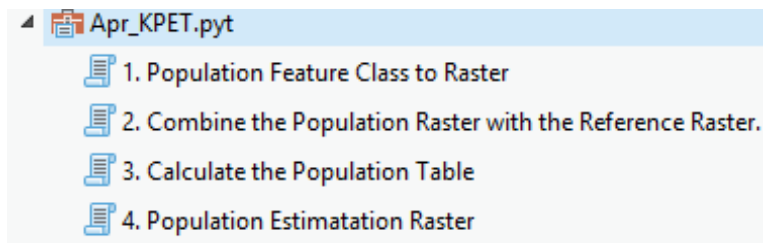


Population units and cells grid



The Estimate Population GIS toolbox

- The workflow was saved as a Python toolbox.
- The input parameters of the main tool are:
 - The population targets layer (Census data)
 - The land cover raster
 - The expected population by cell in each land cover class
- Additional tools:
 - Create a time aware layer.
 - Quality check and estimate the accuracy.



1. Population Feature Class to Raster

Parameters | Environments

- * Population feature class
- * Population Field
- Population ID Field
- * Reference Raster (RS_REF)
- * Output: Population Raster (RS_POP_1)
- * Output: Population working Table (TBL_POP_1)

2. Combine the Population Raster with the Reference Raster

Parameters | Environments

- * Population raster (RS_POP_1)
- * Reference Raster (RS_REF)
- * Output: Combined Population classes Raster (RS_COMB_2)
- * Output: Combined Population classes Table (TBL_COMB_2)

3. Calculate the Population Table

Parameters | Environments

- * Population working Table created by the tool 1 (TBL_POP_1)
- * Population values Field (from TBL_POP_1)
- Area or cell count Field (Count from TBL_POP_1)
- * Combined Population classes Table created by the tool 2 (TBL_COMB_2)
- Population ID Field (the name of the Population Raster RS_POP_1 from TBL_COMB_2)
- * Population class field (the name of the Reference Raster from TBL_COMB_2)
- Cell count field for each combination (Count from TBL_COMB_2)
- Minimum number of cells needed to represent a class: 3

The Python tools

Python toolbox:

- 1) Population data to raster.
- 2) Combine population raster with population density classes raster.
- 3) Recalculate the density according to expected values.
- 4) Create the raster using the Lookup function.

```
def updateMessages(self, parameters):
    """Modify the messages created by internal validation for each tool
    parameter. This method is called after internal validation."""
    return

def execute(self, parameters, messages):
    """The source code of the tool."""
    try:
        AddPrintMessage("Beginning the population polygon to raster conversion...",0)

        popFeatures = parameters[0].valueAsText
        popField = parameters[1].valueAsText
        popIDField = parameters[2].valueAsText
        refRaster = parameters[3].valueAsText

        popRaster = parameters[4].valueAsText
        tblPop = parameters[5].valueAsText

        cellAssignmentType = "CELL_CENTER"
```

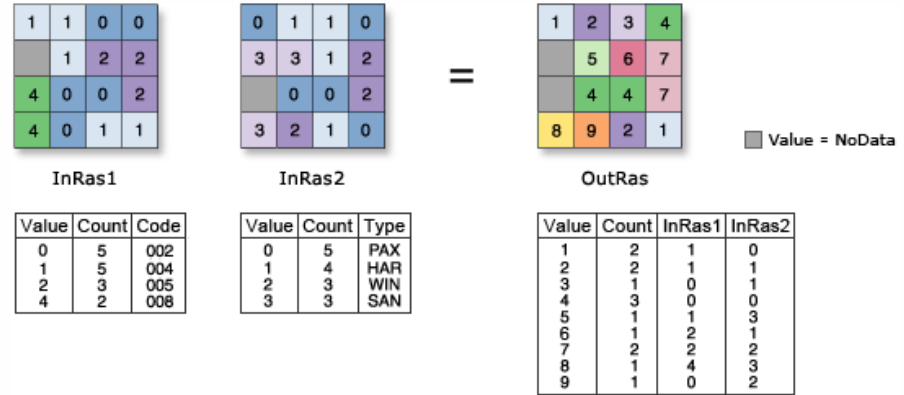
```
class CreatePopulationRaster(object):

def __init__(self):
    """Define the tool (tool name is the name of the class)."""
    self.label = "1. Population Feature Class to Raster"
    self.description = "Convert a polygon Population feature class to raster"
    self.canRunInBackground = True

def getParameterInfo(self):
    """Define parameter definitions"""

    popFeatures = arcpy.Parameter(
        displayName="Population feature class",
        name="in_features",
        datatype="GPFeatureLayer",
        parameterType="Required",
        direction="Input")
    popFeatures.filter.list = ["Polygon"]
```

Combine



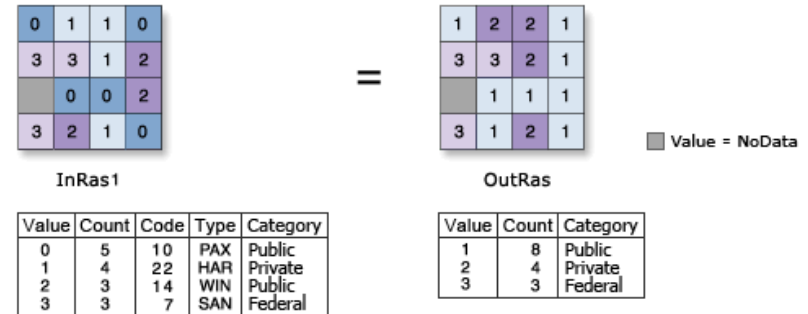
OutRas = Combine([InRas1, InRas2])

Lookup (Spatial Analyst)

Summary

Creates a new raster by looking up values found in another field in the table of the input raster.

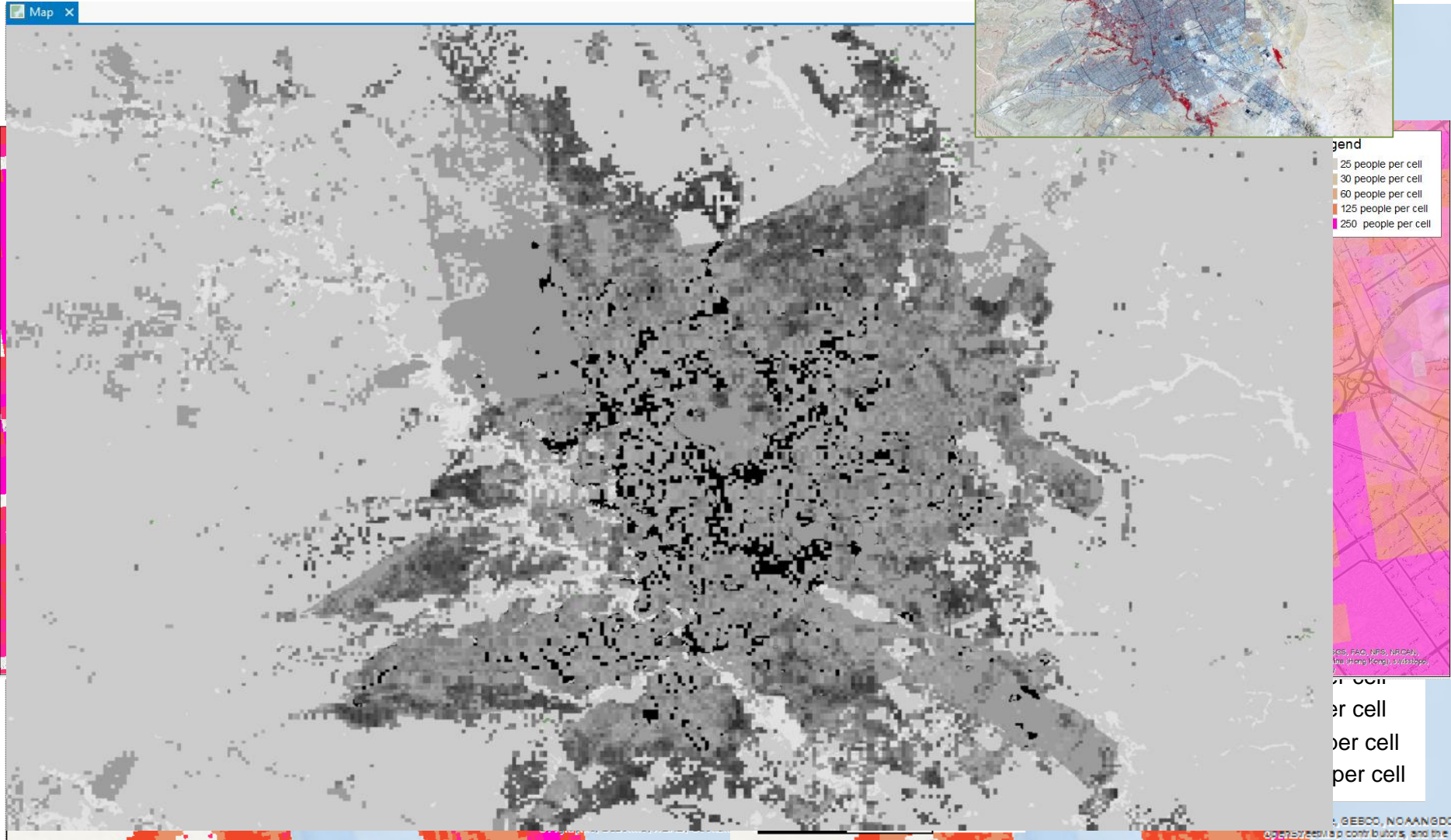
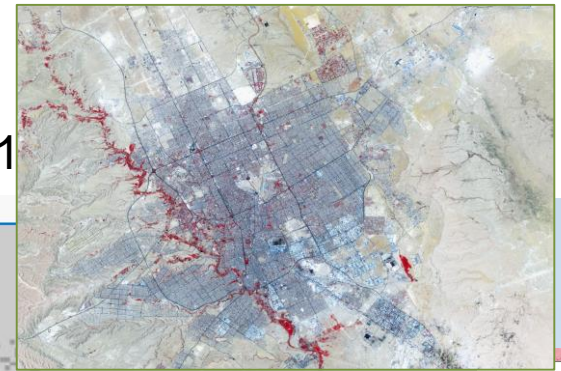
Illustration



Output

Dammam 2016, 25 people per cell
Dammam 2025, 30 people per cell
Riyadh 2016, 30 people per cell
Riyadh 2050, 250 people per cell

Dammam 2016

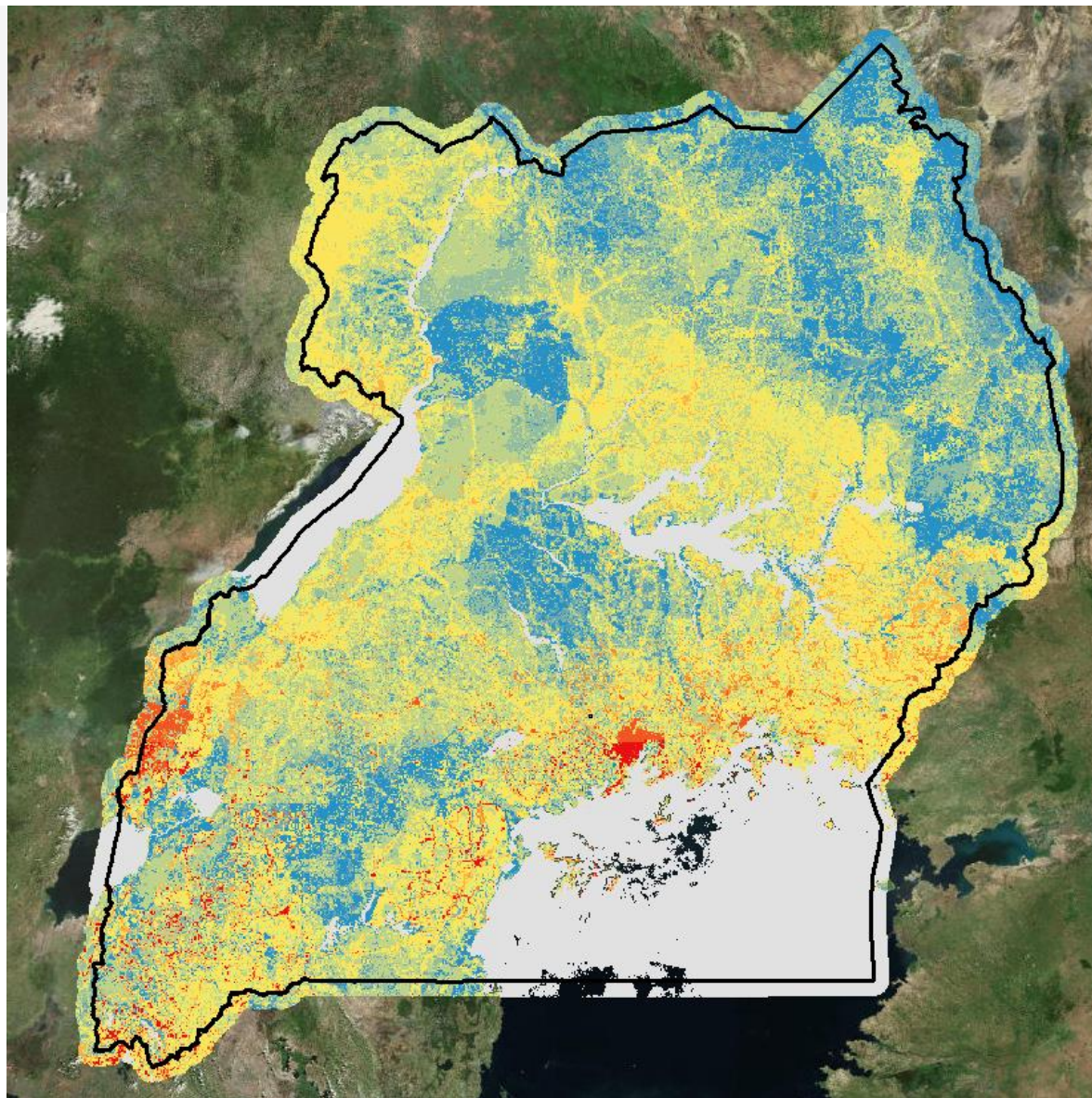
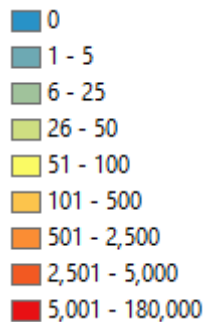


Population clock map: Uganda

Uganda Population clock

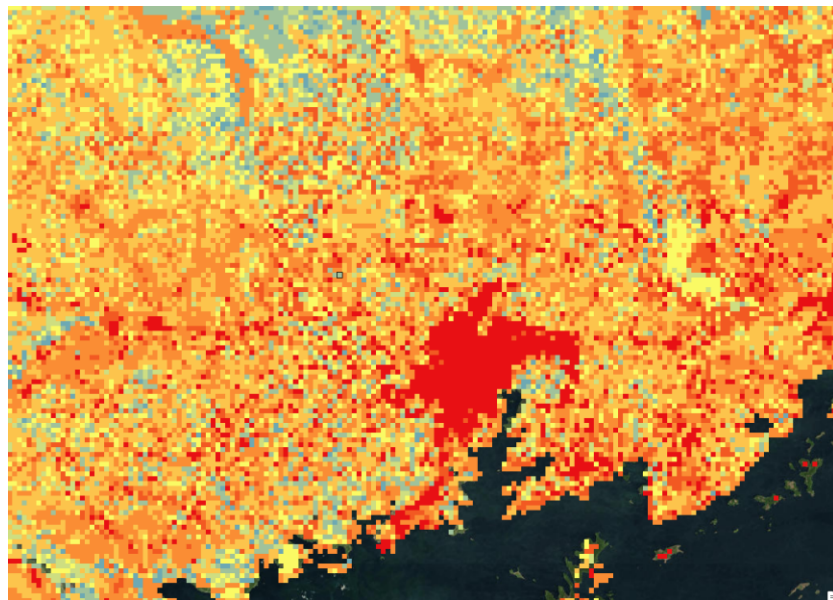
22-05-2016 13:47:09

40 149 386 Current population

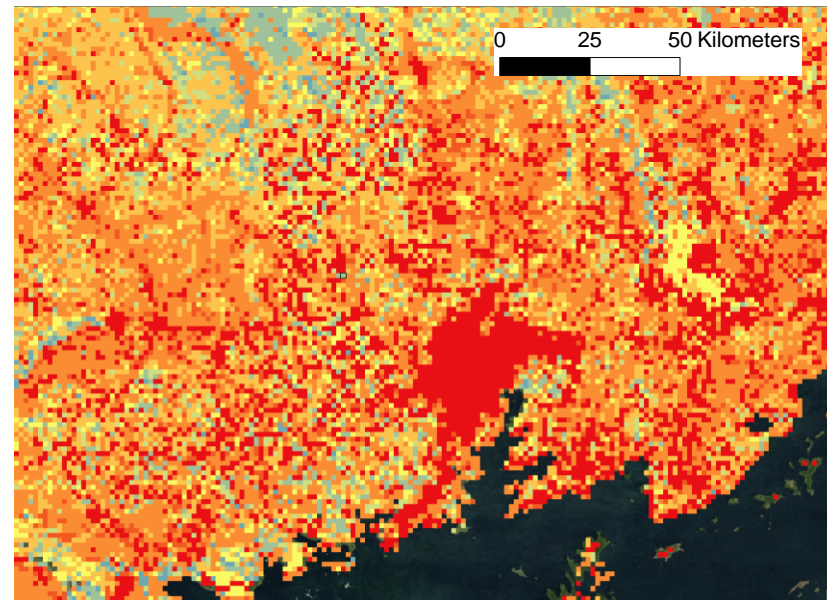


Data sources:
UN Population Division
<http://countrymeters.info/>

Population clock map: Kampala



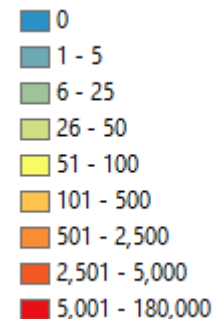
2020: 45 856 367



2025: 53 496 737

Uganda Population Forecast

Year	Population	Yearly % Change	Yearly Change	Migrants (net)	Median Age	Fertility Rate	Density (P/Km ²)	Urban Pop %	Urban Population	Country's Share of World Pop	World Population	Uganda Global Rank
2020	45,856,367	3.27 %	1,364,797	-30,000	17	5.46	230	18.4 %	8,423,333	0.62 %	7,758,156,792	31
2025	53,496,737	3.13 %	1,528,074	-30,000	17	5.02	268	20.4 %	10,889,248	0.69 %	8,141,661,007	28
2030	61,929,165	2.97 %	1,686,486	-30,000	18	4.62	310	22.5 %	13,951,972	0.76 %	8,500,766,052	25
2035	71,101,769	2.8 %	1,834,521	-30,000	19	4.25	356	24.9 %	17,680,154	0.84 %	8,838,907,877	23
2040	80,903,527	2.62 %	1,960,352	-30,000	20	3.92	405	27.3 %	22,116,139	0.92 %	9,157,233,976	20
2045	91,190,212	2.42 %	2,057,337	-30,000	21	3.62	456	30 %	27,334,913	1 %	9,453,891,780	20
2050	101,872,981	2.24 %	2,136,554	-30,000	22	3.37	510	32.8 %	33,366,741	1.08 %	9,725,147,994	18



Source: **Worldometers** (www.Worldometers.info)

Elaboration of data by United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2015 Revision, (Medium-fertility variant).

Conclusions

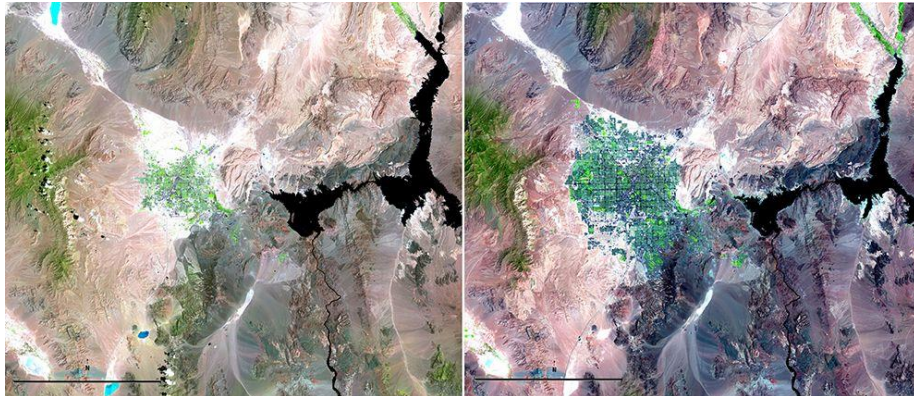
Results:

- A Python ArcGIS Pro toolbox that assists the preparation of the data and performs the calculation to generate a raster representing a scenario of the distribution of human population within an area of interest.

Next steps:

- Create and test validation procedures.
- Create procedures to extract population density classes from satellite images.
- Calibration of the model for different areas,
- Publish the model on ArcGIS for Server to allow the creation and download of the population raster.
- Create land use scenarios and urban sprawl predictions layer.

Las Vegas 1984 and 2007, Image courtesy USGS



San Antonio Sprawl

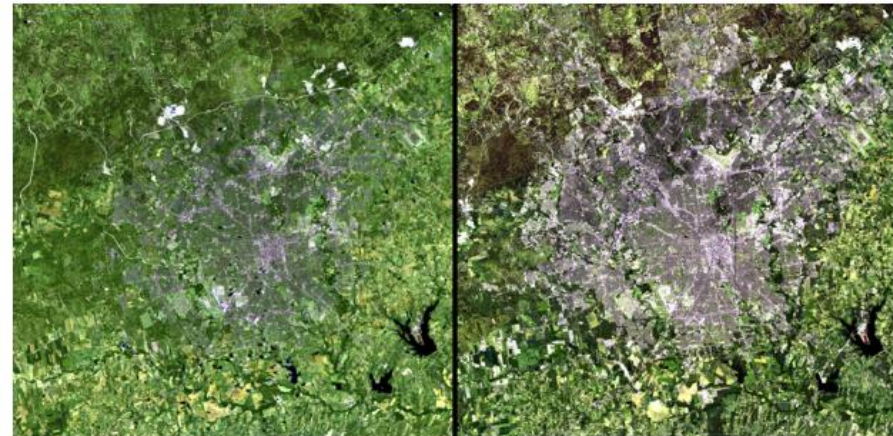


Photo dates (L-R): June 16, 1991 and June 4, 2010

PHOTO BY NASA

Thank you

michele.vittorio@kapsarc.org