Modeling DEGURBA

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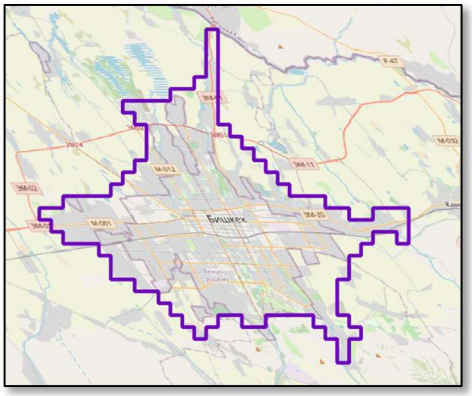
This guide provides methodology for modeling DEGURBA (Degree of Urbanisation) to support the estimation of SDG indicator 11.3.1, "Ratio of land consumption rate to population growth rate."

The guide outlines modelling DEGURBA with QGIS for Bishkek calculated using WorldPop population data for 2020.



A picture of the DEGURBA urban area of Bishkek calculated using WorldPop population data for 2020.

While this guide uses Kyrgyzstan as a case study, the outlined workflows and approaches are designed to be universally applicable, enabling National Statistics Offices (NSOs) and GIS professionals worldwide to integrate statistical and geospatial information effectively. Adopting modern geospatial technology is crucial for advancing statistical methods, particularly for SDG indicator estimation.

Background

This guide offers streamlined workflows for processing existing DEGURBA data and provides a clear methodology for generating proprietary DEGURBA urban areas using open global and national data sources.

Understanding DEGURBA

According to UN-GGIM, "Functional areas/administrative boundaries" is one of the Global Fundamental Geospatial Data Themes used in the estimation process of Sustainable Development Goal (SDG) indicators. For example, modeling SDG indicator 11.3.1, "Ratio of Land Consumption Rate (LCR) to Population Growth Rate (PGR)," requires functional areas (particularly urban areas) as analytical geographies.

The closest traditional concept for analytical geography might be city administrative boundaries. However, for SDG 11.3.1, analytical geography is defined as a specific area within which both population growth rate and land consumption rate are calculated.

Here, the DEGURBA (Degree of Urbanisation) methodology, recommended by the UN Statistical Commission, is deployed as a primary approach to delineate urban territories. DEGURBA classifies the territory of a country along an urban-rural continuum. This approach aligns with the SDG 11.3.1 global metadata, as offered by UN-Habitat. **The main rationale for using DEGURBA classification is that the actual urban areas of a city are not necessarily captured by existing administrative borders.** It is crucial to understand DEGURBA classification for both the adequate use of existing DEGURBA open datasets and for deriving new DEGURBA delineations based on a variety of available population data.

About DEGURBA

The international DEGURBA classification categorizes areas based on their level of urbanization. The methodology involves assessing indicators such as population density, infrastructure development, and land use patterns to determine the degree of urbanization of a specific area. This approach typically involves collecting data from satellite imagery, census data, and land use maps to analyze and classify areas into different urbanization categories, such as rural, peri-urban, or urban. For detailed information, it is recommended to visit the official resources of the European Commission and UN-Habitat.

Governmental agencies involved in SDG estimation can benefit from the DEGURBA methodology as it consistently identifies and compares urban and rural areas across countries. It classifies local areas into categories such as cities, towns and semi-dense areas, and rural areas based on population size and density using gridded population data.

In addition to SDG estimation, DEGURBA may be used as follows:

Use Case	Description
Harmonized classification	Standard urban-rural definitions across countries.
Policy targeting	Informs urban/rural-specific policy and resource allocation.

Monitoring & evaluation	Tracks urbanization and regional development.
Data disaggregation	Improves granularity in statistics.
International comparability	Enables cross-country benchmarking.
Environmental planning	Supports climate and land use strategies.
Census/survey support	Aids sample design and enumeration.
GIS/EO integration	Supports advanced spatial analytics.

The Global Human Settlement Layer (GHSL) web portal, part of the European Copernicus Space program, offers downloadable DEGURBA delimitation datasets. It also provides tools and tutorial materials on the steps to produce your own DEGURBA dataset using open global and national data.

System Requirements

To successfully complete this step-by-step guide, specialists are expected to have operational knowledge of common operating systems (e.g., Windows), a broad understanding of core geospatial concepts, and experience working with databases. The guide primarily uses QGIS, a powerful open-source Geographic Information System, for data manipulation.

The guide shows the use of Quantum Geographic Information System (QGIS) to model the functional areas and administrative areas described by DEGURBA. Please see a previous ESCAP guide which shows how to download QGIS.

Data processing and analytics are significantly influenced by hardware performance; therefore, it is recommended to utilize a machine with the following specifications: Intel i5 or i7 processor (or equivalent), a minimum of 8 GB RAM (16 GB recommended), and a dedicated GPU. Sufficient computer storage capacity is also needed to work with DEGURBA data and instruments (specifically GHS_DUG and Matlab components) offered by the GHSL Web Portal.

Input Geodata Sources

Please use the table below for examples of the input geodata sources. Users should identify equivalent open national or global datasets for their specific region.

The guide outlines methodology for modeling DEGURBA[1] urban areas used in estimation of SDG indicator 11.3.1 *"Ratio of land consumption rate to population growth rate"*.

The guide explains briefly the use of open-source software, namely Quantum Geographic Information System (QGIS) to model the function areas and administrative areas described by DEGURBA in the annex. Please see a previous ESCAP guide which shows how to download QGIS.

The guide is designed to support the efforts of National Statistics Offices (NSOs) in integrating statistical and geospatial information. By adopting modern geospatial technologies, statistical methods can be significantly enhanced – especially in the context of SDG indicator estimation. While Kyrgyzstan is used as a case study for modeling purposes, the methodology is applicable to any country with access to global and national data sources.

To successfully complete this step-by-step guide, users should have operational knowledge of the internet and Windows, a broad understanding of core geospatial concepts, and experience working with databases.

As data processing and analysis are highly dependent on hardware capabilities, it is recommended to use a computer with at least an Intel i5 or i7 processor, a minimum of 8 GB RAM (16 GB recommended), and a dedicated GPU. Additionally, sufficient storage capacity is required to handle DEGURBA data and tools - particularly the GHS_DUG and Matlab components – available through the GHSL Web Portal

The table below shows sources for geodata:

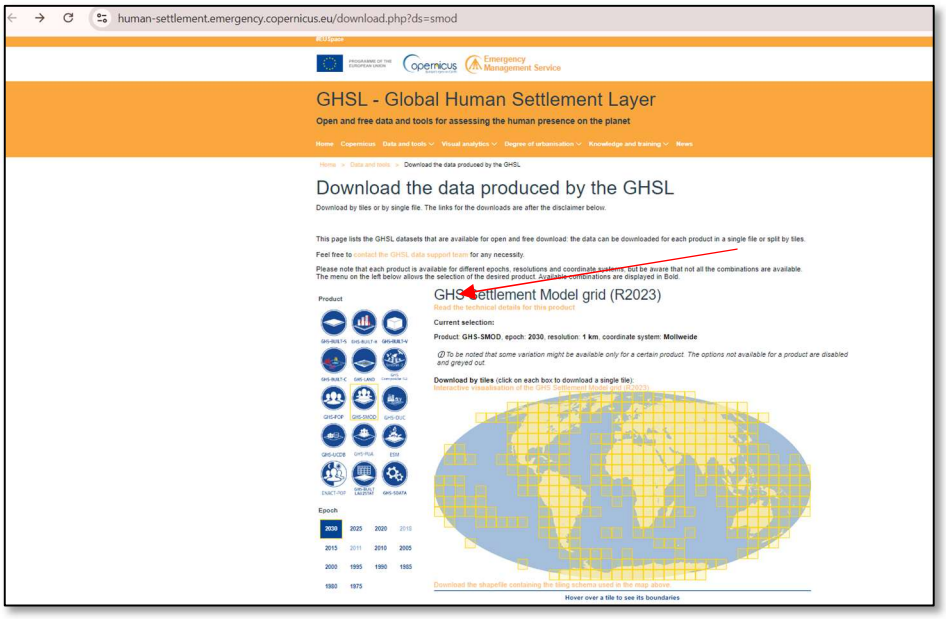
Geodata	Name of geodata	national/open data	Source to download
WorldPop population grid, 2020	kgz_ppp_2020_1km_Aggregated_UNadj.tif	Open	**https://hub.worldpop.org/project/categories?id=3**
Built-up areas for region, source Esri LULC	LULC_2020_region_builtup_final.tif	Open	geospatialSDGs/data/DEGURBA at main · ESCAP-SD/geospatialSDGs

[1] DEGURBA

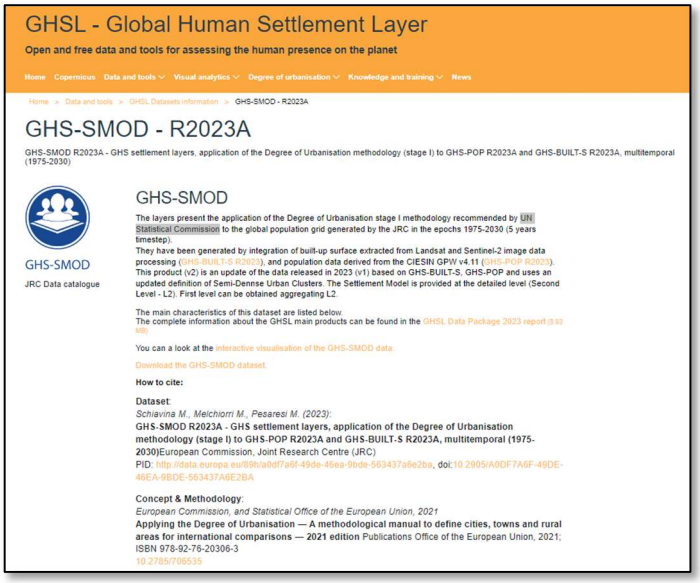
Modelling DEGURBA

STEP 0: Downloading data from GHSL Web Portal existing DEGURBA urban areas based on GHS-Pop population.

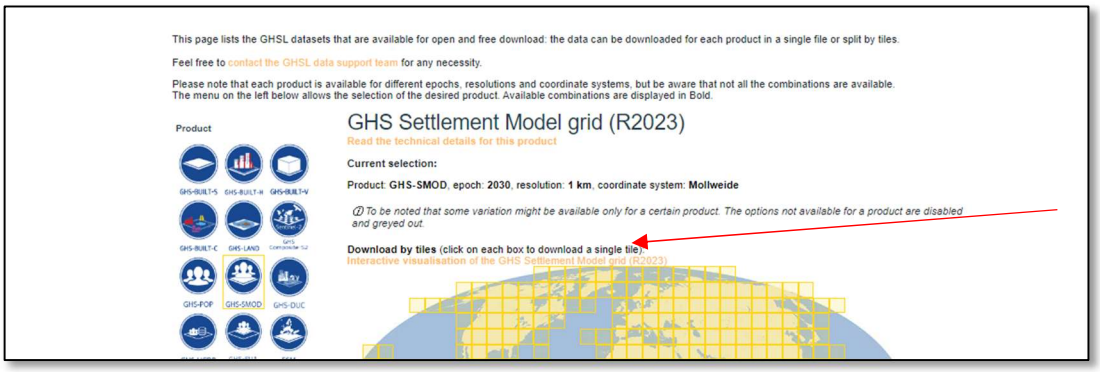
1. Navigate to https://human-settlement.emergency.copernicus.eu/download.php?ds=smod

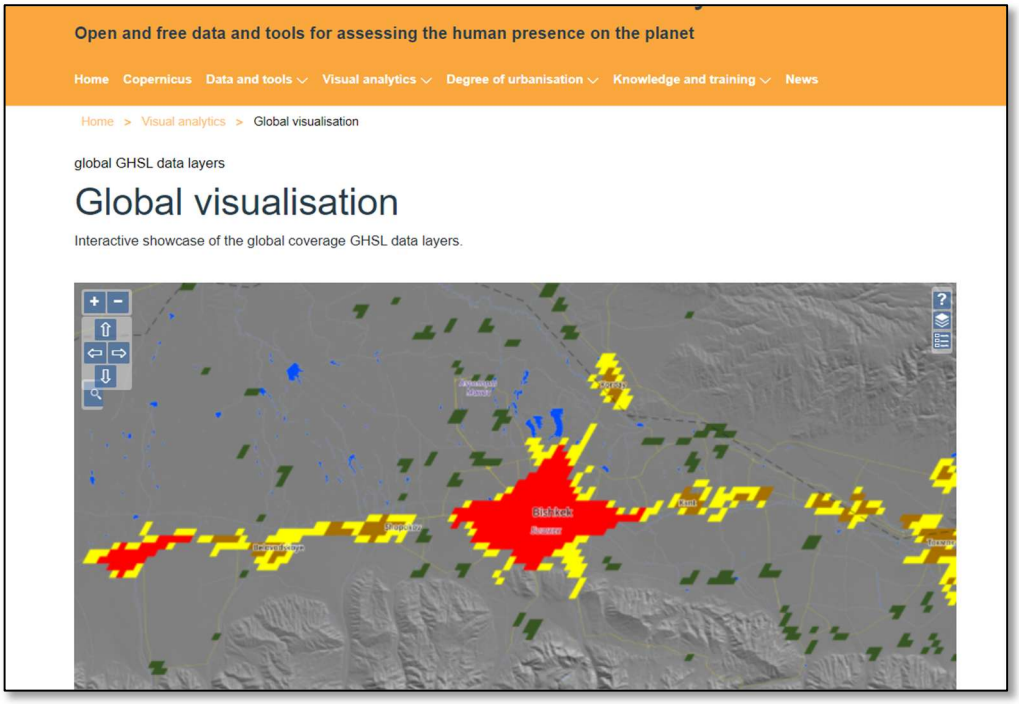


2. Click **“Read the technical details for this product”** link to examine metadata of the DEGURBA dataset.



3. Navigate back to the main page of the GHS Settlement Model grid (R2023) – GHS-SMOD and click on **"Interactive visualisation of the GHS Settlement Model grid (R2023)"** to get DEGURBA urban areas visualized for Bishkek.

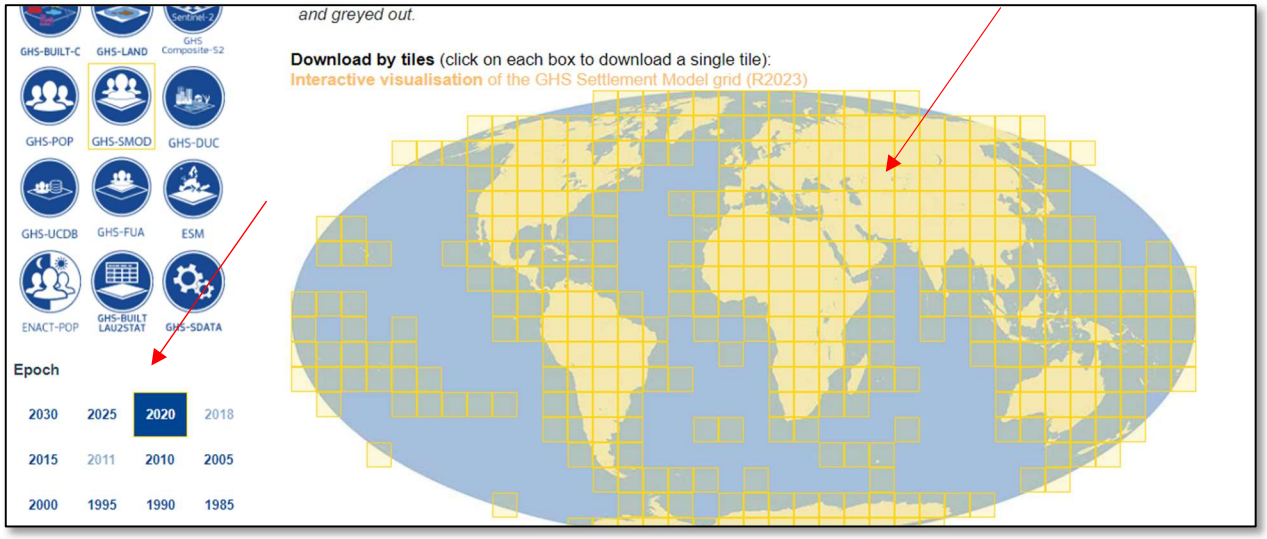




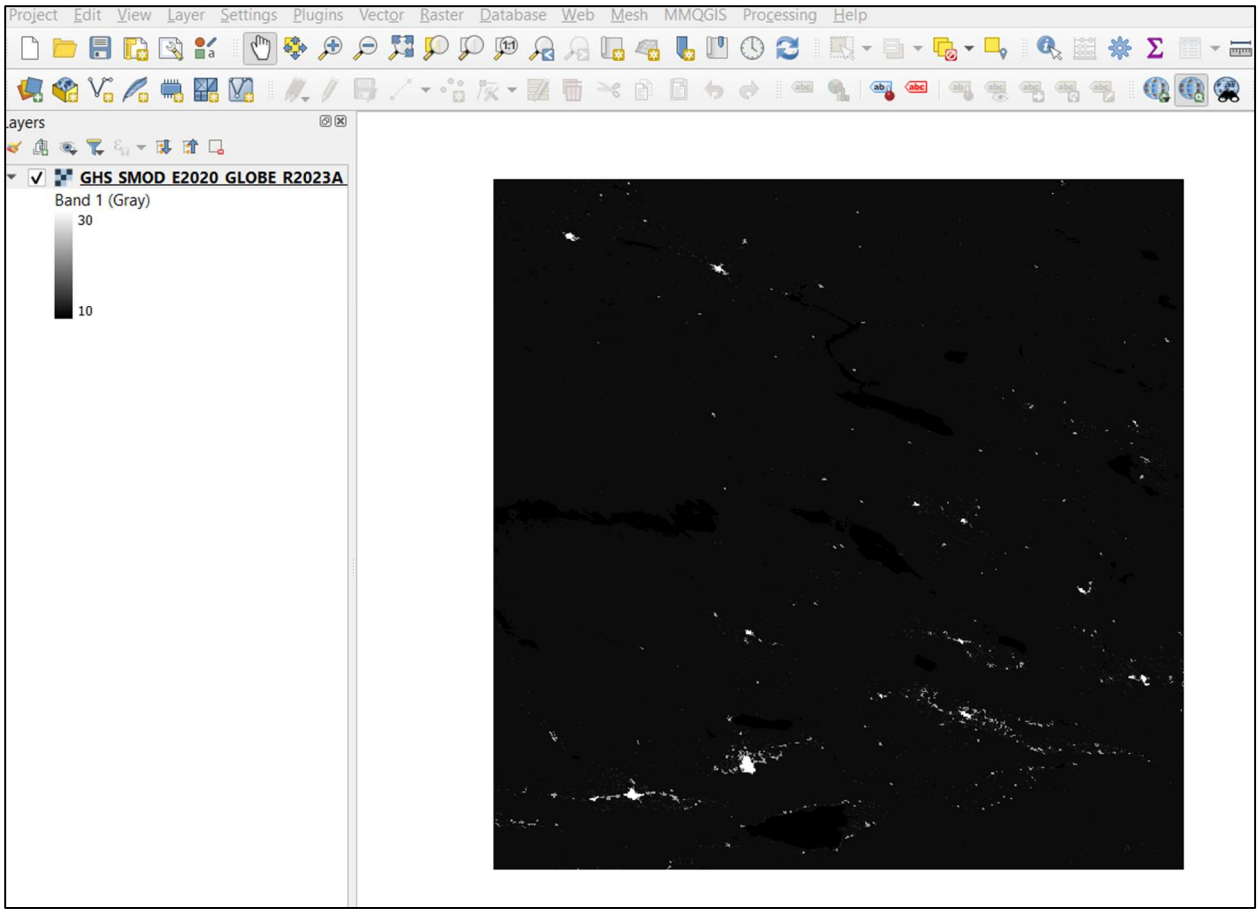
4. Choose Epoch (2020, 1km, Mollweide) and by clicking on respective area on the globe download zipped shapefile for Kyrgyzstan Bishkek area (ex: **GHS_SMOD_E2020_GLOBE_R2023A_54009_1000_V2_0_R4_C25.zip**).

   Please note that R4_C25 represents the tile row 4, column 25

   NOTE: To use DEGURBA for entire Kyrgyzstan download the entire data set by choosing **"Download the global GHS_SMOD_E2020_GLOBE_R2023A_54009_1000_V2_0 dataset in a single file**" option on the page.

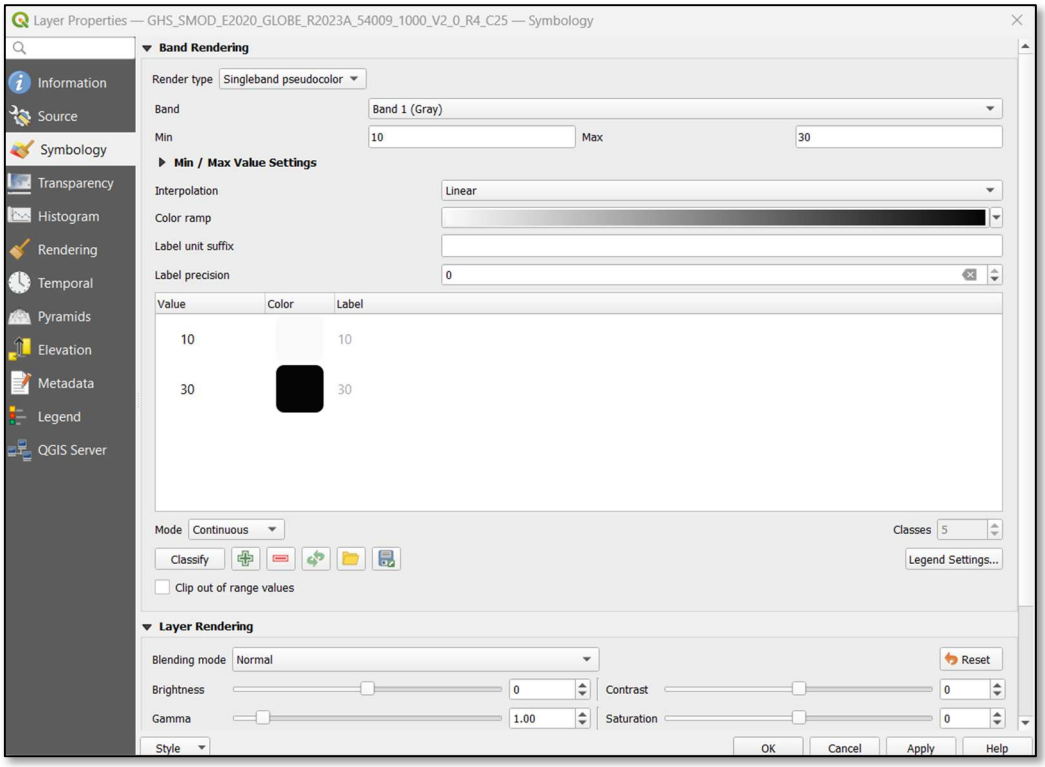


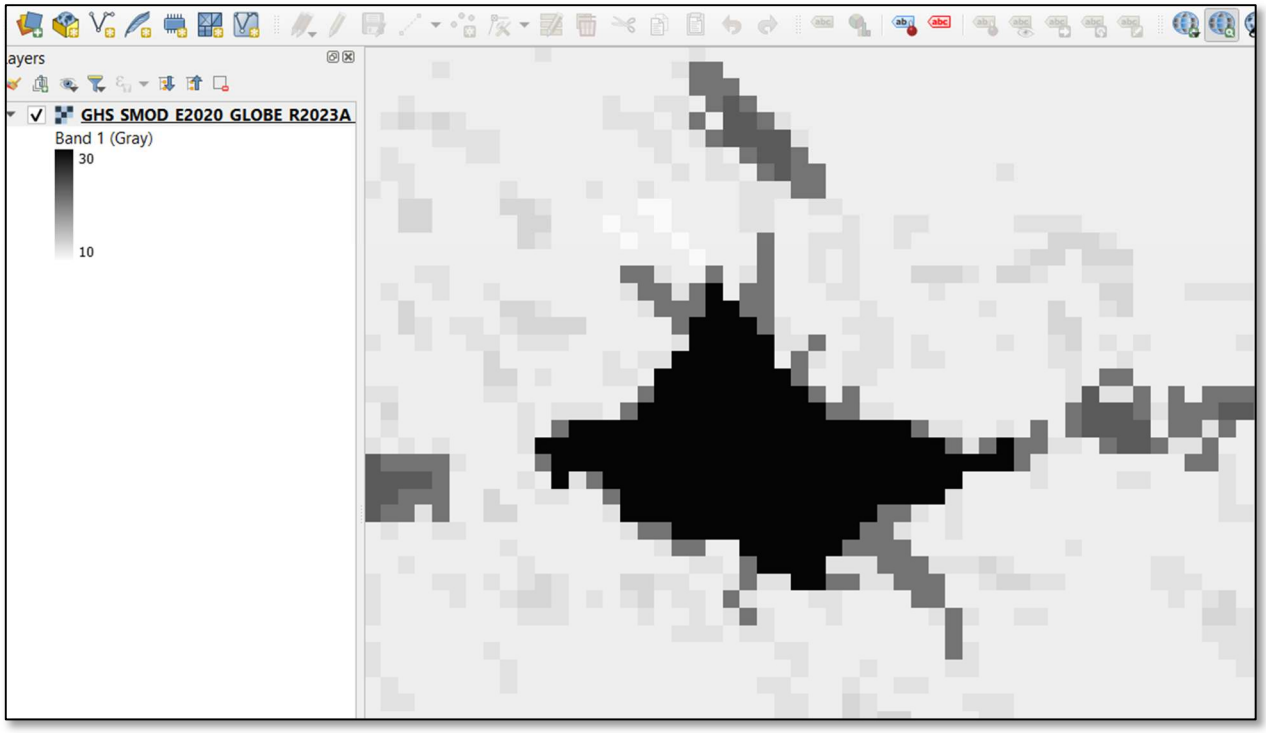
5. Unzip the file to the folder (create new on D:/DEGURBA_GHS) and open the .tif file in a new empty QGIS Project. Save the project as **Degurba_GHS**



6. To better visualize the data in raster Properties (right click) change **Symbology** of the layer (according to the image below)

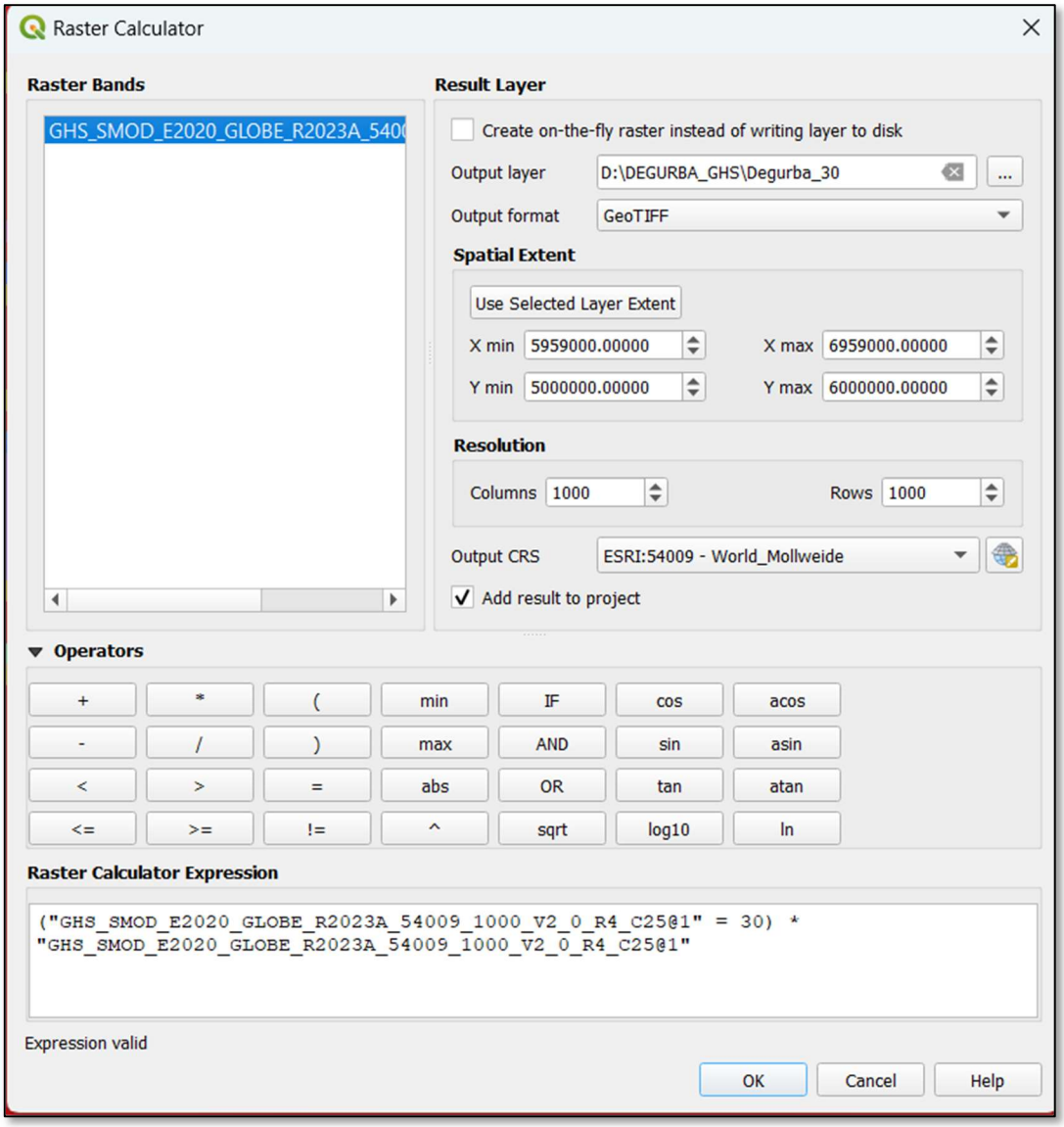
   Right click on the handprint symbol, and ensure that the raster toolbar is on (by ensuring that there is a tick sign next to it)
   If the window does not open, ensure that the “Open the Layer Styling Panel” sign is on


Layer Properties — GHS_SMOD_E2020_GLOBE_R2023A_54009_1000_V2_0_R4_C25 — Symbology
Information
Source
Symbology
Transparency
Histogram
Rendering
Temporal
Pyramids
Elevation
Metadata
Legend
QGIS Server
Band Rendering
Render type
Singleband pseudocolor
Band
Band 1 (Gray)
Min
10
Max
30
Min / Max Value Settings
Interpolation
Linear
Color ramp
Label unit suffix
Label precision
0
Value
Color
Label
10
10
30
30
Mode
Continuous
Classes
5
Classify
Legend Settings...
Clip out of range values
Layer Rendering
Blending mode
Normal
Reset
Brightness
0
Contrast
0
Gamma
1.00
Saturation
0
Style
OK
Cancel
Apply
Help



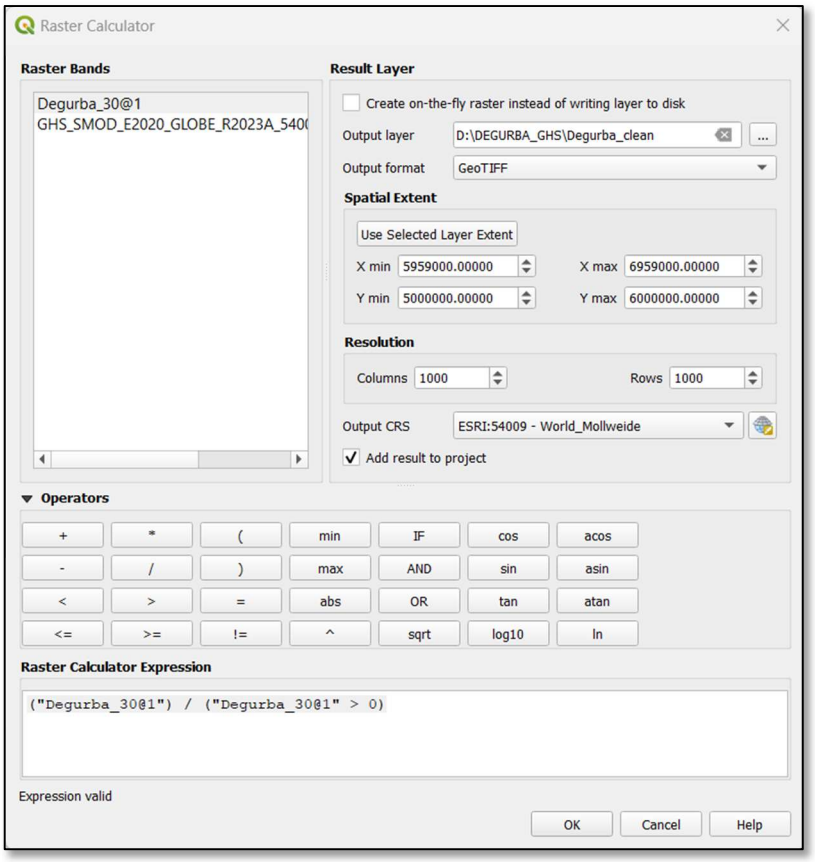
7. Clean the raster by selecting only raster pixel values of 30 (urban centers) and removing 0 values. Launch **Raster > raster calculator** and consecutively run two expressions referenced below:

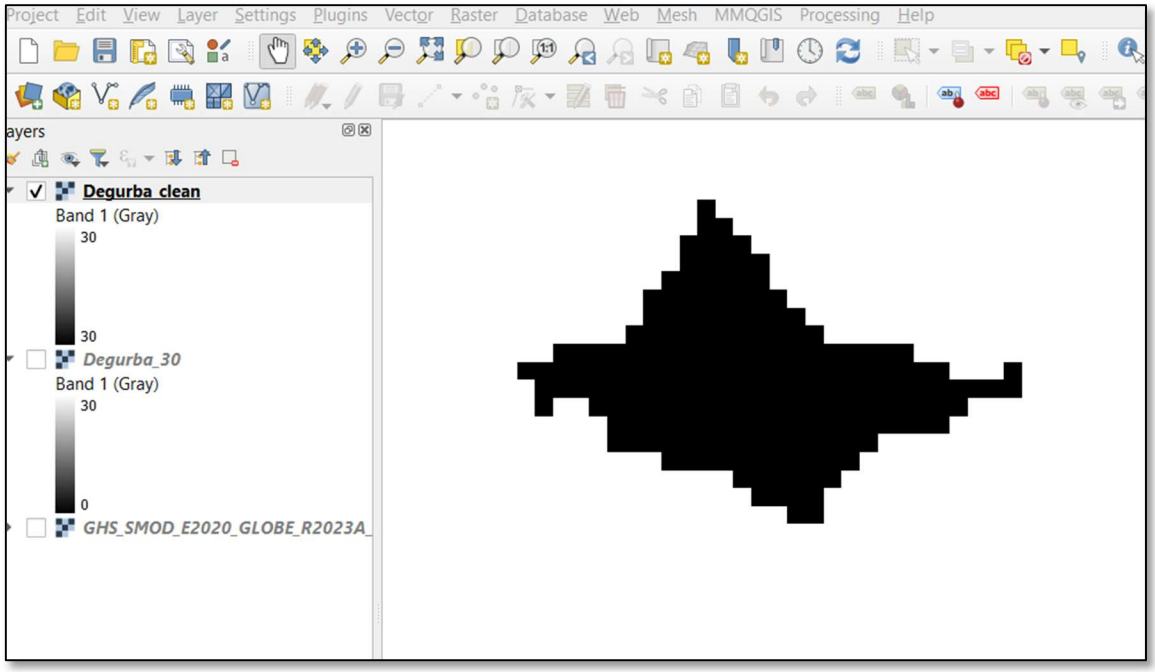
("GHS_SMOD_E2020_GLOBE_R2023A_54009_1000_V2_0_R4_C25@1" = 30) * "GHS_SMOD_E2020_GLOBE_R2023A_54009_1000_V2_0_R4_C25@1"



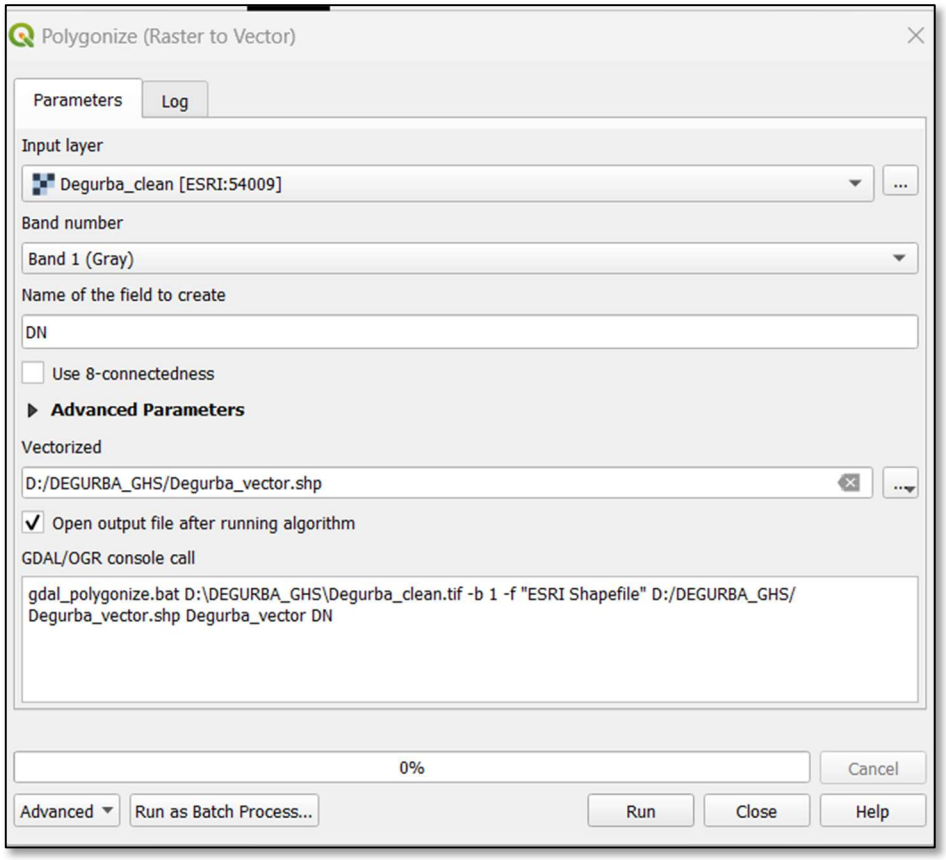
AND

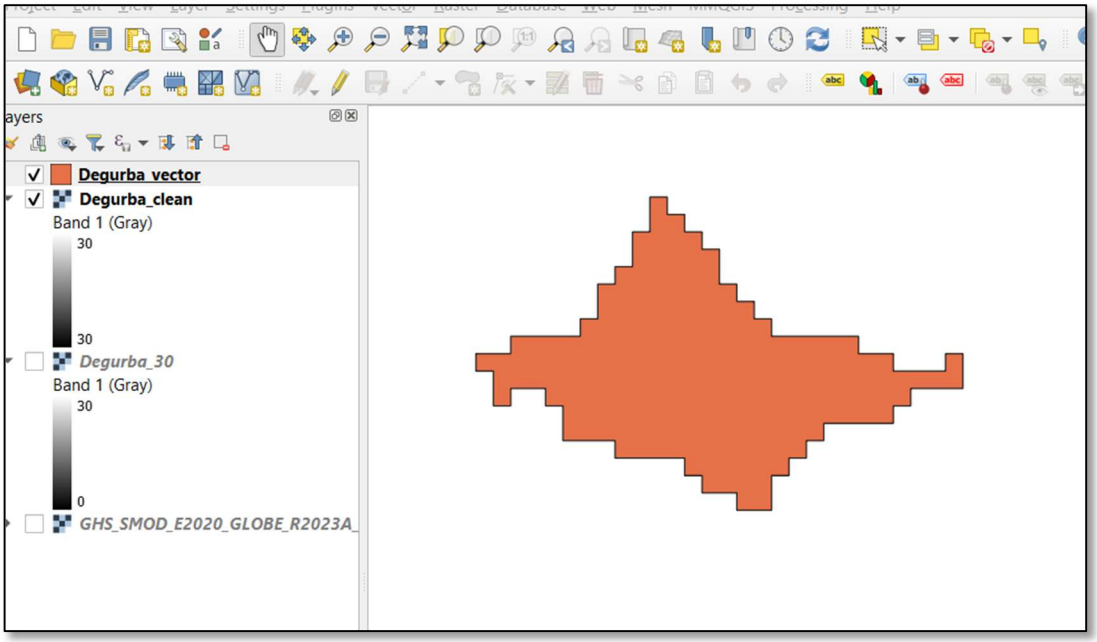
("Degurba_30@1") / ("Degurba_30@1" > 0)


Raster Calculator
Raster Bands
Degurba_30@1
GHS_SMOD_E2020_GLOBE_R2023A_540(
Result Layer
Create on-the-fly raster instead of writing layer to disk
Output layer
D:\DEGURBA_GHS\Degurba_clean
Output format
GeoTIFF
Spatial Extent
Use Selected Layer Extent
X min
5959000.00000
X max
6959000.00000
Y min
5000000.00000
Y max
6000000.00000
Resolution
Columns
1000
Rows
1000
Output CRS
ESRI:54009 - World_Mollweide
Add result to project
Operators
+ * (min IF cos acos
- /) max AND sin asin
< > = abs OR tan atan
<= >= != ^ sqrt log10 ln
Raster Calculator Expression
("Degurba_30@1") / ("Degurba_30@1" > 0)
Expression valid
OK
Cancel
Help



8. Convert .tif raster format layer into shapefile by choosing **Raster > Conversion > Polygonize (Raster to Vector)**

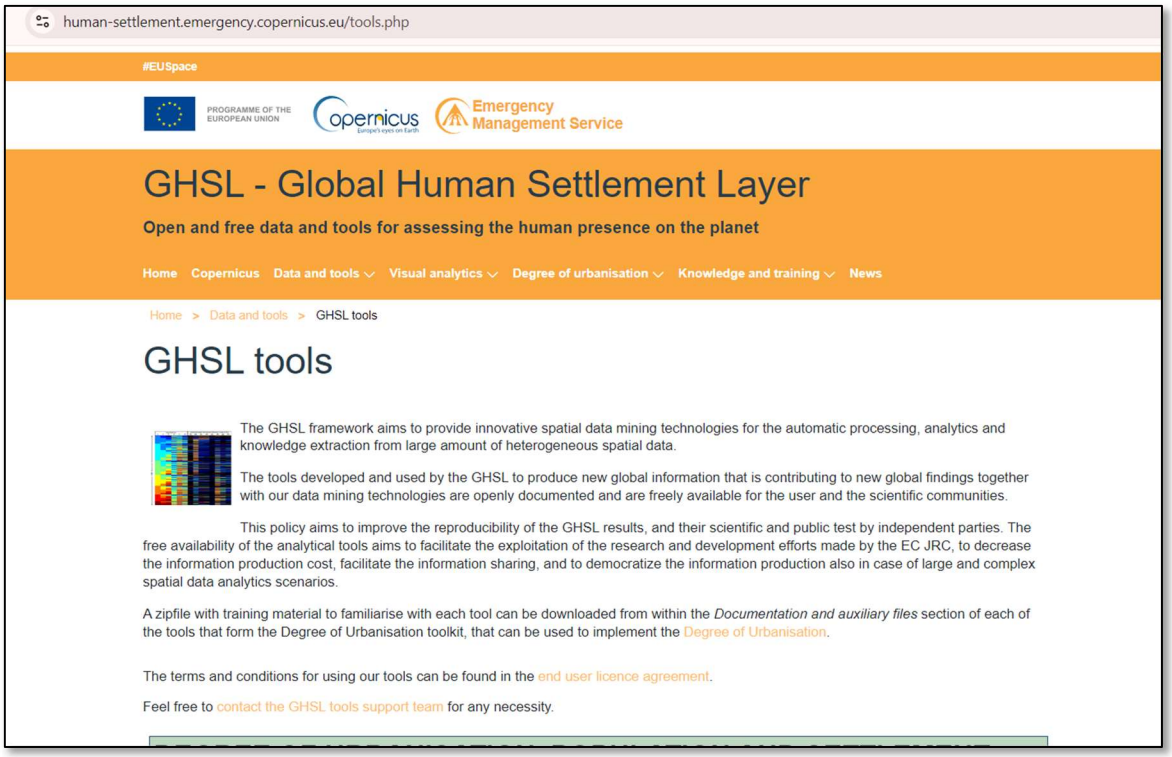

Polygonize (Raster to Vector)
Parameters
Log
Input layer
Degurba_clean [ESRI:54009]
Band number
Band 1 (Gray)
Name of the field to create
DN
Use 8-connectedness
Advanced Parameters
Vectorized
D:/DEGURBA_GHS/Degurba_vector.shp
Open output file after running algorithm
GDAL/OGR console call
gdal_polygonize.bat D:\DEGURBA_GHS\Degurba_clean.tif -b 1 -f "ESRI Shapefile" D:/DEGURBA_GHS/ Degurba_vector.shp Degurba_vector DN
0%
Cancel
Advanced
Run as Batch Process...
Run
Close
Help



Now you have DEGURBA urban areas elaborated on the basis of GHS-Pop population grid ready for SDG 11.3.1 modelling.

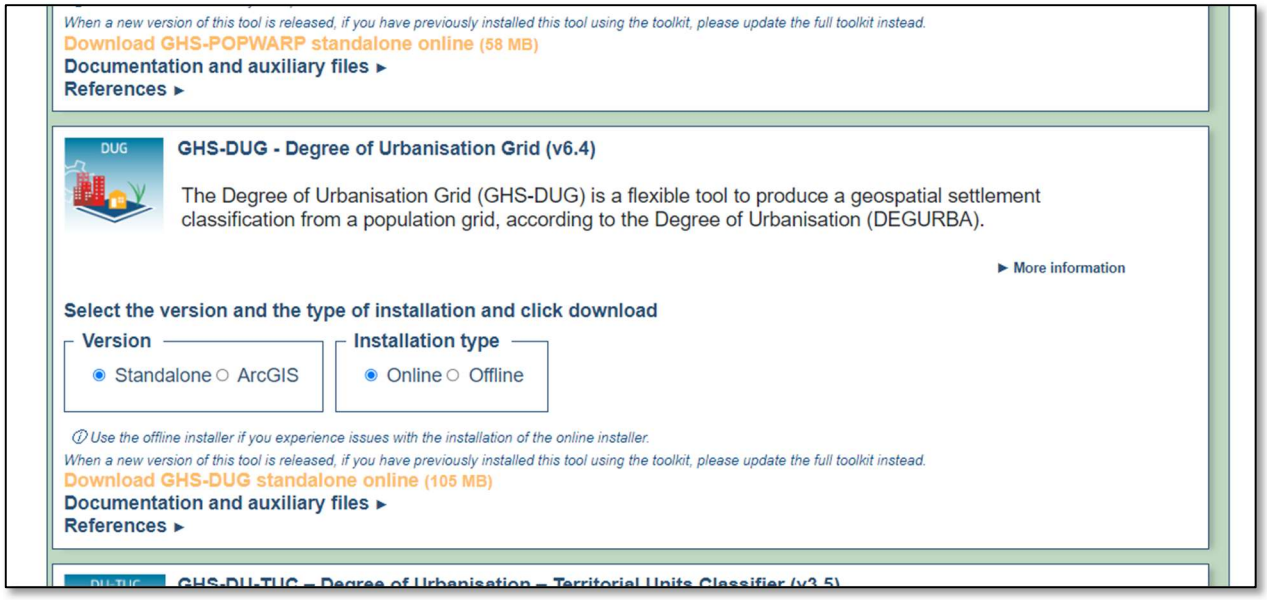
STEP 1: Generating DEGURBA Urban Areas based on WorldPop Population Data using GHS-DUGTool[2].

9. **Navigate to GHSL Tools Page**: Open your browser and go to **https://human-settlement.emergency.copernicus.eu/tools.php**



10. **Download GHS-DUG Tool**: Locate the section with tool options and click **"Download GHS-DUG standalone online (105 MB)"** to download The Degree of Urbanisation Grid (GHS-DUG) Tool.

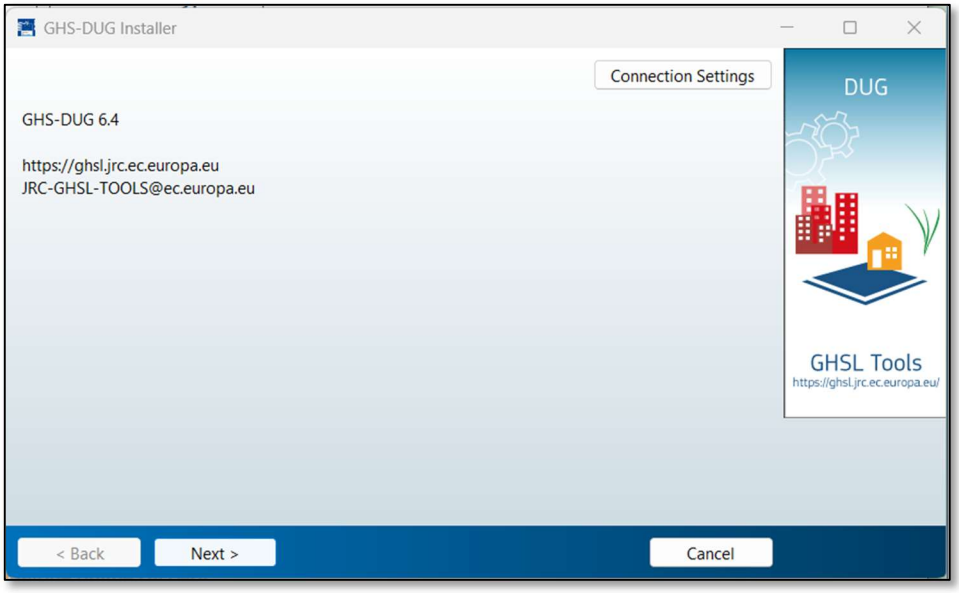
[2] **NOTE: GHS-DUG Tool (Global Human Settlement Degree of Urbanisation Grid Tool) is a GIS-based tool used for classifying and analyzing the Degree of Urbanisation (DEGURBA) using satellite data and population grids from the Global Human Settlement Layer (GHSL).**



11. **Run GHS-DUG Installer**: Execute the **GHS-DUG_installer.exe** on your machine. If prompted, install any **Matlab** components, as the tool may rely on them.

NOTE: A free trial version of Matlab is available via this website https://matlab.mathworks.com/

A commercial license is needed for long-term use of MatLab. However, components of MatLab programming may be done in open-source software such as Python and R.



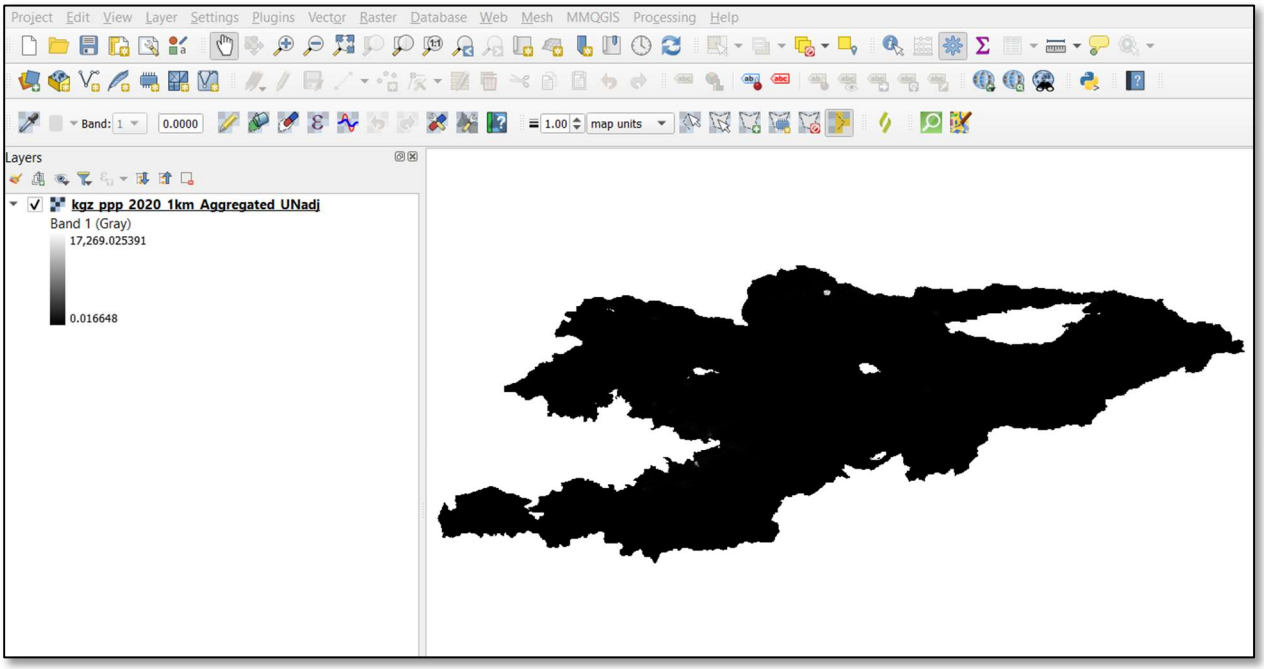
12. **Prepare WorldPop Dataset**: The GHS-DUB Tool requires a 1km Mollweide population dataset. Molleweide is a population projection setting that is built into QGIS.

    NOTE: You can download additional WorldPop Datasets for Kyrgyzstan or other regions from the WorldPop website here:
    https://hub.worldpop.org/project/categories?id=3

    For the purposes of this guide, click the Unconstrained individual countries 2000-2020 UN adjusted (1 km resolution)

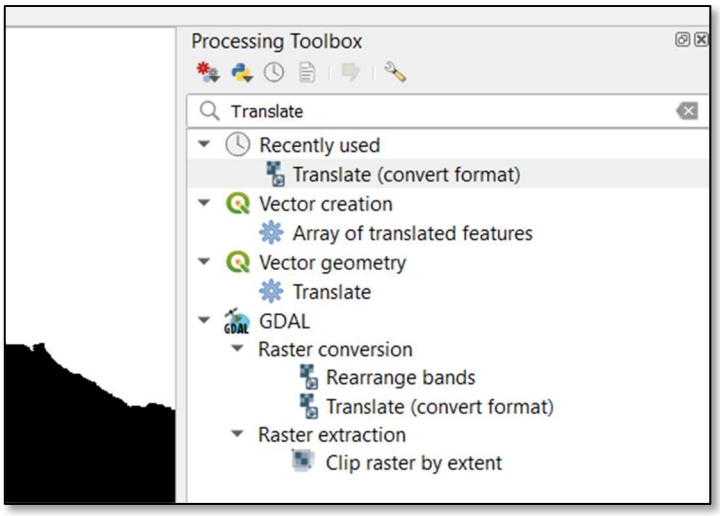
    Click on Kyrgyz Republic and scroll to year 2020 to access the dataset

13. **Add WorldPop Data to QGIS**: In QGIS, navigate to the unzipped input data folder (for example: **Degurba_stepbystep_inputdata or a name of your choosing)** and add WorldPop dataset (for example:**kgz_ppp_2020_1km_Aggregated_UNadj.tif or a name of your choosing**)to the QGIS Project.



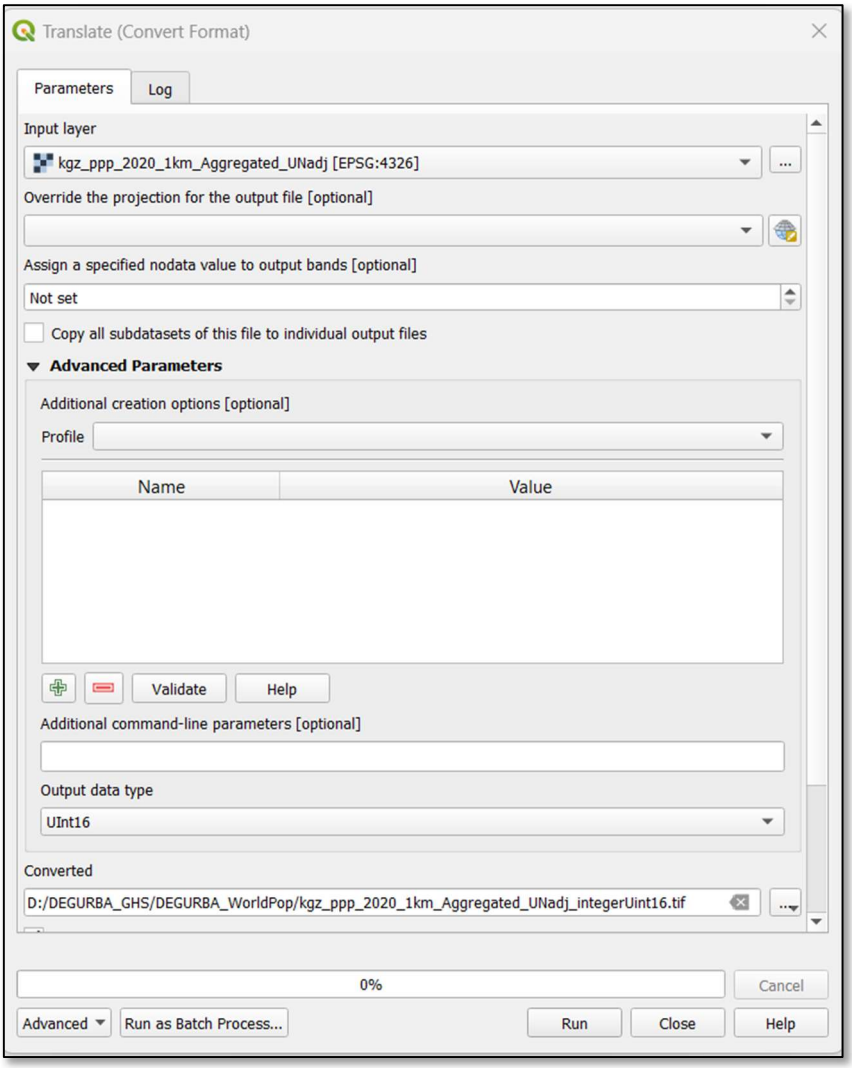
14. **Convert Raster Format (From Float32 format to UInt16)**: Choose **Processing > Toolbox** and search for the **Translate (convert format)** function, and save as a .tif file (not .tiff) file.format

This step is to convert the population raster from Float32 format to UInt16 format

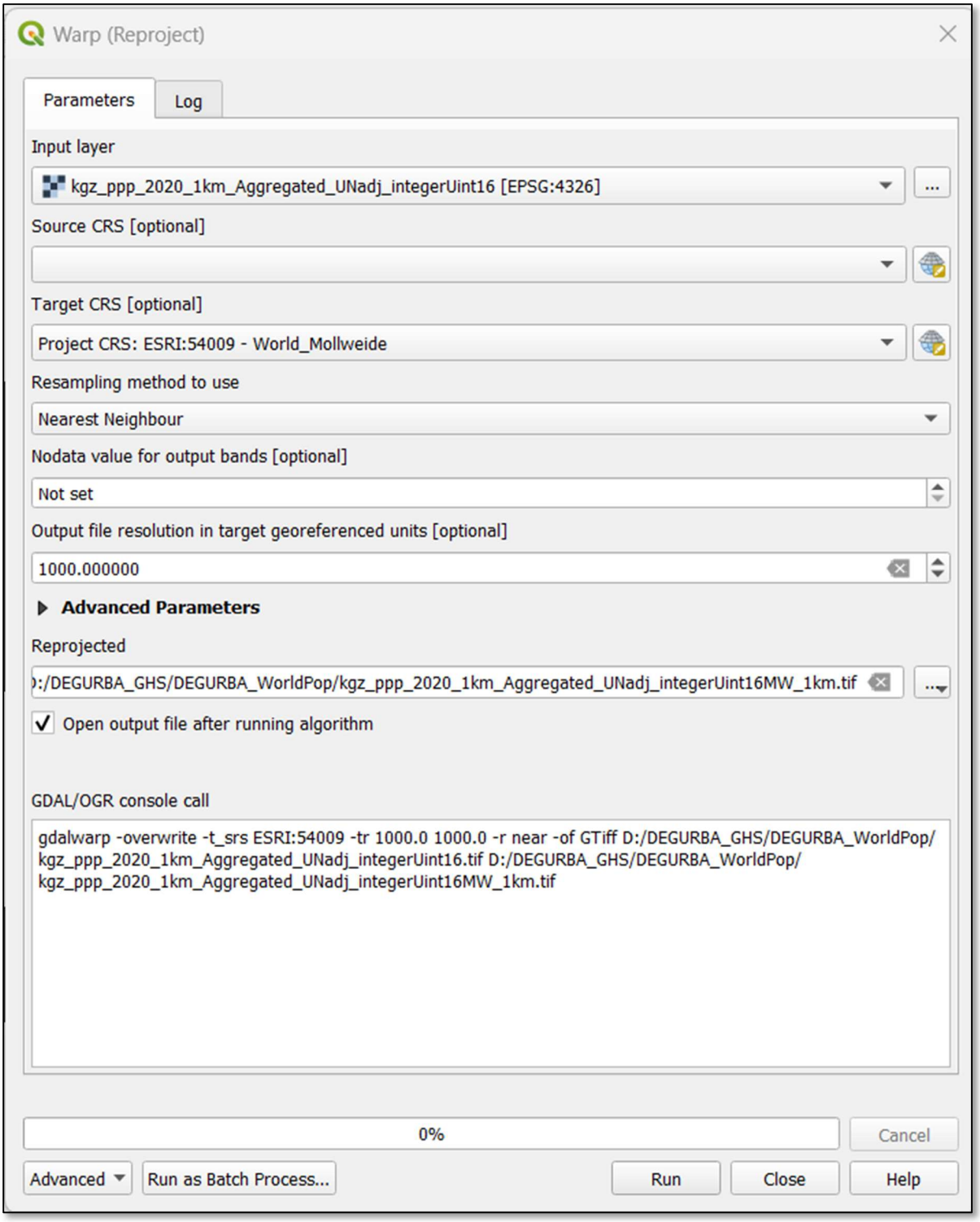


15. **Run Translate tool:** Execute the Translate **(convert format)** tool using the parameters visualized on the image below to create new raster dataset (for example:**kgz_ppp_2020_1km_Aggregated_UNadj_integerUint16.tif.** or a name of your choosing)

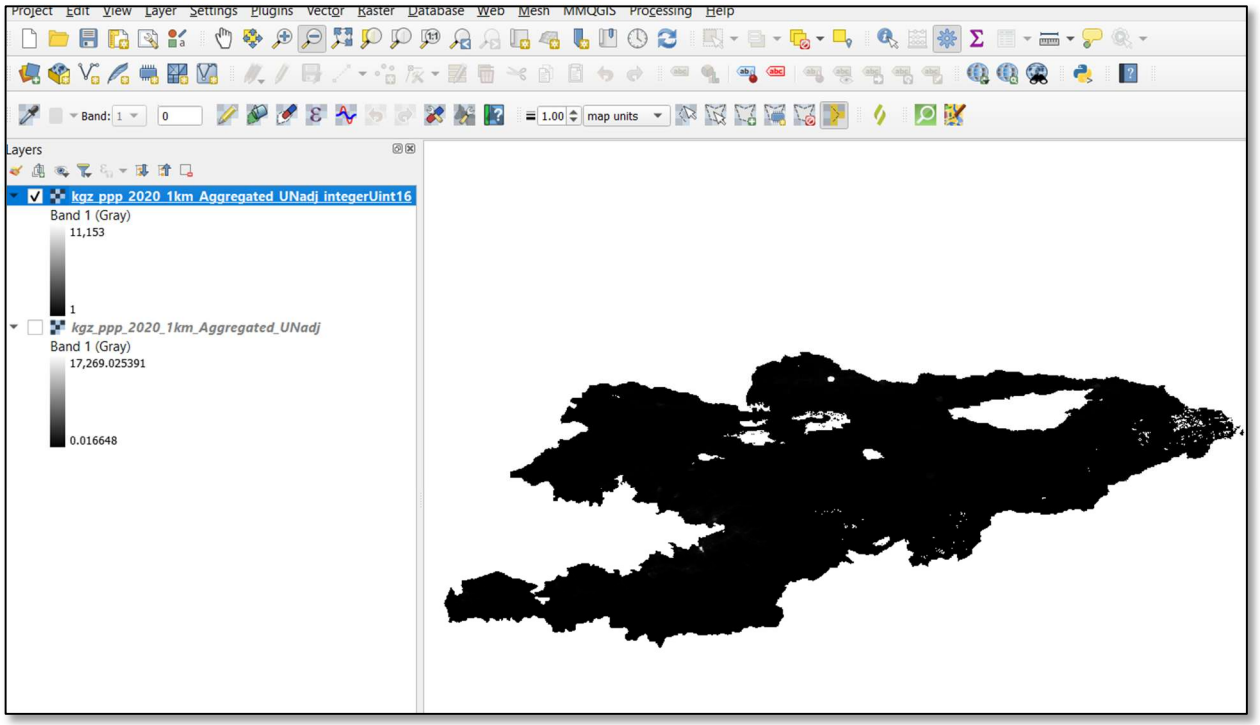
    NOTE: Ensure the 'Output data type' is set to UInt16.



16. **Reproject to Mollweide and Resample**: Next, convert the newly obtained raster layer into Mollweide reference system (ESRI: 54009 – World_Mollweide) while resampling to 1 km grid. Choose **Raster>Projections>Warp (Reproject).**
    Complete parameters according to the image below to derive the raster dataset (for example: **kgz_ppp_2020_1km_Aggregated_UNadj_integerUint16MW_1km.tif. or a name of your choosing).**


Warp (Reproject)
Parameters
Log
Input layer
kgz_ppp_2020_1km_Aggregated_UNadj_integerUint16 [EPSG:4326]
Source CRS [optional]
Target CRS [optional]
Project CRS: ESRI:54009 - World_Mollweide
Resampling method to use
Nearest Neighbour
Nodata value for output bands [optional]
Not set
Output file resolution in target georeferenced units [optional]
1000.000000
Advanced Parameters
Reprojected
):/DEGURBA_GHS/DEGURBA_WorldPop/kgz_ppp_2020_1km_Aggregated_UNadj_integerUint16MW_1km.tif
Open output file after running algorithm
GDAL/OGR console call
gdalwarp -overwrite -t_srs ESRI:54009 -tr 1000.0 1000.0 -r near -of GTiff D:/DEGURBA_GHS/DEGURBA_WorldPop/
kgz_ppp_2020_1km_Aggregated_UNadj_integerUint16.tif D:/DEGURBA_GHS/DEGURBA_WorldPop/
kgz_ppp_2020_1km_Aggregated_UNadj_integerUint16MW_1km.tif
0%
Cancel
Advanced
Run as Batch Process...
Run
Close
Help

- Set 'Target CRS' to ESRI:54009 - World_Mollweide.
- Set 'Resampling method to use' to Nearest Neighbour.
- Set 'Output file resolution in target georeferenced units' to 1000.000000.

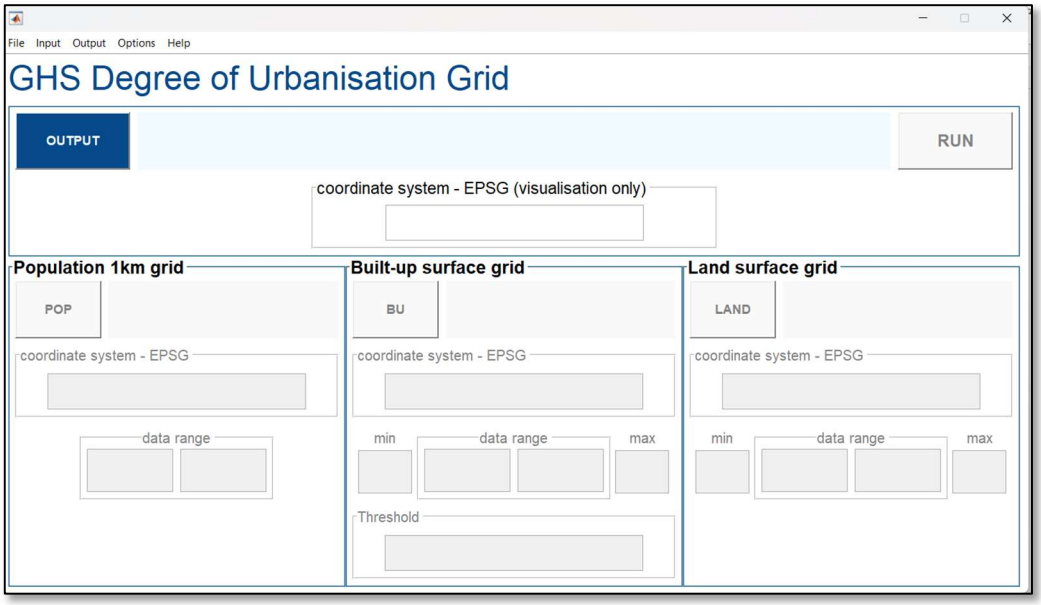


NOTE: The DEGURBA tool also requires Built-up spatial data. We will use the dataset produced within SDG 11.3.1 step-by-step Guide (dataset to be downloaded from the link in the folder «Degurba_stepbystep_inputdata» or the name you assigned to the built-up layer for your region).

NOTE: Please see the SDG 11.3.1 step-by-step Guide published as part of this series

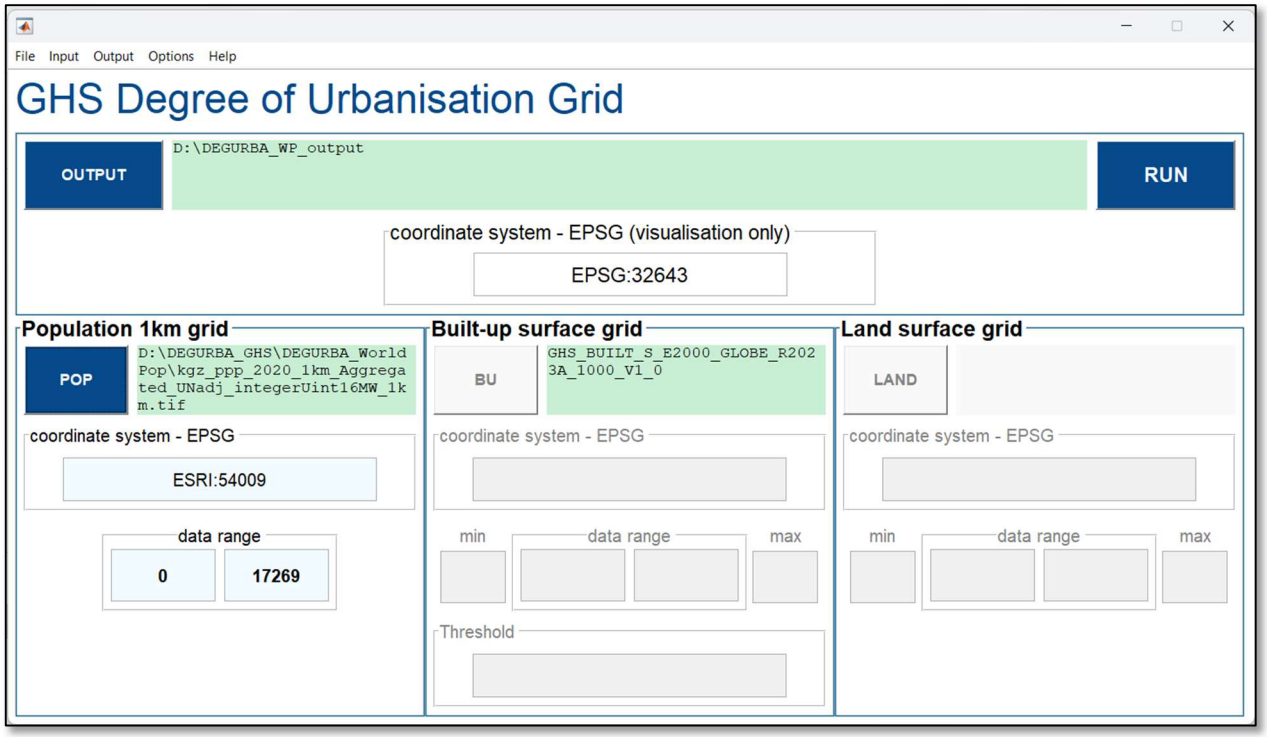
17. **Create Output Folder**: Created a dedicated folder for the output files (for example **D:/DEGURBA_WP_output, or a name of your choosing)**

18. **Launch DEGURBA Tool**: Launch the GHS-DUG tool located in its installation folder, or via its shortcut on the Desktop.

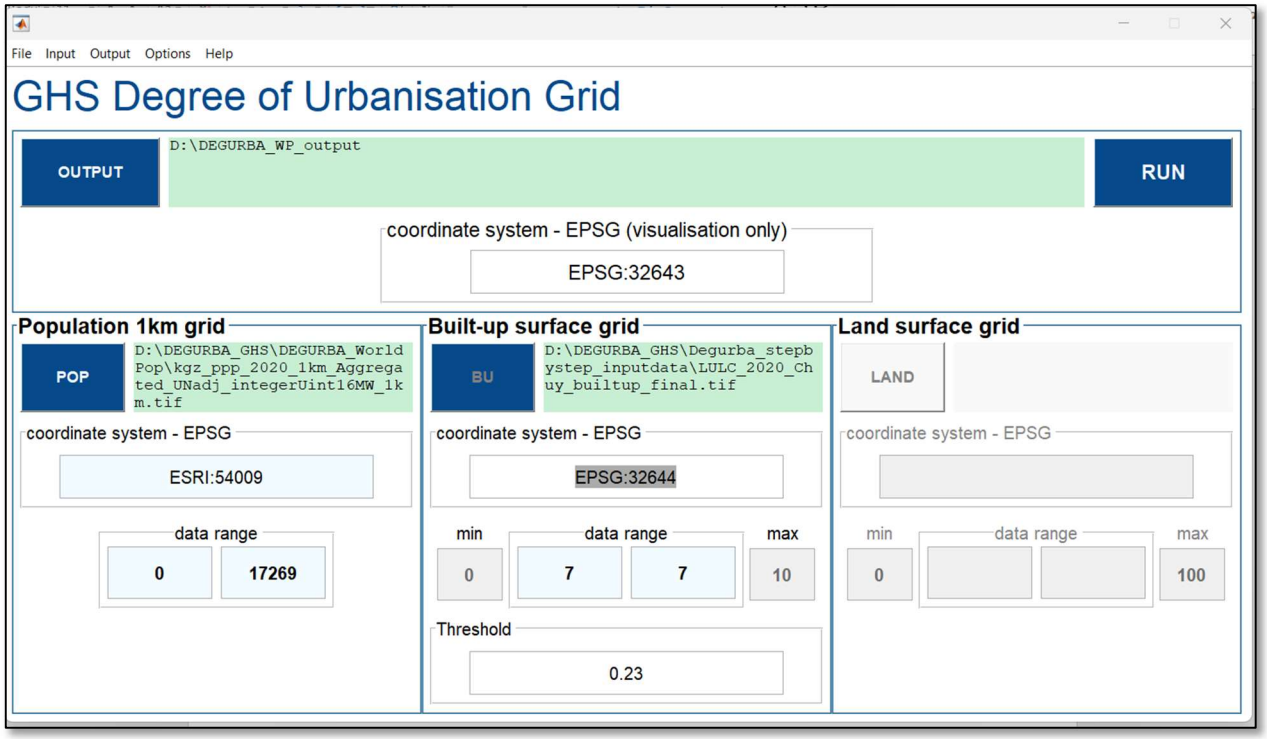


19. **Set up Tool Parameters**: Configure the tool parameters as follows:

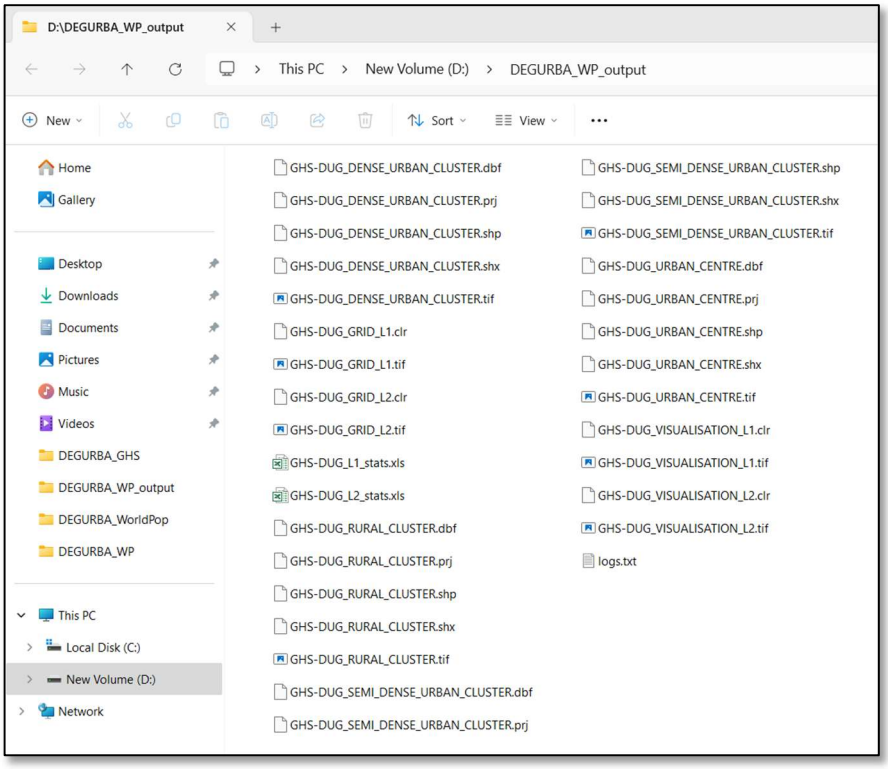
- **OUTPUT:** Choose dedicated folder (For example: D: DEGURBA_WP_output or the name of your choosing)
- **POP (Population 1 km grid):** Navigate to and select the population raster obtained in step 16 (For example: kgz_ppp_2020_1km_Aggregated_UNadj_integerUint16MW_1km.tif. or the name of your choosing)
- **BU (Built-up surface grid)**: In the 'Options' section, select Reduce Urban Center fragmentation > GHSL 2020 or select a custom built-up dataset from your input data folder (For example: LYLC_2020_Chuy_builtup_final.tif or a name of your choosing).
- **Click RUN**


File Input Output Options Help
GHS Degree of Urbanisation Grid
OUTPUT
D:\DEGURBA_WP_output
RUN
coordinate system - EPSG (visualisation only)
EPSG:32643
Population 1km grid
POP
D:\DEGURBA_GHS\DEGURBA_WorldPop\kgz_ppp_2020_1km_Aggregated_UNadj_integerUint16MW_1km.tif
coordinate system - EPSG
ESRI:54009
data range
0
17269
Built-up surface grid
BU
GHS_BUILT_S_E2000_GLOBE_R2023A_1000_V1_0
coordinate system - EPSG
min
data range
max
Threshold
Land surface grid
LAND
coordinate system - EPSG
min
data range
max

OR

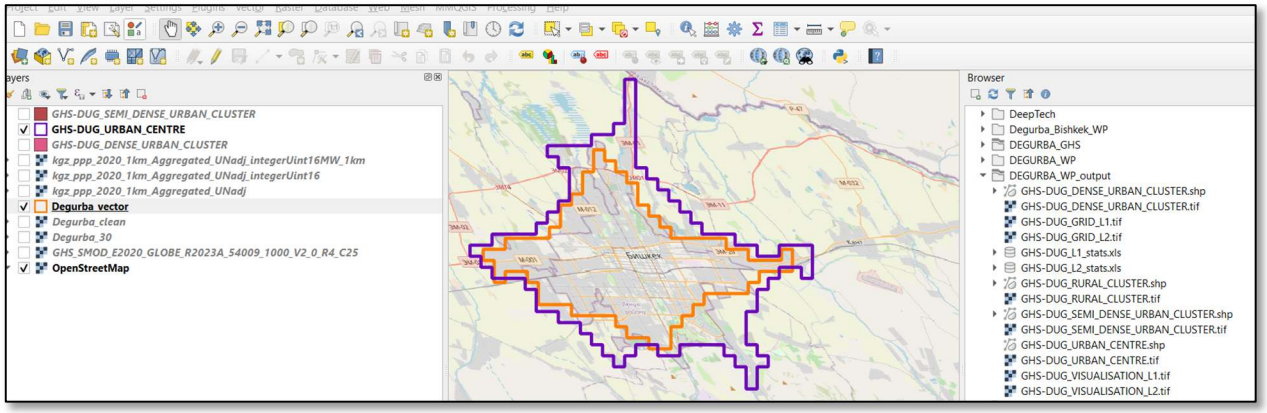


20. **Review Output**: As a result, the specified output folder (For example: **D: DEGURBA_WP_output)** will be populated with DEGURBA files.



21. **Add Generated Shapefiles to QGIS**: In QGIS Project, add the newly generated DEGURBA shapefiles (For example:GHS-DUG URBAN CENTRE, GHS-DUG DENSE URBAN CLUSTER, GHS-DUG SEMI DENSE URBAN CLUSTER).

    Change Symbology for the layers **GHS-DUG URBAN CENTRE** (based on WorldPop and Built-up Esri data) to compare with already available DEGURBA data from GHSL Portal or for better visualisation.



Conclusion

By following these steps, you will successfully generate DEGURBA urban areas in a shapefile format, ready for various spatial analyses, including the estimation of SDG indicator 11.3.1. It is crucial for maintaining data consistency and quality that for each iteration of SDG 11.3.1 estimation, DEGURBA is recalculated using updated entry data. Furthermore, every DEGURBA dataset should be validated against its foundational data to ensure accuracy. When using pre-existing DEGURBA data from portals like the GHSL Web Portal, always apply the corresponding GHS-Pop geospatial layers for precise indicator estimation. Similarly, when utilizing derived DEGURBA urban areas, it is essential to use the same population grid that was initially employed to generate them. This methodology provides a robust framework for statisticians and GIS professionals globally to leverage geospatial data for a deeper understanding of urbanization patterns and their implications for sustainable development.

Additional Information

The guide was developed by Elena Hristev, ESCAP Consultant. For more details, please contact directly at lena.hristev@gmail.com or contact ESCAP-Statistics at stat.unescap@un.org

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2. https://unhabitat.org/sites/default/files/2022/08/sdg_indicator_metadata-11.3.1.pdf
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4. https://human-settlement.emergency.copernicus.eu/index.php

5. To do: format pictures, format intros to each step, format highlights