

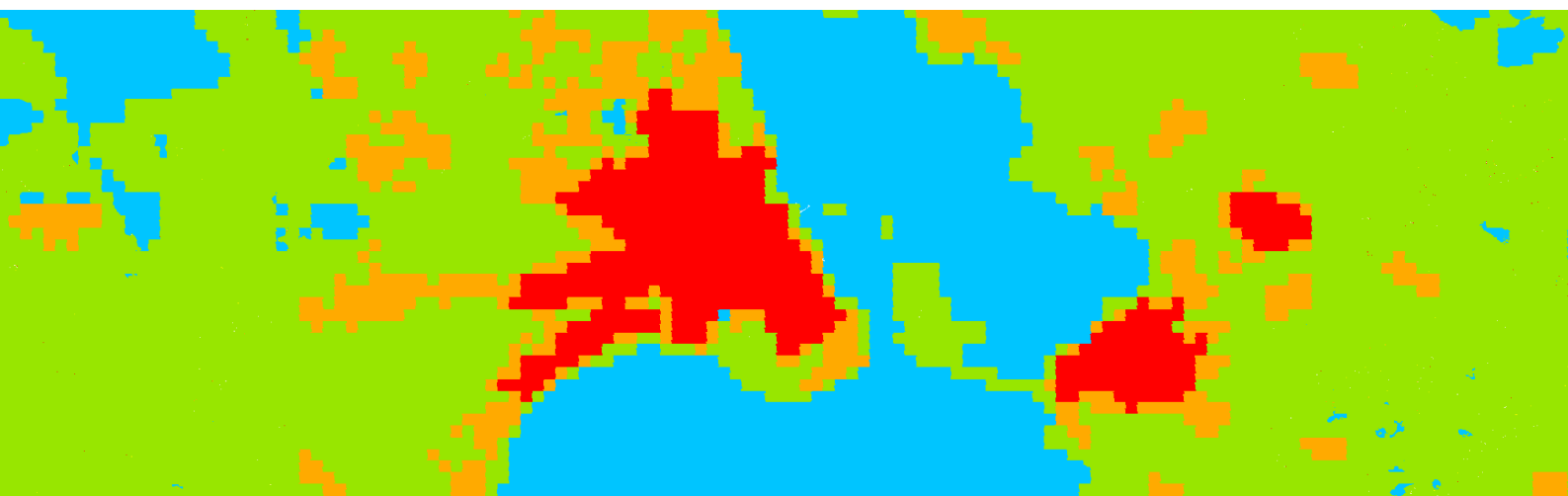


DUG User Guide

Version 2.1

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Abstract

This user guide accompanies the DUG tool which is a public tool for applying the “Degree of urbanisation” (DEGURBA) model at one kilometer grid.

DUG stands for Degree of Urbanisation Grid. It has been developed in the frame of the “Global Human Settlement Layer” (GHSL) project of the European Commission’s Joint Research Centre, with the overall objective to support the DEGURBA activities. The tool builds on the GHS SMOD model that implements settlement model classifier at 1 km grid.

The tool uses population and built-up grids as input data, and optionally a water mask. It has been developed and tested using [GHS P2016 datasets](#)¹; however other grids can be used on user responsibility.

This user guide is a comprehensive guide to all aspects of using the DUG tool. It includes instructions for the set-up of the software, the use of the tool and the manipulation of the data. It presents briefly the basic principles and background information on the methodology and its implementation. Some guidelines on the parametrization are also provided.

1. Introduction

1.1 Overview

The DUG tool has been developed under the [GHSL project](#) of the European Commission’s [Joint Research Centre](#) with the overall objective to support the DEGURBA activities.

It builds on GHS SMOD model² implemented within the GHSL framework, and it is consistent with the “Degree of urbanisation” (DEGURBA) model adopted by EUROSTAT³.

The purpose of the DUG tool is to allow user to experiment with the GHS SMOD model to test urban/rural hypothesis. This free software policy aims at decreasing the information production cost while increasing interoperability of the information products and facilitating uptake by Member States and other stakeholders.

The objective of this documentation is to provide a walk-through of this tool.

1.2 Rationale

Statistical information is an important tool for analysing changing patterns of urban development and the impact that policy decisions have on life in our cities, towns and suburbs. Statistics on cities, towns and suburbs provides detailed information for a number of territorial typologies that can be used to paint a picture of urban developments and urban life.

¹ <http://ghsl.jrc.ec.europa.eu/data.php>

² <http://ghsl.jrc.ec.europa.eu/data.php?sl=4>

³ <http://ec.europa.eu/eurostat/web/degree-of-urbanisation/overview>

The definition of urban area varies across countries. This Degree of urbanisation model, developed and applied in Europe to overcome those discrepancies creates a three-way classification of municipalities as follows:

1. Cities (alternate name: densely populated areas): At least 50% of the population lives in urban centres.
2. Towns and suburbs (alternate name: intermediate density areas): At least 50% of the population lives in urban clusters and Less than 50% of the population lives in urban centres.
3. Rural areas (alternate name: thinly populated areas): At least 50% of the population lives in rural grid cells.

This model has been adopted to a one kilometer grid, which allows classifying the land area of the world in a consistent manner.

A consensus on a common approach at global scale, and adoption of the proposed model, may require a possibility to test different hypothesis on population thresholds.

1.3 History and versioning

The GHS SMOD method was initially implemented in the early 2016 by JRC as an implementation of the degree of urbanization at 1 km grid.

In 2017, the DUG tool was proposed to support the DEGURBA activities, namely to enable national statistical offices to test different urban/rural definitions.

1.4 Main features of the DUG tool

This user manual provides instructions about the installation of the required software and the data set-up (chapter 2). The classifier and the basic aspects and definitions are illustrated in the chapter 3 along with the workflow schema. The graphical user interface and the use of the tool are presented in chapter 4.

2. Getting started

The algorithms have been coded in the scripting language of MATLAB R2016b. We note here that some sub-routines have been developed in C and JAVA programming languages in order to resolve performance issues and improve the modules interfacing. For image reading and writing, we employ MATLAB wrappers of the respective GDAL functionalities (Geospatial Data Abstraction Library: <http://www.gdal.org/>).

2.1 System Requirements

To use DUG, your system must meet the following minimum requirements:

Operating system	Processor	Disk space	RAM
Windows 7 or Windows 10	Any Intel or AMD x86-64 processor	100 Mb (+ 700 Mb for Matlab Runtime)	16 GB (recommended)

2.2 Installing DUG

To have DUG running on your computer you need to install Matlab Runtime

2.2.1 Installing Matlab Runtime

Verify the MATLAB Runtime is installed and ensure you have installed version **9.1 (R2016b)**.

If not already installed, download the Windows 64-bit R2016b version of the MATLAB Runtime from the MathWorks Web site:

<http://www.mathworks.com/products/compiler/mcr/index.html>

For more information about the MATLAB Runtime and the MATLAB Runtime installer, see Package and Distribute in the MATLAB Compiler documentation in the MathWorks Documentation Center.

2.2.2 Installing DUG

The Windows installer is included in the zip file.

After saving it on your hard drive, unzip the zip file and run the executable directly.

2.2.3 Uninstalling DUG

To remove DUG just delete the executable file and its folder.

Matlab Runtime can be uninstalled as well if not needed by other applications.

3. The method

3.1 The GHS Settlement Model (GHS SMOD)

In the GHSL framework (Pesaresi, M., et al. 2016), there are three main information components hierarchically placed at three different levels of abstraction: Global Human Settlement built-up areas (GHS-BU), the GHS population grids (GHS-POP) and the GHS urban/rural classification model (GHS-SMOD).

The top abstraction information layer of the GHSL it is the urban/rural classification model (GHS-SMOD). It is provided with the least spatial detail (1 km) by combining the two less-abstract and more-spatially-detailed built-up and population grids, GHS-BU and GHS-POP, respectively. The GHS-SMOD model implemented by the GHSL it is consistent with the "Degree of urbanisation" (DEGURBA) model adopted by EUROSTAT⁴. It discriminates three settlement class abstractions: 1) Cities, 2) Towns and suburbs and 3) Rural areas. The discrimination is based on the population density in the square kilometre grid⁵, total settlement population and other spatial generalization parameters.

In the GHSL paradigm, the base layer GHS-BU it is designed to be the most stable against different visions and approaches, while GHS-SMOD is the most abstract and as such exposed to conceptual changes and alternative problem settings proposed by the different stakeholders involved in the post-2015 international framework processes. The modular hierarchical abstraction schema used in the GHSL design allows to protect the investment made in the global, fine-scale information gathering from perturbations on the abstract classification schema that may be introduced by different decision-makers involved in the process and potentially producing different problem setting and abstractions. On the other side, the modular hierarchical abstraction schema facilitates the test of alternative abstract models on the same agreed information baseline, facilitating the discussion and the comparison of the results also between international stakeholders not necessary sharing the same high abstraction definitions.

Figure 1 illustrates the key elements and rules of the settlement model, derived from the New Degree of Urbanization (Dijkstra L. and H. Poelman 2014): specifically, the rules for defining *Urban Centres* and *Urban Clusters* are illustrated. The remaining pixels are classified as Rural Area or Water.

⁴ <http://ec.europa.eu/eurostat/web/degree-of-urbanisation/overview>

⁵ densely, intermediate density and thinly populated areas

The GHSL Settlement Model

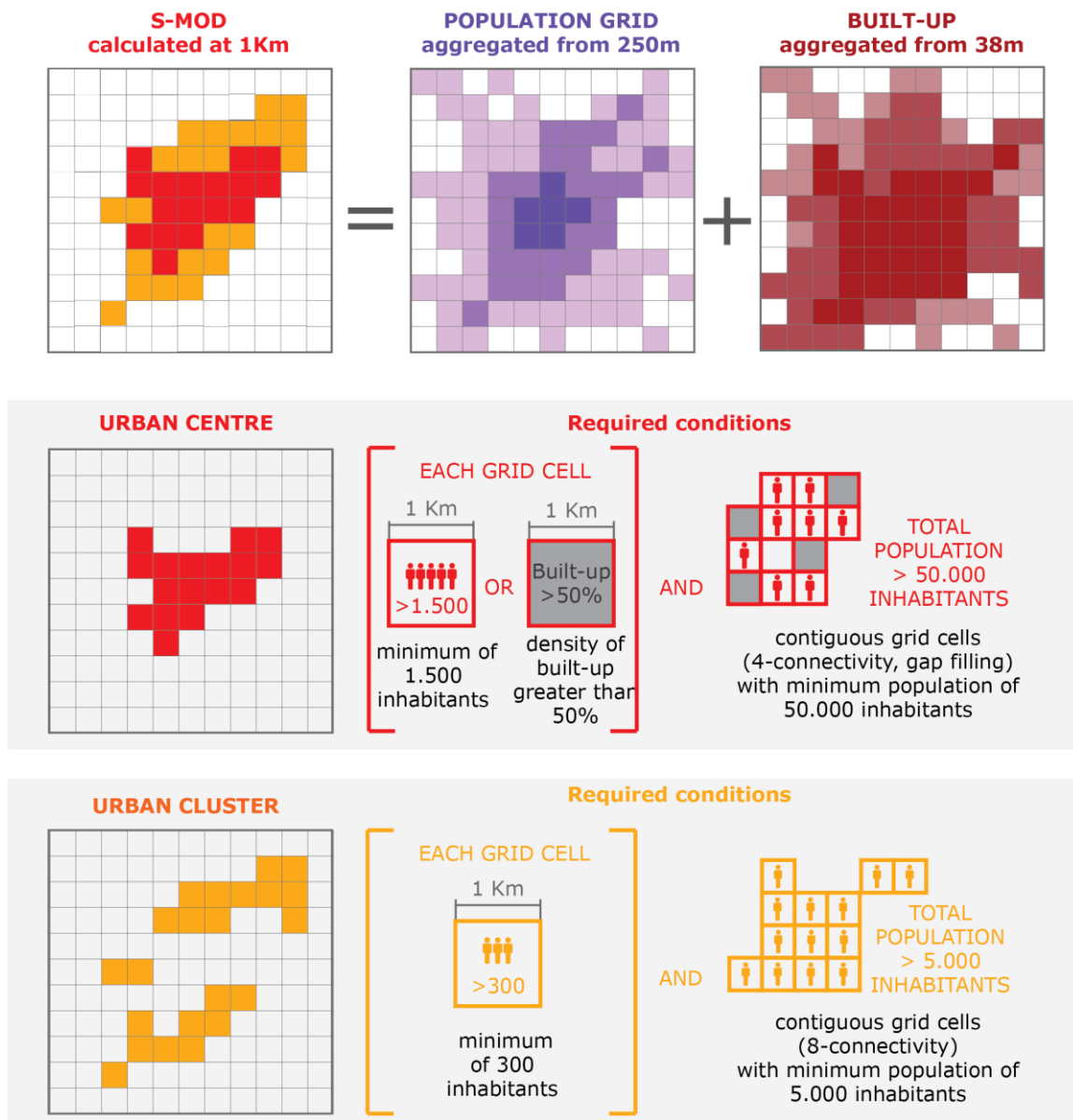


Figure 1. The Key elements and the rules of the settlement model.

1. Input data

1.1 Input GRIDs

Parameter	Definition
Population grid	Population density grid, 1 km. The data range shall be between 0 and N (float/integer data type). If nodata area is encoded, the nodata value shall be lower than zero.
Built-up grid	Built-up area density grid, 1 km. The data range shall be between 0 and 1 (float/integer data type) depicting the % of the pixel that is covered by built-up structures. If nodata area is encoded, the nodata value shall be lower than zero.
Water grid	Water mask grid, 1 km. The data range shall be 0 or 1 (no-water, water). If nodata area is encoded, the value shall be lower than zero. This mask will be encoded within the output layer.

1.2 Defining the population thresholds

Parameter Group	Parameter	Default Value	Definition
Urban Centre	Density	5000	Second order population density threshold – it is applied on 1 km cells to identify a spatial domain of potential <i>urban centres</i> . The potential urban centers are collections of contiguous grid cells (4-connectivity rule) within the identified spatial domain.
	Total Population	50000	Second order total population threshold – it is applied on the total population accounted within an urban high density continuous space (connected component), in order to discriminate the <i>urban centres</i> .

Urban Cluster	<i>Density</i>	300	First order population density threshold – it is applied on 1 km cells to identify a spatial domain of potential <i>urban clusters</i> . The potential urban clusters are collections of contiguous grid cells (8-connetivity rule) within the identified spatial domain.
	<i>Total Population</i>	1500	First order total population threshold – it is applied on the total population accounted within the urban low density space (connected component), in order to discriminate the <i>urban cluster</i> .

4. Using the tool

4.1 Basic usage

4.1.1 Launching the tool

There are two ways to initialize the tool a. by clicking on the executable dug.exe, b. by typing the full path of the executable in the Windows Command Prompt (cmd.exe) and pressing ENTER (Figure 2).

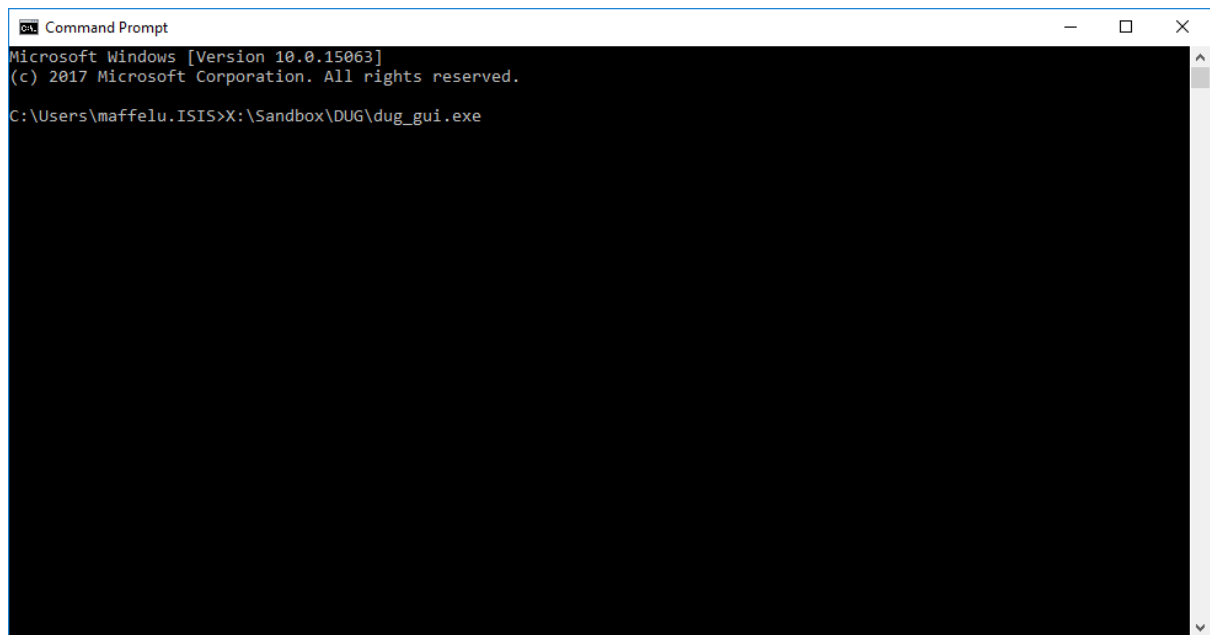


Figure 2. Running the DUG executable from windows command prompt

The graphical user interface (GUI) will be loaded (Figure 3). After selection of the input files (and modification of the parameters, if necessary) the process can be executed by clicking the RUN control button. During the execution of the tool, the "working" status is indicated by the RUN control.

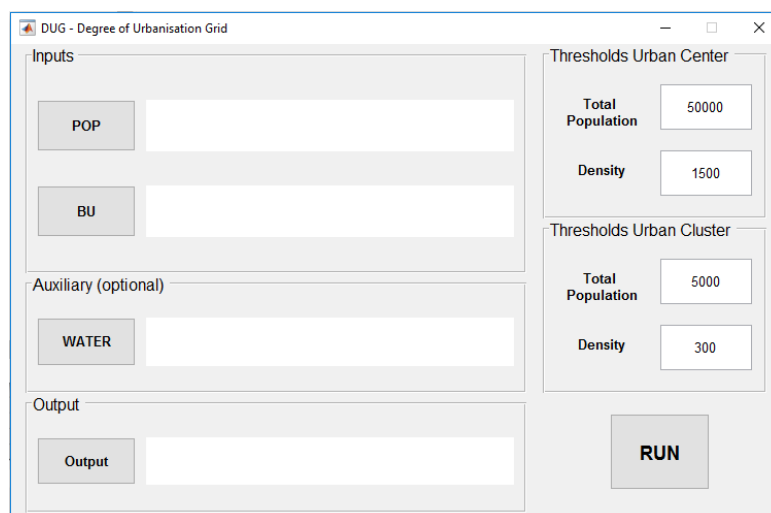


Figure 3. Graphical user interface of the DUG tool

4.2 Output files

The tool produces a GeoTIFF file with GHS-SMOD model layer, and a color map (*.clr).

Table 1. Classification schema.

Class	Code
Water	0
Rural Area	1
Urban cluster	2
Urban centre	3
NoData	255

- GHS-SMOD.tif
- Rural Area
- Water
- Urban Cluster
- Urban Centre

Figure 3. Legend corresponding with the colour map.

References

Pesaresi, M., Melchiorri, M., Siragusa, A. and T. Kemper, 2016. Atlas of the Human Planet - Mapping Human Presence on Earth with the Global Human Settlement Layer. EUR - Scientific and Technical Research Reports, Publications Office of the European Union

Dijkstra, L. and H. Poelman. 2014. "A Harmonised Definition of Cities and Rural Areas: The New Degree of Urbanisation." Regional Working Paper 2014 WP 01/2014. Bruxelles: European Commission, Regional and Urban Policy

Other useful Resources

GHSL project

<http://ghsl.jrc.ec.europa.eu>

External components and libraries:

MATLAB Runtime

<http://uk.mathworks.com/products/compiler/mcr/>

GDAL

<http://www.gdal.org/>



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