

# MEASURING THE BUILT ENVIRONMENT WITH GIS

Toolbox for ArcGIS 10 | 10.1 and latest versions  
Instructions Manual



© **InLUT – Integration of Land Use and Transport in Medium-Sized Cities** – is a research project funded by the Portuguese Funding Agency for Science, Research and Technology (project reference PTDC/AUR-URB/111013/2009), in the domain of Land Use and Transport, managed by three Portuguese research centers: Universidade de Trás-os-Montes e Alto Douro, Faculdade de Arquitetura da Universidade de Lisboa, e Universidade do Algarve.

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**Toolset usage:** One of the main focuses of this research project was the development accessibility concept, from a multimodal perspective, as a tool to evaluate the integration of land use and transport. This specific toolset was developed in order to deeply understand mobility and comparing different neighborhoods, either with similar or distinct characteristics, from the same city or different cities.

Feel free to contact us if you find any problems, or just to say thank you! If your experience any problems, please always attach a print screen of the error message.

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**How to cite this manual:**

Vale, D; Pereira, M; Rodrigo, C; Saraiva, M and Rodrigues, F (2015) **Measuring the built environment with GIS – a toolbox for ArcGIS 10.0, 10.1 and latest versions** Lisbon, Integration of Land Use and Transport in medium-sized cities. Available at: <http://inlut.fa.ulisboa.pt/arcgis-toolboxes/>

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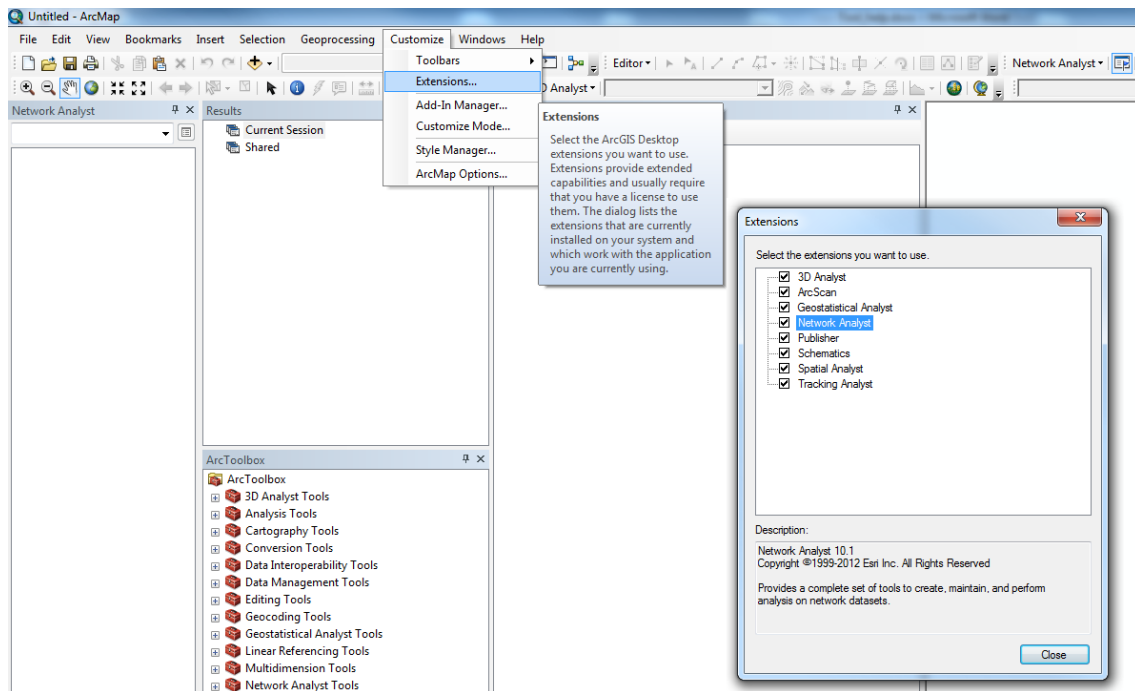
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## 1. Installation Guidelines

### Prerequisites:

Using the Measuring Built Environment with Floating Catchment Area (FCA) toolbox requires that you have ArcGIS 10 or 10.1 and the *Network Analyst* extension. If you have a working license for the Network Analyst extension, you can enable the extension by going to the *Customize* menu → *Extensions...* → and check the box next to Network Analyst.



**Figure 1.**The Measuring Built Environment with Floating Catchment Area (FCA) toolbox requires the Network Analyst Extension to be enabled.

### Download:

Download de [Built Environment Tools for ArcGIS 10.0](#) or [Built Environment Tools for ArcGIS 10.1 \(and latest versions\)](#) and unzip the content. It contains two toolboxes, one for Float Catchment Area and one for Homogeneous or pre-defined Areas, the test files for the two toolboxes and the Instruction Manual. You can delete this folder if you are not interested in using the test files.

### Installation:

To install the toolbox, open ArcMap 10 or 10.1, make sure the toolbox tab is visible, and right click inside the toolbox tab. Choose Add Toolbox... then choose the downloaded Built Environment file from where you saved it, and click Open.

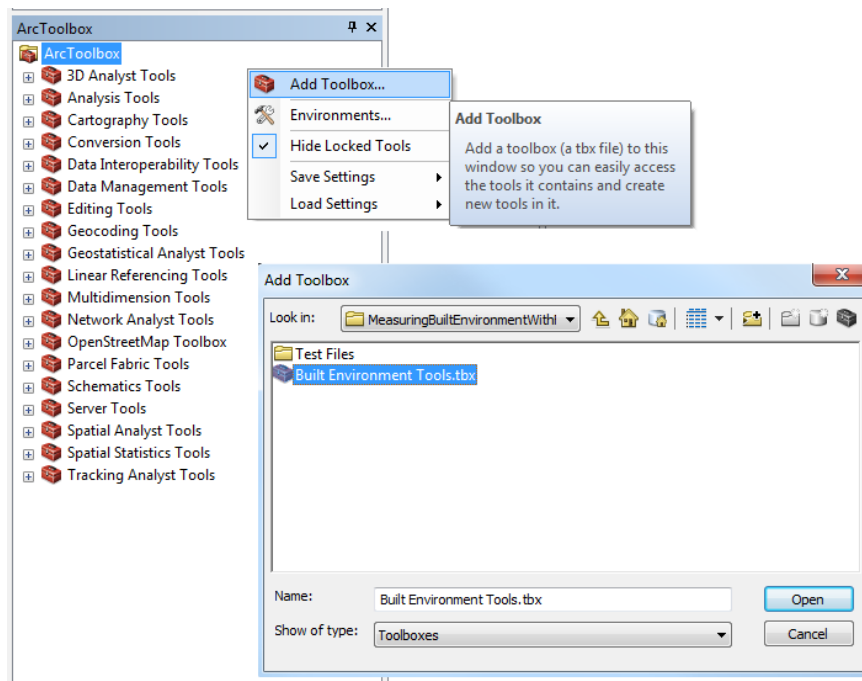


Figure 2 Adding the Built Environment Toolbox to the ArcGIS tools tab.

The Built Environment Toolbox should now appear in your toolbox list as, as shown below.

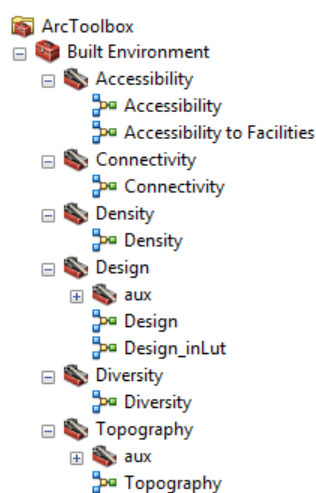
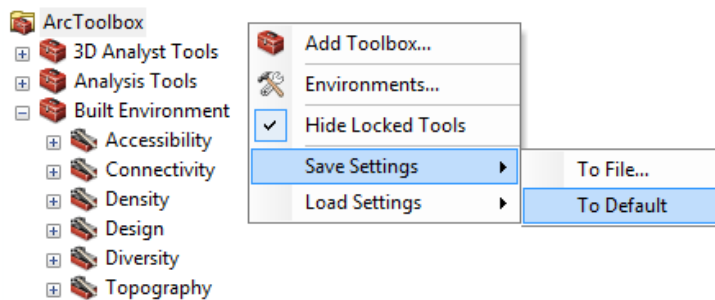


Figure 3 Built Environment Tools



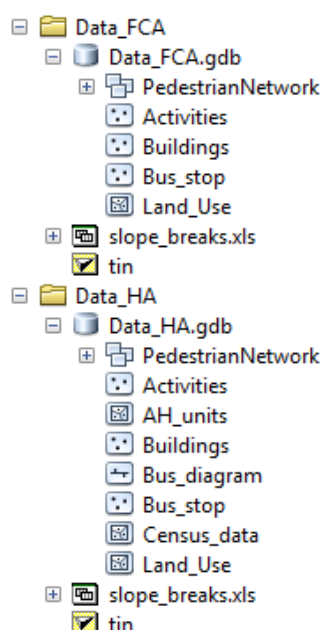
If you want, you can have ArcGIS to load this toolbox by default along with other toolboxes every time you open the program by right-clicking on a white area inside the toolbox tab and choosing Save Settings → To Default.



**Figure 4** Saving the Built Environment Tools to default settings to be loaded by ArcGIS every time the software is started.

### Test Files:

The downloaded zip folder ([Built Environment Tools for ArcGIS 10.1.zip](#)) contains some data of Santarém, a Portuguese medium-sized city, for you to test the toolbox. It contains a street network file (Pedestrian Network), a building point feature class (Buildings), activities point feature class (Activities), a public transport stops point feature class (Bus Stop), a land use polygon feature class (Land Use), a terrain model (TIN) and a Table (in x/s format) with TIN breaks classification for the same area (slope breaks). The Homogeneous Areas folder contains, besides the data of FCA folder, a polygon data file with homogeneous areas, the bus diagram and the Census Data.



**Figure 5** Contents of the Test Files.



## 2. Introduction

The focus of this research project was the development accessibility concept from a multimodal perspective, as a tool to evaluate the integration of land use and transport. This custom made GIS tool was used to calculate all environmental require measurements for the built environment characterization. Two different approaches were considered, first for floating catchment areas of each buildings location (Vol I.) and the second for pre-defined areas or homogeneous areas (Vol II.), in order to deeply understand mobility and comparing different neighborhoods, either with similar or distinct characteristics, from the same city or different cities.

Built environment is the most researched and discussed subject among urban and transportation planners because of the nature of relationships between travel and land use. A land mark study was produced in 1997 by Cervero and Kockelman where was set the original “three Ds”: Density, Diversity and Design. The concepts of Density, Design and Diversity used in this project aren’t exactly the same as Cervero and Kockelman’s paper, as we have also included the concepts of Accessibility, Connectivity and Topography that are not more than a reinterpretation of the original “three Ds”. Therefore, we have calculated indicators for 6 components of the built environment, namely; Accessibility, Connectivity, Density, Design, Diversity and Topography – see next picture.

All formulas used and methodological options are detailed in the last section of this manual – **Vol. III** see page 67.



Figure 6 Indicators calculated in InLUT project, with the InLUT toolbox

The toolbox for float catchment area is composed by 8 Model Tools. There are 2 additional auxiliary toolboxes for the operationalization of the Design and Topography models, which should not be used isolated.. The toolbox for Homogeneous Area is composed by 7 Model Tools. Those tools were created using ArcGIS's Model Builder with additional scripting in Visual Basic and Python.

## **VOL.I Measuring the built environment with floating catchment areas**

### 3. Accessibility Tool

#### Prerequisites:

This tool requires a Network Dataset file of the street network with an \*.nd extension. If you do not have a Network Dataset file of your street network yet, then you can easily create a Network Dataset from your \*.shp, \*.dwg, or \*.dxf files using ArcMap or ArcCatalog.

ArcGIS versions 10 and 10.1 make it particularly easy to convert a polyline layer to a Network Dataset. Simply open the ArcCatalog Tree in ArcMap, navigate to the polyline file that contains the appropriate network file, right-click, choose New Network Dataset, and follow the instructions.

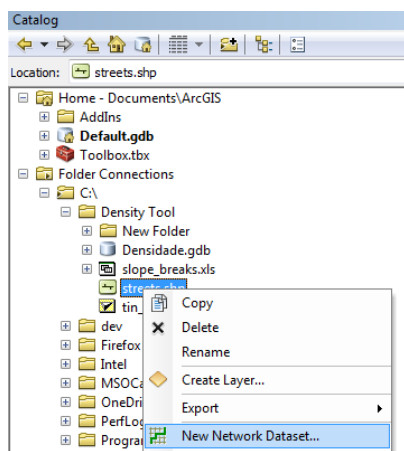


Figure 7 Creating a New Network Dataset from a polyline shapefile in ArcMAP 10.1

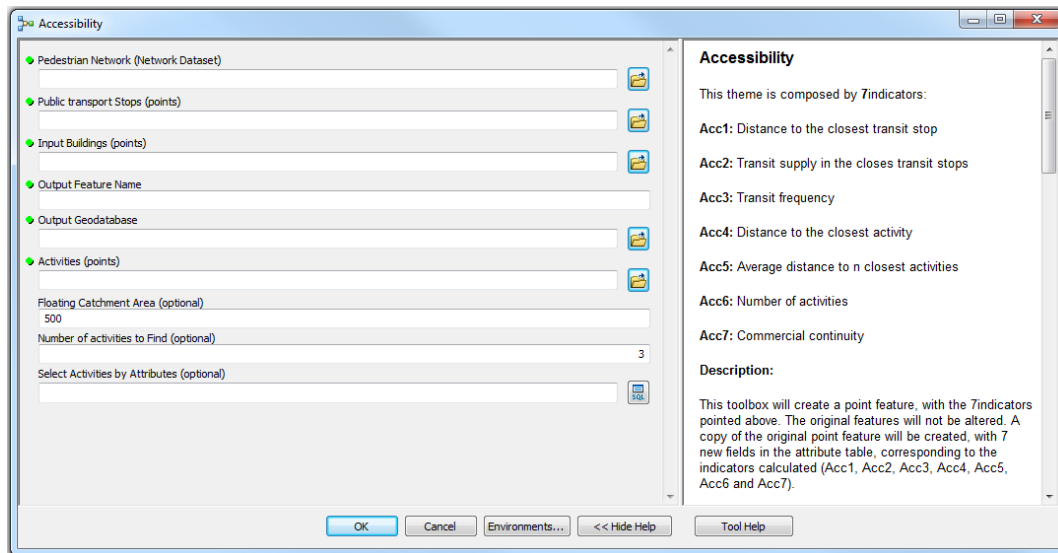


Figure 8 Accessibility tool user interface.

This tool calculates **7** indicators:

**Acc1:** Distance to the closest transit stop (meters)

**Acc2:** Transit supply in the closes transit stops (total supply per day)

**Acc3:** Transit frequency (Supply per day by public transit stop)

**Acc4:** Distance to the closest activity (meters)

**Acc5:** Average distance to  $n$  closest activities (meters)

**Acc6:** Number of activities (integral number)

**Acc7:** Commercial continuity (number of activities per 100 m of route length)

### 3.1.1 Description

This toolbox will create a point feature, with the **7** indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with **7** new fields in the attribute table, corresponding to the indicators calculated (Acc1, Acc2, Acc3, Acc4, Acc5, Acc6 and Acc7).

### 3.1.2. Toolbox Inputs:

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

1) **Pedestrian Network:** a network dataset is required. The network used to create the dataset was the pedestrian network.

2) **Public transport Stops:** a point feature is required, the BUS stops of the urban area. The attribute table must have the following field (**Double**):

'PT\_SUPPLY': the public transit frequency in each transit stops. (**All Caps**)

**Note:** If you don't have this information please use the **Accessibility to Facilities tool**.

3) **Input Buildings:** a point feature is required with the buildings of the urban area.

**Note:** If you want, you can use any other point feature to calculate the indicators, as for instance centroids of TAZs, blocks or even a regular grid of points.

4) **Output Feature Name:** The name of the output feature to be created by the toolbox.

5) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.

6) **Activities:** point feature is required. The activities must match with the same point as buildings information.

**Note:** If you want make a specific selection by one or several types of activities classification the attribute table must have the following field (**Text**):

**CODE\_TYPE:** Activities code classification with 7 type uses. (**All Caps**)

CODE_TYPE	Type of use
CS1	Diário/ Diary
CS2	Ocasional/ Occasional
CS3	Excepcional/ Exceptional
E1	Equipamentos de Ensino/ Facilities
E2	Outros Equipamentos / Other Facilities
O	Outros/ Other
V	Vago/ Unoccupied

- 7) **Floating Catchment Area:** The definition of the Floating Catchment Area analysis for each building it's a value in meters. The default is 500 m, but you can define a different value.
- 8) **Number of activities to find:** Insert the number of stores of a given activity to find. If you select one, the value for indicators Acc4 and Acc5 will be the same. The default value is 3 however you can choose other value. The minimum recommended value for the input is 2 since the result is a mean value.
- 9) **Expression:** Select the activities by type of use.

### 3.1.3. Calculating the accessibility indicators with our test files

If you are using our example files, the toolbox should look like this:

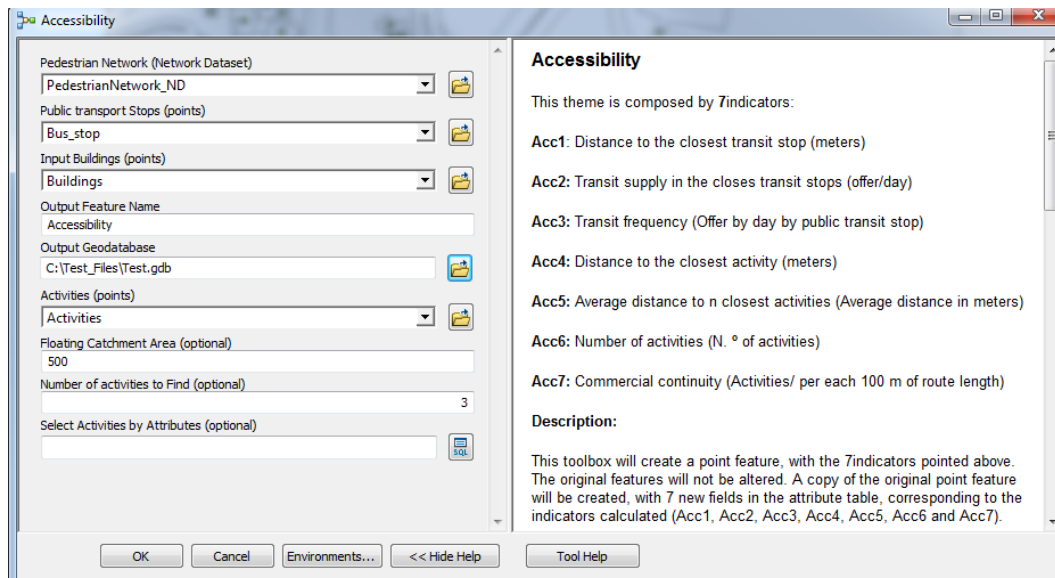


Figure 9 Accessibility tool user interface with our test files



## Results:

Table													
ACC_TEST_FINAL													
OBJECTID *	Shape *	AREA	NFLOOR_AG	NFLOOR_UG	NFRAC_TOT	NDWELLINGS	NACTIVITY	Acc5	Acc4	Acc6	Acc7	Acc1	Acc2
1	Point	211.9803	8	1	17	17	0	40.823098	38.980469	207	2.532803	293.691098	88
2	Point	205.0939	8	1	19	15	4	0	0	205	3.00493	342.278337	88
3	Point	217.2545	8	1	17	17	0	20.363694	20.363694	206	2.788993	321.912644	88
4	Point	223.6372	8	1	17	17	0	37.97725	37.97725	207	2.626776	304.299088	88
5	Point	247.41665	8	1	17	17	0	34.805587	32.963958	207	2.484984	287.674587	88
6	Point	229.86295	5	1	8	8	2	5.774866	0	150	1.765291	85.759426	88
7	Point	247.55465	6	1	12	10	2	5.179261	0	170	1.935349	211.100174	88
8	Point	286.9597	9	1	17	15	2	5.947536	0	172	1.940985	193.257566	88
9	Point	238.68925	7	1	13	11	2	1.510365	0	168	2.127158	204.888912	88
10	Point	260.72515	7	1	12	10	2	1.63361	0	168	2.118257	202.936711	88
11	Point	312.725486	6	2	18	15	3	0	0	149	1.853875	122.870268	26
12	Point	1454.8472	1	1	1	0	1	78.72871	0	134	1.975502	170.109145	26
13	Point	1006.400286	1	0	2	0	2	0.921314	0	207	2.519194	297.060613	88
14	Point	239.8386	7	1	13	12	1	94.4453	0	98	1.567194	130.674767	88
15	Point	228.49995	5	1	8	8	0	93.428223	15.862613	101	1.544767	114.612153	88
16	Point	222.2551	5	1	8	8	0	87.558207	33.47206	105	1.519329	97.202706	88
17	Point	263.0463	5	1	8	8	0	74.330338	47.375616	112	1.514794	53.368711	88
18	Point	257.75235	7	1	14	13	1	90.12221	0	104	1.662395	100.744327	88
19	Point	278.6687	4	1	11	9	2	17.522341	0	163	2.400845	189.132733	26
20	Point	256.2245	5	1	8	8	0	85.529606	39.557864	108	1.531838	91.116903	88
21	Point	271.54065	7	1	13	13	0	99.222425	14.331377	94	1.567764	145.006143	88
22	Point	230.35115	7	1	13	13	0	99.222425	14.331377	94	1.567764	145.006143	88
23	Point	186.67315	2	0	2	2	0	352.034337	46.783027	2	0.126251	1057.501711	88
24	Point	123.83095	1	1	2	2	0	328.396662	23.125352	2	0.126251	1033.944036	88
25	Point	90.1545	1	1	1	1	0	321.389505	16.118195	2	0.126251	1026.936879	88
26	Point	86.1337	1	1	2	2	0	303.980286	3.873072	2	0.126251	1006.945612	88
27	Point	30.11	2	1	3	3	0	300.728784	13.633549	2	0.126251	997.185134	88
28	Point	135.1767	1	1	2	2	0	295.691464	19.548898	2	0.126251	982.079145	88
29	Point	246.3564	7	1	12	12	0	71.255129	66.193789	154	1.929923	150.944899	88

Figure 10 Attribute table of the calculated indicators

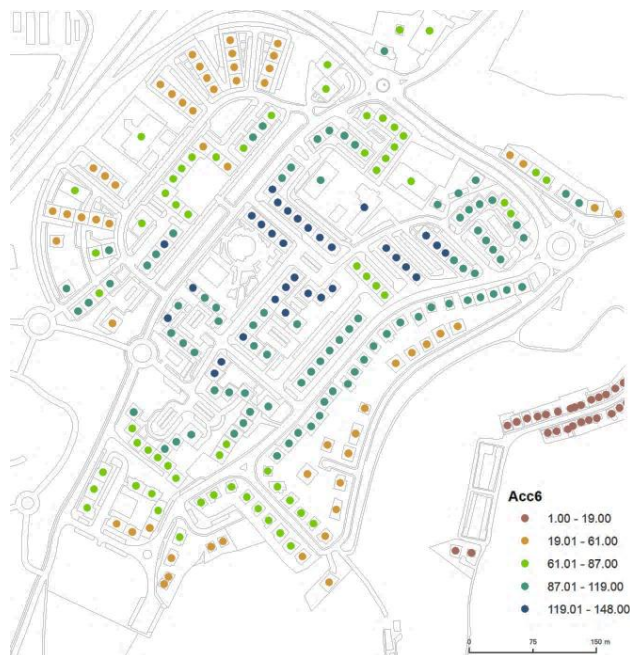


Figure 11 Representation of the values of Commercial continuity (ACC6)

## 3.2. Accessibility to Facilities

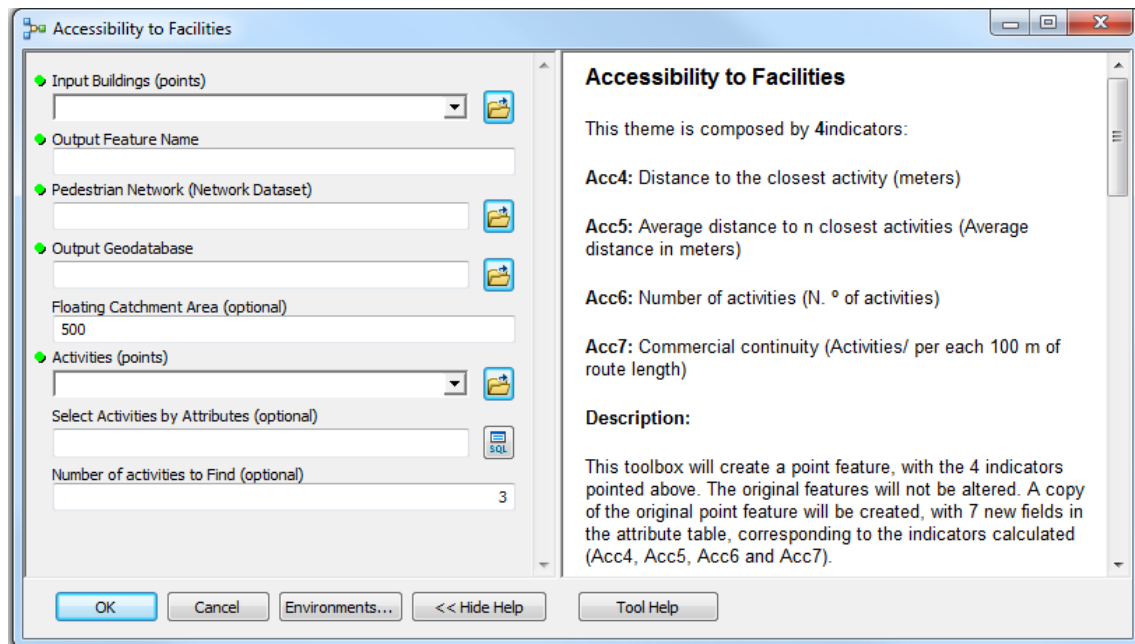


Figure 12 Accessibility to Facilities tool user interface

This tool calculates **4** indicators:

**Acc4:** Distance to the closest activity (meters)

**Acc5:** Average distance to *n* closest activities (meters)

**Acc6:** Number of activities (integral number)

**Acc7:** Commercial continuity (number of activities per 100 m of route length)

### 3.2.1. Description

This toolbox will create a point feature, with the **4** indicators pointed above. A copy of the original point feature will be created, with **4** new fields in the attribute table, corresponding to the indicators calculated (Acc4, Acc5, Acc6 e Acc7).

**Usage:** Use this tool if you don't have the public transit frequency in each transit stops ('PT\_SUPPLY').

### 3.2.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) **Pedestrian Network:** a network dataset is required. The network used to create the dataset was the pedestrian network.
- 2) **Input Buildings:** a point feature is required with the buildings of the urban area.  
**Note:** If you want, you can use any other point feature to calculate the indicators, as for instance centroids of TAZs, blocks or even a regular grid of points.
- 3) **Output Feature Name:** The name of the output feature to be created by the toolbox.
- 4) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.
- 5) **Activities:** point feature is required. The activities must match with the same point as buildings information  
**Note:** If you want make a specific selection by one or several types of activities classification the attribute table must have the following field (**Text**):

**CODE\_TYPE:** Activities code classification with 7 type uses. (**field - text and All Caps**).

CODE_TYPE	Type of use
CS1	Diário/ Diary
CS2	Ocasional/ Occasional
CS3	Excepcional/ Exceptional
E1	Equipamentos de Ensino/ Facilities
E2	Outros Equipamentos / Other Facilities
O	Outros/ Other
V	Vago/ Unoccupied

- 6) **Floating Catchment Area:** The definition of the Floating Catchment Area analysis for each building it's a value in meters. The default is 500 m, but you can define a different value.
- 7) **Number of activities to find:** Insert the number of stores of a given activity to find. If you select one, the value for indicators Acc4 and Acc5 will be the same. The default value is 3 however you can choose other value. The minimum recommended value for the input is 2 since the result is a mean value.
- 8) **Expression:** Select the activities by type of use.

### 3.2.3. Calculating the accessibility to facilities indicators with our test files

If you are using our example files, the toolbox should look like this:

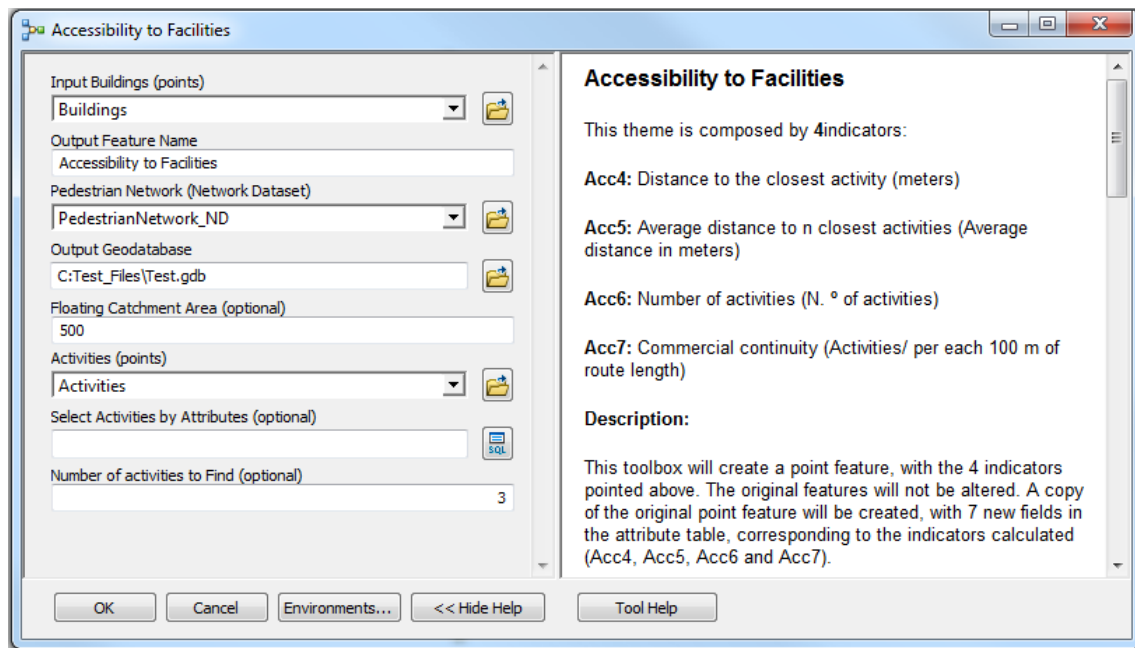


Figure 13 Accessibility to Facilities tool user interface with our test files

## Results:






Table																	
    																	
AccessibilityFacilities																	
	OBJECTID *	Shape *	CHAVE	NFLOOR AG	NFLOOR UG	NFRAC TOT	NDWELLINGS	NACTIVITY	AREA	Ed unifam	ABC	ABC hab	ABC com	Acc5	Acc4	Acc3	Acc2
1	Point	1416_253_1	8	1	17	17	0	211.9003	0	1907.8227	1907.8227	0	54.09357	25.896764	140	1.840706	
2	Point	1416_253_5	8	1	19	15	4	205.9939	0	1845.8451	1457.246132	388.598968	0	0	65	2.334037	
3	Point	1416_253_6	8	1	17	17	0	217.2545	0	1955.2905	1955.2905	0	15.061923	15.061923	68	2.253129	
4	Point	1416_253_7	8	1	17	17	0	223.8372	0	2012.7348	2012.7348	0	30.800952	30.800952	68	2.158775	
5	Point	1416_253_8	8	1	17	17	0	247.41665	0	2226.74985	2226.74985	0	47.61758	47.61758	65	2.263193	
6	Point	1416_264_4	5	1	8	8	2	229.98295	0	1379.8977	1034.923275	344.974425	17.676292	0	68	1.053655	
7	Point	1416_264_7	6	1	12	10	2	247.55465	0	1732.88255	1444.068792	288.813758	10.358531	0	119	1.357544	
8	Point	1416_264_8	9	1	17	15	2	286.9597	0	2869.597	2531.997353	337.599647	16.432736	0	114	1.319571	
9	Point	1416_265_2	7	1	13	11	2	238.68925	0	1909.514	1615.742615	293.771385	11.818371	0	65	1.091012	
10	Point	1416_265_8	7	1	12	10	2	280.72515	0	2085.8012	1738.167667	347.633533	10.715388	0	77	1.170784	
11	Point	1416_642_2	6	2	18	15	3	312.725486	0	2501.803886	2084.836572	416.967314	69.159015	0	98	1.18631	
12	Point	1416_555_2	1	1	1	0	1	1454.8472	1	2909.6944	0	2909.6944	45.127215	0	69	1.017236	
13	Point	1416_250_23	1	0	2	0	2	1006.400286	0	1006.400286	0	1006.400286	44.656992	0	146	1.776823	
14	Point	1416_268_6	7	1	13	12	1	239.8386	0	1918.7088	1771.115815	147.592985	119.655662	0	49	1.061252	
15	Point	1416_268_7	5	1	8	8	0	228.49995	0	1370.9997	1370.9997	0	135.861338	16.205676	45	1.051991	
16	Point	1416_268_8	5	1	8	8	0	222.2551	0	1333.5306	1333.5306	0	144.430798	31.776333	45	1.089219	
17	Point	1416_270_1	5	1	8	8	0	263.0463	0	1578.2778	1578.2778	0	138.591128	49.319342	48	1.147719	
18	Point	1416_270_5	7	1	14	13	1	257.75235	0	2062.0188	1914.731743	147.287057	105.850115	0	51	1.031478	
19	Point	1416_642_1	4	1	11	9	2	278.8687	0	1393.3435	1140.008318	253.335182	2.058806	0	92	1.997742	
20	Point	1416_268_1	5	1	8	8	0	256.2245	0	1537.347	1537.347	0	213.559358	165.87371	44	1.152517	
21	Point	1416_268_4	7	1	13	13	0	271.54965	0	2172.3252	2172.3252	0	163.379851	115.694204	49	1.017812	
22	Point	1416_268_5	7	1	13	13	0	230.35115	0	1842.8092	1842.8092	0	114.230504	16.275476	49	0.985065	
23	Point	1416_235_32	2	0	2	2	0	108.67315	0	217.3463	217.3463	0	636.22533	46.762985	1	0.063126	

Figure 14 Attribute table of the calculated indicators

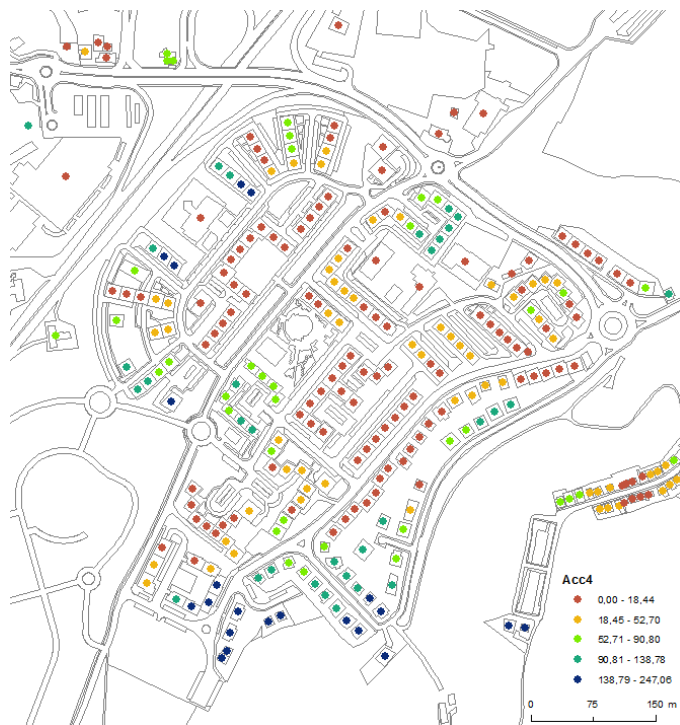


Figure 15 Representation of the values of Distance to the closest activity (ACC4)

## 4. Connectivity Tool

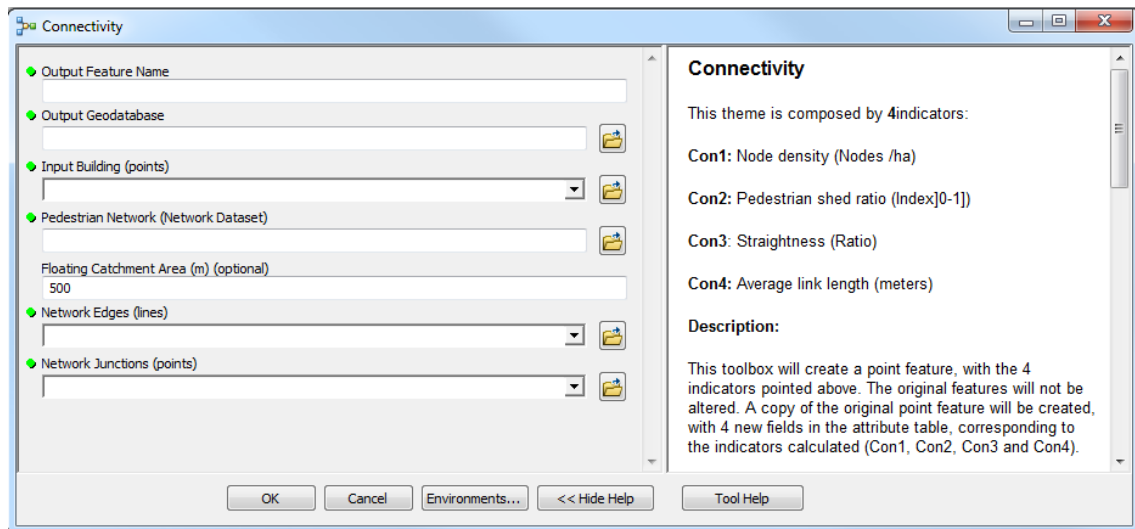


Figure 16 Connectivity tool user interface.

This tool calculates **4** indicators:

**Con1:** Node density (Nodes per ha)

**Con2:** Pedestrian shed ratio (Index [0-1] )

**Con3:** Straightness (ratio)

**Con4:** Average link length (meters)

### 4.1. Description

This toolbox will create a point feature, with the **4** indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with **4** new fields in the attribute table, corresponding to the indicators calculated (Con1, Con2, Con3 and Con4).

## 4.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) **Output Feature Name:** The name of the output feature to be created by the toolbox.
- 2) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.
- 3) **Input Buildings:** a point feature is required with the buildings of the urban area.
- 4) **Pedestrian Network:** a network dataset is required. The network used to create the dataset was the pedestrian network.
- 5) **Floating Catchment Area:** The definition of the Floating Catchment Area analysis for each building it's a value in meters. The default is 500 m.
- 6) **Network Edges:** Line feature is required, with the lines that was used to create the network dataset.
- 7) **Network Junctions:** Point feature created by the network dataset.

## 4.3. Calculating the connectivity indicators with our test files

If you are using our example files, the toolbox should look like this:

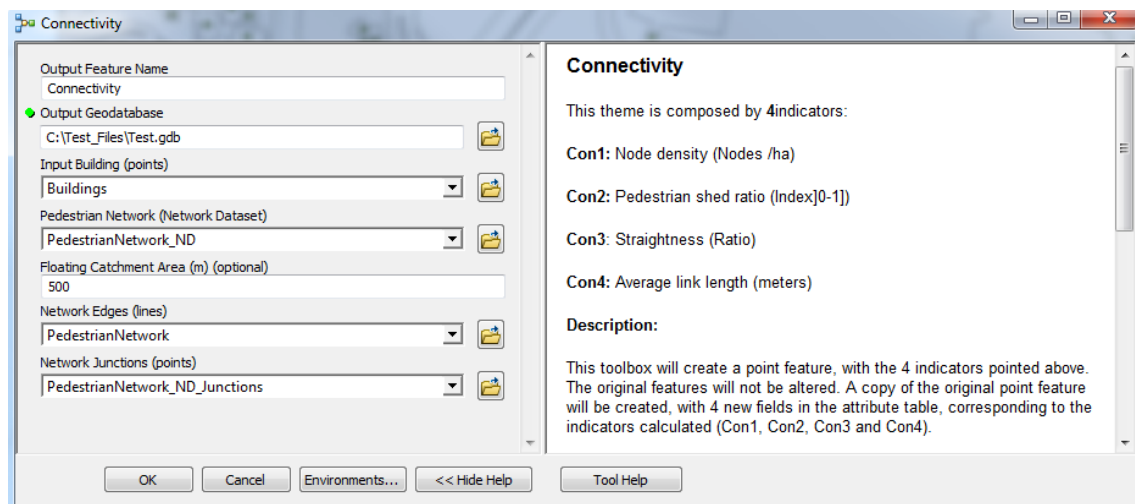


Figure 17 Connectivity tool user interface with our test files



Results:

Table													
CON_TEST_FINAL													
OBJECTID *	Shape *	AREA	NFLOOR AG	NFLOOR UG	NFRAC TOT	NDWELLINGS	NACTIVITY	FacilityID	Con2	Con4	Con1	Con3	
1	Point	211,9803	8	1	17	17	0	1	0,319694	41,910379	3,425104	0,649348	
2	Point	205,0939	8	1	19	15	4	2	0,242151	41,349104	3,785789	0,609648	
3	Point	217,2545	8	1	17	17	0	3	0,274124	41,728598	3,576463	0,621859	
4	Point	223,6372	8	1	17	17	0	4	0,301242	41,257334	3,550369	0,63893	
5	Point	247,41665	8	1	17	17	0	5	0,327923	41,236574	3,416809	0,658873	
6	Point	229,98295	5	1	8	6	2	6	0,378984	41,651871	2,889268	0,648908	
7	Point	247,55465	6	1	12	10	2	7	0,398436	43,180155	2,780165	0,685542	
8	Point	286,9597	9	1	17	15	2	8	0,407212	42,602014	2,782783	0,697568	
9	Point	238,68925	7	1	13	11	2	9	0,339647	43,393557	2,886509	0,641981	
10	Point	260,72515	7	1	12	10	2	10	0,342228	43,575905	2,864738	0,650001	
11	Point	312,725486	6	2	18	15	3	11	0,46935	43,24957	2,224474	0,705898	
12	Point	1454,8472	1	0	1	0	1	12	0,416266	44,044714	2,018751	0,727159	
13	Point	1006,400286	1	0	2	0	2	13	0,338338	42,573432	3,19874	0,689454	
14	Point	239,8386	7	1	13	12	1	14	0,270659	41,410792	3,104786	0,680664	
15	Point	228,49995	5	1	8	8	0	15	0,293885	41,119573	2,98939	0,679443	
16	Point	222,2551	5	1	8	8	0	16	0,314657	42,397189	2,872972	0,68435	
17	Point	263,0463	5	1	8	8	0	17	0,33031	38,709571	3,122295	0,721126	
18	Point	257,75235	7	1	14	13	1	18	0,270589	41,985583	3,105589	0,72828	
19	Point	278,6687	4	1	11	9	2	19	0,390443	47,150299	2,08705	0,798814	
20	Point	256,2245	5	1	8	8	0	20	0,326987	42,728152	2,842515	0,688001	

Figure 18 Attribute table of the calculated indicators



Figure 19 Representation of the values of Node density (Con1)

## 5. Density Tool

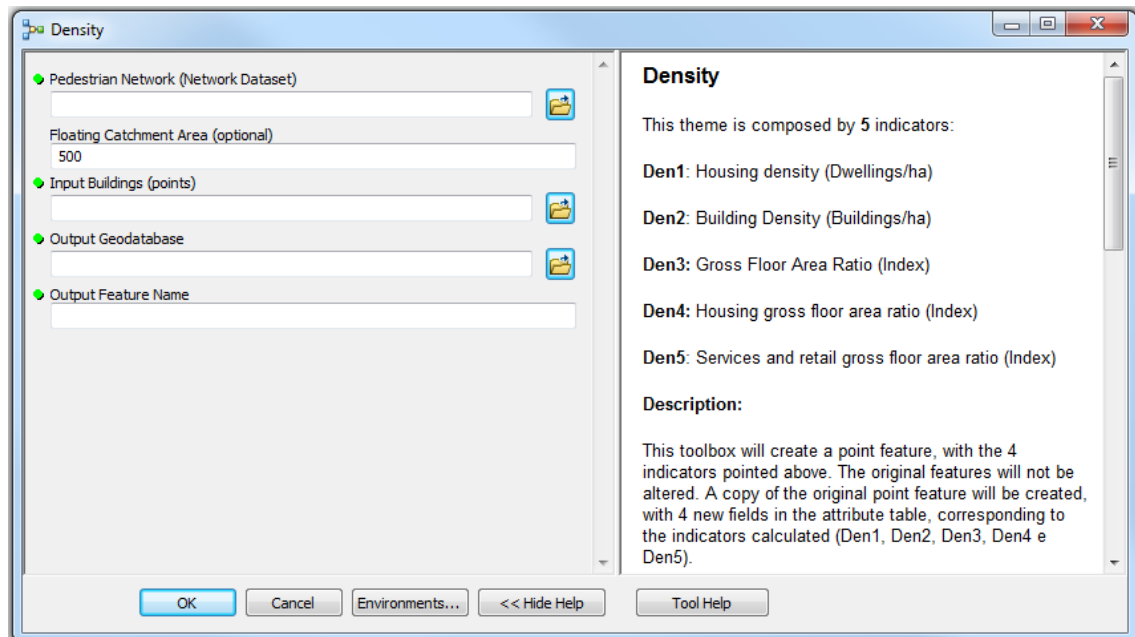


Figure 20 Density tool user interface.

This tool calculates **5** indicators:

**Den1:** Housing density (Dwellings per ha)

**Den2:** Building Density (Buildings per ha)

**Den3:** Gross Floor Area Ratio (Index)

**Den4:** Housing gross floor area ratio (Index)

**Den5:** Services and retail gross floor area ratio (Index)

### 5.1. Description

This toolbox will create a point feature, with the **5** indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with **5** new fields in the attribute table, corresponding to the indicators calculated (Den1, Den2, Den3, Den4 and Den5).

## 5.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

1) **Pedestrian Network:** a network dataset is required. The network used to create the dataset was the pedestrian network.

2) **Floating Catchment Area:** The definition of the Floating Catchment Area analysis for each building it's a value in meters. The default is 500 m.

3) **Input Buildings:** a point feature is required, the buildings of the urban area

The attribute table of the input buildings must have the following fields (**double**):

**AREA:** Ground floor gross area (m2) of each building (**All Caps**)

**NFLOOR\_AG:** Number of floors above ground (including ground floor) (**All Caps**)

**NFLOOR\_UG:** Number of floors under ground (excluding ground floor) (**All Caps**)

**NFRAC\_TOT:** Number of fractions (dwellings and commercial units) (**All Caps**)

**NDWELLINGS:** Number of dwellings (only housing) (**All Caps**)

**NACTIVITY:** Number of non-housing fractions( **All Caps**)

4) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.

5) **Output Feature Name:** The name of the output feature to be created by the toolbox

### 5.3. Calculating the density indicators with our test files

If you are using our example files, the toolbox should look like this:

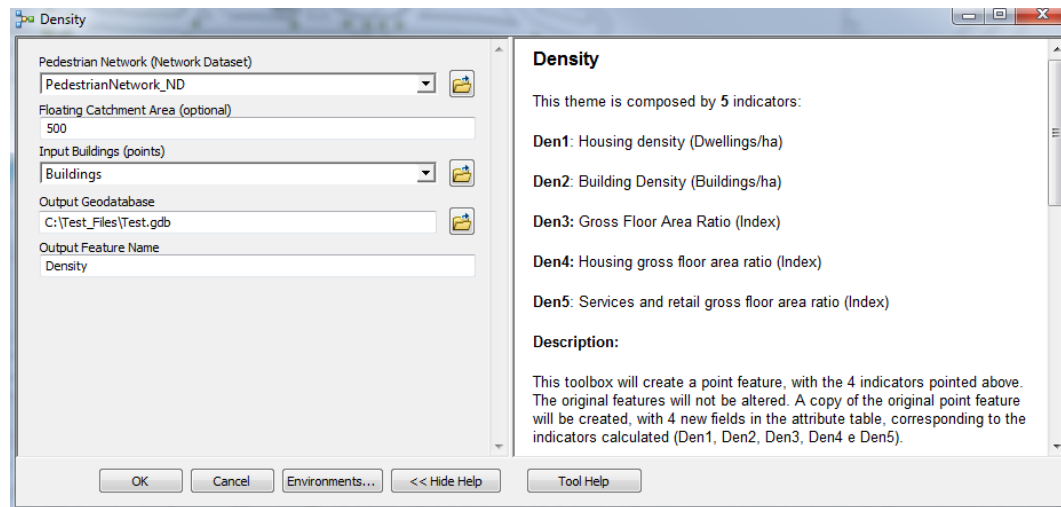


Figure 21 Density tool user interface with our test files

Results:

Table																
<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div></div>																
DEN_TEST_FINAL																
OBJECTID	Shape	AREA	NFLOOR AG	NFLOOR UC	NFRAC TOT	NDWELLINGS	NACTIVITY	Ed unifam	ABC	ABC hab	ABC com	Den1	Den2	Den3	Den4	Den5
47	Point	37.48375	1	0	1	0	1	0	37.48375	0	37.48375	0.681864	0.307171	0.007428	0.007428	0
48	Point	162.3008	2	0	1	1	0	0	324.6016	324.6016	0	0.655753	5.323175	0.008589	0.008589	0
49	Point	272.2147	7	1	14	14	0	0	2177.7176	2177.7176	0	0.691185	6.667899	0.007757	0.007757	0
50	Point	844.75335	1	0	1	0	1	0	844.75335	0	844.75335	0.560153	5.733332	0.006286	0.006286	0
51	Point	190.18835	2	0	1	1	0	0	380.3767	380.3767	0	0.692593	5.309881	0.010722	0.008773	0.00195
52	Point	294.4867	3	0	1	0	1	0	883.4601	0	883.4601	0.326313	3.371901	0.007505	0.005628	0.001876
53	Point	377.67885	1	0	2	0	2	0	377.67885	0	377.67885	0.264771	4.986521	0.006099	0.004567	0.001522
54	Point	249.1597	2	0	1	1	0	0	498.3194	498.3194	0	0	5.301631	0.000159	0	0.000159
55	Point	156.54925	2	0	1	1	0	0	313.0985	313.0985	0	0	5.318915	0.000153	0	0.000153
56	Point	220.8675	2	1	1	1	0	1	662.6025	662.6025	0	0.565064	5.901781	0.008748	0.007158	0.001591
57	Point	204.74045	2	0	1	1	0	0	409.4809	409.4809	0	0.430823	4.739049	0.00667	0.005457	0.001213
58	Point	137.17375	2	0	1	1	0	0	274.3475	274.3475	0	0	5.246514	0.000165	0	0.000165
59	Point	122.1986	2	0	1	1	0	0	244.3972	244.3972	0	0	4.796688	0.00014	0	0.00014
60	Point	182.706	2	0	1	1	0	0	365.412	365.412	0	0	4.994619	0.000141	0	0.000141
61	Point	166.01785	2	0	1	1	0	0	332.0357	332.0357	0	0.642204	5.213186	0.008412	0.008412	0

Figure 22 Attribute table of the calculated indicators

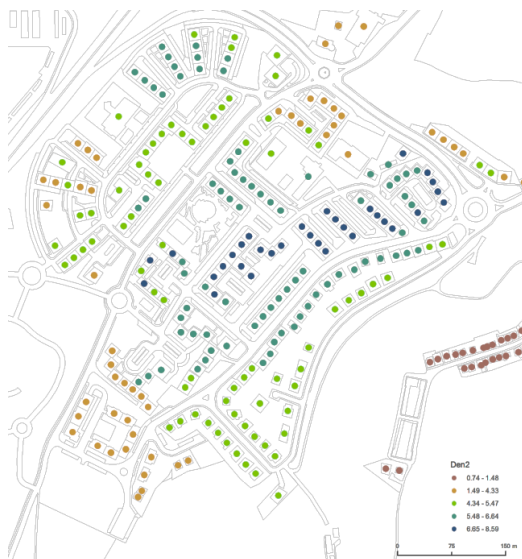


Figure 23 Representation of the values of Building density (Den2)

## 6. Design inLut Tool

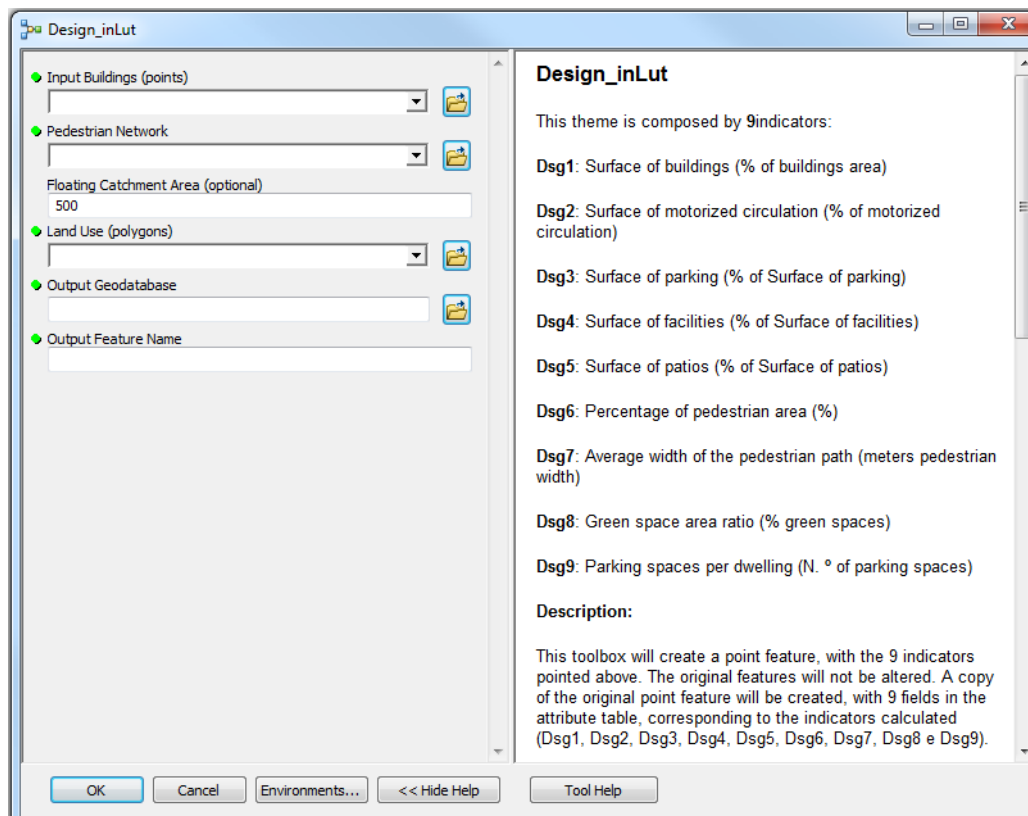


Figure 24 Design inLut tool user interface

**NOTE:** As this tool relates points (origins) with polygons (several land uses), its computation takes **very long time**. For example, in Santarém, a city with 6000 buildings, it took 19 hours to calculate. It is recommended that you make Geometry Check on the file of land use. If any problem was detected we recommend you to run a Repair Geometry.

For the test file we are providing it should take around 20 minutes to compute.

This tool calculates **9** indicators:

**Dsg1:** Surface of buildings (% of buildings area)

**Dsg2:** Surface of motorized circulation (% of motorized circulation)

**Dsg3:** Surface of parking (% of Surface of parking)

**Dsg4:** Surface of facilities (% of Surface of facilities)

**Dsg5:** Surface of patios (% of Surface of patios)

**Dsg6:** Percentage of pedestrian area (%)

**Dsg7:** Average width of the pedestrian path (meters pedestrian width)

**Dsg8:** Green space area ratio (% green spaces)

**Dsg9:** Parking spaces per dwelling (N.º of parking spaces)

### 6.1.1. Description

This toolbox will create a point feature, with the 9 indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with 9 fields in the attribute table, corresponding to the indicators calculated (Dsg1, Dsg2, Dsg3, Dsg4, Dsg5, Dsg6, Dsg7, Dsg8 and Dsg9).

### 6.1.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) **Input Buildings:** a point feature is required, the buildings of the urban area

The attribute table of the input buildings must have the following fields:

**NFRAC\_TOT:** Number of fractions (dwellings and commercial units) (**All Caps**)

**Note:** If you don't have this field information please use **the Design Tool**.

- 2) **Pedestrian Network:** a network dataset is required. The network used to create the dataset was the pedestrian network.
- 3) **Floating Catchment Area:** The definition of the Floating Catchment Area analysis for each building it's a value in meters. The default is 500 m.

- 4) **Land Use:** a polygon feature is required, the land use classification.  
The attribute table must have a field designated **LAND\_USE (field - text and All Caps)**.

**LAND\_USE:** the land use classification using the classes defined for the InLUT project.

"circ\_motorizada"  
"circ\_pedonal"  
"edificios"  
"equipamentos"  
"espaços\_verdes"  
"estacionamento"  
"logradouro"

**Note:** If you don't have this land use classifications please use **the Design Tool**.

- 5) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.
- 6) **Output Feature Name:** The name of the output feature to be created by the toolbox

### 6.1.3. Calculating the design indicators with our test files

If you are using our example files, the toolbox should look like this:

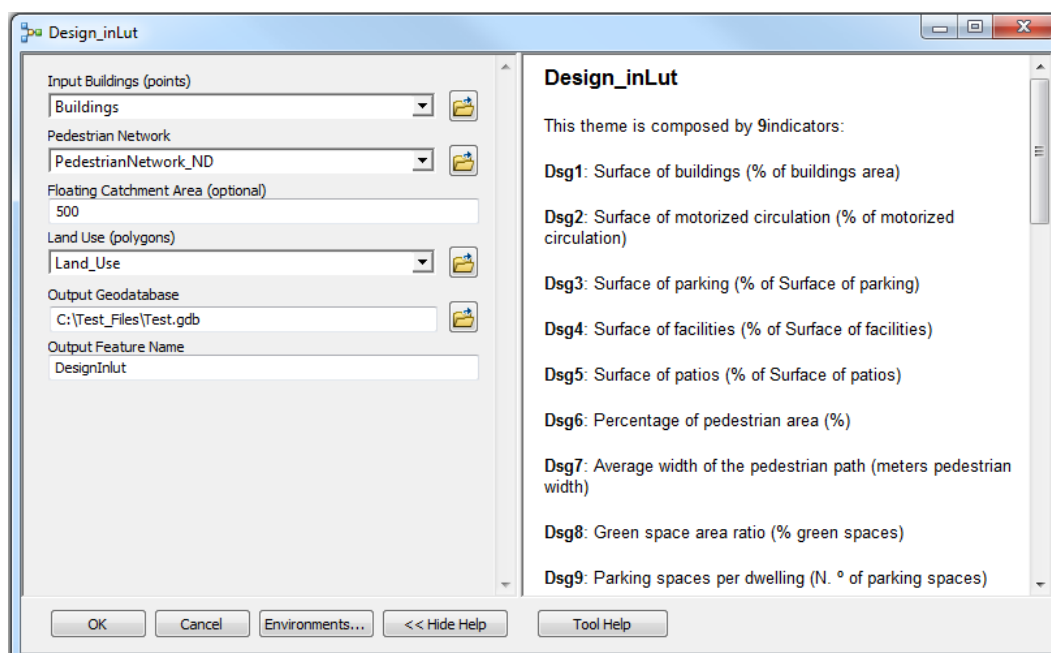


Figure 25 Design inLut tool user interface with our test files



## Results:

Table																	
DSG																	
OBJECTID*	Shape*	AREA	NFLOOR AG	NFLOOR UG	NFRAC TOT	NDWELLINGS	NACTIVITY	Dsg1	Dsg2	Dsg3	Dsg4	Dsg5	Dsg6	Dsg7	Dsg8	Dsg9	
1	Point	211,9803	8	1	17	17	0	18,737856	24,304784	6,066439	1,491131	7,84947	19,392335	5,957974	2,172512	0,34856	
2	Point	205,0939	8	1	19	15	4	20,409177	26,742408	6,757974	1,95853	8,967197	22,377181	6,237799	2,868209	0,309702	
3	Point	217,2545	8	1	17	17	0	19,662875	25,517304	6,459438	1,730092	8,192589	20,973056	6,113525	2,533669	0,33318	
4	Point	223,6372	8	1	17	17	0	18,877047	24,734291	6,120692	1,574347	8,046327	20,019286	6,010628	2,305585	0,338981	
5	Point	247,41685	8	1	17	17	0	18,406121	24,030058	6,063146	1,44989	8,013094	19,105731	5,907336	2,117995	0,369972	
6	Point	229,98295	5	1	8	6	2	15,228366	24,517417	7,378521	3,339063	5,011018	16,265289	5,897799	1,832638	0,547954	
7	Point	247,55465	6	1	12	10	2	15,583959	22,776329	5,994008	1,628888	4,587996	15,817938	5,647007	1,743164	0,42688	
8	Point	286,9597	9	1	17	15	2	15,236354	22,602203	5,894222	1,546492	4,257844	15,370891	5,547741	1,705596	0,430194	
9	Point	238,68925	7	1	13	11	2	17,243446	23,944916	7,324859	1,972325	5,017705	17,901051	6,04644	2,044886	0,475186	
10	Point	260,72515	7	1	12	10	2	17,171175	23,946928	7,320269	1,957517	4,984481	17,814713	6,037635	2,029463	0,476643	
11	Point	312,725486	6	2	18	15	3	9,678149	19,035218	5,051905	3,496226	5,456143	10,114284	4,513428	1,479791	0,614609	
12	Point	1454,8472	1	1	1	0	1	8,484886	17,492545	5,170385	3,79064	4,425427	9,351591	4,507463	1,668498	0,669192	
13	Point	1006,400286	1	0	2	0	2	17,693087	22,827685	5,649814	1,410569	7,717733	18,294957	5,916844	2,052801	0,343395	
14	Point	239,8386	7	1	13	12	1	14,753293	25,782217	6,472863	2,474921	5,65521	14,117067	4,799171	2,566106	0,532908	
15	Point	228,49995	5	1	8	8	0	14,025932	24,999976	6,907062	2,524656	5,779979	13,98532	4,937343	2,363308	0,598447	
16	Point	222,2551	5	1	8	8	0	13,654844	24,973587	7,015253	2,939732	5,684193	13,87151	4,960506	2,207293	0,608311	
17	Point	263,0463	5	1	8	8	0	14,157106	25,752596	7,110934	4,041754	5,724896	14,006948	4,914766	2,102693	0,614098	
18	Point	257,75235	7	1	14	13	1	15,511309	25,055809	7,711101	3,688101	6,871451	14,647008	4,975793	2,56677	0,612851	
19	Point	278,6687	4	1	11	9	2	11,24821	16,301462	3,524983	1,136137	9,678093	10,476984	4,731909	1,167396	0,398235	
20	Point	256,2245	5	1	8	8	0	13,644036	24,823024	7,12026	2,949185	5,519411	14,059738	5,121524	2,12406	0,590248	
21	Point	271,54065	7	1	13	13	0	15,001343	25,761244	7,047409	2,504384	5,838213	14,145756	4,78629	2,627015	0,56242	
22	Point	230,35115	7	1	13	13	0	15,001343	25,761244	7,047409	2,504384	5,838213	14,145756	4,78629	2,627015	0,56242	

Figure 26 Attribute table of the calculated indicators

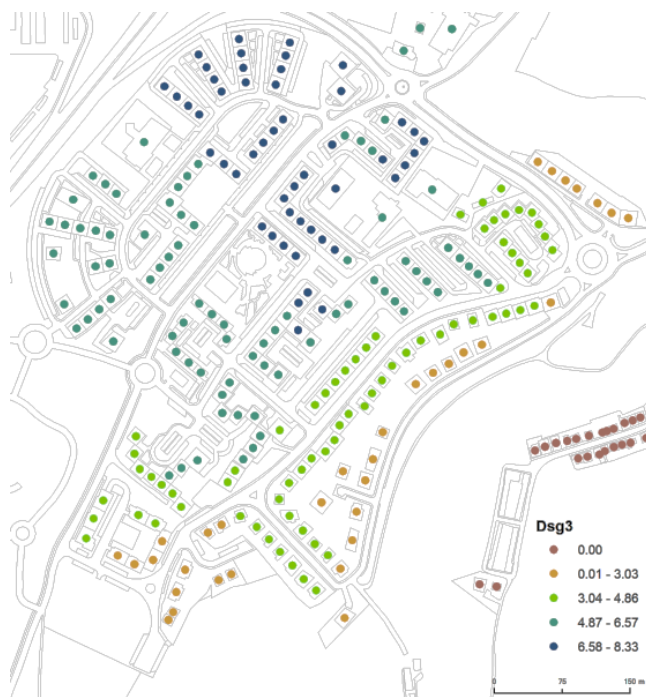


Figure 27 Representation of the values of Surface of parking (Dsg3)

## 6.2 Design Tool

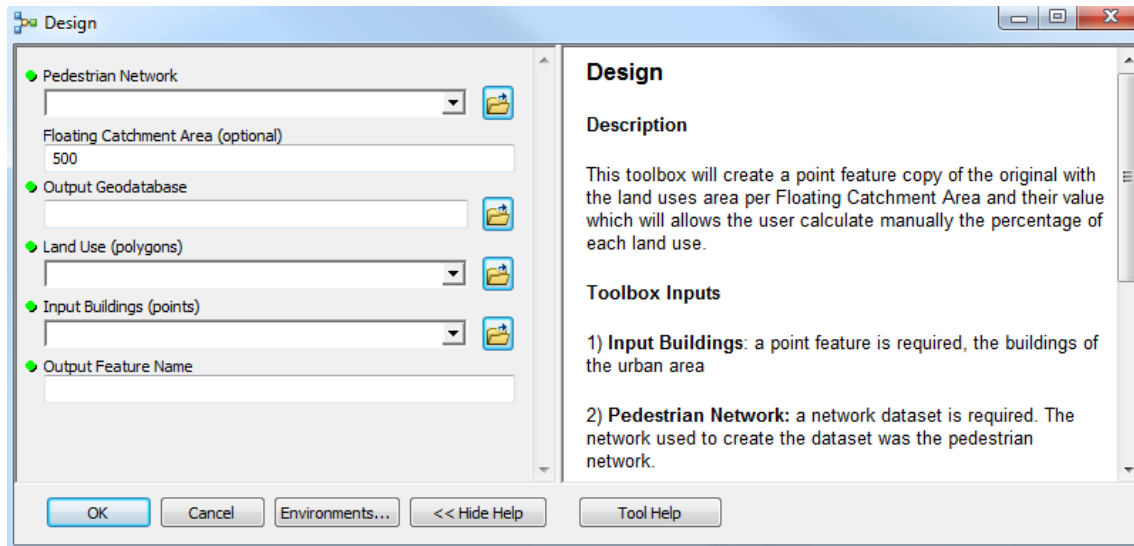


Figure 28 Design tool user interface

**NOTE:** As this tool relates points (origins) with polygons (several land uses), its computation takes **very long time**. For example, in Santarém, a city with 6000 buildings, it took 19 hours to calculate. It is recommended that you make a Geometry Check on the file of land use. If any problem was detected we recommend you to run a Repair Geometry.

For the test file we are providing it should take around 20 minutes to compute.

### 6.2.1. Description

This toolbox will create a point feature copy of the original with the land uses area per Floating Catchment Area and their value which will allow the user to calculate manually the percentage of each land use type.

### 6.2.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) **Input Buildings:** a point feature is required, the buildings of the urban area
- 2) **Pedestrian Network:** a network dataset is required. The network used to create the dataset was the pedestrian network.
- 3) **Floating Catchment Area:** The definition of the Floating Catchment Area analysis for each building it's a value in meters. The default is 500 m.
- 4) **Land Use:** a polygon feature is required with the land use classification.
- 5) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.
- 6) **Output Feature Name:** The name of the output feature to be created by the toolbox

### 6.2.3. Calculating the design indicators with our test files

If you are using our example files, the toolbox should look like this:

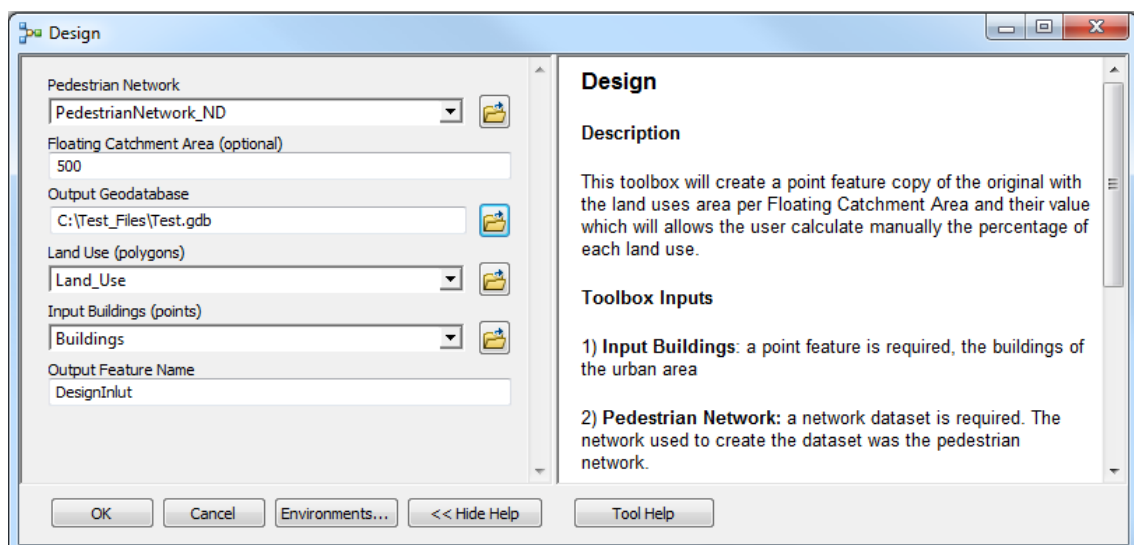


Figure 29 Design tool user interface with our test files

## Results:

OBJECTID	Shape	CHAVE	Espacos urbanizados não const.	espacos verdes	estacionamento	logradouro	verdes enquadramento	FCA Area	FCA LENGTH
1	Point	1416_253_1	30657,986972	5454,901368	13076,857421	19165,686876	6861,353413	240541,852295	7605,555713
2	Point	1416_253_5	3659,009867	1592,377877	8625,137205	16392,711393	3814,888655	103588,558158	2784,792724
3	Point	1416_253_6	4669,886219	1874,280258	6837,61378	17646,122523	3814,888655	112609,776368	3017,936726
4	Point	1416_253_7	5268,53879	1944,323336	6940,531942	18596,482361	3814,888655	118285,440122	3149,842078
5	Point	1416_253_8	3976,777752	1593,977161	6673,427811	16879,376623	3814,888655	106843,075058	2871,964204
6	Point	1416_264_4	23410,961502	5454,901368	16913,400018	14605,344876	17303,134599	217383,260206	6453,533643
7	Point	1416_264_7	58690,134813	5454,901368	18757,112597	14357,270225	26055,69274	312931,083413	8765,571316
8	Point	1416_264_8	63193,567747	5454,901368	18533,009603	11788,939637	28007,944109	319016,097813	8638,914317
9	Point	1416_265_2	21110,257349	5454,901368	15554,330624	14095,280752	13785,849819	200593,676558	5957,595982
10	Point	1416_265_6	43951,108649	5454,901368	15432,774897	6243,808698	23646,377433	236152,711425	6576,593772
11	Point	1416_642_2	34786,392651	5454,901368	18622,861037	20112,789217	20185,391063	368626,50034	6280,668449
12	Point	1416_555_2	32847,899699	5454,901368	16903,789057	14468,261838	17662,161185	326934,832866	6782,885165
13	Point	1416_250_23	35356,533678	5454,901368	15013,232075	20508,306565	7844,53928	265729,660992	8216,672617
14	Point	1416_268_6	16802,819007	4574,124858	10142,594673	8585,299521	12865,009068	140598,167847	4617,052819
15	Point	1416_268_7	14053,953757	3922,043549	9827,245098	7796,650249	10960,218287	125310,032149	4277,477178
16	Point	1416_268_8	13105,879104	3929,089606	9348,641164	7799,0337	10525,438846	120582,334045	4131,277243
17	Point	1416_270_1	13480,981131	4656,778312	8927,33888	8647,593579	11263,088738	127468,700395	4182,085681
18	Point	1416_270_5	15945,898204	5183,842336	11131,815634	11662,23633	12541,77724	156234,267192	4944,214398
19	Point	1416_642_1	13030,462454	4300,669413	5494,254869	16286,515784	1843,523796	143902,326715	4605,065972
20	Point	1416_268_1	10791,963369	3314,578876	9026,642508	6161,267376	10458,680114	108352,876373	3817,616887
21	Point	1416_268_4	17519,916335	4616,184203	10569,498389	8700,940191	14592,58838	145413,062608	4814,107873
22	Point	1416_268_5	18124,001685	4727,886548	10862,653404	9403,086357	14620,890147	150859,751441	4974,145101
23	Point	1416_235_32	0	0	0	5218,576961	0	206897,267364	1584,093664
24	Point	1416_235_34	0	0	0	5218,576961	0	206163,285058	1584,093664
25	Point	1416_235_35	0	0	0	5218,576961	0	205700,308616	1584,093664
26	Point	1416_235_37	0	0	0	5218,576961	0	202817,468963	1584,093664
27	Point	1416_235_38	0	0	0	5218,576961	0	201910,79677	1584,093664

Figure 30 Attribute table of the calculated indicators

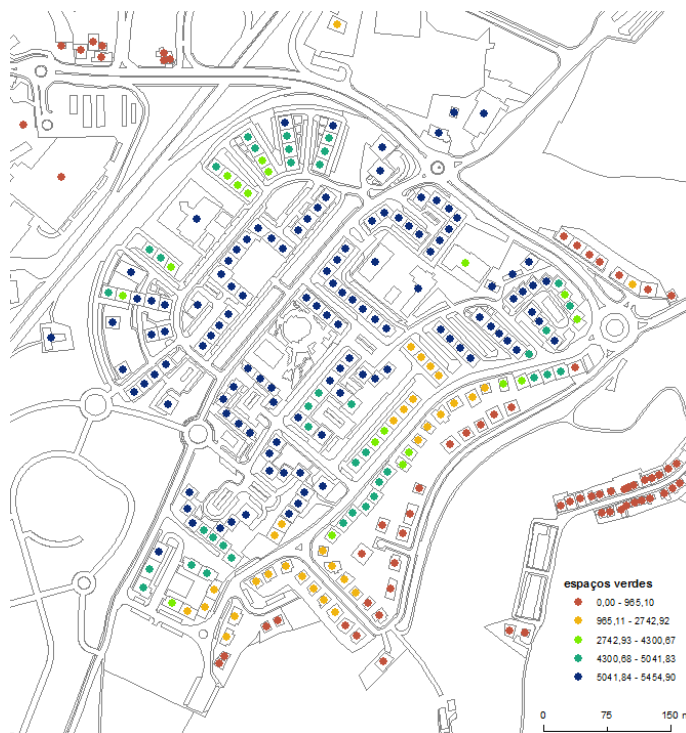


Figure 31 Representation of the area values of Green spaces (Espaços verdes)

## 7. Diversity Tool

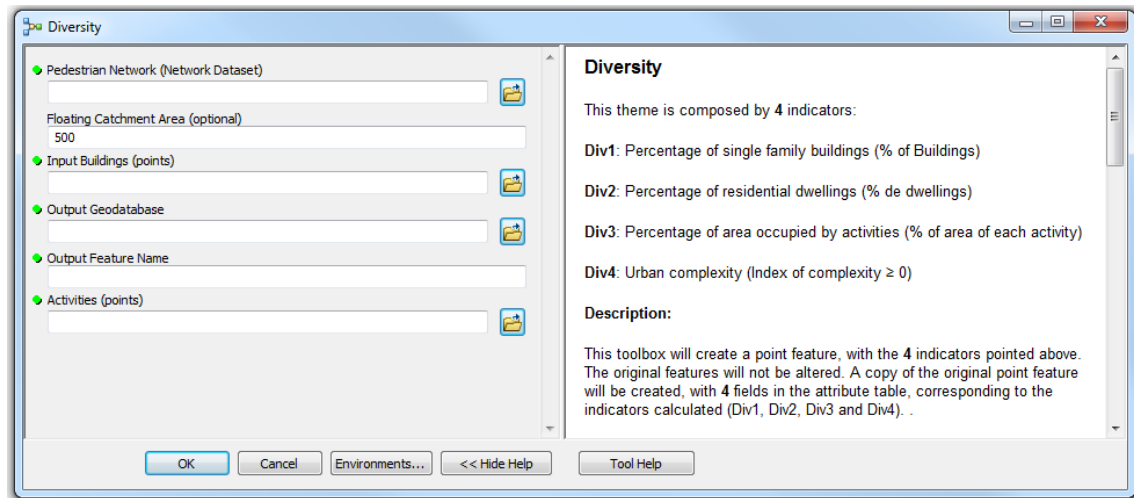


Figure 32 Diversity tool user interface.

This tool calculates **4** indicators:

**Div1:** Percentage of single family buildings (% of buildings)

**Div2:** Percentage of residential dwellings (% of dwellings)

**Div3:** Percentage of area occupied by activities (% of area of each activity)

**Div4:** Urban complexity (Index  $\geq 0$ )

### 7.1. Description

This toolbox will create a point feature, with the **4** indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with **4** fields in the attribute table, corresponding to the indicators calculated (Div1, Div2, Div3 and Div4).

## 7.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

1) **Pedestrian Network:** a network dataset is required. The network used to create the dataset was the pedestrian network.

2) **Floating Catchment Area:** The definition of the Floating Catchment Area analysis for each building it's a value in meters. The default is 500 m.

3) **Input Buildings:** a point feature is required, the buildings of the urban area

The attribute table of the input buildings must have the following fields:

**AREA:** Ground floor gross area (square meters) of each building (**All Caps**)

**NFLOOR\_AG:** Number of floors above ground (including ground floor) (**All Caps**)

**NFLOOR\_UG:** Number of floors under ground (excluding ground floor) (**All Caps**)

**NFRAC\_TOT:** Number of fractions (dwellings and commercial units) (**All Caps**)

**NDWELLINGS:** Number of dwellings (only housing) (**All Caps**)

**NACTIVITY:** Number of non-housing fractions(**All Caps**)

4) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.

5) **Output Feature Name:** The name of the output feature to be created by the toolbox.

6) **Activities:** point feature is required with the activities classification.

The attribute table must have one field designated **CODE\_TYPE (Text)**, which will have the codes for each activity type.

**CODE\_TYPE:** Activities code classification with 7 type uses. (field - text and All Caps)

CODE_TYPE	Type of use
CS1	Diário/ Diary
CS2	Ocasional/ Occasional
CS3	Excepcional/ Exceptional
E1	Equipamentos de Ensino/ Facilities
E2	Outros Equipamentos / Other Facilities
O	Outros/ Other
V	Vago/ Unoccupied

### 7.3. Calculating the diversity indicators with our test files

If you are using our example files, the toolbox should look like this:

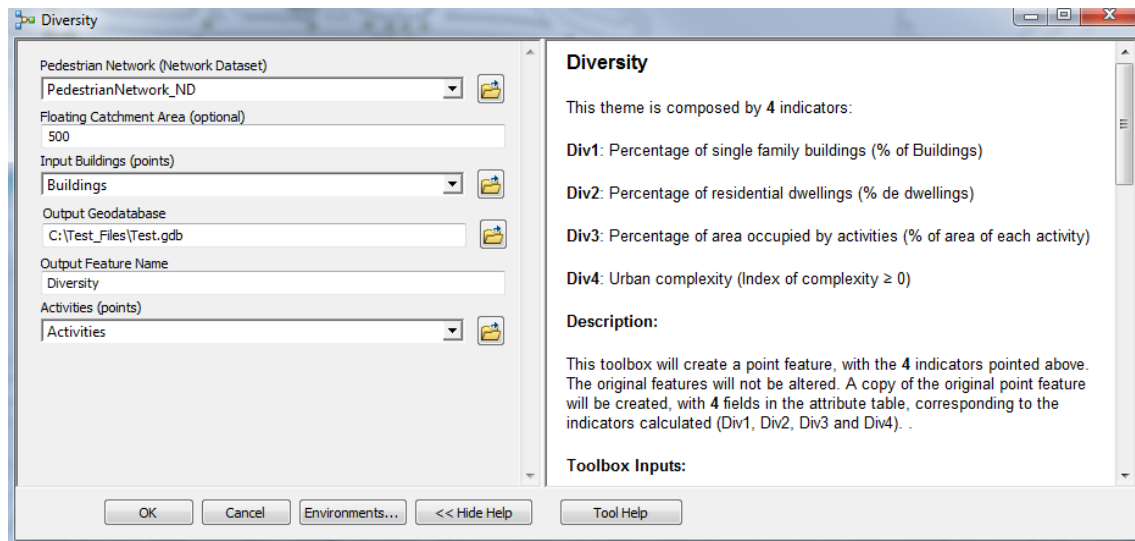


Figure 33 Diversity tool user interface with our test files



## Results:

Table															
DIV_TEST_FINAL															
Shape *	AREA	NFLOOR AG	NFLOOR UG	NFRAC TOT	NOWELLINGS	NACTIVITY	Ed unifam	ABC	ABC hab	ABC com	Div1	Div2	ABC perFrac	Div3	Div4
Point	250,0966	1	0	2	1	1	0	250,0966	125,0483	125,0483	0	83,333333	125,0483	22,704013	2,3003
Point	247,59	1	0	1	1	0	1	247,59	247,59	0	0	83,333333	247,59	22,704013	2,3003
Point	100,90115	2	0	1	1	0	1	201,8023	201,8023	0	0	100	201,8023	60,836973	2,468982
Point	42,4284	1	0	1	0	1	0	42,4284	0	42,4284	0	83,333333	42,4284	22,704013	2,3003
Point	252,55845	4	0	3	0	3	0	1010,2338	0	1010,2338	0	100	336,7446	65,986974	2,513933
Point	108,797	1	2	2	2	0	0	326,391	326,391	0	0	100	163,1955	0,078883	1
Point	41,8893	1	0	1	1	0	1	41,8893	41,8893	0	0	100	41,8893	0,078883	1
Point	63,2305	1	1	1	1	0	1	136,461	136,461	0	0	100	136,461	0,078883	1
Point	196,7535	1	0	1	1	0	1	196,7535	196,7535	0	1,0989	100	196,7535	17,445679	2,469102
Point	97,38525	1	0	1	1	0	1	97,38525	97,38525	0	1,0989	100	97,38525	17,445679	2,469102
Point	315,72415	6	2	12	12	0	0	2525,7932	2525,7932	0	0	100	210,482767	47,156175	2,502665
Point	311,63945	6	2	14	10	4	0	2493,1156	1780,796857	712,318743	0	100	178,079686	51,777764	2,479158
Point	270,731122	6	2	15	10	5	0	2165,848976	1443,699317	721,949659	0	100	144,389932	47,373217	2,496178
Point	215,676	4	1	8	8	0	0	1078,38	1078,38	0	0	0	134,7975	26,124171	2,362119
Point	222,9275	3	0	2	2	0	0	668,7825	668,7825	0	0	83,333333	334,39125	22,517995	2,426875
Point	118,7812	2	0	1	1	0	1	237,5624	237,5624	0	0	88,235294	237,5624	18,557505	2,43781
Point	111,28675	3	0	1	1	0	1	333,86625	333,86625	0	1,0309	100	333,86625	18,678874	2,427235
Point	116,418551	3	0	1	1	0	1	349,255654	349,255654	0	1,0752	100	349,255654	18,224798	2,444967
Point	308,249036	7	0	14	14	0	0	2157,743252	2157,743252	0	0	83,333333	154,124518	22,712553	2,414338
Point	282,4968	7	0	14	14	0	0	1977,4776	1977,4776	0	0	83,333333	141,2484	22,712553	2,414338
Point	305,441196	7	0	14	14	0	0	2138,088369	2138,088369	0	0	83,333333	152,720598	22,712553	2,414338

Figure 34 Attribute table of the calculated indicators

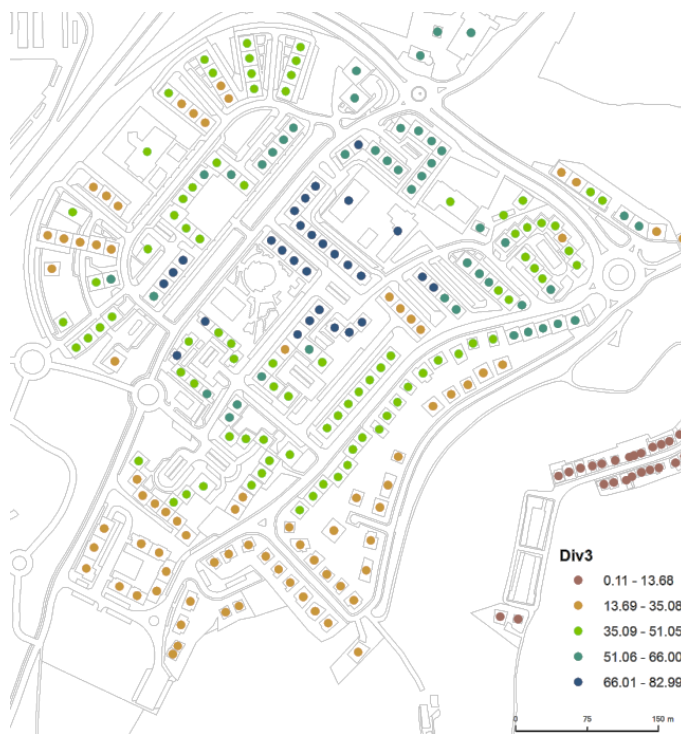


Figure 35 Representation of the values of Percentage of area occupied by activities (Div3)

## 8. Topography Tool

### Prerequisites:

This tool requires a TIN (Triangular Irregular Network). If you do not have a TIN yet, you can easily create a Triangular Irregular Network from your \*.shp, \*.dwg, or \*.dxf files using ArcMap or ArcCatalog.

ArcGIS versions 10 and 10.1 make it particularly easy to convert a \*.dwg, or \*.dxf files into a \*.shp. Simply open the ArcCatalog or in the ArcMap table of contents, navigate to the polyline and/or point files that contain the appropriate information (altimetry data, elevation points), right-click, choose Export, and follow the instructions. Follow the Figure 37 to create the TIN.

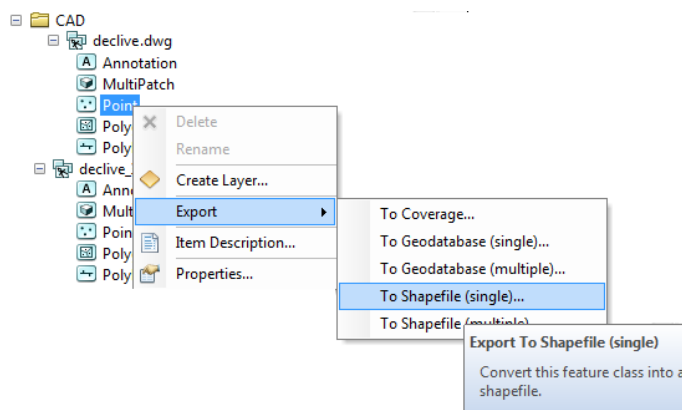


Figure 36 Convert a \*.dwg, or \*.dxf file into a .shp

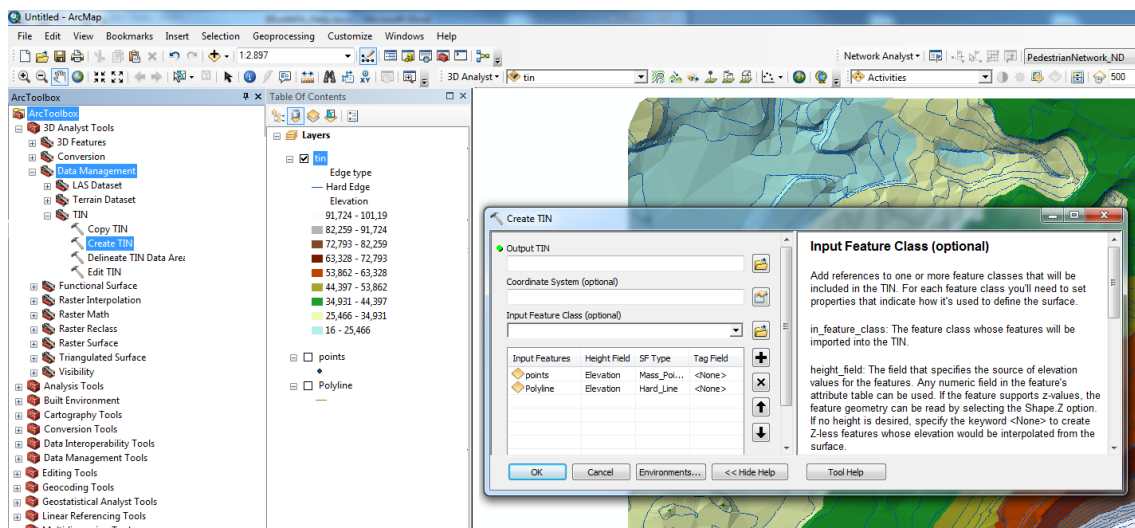


Figure 37 TIN creation from altimetry data and elevation points

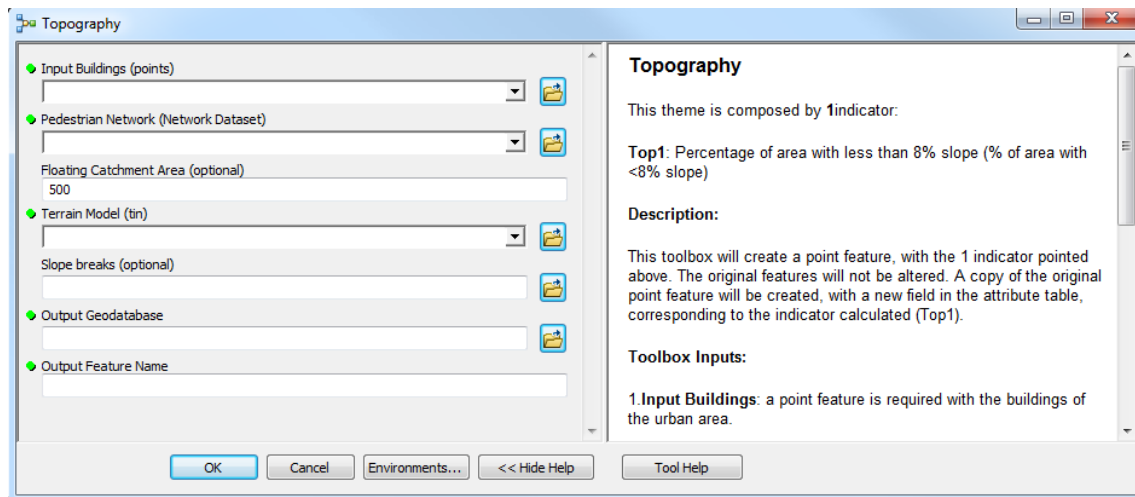


Figure 38 Topography tool user interface.

This tool calculates only **1** indicator:

**Top1:** Percentage of area with more than 8% slope (% of area with <8% slope)

## 8.1. Description

This toolbox will create a point feature, with the **1** indicator pointed above. The original features will not be altered. A copy of the original point feature will be created, with a **new** field in the attribute table, corresponding to the indicator calculated (Top1).

## 8.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) Input Buildings:** a point feature is required with the buildings of the urban area.
- 2) Pedestrian Network:** a network dataset is required. The network used to create the dataset was the pedestrian network.

3) **Floating Catchment Area:** The definition of the Floating Catchment Area analysis for each building it's a value in meters. The default is 500 m.

4) **Terrain Model:** A tin model is required.

5) **Slope breaks:** An excel file is required with the slope break at 8% like the example: **(All Caps)**

CLASS_BREAK	CODE
8	8

6) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.

7) **Output Feature Name:** The name of the output feature to be created by the toolbox

### 8.3. Calculating the topography indicator with our test files

If you are using our files, the toolbox should look like this:

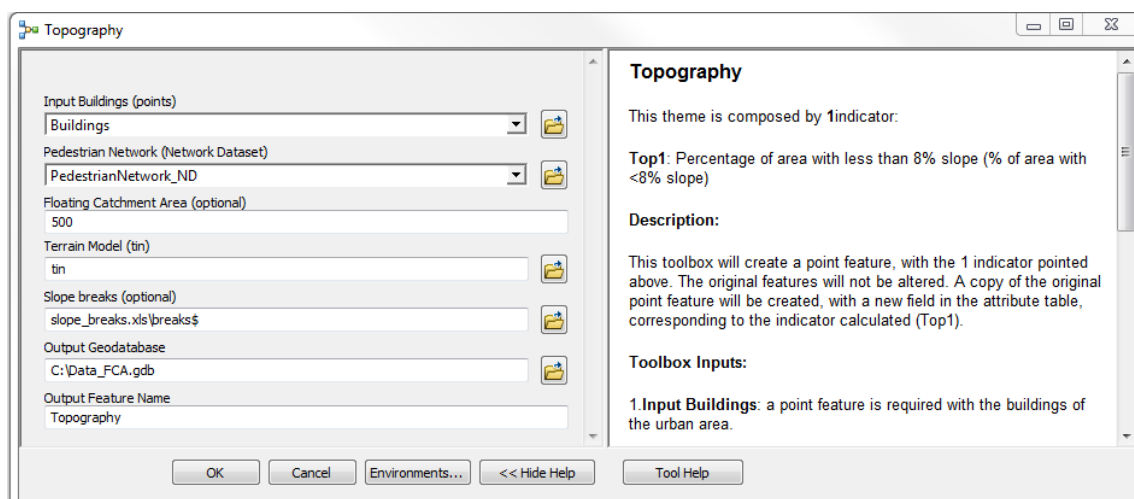


Figure 39 Topography tool user interface with our test files

Results:

OBJECTID *	Shape *	AREA	NFLOOR AG	NFLOOR UG	NFRAC TOT	NDWELLINGS	NACTIVITY	Top1
1	Point	211,9803	8	1	17	17	0	61,737737
2	Point	205,0939	8	1	19	15	4	70,512306
3	Point	217,2545	8	1	17	17	0	10,28668
4	Point	223,6372	8	1	17	17	0	10,274993
5	Point	247,41665	8	1	17	17	0	10,242654
6	Point	229,98295	5	1	8	6	2	10,382162
7	Point	247,55465	6	1	12	10	2	37,519054
8	Point	286,9597	9	1	17	15	2	57,662683
9	Point	238,68925	7	1	13	11	2	23,041738
10	Point	260,72515	7	1	12	10	2	50,384219
11	Point	312,725486	6	2	18	15	3	51,429304
12	Point	1454,8472	1	1	1	0	1	51,939654
13	Point	1006,400286	1	0	2	0	2	54,993941
14	Point	239,8386	7	1	13	12	1	51,977743
15	Point	228,49995	5	1	8	8	0	50,696112
16	Point	222,2551	5	1	8	8	0	49,083702
17	Point	263,0463	5	1	8	8	0	51,619435
18	Point	257,75235	7	1	14	13	1	50,597951
19	Point	278,6687	4	1	11	9	2	50,579106

Figure 40 Attribute table of the calculated indicators

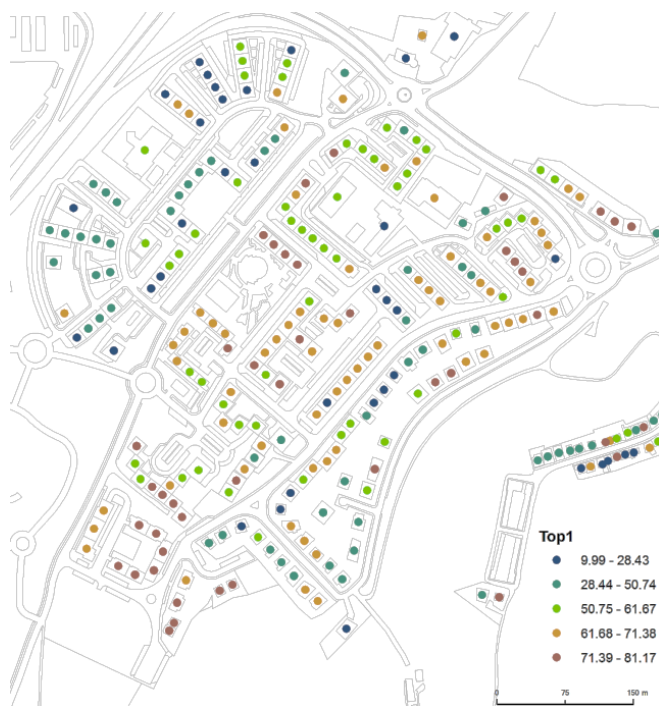


Figure 41 Representation of the values of Percentage of area with more than 8% slope (Top1)

## **VOL.II Measuring the built environment for pre-defined areas or homogeneous areas**

## 9. Accessibility AH Tool

### Installation:

To install the toolbox, open ArcMap 10 or 10.1, make sure the toolbox tab is visible, and right click inside the toolbox tab. Choose Add Toolbox... then choose the downloaded Built Environment AH Tool from where you saved it (see page 6 and 7) and click Open.

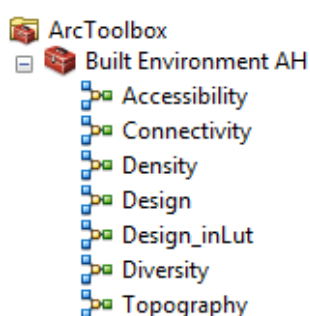


Figure 42 Built Environment AH Tools

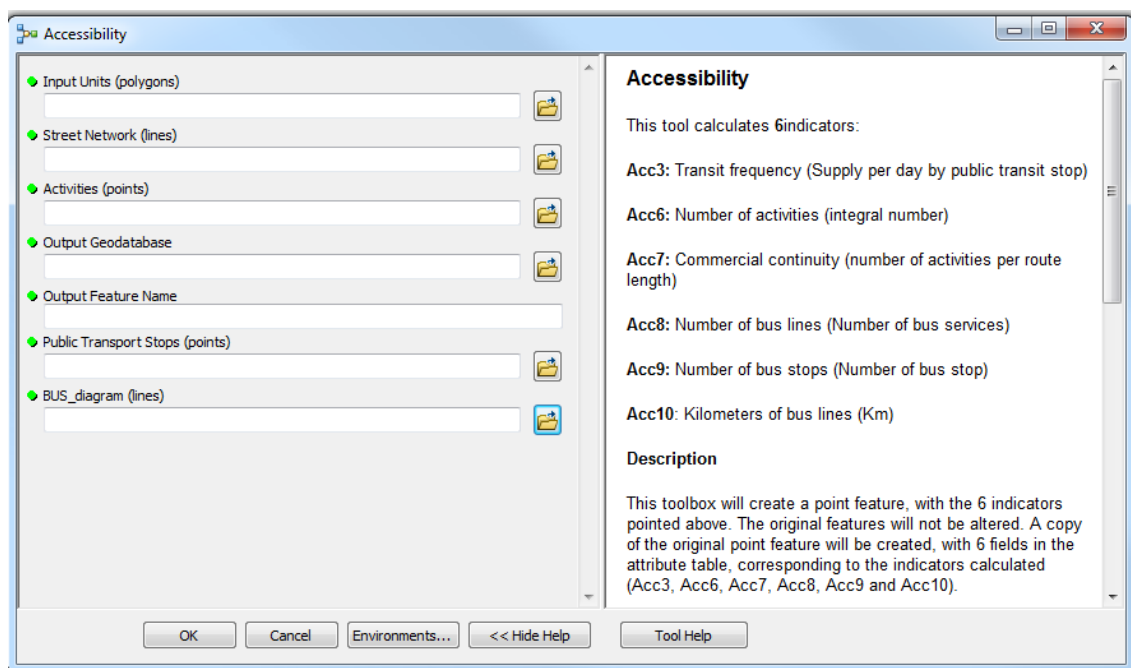


Figure 43 Accessibility AH tool user interface.

This tool calculates **6** indicators:

**Acc3:** Transit frequency (Supply per day by public transit stop)

**Acc6:** Number of activities (integral number)

**Acc7:** Commercial continuity (number of activities per route length)

**Acc8:** Number of bus lines (Number of bus services)

**Acc9:** Number of bus stops (Number of bus stop)

**Acc10:** Kilometers of bus lines (Km)

## 9.1. Description

This toolbox will create a point feature, with the **6** indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with **6** fields in the attribute table, corresponding to the indicators calculated (Acc3, Acc6, Acc7, Acc8, Acc9 and Acc10).

## 9.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) **Input Units:** a polygon feature is required with predefined area units (homogeneous areas)
- 2) **Street network:** a line feature is required with the lines that were used to create the network dataset. (see page 11)
- 3) **Activities:** a point feature with the activities is required.
- 4) **Public transport stops:** a point feature is required, the bus stops of urban area

The attribute table must have the following field (**Double**):

**PT\_SUPPLY:** The public transit frequency in each transit stops. (**All Caps**)



- 5) **BUS diagram:** a line feature is required, with the lines that define each bus line. For each line is required one entry in attribute table. If you have BUS line divided by segments you need to duplicate if the segments serve more than one BUS line you have to dissolve by the BUS line identification.
- 6) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.
- 7) **Output Feature Name:** The name of the output feature to be created by the toolbox

### 9.3. Calculating the topography indicator with our test files

If you are using our files, the toolbox should look like this:

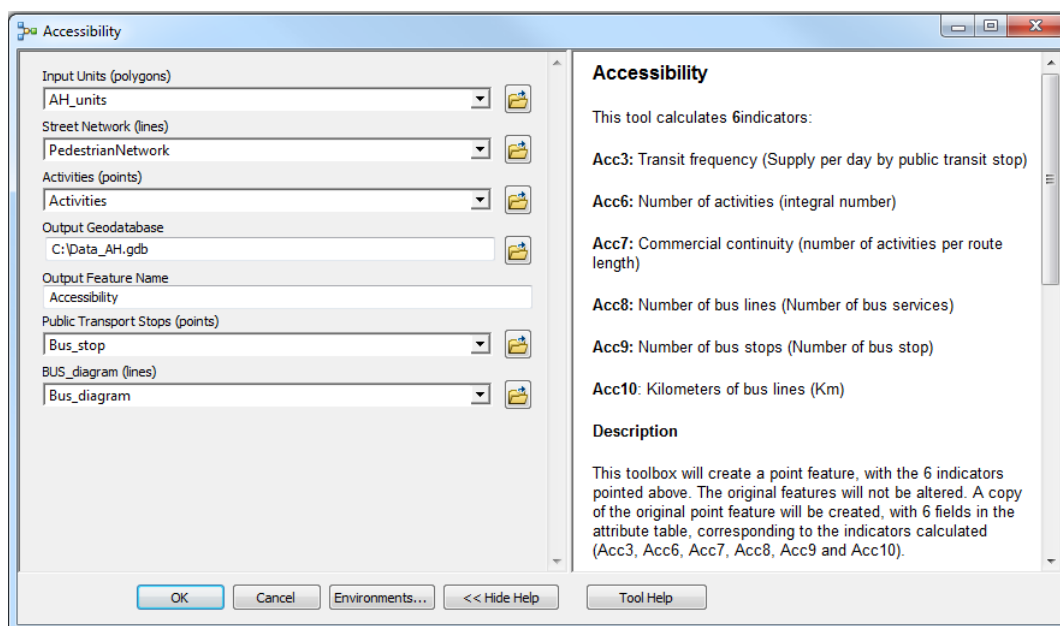


Figure 44 Accessibility AH tool user interface with our test files.

## Results:

OBJECTID *	Shape *	NRESIDENT	Shape_Length	Shape_Area	Acc6	Acc7	Acc3	Acc9	Acc8	Acc10
38	Polygon ZM	82	229,252372	2722,590534	<Null>	<Null>	0	0	1	0,026933
41	Polygon ZM	114	246,820727	3480,609331	<Null>	<Null>	0	0	1	0,02561
46	Polygon ZM	162	197,269507	1101,236968	<Null>	<Null>	0	0	1	0,10917
47	Polygon ZM	0	496,586098	7626,117846	<Null>	<Null>	114	1	1	0,233257
7	Polygon ZM	77	285,992103	4076,69282	1	0,34966	0	0	1	0,081666
12	Polygon ZM	94	1285,169704	56986,514198	1	0,077811	0	0	1	0,052167
23	Polygon ZM	60	184,929401	1952,374576	1	0,540747	0	0	1	0,094813
26	Polygon ZM	130	389,454306	8166,354899	1	0,25677	0	0	1	0,016945
31	Polygon ZM	208	438,400324	6017,855677	1	0,228102	0	0	1	0,00934
34	Polygon ZM	84	268,221032	3476,878103	1	0,372827	0	0	1	0,000832
39	Polygon ZM	102	243,483156	3308,772235	1	0,410706	0	0	1	0,067048
40	Polygon ZM	98	229,167802	2914,875701	1	0,436361	0	0	1	0,029541
9	Polygon ZM	415	572,636093	10911,488199	2	0,34914	88	1	1	0,014412
24	Polygon ZM	158	227,104338	2274,31346	3	1,320979	0	0	1	0,172096
28	Polygon ZM	134	477,447048	6830,483415	3	0,628342	0	0	1	0,027579
29	Polygon ZM	83	226,593295	3294,720127	3	1,323958	0	0	1	0,030862
45	Polygon ZM	6	979,371461	45715,87622	4	0,408425	0	0	1	0,094968
2	Polygon ZM	138	465,804231	11675,875169	5	1,073412	0	0	1	0,071133
35	Polygon ZM	88	304,769361	5514,069286	5	1,640585	88	1	1	0,11004
21	Polygon ZM	77	318,880083	5616,564807	6	1,881585	0	0	1	0,089474
37	Polygon ZM	121	779,772954	23846,971342	6	0,769455	26	1	1	0,007905
43	Polygon ZM	86	1584,45072	70051,659279	6	0,37868	54	2	1	0,004048
20	Polygon ZM	87	326,73391	4510,122402	7	2,142422	0	0	1	0,362346
42	Polygon ZM	125	452,330838	9163,997841	8	1,788617	0	0	1	0,02141
8	Polygon ZM	314	501,572009	12528,519486	10	1,993732	0	0	1	0,01804
33	Polygon ZM	266	409,659543	10219,164961	14	3,417472	0	0	1	0,054014
44	Polygon ZM	132	1344,905138	66586,815479	16	1,189675	0	0	1	0,130892
10	Polygon ZM	172	401,26807	6166,80026	21	5,233409	0	0	1	0,076583
13	Polygon ZM	261	1082,712839	33163,623957	21	1,939572	0	0	1	0,081671
16	Polygon ZM	439	486,740987	13052,556382	21	4,31441	0	0	1	0,063888

Figure 45 Attribute table of the calculated indicators.

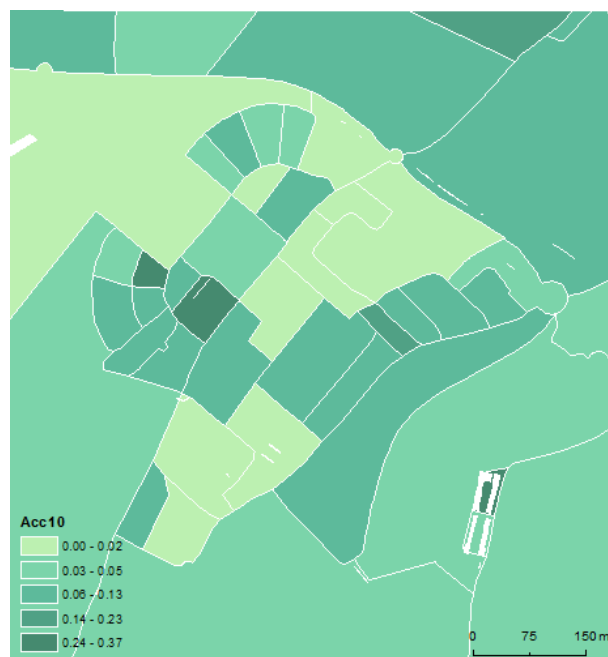


Figure 46 Representation of the values of Accessibility (Acc 10)

## 10. Connectivity AH Tool

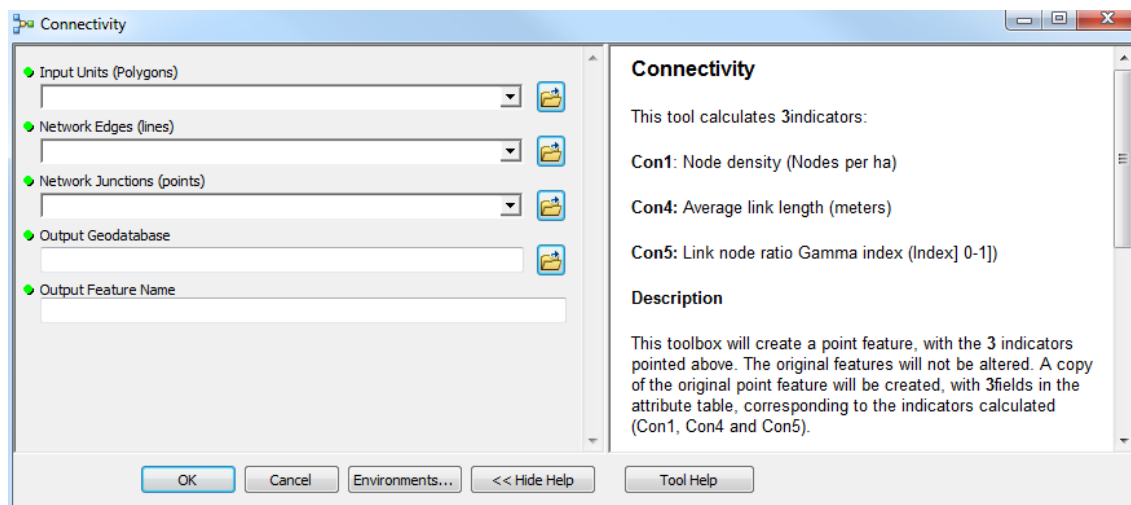


Figure 47 Connectivity AH tool user interface

This tool calculates **3** indicators:

**Con1:** Node density (Nodes per ha)

**Con4:** Average link length (meters)

**Con5:** Link node ratio *Gamma index* (Index] 0-1])

### 10.1. Description

This toolbox will create a point feature, with the **3** indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with **3** fields in the attribute table, corresponding to the indicators calculated (Con1, Con4 and Con5).

## 10.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) **Input Units:** a polygon feature is required with predefined area units (homogeneous areas)
- 2) **Street network:** a line feature is required with the lines that were used to create the network dataset. (see page 11)
- 3) **Network Junctions:** Point feature created by the network dataset.
- 4) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.
- 5) **Output Feature Name:** The name of the output feature to be created by the toolbox

## 10.3. Calculating the topography indicator with our test files

If you are using our files, the toolbox should look like this:

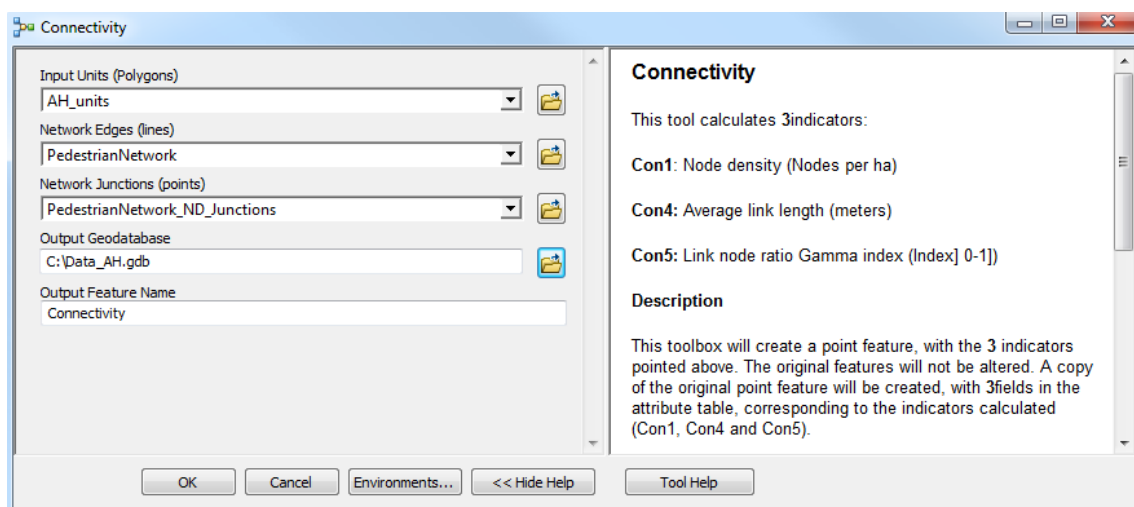


Figure 48 Connectivity AH tool user interface with our test files.

Results:

Table							
Connectivity							
OBJECTID *	Shape *	NRESIDENT	Shape Length	Shape Area	Con1	Con5	Con4
1	Polygon ZM	139	509,866494	13768,23657	0	0,6	109,983171
2	Polygon ZM	138	465,804231	11675,875169	2,569401	1,142857	52,099836
3	Polygon ZM	0	369,662102	1256,118395	7,961033	3	6,752227
4	Polygon ZM	43	1498,561191	80326,163646	0,622462	0,842105	82,903034
5	Polygon ZM	36	348,335773	6332,044949	1,579269	4	18,398971
6	Polygon ZM	0	374,86391	1132,3657	8,831069	3	18,102047
7	Polygon ZM	77	285,992103	4076,69282	0	-0,5	10,549772
8	Polygon ZM	314	501,572009	12528,519486	4,789073	0,636364	73,492097
9	Polygon ZM	415	572,836093	10911,488199	3,665861	0,923077	35,030695
10	Polygon ZM	172	401,26807	6166,80026	1,621586	1,25	50,402218
11	Polygon ZM	52	308,150613	4469,251597	8,950044	0,6	45,289135
12	Polygon ZM	94	1285,169704	56986,514198	0,70192	1,153846	180,317212
13	Polygon ZM	261	1082,712839	33163,623957	1,206141	0,846154	81,325004
14	Polygon ZM	86	297,762761	3882,004772	15,455932	1	28,638069
15	Polygon ZM	313	986,726705	52940,579737	0	-0,5	42,388809
16	Polygon ZM	439	486,740987	13052,558382	1,532267	0,692308	46,296172
17	Polygon ZM	139	244,286905	3065,064025	0	-1,5	12,500414
18	Polygon ZM	12	175,454716	1928,211125	0	-1	27,592673
19	Polygon ZM	18	275,793771	4622,675592	0	-1	18,998311
20	Polygon ZM	87	326,73301	4510,122402	2,217235	5	26,600155

Figure 49 Attribute table of the calculated indicators.

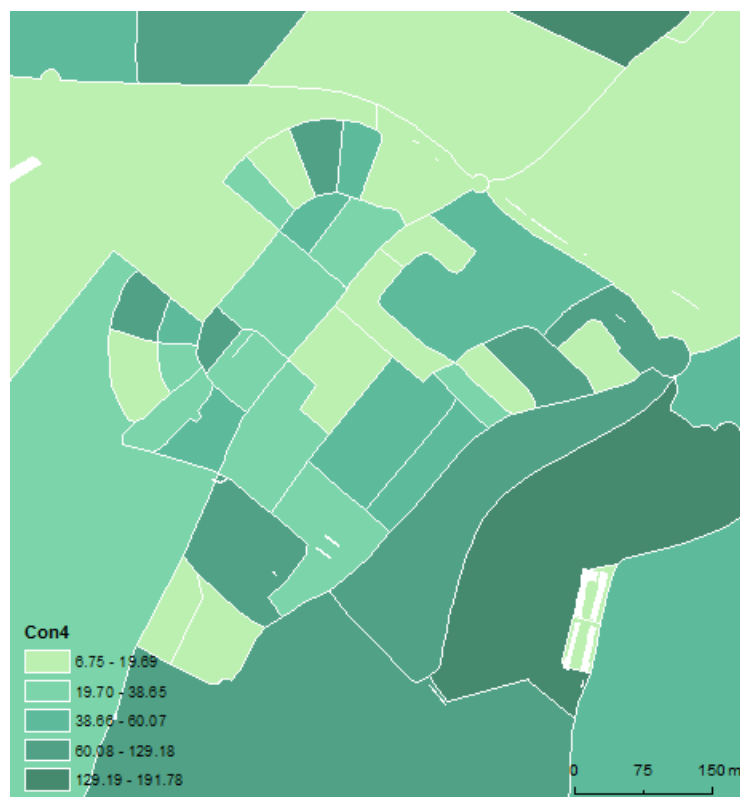


Figure 50 Representation of the values of Connectivity (Con4)

## 11. Density AH Tool

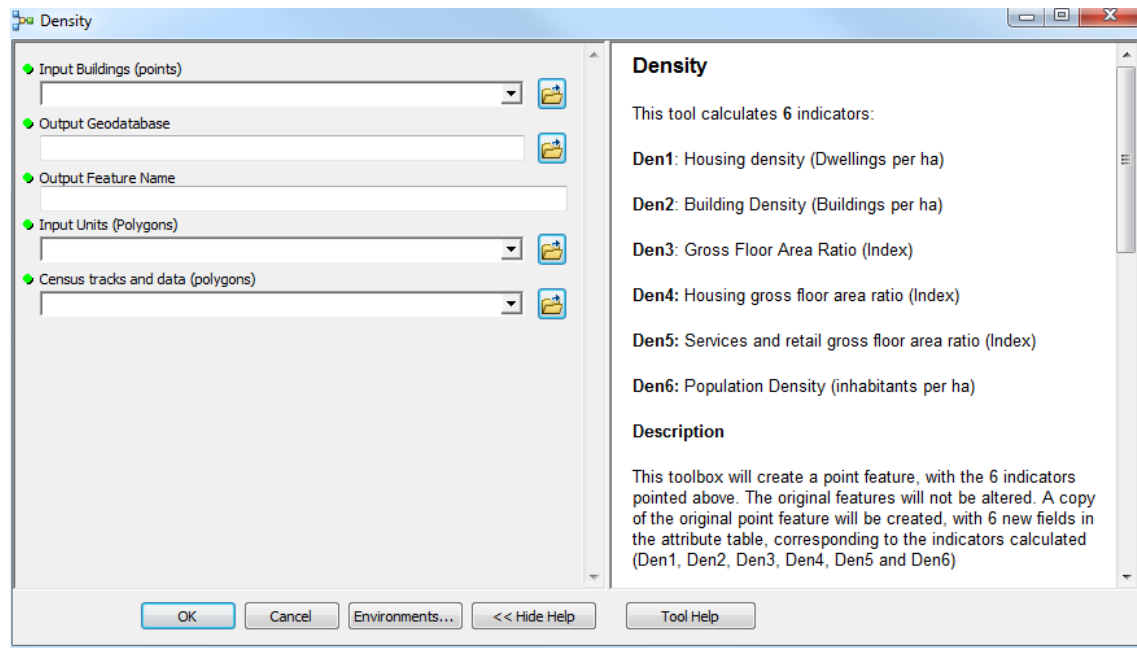


Figure 51 Density AH tool user interface

This tool calculates **6** indicators:

**Den1:** Housing density (Dwellings per ha)

**Den2:** Building Density (Buildings per ha)

**Den3:** Gross Floor Area Ratio (Index)

**Den4:** Housing gross floor area ratio (Index)

**Den5:** Services and retail gross floor area ratio (Index)

**Den6:** Population Density (inhabitants per ha)

### 11.1. Description

This toolbox will create a point feature, with the 6 indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with 6 new fields in the attribute table, corresponding to the indicators calculated (Den1, Den2, Den3, Den4, Den5 and Den6).

### 11.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

**1) Input Buildings:** a point feature is required, the buildings of the urban area

The attribute table of the input buildings must have the following fields (**Double**):

**AREA:** Ground floor gross area (m2) of each building (**All Caps**)

**NFLOOR\_AG:** Number of floors above ground (including ground floor) (**All Caps**)

**NFLOOR\_UG:** Number of floors under ground (excluding ground floor) (**All Caps**)

**NFRAC\_TOT:** Number of fractions (dwellings and commercial units) (**All Caps**)

**NDWELLINGS:** Number of dwellings (only housing) (**All Caps**)

**NACTIVITY:** Number of non-housing fractions (**All Caps**)

**2) Input Units:** a polygon feature is required with predefined area units (homogeneous areas)

**3) Census track with data:** a polygon feature is required, the census tracks with the statistical data.

The attribute table must have the following field (**Double**):

**NRESIDENT:** Number of residents (**All Caps**)

- 4) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.
- 5) **Output Feature Name:** The name of the output feature to be created by the toolbox

### 11.3. Calculating the topography indicator with our test files

If you are using our files, the toolbox should look like this:

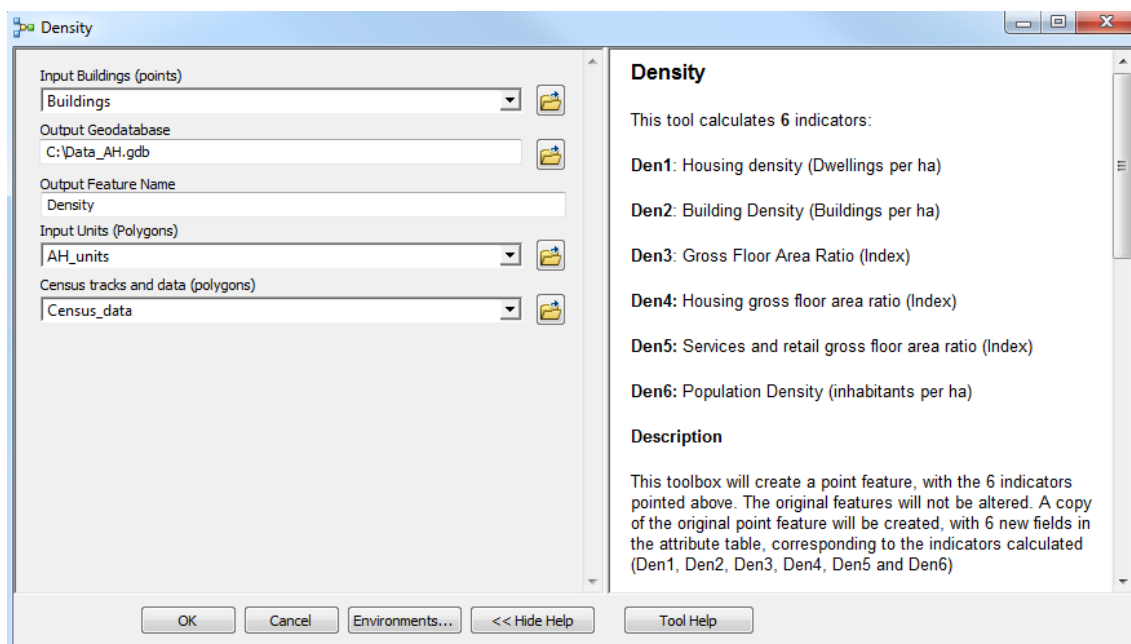


Figure 52 Density AH tool user interface with our test files.



## Results

Table											
Density											
OBJECTID	Shape	NRESIDENT	Shape_Length	Shape_Area	Den1	Den2	Den3	Den4	Den5	Den6	
30	Polygon ZM	0	1496,843778	78828,100862	0	0,126858	0,004791	0	0,004791	0	
2	Polygon ZM	138	465,804231	11675,875169	1,712934	4,282334	0,073278	0,031915	0,060686	118,192425	
1	Polygon ZM	139	509,866494	13768,23657	2,178928	2,178928	0,017951	0,017951	0	100,95701	
4	Polygon ZM	43	1498,561191	80326,163646	2,240864	1,991879	0,078739	0,078739	0,002737	5,353175	
45	Polygon ZM	6	979,371461	45715,876222	3,499878	0,87497	0,142112	0,050018	0,092093	19,823744	
15	Polygon ZM	313	986,726705	52940,579737	4,155602	1,88891	0,044744	0,044744	0	59,122889	
43	Polygon ZM	86	1584,45072	70051,659279	5,139065	0,856511	0,242237	0,07969	0,162547	12,276654	
12	Polygon ZM	94	1285,169704	56986,514198	7,545645	2,807682	0,085671	0,082783	0,002888	16,495131	
44	Polygon ZM	132	1344,905138	66586,815479	9,010793	1,201439	0,210969	0,156649	0,05432	0	
37	Polygon ZM	121	779,772954	23846,971342	24,741087	5,451426	0,468384	0,290677	0,177707	50,740196	
13	Polygon ZM	261	1082,712839	33163,623957	31,661196	11,759873	0,811831	0,69113	0,120701	78,700687	
19	Polygon ZM	18	275,793771	4622,675592	43,264987	4,326499	0,723436	0,723436	0	38,938488	
11	Polygon ZM	52	308,150613	4489,251597	62,65031	2,237511	0,718257	0,718257	0	116,350577	
21	Polygon ZM	77	318,880083	5616,564807	67,657013	10,682686	1,150439	1,008813	0,141626	137,094474	
42	Polygon ZM	125	452,330838	9163,997841	72,020969	2,182454	1,468972	1,115038	0,353934	136,403349	
26	Polygon ZM	130	389,454306	8166,354899	74,696729	4,898146	0,834451	0,834451	0	159,189751	
35	Polygon ZM	88	304,769361	5514,069286	77,982335	7,254171	1,553273	1,308229	0,245044	159,591756	
7	Polygon ZM	77	285,992103	4076,69282	83,400937	7,358906	1,868787	1,774699	0,094088	188,878592	
22	Polygon ZM	64	257,344855	3801,587877	84,175353	10,521919	0,931593	0,931593	0	168,350705	
25	Polygon ZM	195	444,450926	10495,992783	85,74701	8,574701	0,790686	0,790686	0	185,785189	
20	Polygon ZM	87	326,73301	4510,122402	95,341093	8,868939	1,850363	1,558312	0,292051	192,899421	
28	Polygon ZM	134	477,447048	6830,483415	96,625665	11,712202	1,016584	0,968584	0,048	196,17938	
14	Polygon ZM	86	297,762761	3882,004772	103,039544	10,303954	1,817092	1,817092	0	221,535019	
34	Polygon ZM	84	268,221032	3476,878103	112,169593	14,380717	1,302602	1,267197	0,035405	241,596045	
33	Polygon ZM	266	409,659543	10219,164961	115,469317	8,806982	2,251353	1,951243	0,30011	260,29524	
6	Polygon ZM	314	501,572009	12528,519486	118,928657	7,981789	1,621151	1,518862	0,102289	250,628177	
41	Polygon ZM	114	246,820727	3480,609331	120,668527	11,492241	2,085846	2,085846	0	327,528858	
23	Polygon ZM	60	184,929401	1952,374576	122,927231	5,121968	2,218443	2,129706	0,088738	307,318077	

Figure 53 Attribute table of the calculated indicators.

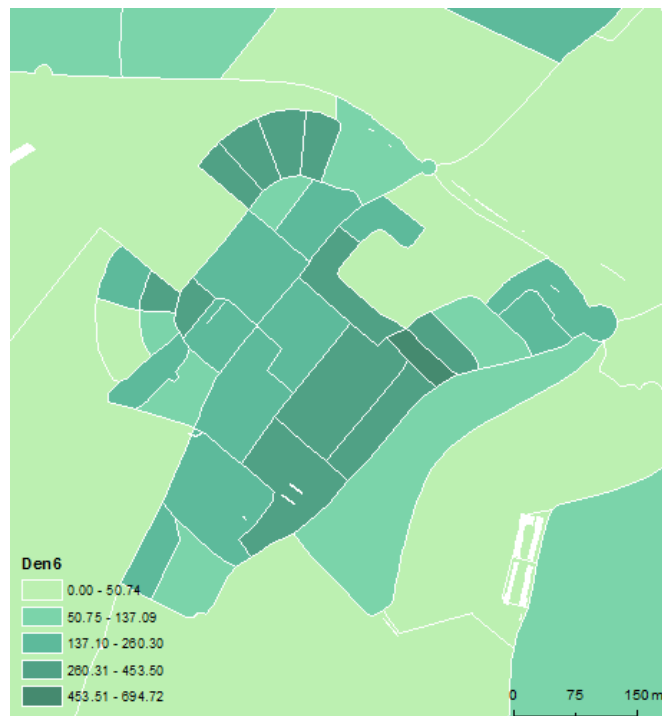


Figure 54 Representation of the values of Density (Den 6)

## 12. Design inLut AH Tool

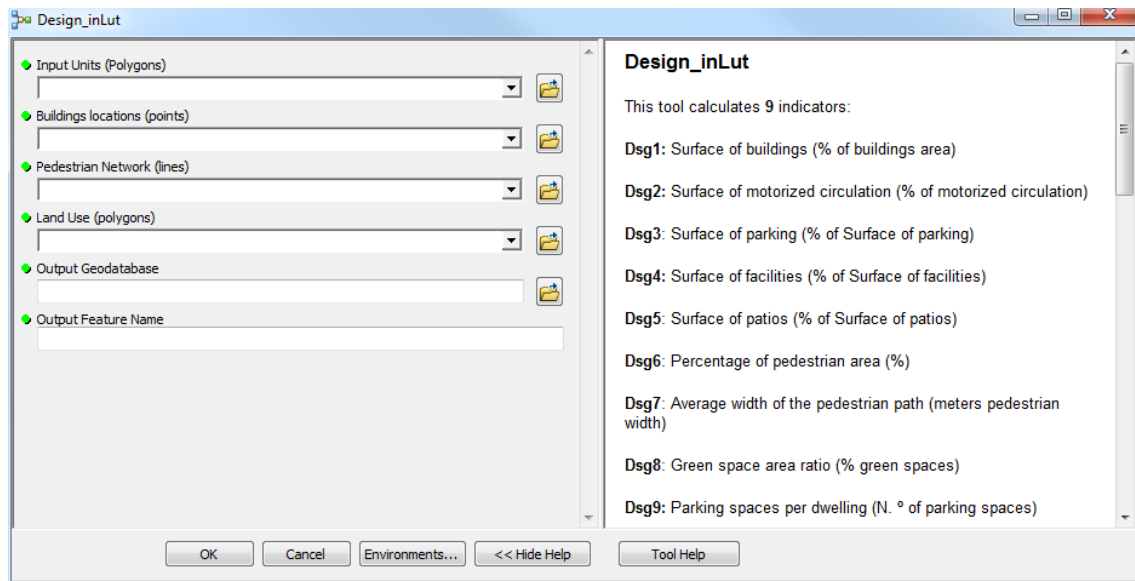


Figure 55 Design inLut AH tool user interface.

This tool calculates **9** indicators:

**Dsg1:** Surface of buildings (% of buildings area)

**Dsg2:** Surface of motorized circulation (% of motorized circulation)

**Dsg3:** Surface of parking (% of Surface of parking)

**Dsg4:** Surface of facilities (% of Surface of facilities)

**Dsg5:** Surface of patios (% of Surface of patios)

**Dsg6:** Percentage of pedestrian area (%)

**Dsg7:** Average width of the pedestrian path (meters pedestrian width)

**Dsg8:** Green space area ratio (% green spaces)

**Dsg9:** Parking spaces per dwelling (N. ° of parking spaces)

### 12.1.1. Description

This toolbox will create a point feature, with the **9** indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with **9** fields in the attribute table, corresponding to the indicators calculated (Dsg1, Dsg2, Dsg3, Dsg4, Dsg5, Dsg6, Dsg7, Dsg8 and Dsg9).

### 12.1.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

**1) Input Units:** a polygon feature is required with predefined area units (homogeneous areas)

**2) Input Buildings:** a point feature is required, the buildings of the urban area

The attribute table of the input buildings must have the following fields:

**NFRAC\_TOT:** Number of fractions (dwellings and commercial units) (**All Caps**)

**Note:** If you don't have this field information please use **the Design AH Tool**.

**3) Pedestrian Network:** a line feature is required with the lines that were used to create the network dataset. (see page 11)

**4) Land Use:** a polygon feature is required, the land use classification.

The attribute table must have a field designated **LAND\_USE** (Field type text and all Caps).

**LAND\_USE:** the land use classification using the classes defined for the InLUT project.

"circ\_motorizada"  
"circ\_pedonal"  
"edificios"  
"equipamentos"  
"espaços\_verdes"  
"estacionamento"  
"logradouro"

**Note:** If you don't have this land use classifications please use **the Design AH Tool**.

**5) Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.

**6) Output Feature Name:** The name of the output feature to be created by the toolbox

### 12.1.3. Calculating the topography indicator with our test files

If you are using our files, the toolbox should look like this:

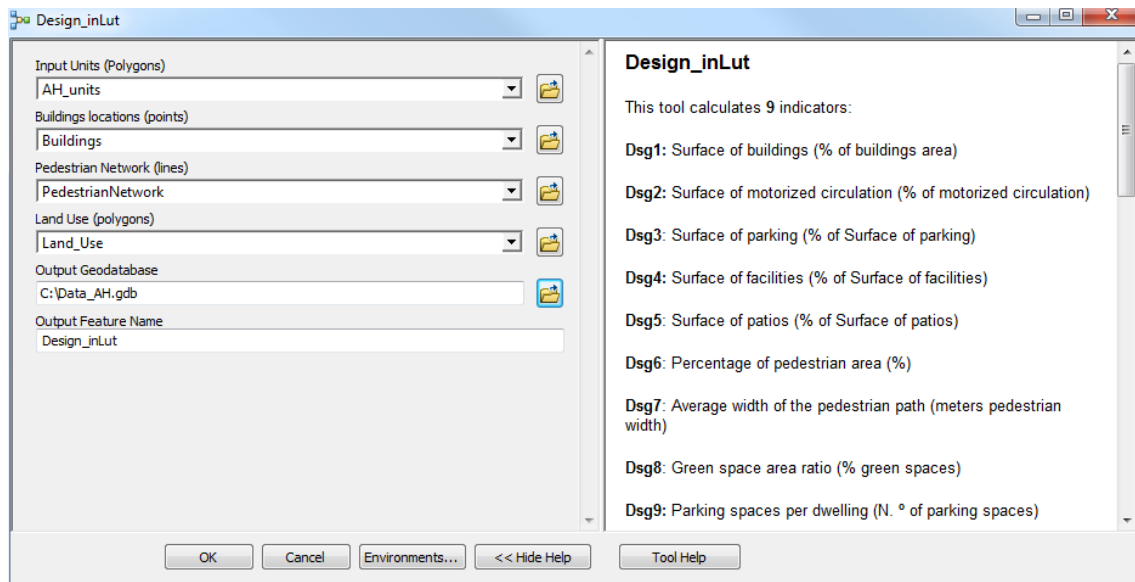


Figure 56 Design inLut AH tool user interface with our test files.

## Results

Table													
Design_inLut													
OBJECTID *	Shape *	NRESIDENT	Shape Length	Shape Area	Dsg1	Dsg2	Dsg3	Dsg4	Dsg5	Dsg6	Dsg7	Dsg8	Dsg9
9	Polygon ZM	415	572,836093	10911,488199	26,897631	19,98758	5,910967	0	0	20,873987	0,11324	0	0,174317
10	Polygon ZM	172	401,268807	6166,80026	28,523306	26,046898	11,906339	0	0	33,523457	0,099081	0	0,330739
11	Polygon ZM	52	308,150613	4469,251597	7,182574	34,10058	3,508801	0	0	8,161236	0,775649	0	0,280031
12	Polygon ZM	94	1285,169704	58986,514198	3,650222	8,886301	0	0	4,82375	2,244044	0,947563	0	0
13	Polygon ZM	261	1082,712839	33163,623957	25,258755	10,186265	0,59803	0	53,997959	9,504743	0,142427	0	0,075698
14	Polygon ZM	86	297,762761	3882,004772	25,752811	34,55844	4,135934	0	0	16,439017	0,347469	0	0,200696
15	Polygon ZM	313	986,726705	52940,579737	2,226475	0,51846	0	0	2,337078	0,260215	0,320322	0	0
16	Polygon ZM	439	486,740987	13052,558382	26,851466	30,041654	9,64987	0	0,192041	33,264969	0,114745	0	0,281151
17	Polygon ZM	139	244,286905	3065,064025	26,85769	28,497449	7,761197	0	0	36,883664	0,138456	0	0,174916
18	Polygon ZM	12	175,454716	1928,211125	25,533656	28,495722	11,318983	0	0	34,651639	0,073859	0	0,454696
19	Polygon ZM	18	275,793771	4622,875592	10,283642	14,532154	11,940822	0	0	9,270652	0,293278	0	1,379964
20	Polygon ZM	87	326,73201	4510,122402	23,70694	35,288539	6,598792	0	0	12,281229	0,234645	19,182639	0,291778
21	Polygon ZM	77	318,880083	5616,564807	23,542674	32,11458	16,13327	0	0	26,061774	0,208911	0	1,029699
22	Polygon ZM	64	257,344855	3801,587877	23,289817	31,317959	14,209075	0	0	25,26387	0,177924	0	0,844016
23	Polygon ZM	60	184,929401	1952,374576	22,184434	36,07684	11,512065	0	0	20,621221	0,205081	0	0,449517
24	Polygon ZM	158	227,104338	2274,31346	39,282283	20,589266	10,038236	0	0	30,090215	0,074357	0	0,163072
25	Polygon ZM	195	444,450926	10495,992783	21,981577	27,290224	13,605254	6,167857	0	33,170103	0,102223	0	0,793337
26	Polygon ZM	130	389,454306	8166,354899	11,920731	13,945741	8,511914	0	0	39,347752	0,081158	26,673861	0,569765
27	Polygon ZM	83	188,08792	1715,180458	33,323794	34,15325	7,727117	0	0	26,903406	0,230616	0	0,276109
28	Polygon ZM	134	477,447048	6830,483415	24,394655	38,677815	2,565463	0	0,082531	29,678467	0,145631	0	0,126981
29	Polygon ZM	83	226,593295	3294,720127	39,501504	21,799109	13,913951	0	0	30,328197	0,125516	0	0,520938
30	Polygon ZM	0	1496,643778	78828,100862	0,479117	17,51919	0,956937	0	0	0,004592	468,062345	0	18,858389
31	Polygon ZM	208	438,400324	6017,855677	36,636128	28,353874	5,475086	0	0	29,534913	0,153542	0	0,164741
32	Polygon ZM	312	439,633992	8017,362959	0	11,224281	0	0	0,053964	3,212756	0,698308	0	<Null>
33	Polygon ZM	266	409,659543	10219,164961	26,292755	18,593818	9,340837	0	0	32,782742	0,142841	11,289819	0,35094
34	Polygon ZM	84	268,221032	3476,878103	32,565057	23,438499	13,727424	0	0	30,269027	0,081878	0	0,596607
35	Polygon ZM	88	304,769361	5514,069286	19,216606	29,381766	10,154842	0	0	15,400366	0,278844	22,809587	0,548966
36	Polygon ZM	0	218,593012	2676,853049	0	24,636879	12,396816	0	0	23,73456	0,112881	0	<Null>
37	Polygon ZM	121	779,772954	23846,971342	23,356771	30,045893	2,896153	12,904995	29,981736	13,212968	0,179619	0	0,515407
38	Polygon ZM	81	270,757273	2723,508534	38,648238	27,209245	10,608236	0	0	23,554138	0,245354	0	0,252323

Figure 57 Attribute table of the calculated indicators.

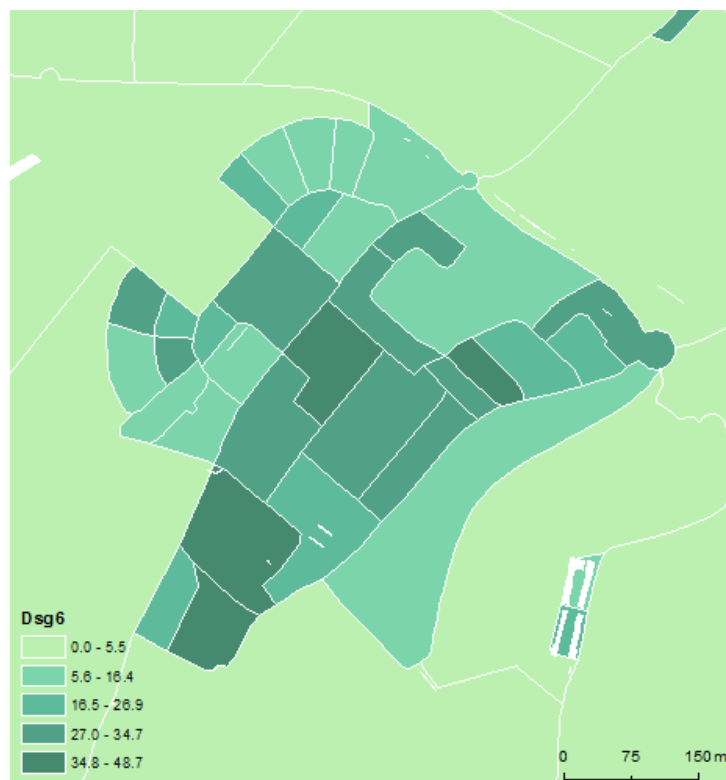


Figure 58 Representation of the values of Design\_inLUT (Dsg 6)

## 13. Design AH Tool

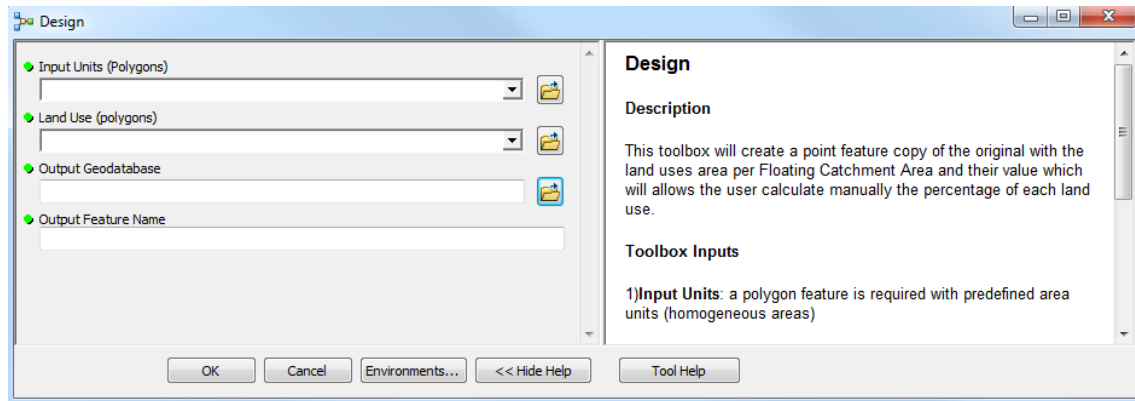


Figure 59 Design AH tool user interface.

### 13.2.1. Description

This toolbox will create a point feature copy of the original with the land uses area per Homogeneous Area and their value which will allows the user calculate manually the percentage of each land use type.

### 13.2.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) **Input Units:** a polygon feature is required with predefined area units (homogeneous areas)
- 2) **Pedestrian Network:** a line feature is required with the lines that were used to create de network dataset. (see page 11)

- 3) **Land Use:** a polygon feature is required with any land use classification.
- 4) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.
- 5) **Output Feature Name:** The name of the output feature to be created by the toolbox

### 13.2.3. Calculating the design indicators with our test files

If you are using our files, the toolbox should look like this:

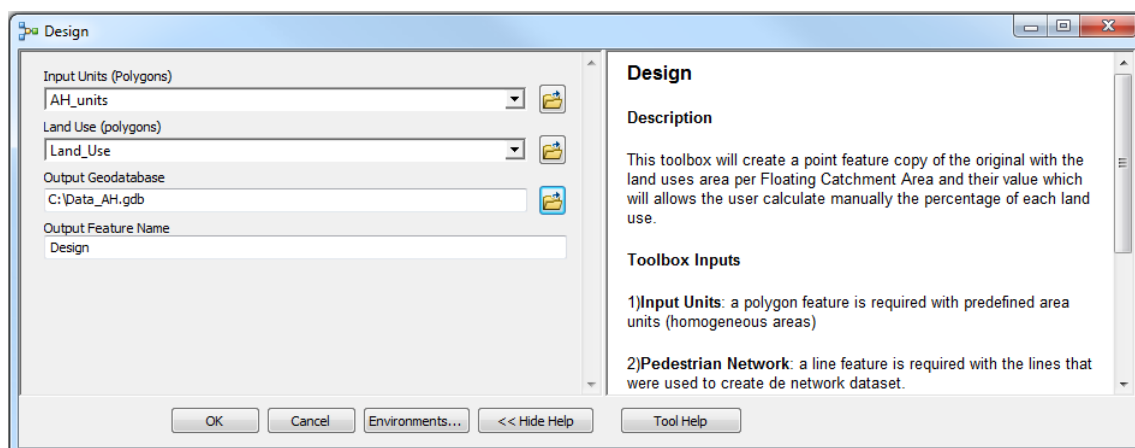


Figure 60 Design AH tool user interface with our test files.

## Results

OBJECTID *	Shape *	Espaços urbanizados não const	espaços verdes	estacionamento	logradouro	verdes enquadramento	Shape Area
1	Polygon ZM	0	0	0	0	4497,648753	13768,23657
2	Polygon ZM	1076,933544	0	0	6944,539744	0	11675,875169
3	Polygon ZM	0	0	0	652,451333	0	1256,118395
4	Polygon ZM	9765,66425	0	944,5611	8161,57255	0	80326,163646
5	Polygon ZM	0	0	257,162873	1074,955719	0	6332,044949
6	Polygon ZM	0	0	0	566,604261	0	1132,3857
7	Polygon ZM	0	0	487,01765	0	109,174727	4076,89282
8	Polygon ZM	0	0	1261,226056	0	243,565188	12528,519486
9	Polygon ZM	0	0	644,974485	0	2872,976878	10911,488199
10	Polygon ZM	0	0	734,240132	0	0	6166,80026
11	Polygon ZM	1708,572062	0	156,81715	0	263,664883	4469,251597
12	Polygon ZM	0	0	0	2748,887147	0	56986,514198
13	Polygon ZM	0	0	198,3285	17907,679996	151,30829	33163,623957
14	Polygon ZM	825,067025	0	160,557173	0	177,038534	3882,004772
15	Polygon ZM	0	0	0	1237,262523	0	52940,579737
16	Polygon ZM	0	0	1259,554961	25,066239	0	13052,558362
17	Polygon ZM	0	0	237,885655	0	0	3065,084025
18	Polygon ZM	0	0	215,253896	0	0	1928,211125
19	Polygon ZM	2494,982711	0	551,985472	0	0	4622,675592
20	Polygon ZM	0	865,160483	297,613598	0	0	4510,122402
21	Polygon ZM	0	0	906,13555	0	120,6271	5616,564807
22	Polygon ZM	0	0	540,170486	0	225,0278	3801,587877
23	Polygon ZM	0	0	224,758636	0	187,534111	1952,374576
24	Polygon ZM	0	0	228,300948	0	0	2274,31346
25	Polygon ZM	0	0	1428,00647	0	520,812879	10495,992783
26	Polygon ZM	0	2178,28215	695,113127	0	0	8166,354899
27	Polygon ZM	0	0	132,532453	0	105,442295	1715,160458
28	Polygon ZM	0	0	175,233518	4,271165	318,832366	6830,483415
29	Polygon ZM	59,802591	0	458,425746	0	0	3294,720127
30	Polygon ZM	51458,228615	0	754,225577	0	47627,357226	79296,418057

Figure 61 Attribute table of the calculated indicators.

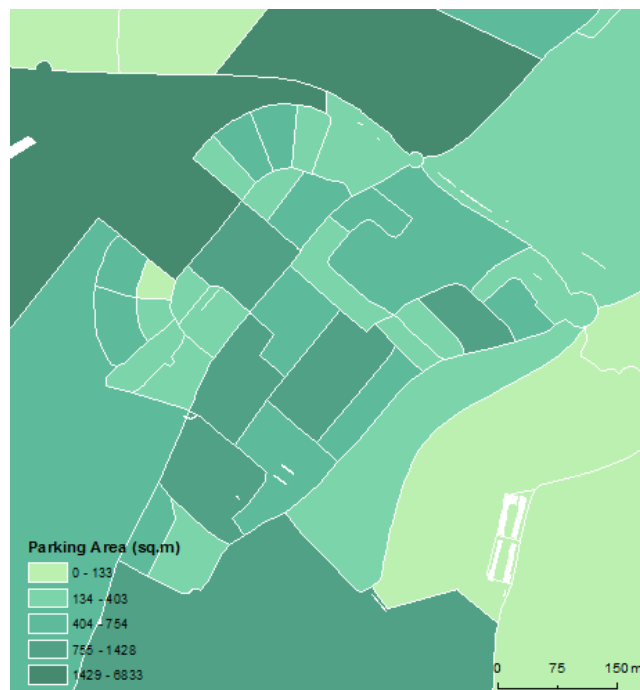


Figure 62 Representation of the values of Design



## 14. Diversity AH Tool

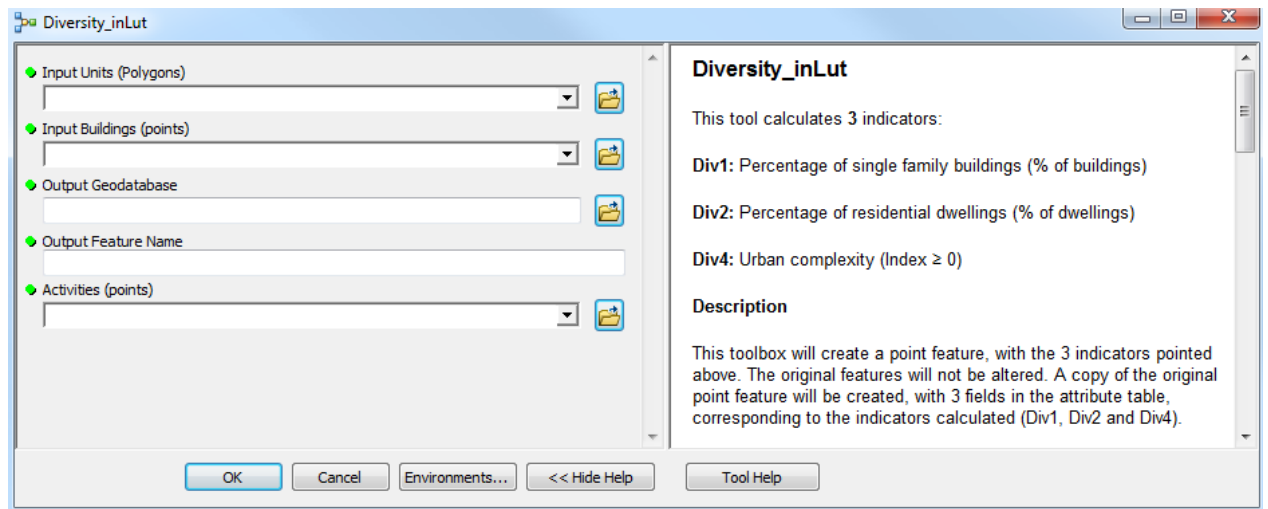


Figure 63 Diversity AH tool user interface

This tool calculates **3** indicators:

**Div1:** Percentage of single family buildings (% of buildings)

**Div2:** Percentage of residential dwellings (% of dwellings)

**Div4:** Urban complexity (Index  $\geq 0$ )

### 14.1.1. Description

This toolbox will create a point feature, with the **3** indicators pointed above. The original features will not be altered. A copy of the original point feature will be created, with **3** fields in the attribute table, corresponding to the indicators calculated (Div1, Div2 and Div4).

### 14.1.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) **Input Units:** a polygon feature is required with predefined area units (homogeneous areas)

- 2) **Input Buildings:** a point feature is required, the buildings of the urban area

The attribute table of the input buildings must have the following fields:

**AREA:** Ground floor gross area (square meters) of each building (**All Caps**)

**NFLOOR\_AG:** Number of floors above ground (including ground floor) (**All Caps**)

**NFLOOR\_UG:** Number of floors under ground (excluding ground floor) (**All Caps**)

**NFRAC\_TOT:** Number of fractions (dwellings and commercial units) (**All Caps**)

**NDWELLINGS:** Number of dwellings (only housing) (**All Caps**)

**NACTIVITY:** Number of non-housing fractions (**All Caps**)

- 3) **Activities:** point feature is required with the activities classification.

The attribute table must have one field designated **CODE\_TYPE (Text)**, which will have the codes for each activity type.

**CODE\_TYPE:** Activities code classification with 7 type uses.

CODE_TYPE	Type of use
CS1	Diário/ Diary
CS2	Ocasional/ Occasional
CS3	Excepcional/ Exceptional
E1	Equipamentos de Ensino/ Facilities
E2	Outros Equipamentos / Other Facilities
O	Outros/ Other
V	Vago/ Unoccupied

- 4) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.
- 5) **Output Feature Name:** The name of the output feature to be created by the toolbox.

### 14.1.3. Calculating the diversity indicators with our test files

If you are using our example files, the toolbox should look like this:

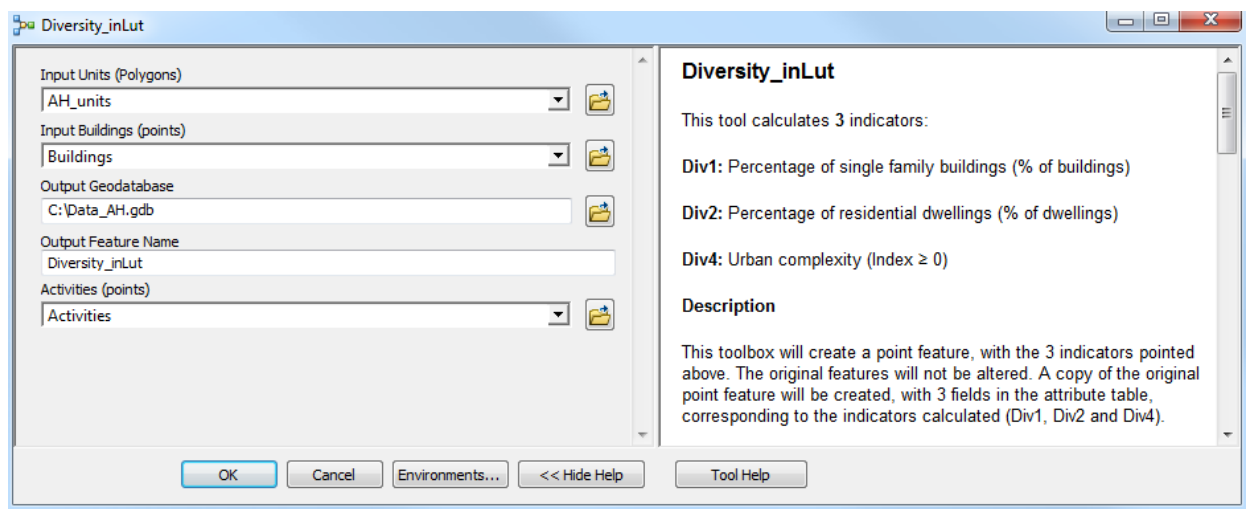


Figure 64 Diversity inLut AH tool user interface with our test files.

## Results

OBJECTID *	Shape *	NRESIDENT	Shape Length	Shape Area	Div1	Div2	Div4
30	Polygon ZM	0	1496,643778	78828,100862	0	0	0
2	Polygon ZM	138	465,804231	11675,875169	20	33,333333	1,584963
43	Polygon ZM	86	1584,45072	70051,659279	0	69,230769	1
44	Polygon ZM	132	1344,905138	66586,815479	12,5	73,170732	0
42	Polygon ZM	125	452,330838	9163,997841	0	75,862069	0
45	Polygon ZM	6	979,371461	45715,87622	25	76,190476	0
10	Polygon ZM	172	401,26807	6166,80026	0	78,378378	0
13	Polygon ZM	261	1082,712839	33163,623957	58,974359	80,152672	0
20	Polygon ZM	87	326,73301	4510,122402	0	84,313725	0
35	Polygon ZM	88	304,769361	5514,069286	0	84,313725	0
16	Polygon ZM	439	486,740987	13052,558382	0	86,160714	0
21	Polygon ZM	77	318,880083	5616,564807	0	86,363636	0
33	Polygon ZM	266	409,659543	10219,164961	0	86,764706	0
37	Polygon ZM	121	779,772954	23846,971342	0	88,059701	1
8	Polygon ZM	314	501,572009	12528,519486	0	93,125	1
29	Polygon ZM	83	226,593295	3294,720127	0	93,181818	0
24	Polygon ZM	158	227,104338	2274,31346	0	94,285714	0
7	Polygon ZM	77	285,992103	4076,69282	0	94,444444	0
12	Polygon ZM	94	1285,169704	56986,514198	31,25	95,555556	0
28	Polygon ZM	134	477,447048	6830,483415	0	95,652174	0

Figure 65 Attribute table of the calculated indicators.

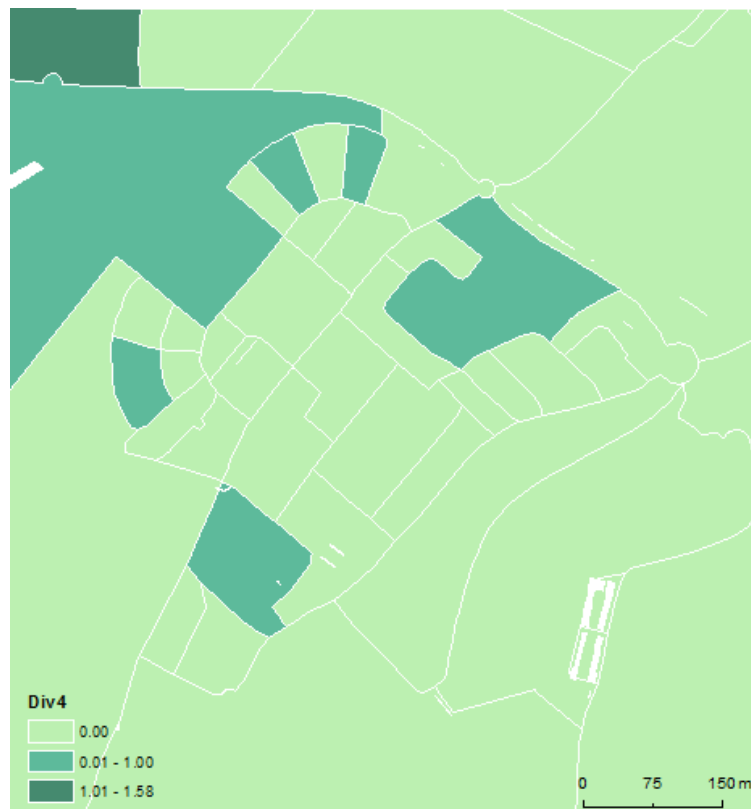


Figure 66 Representation of the values of Density (Div 4)

## 15. Topography AH Tool

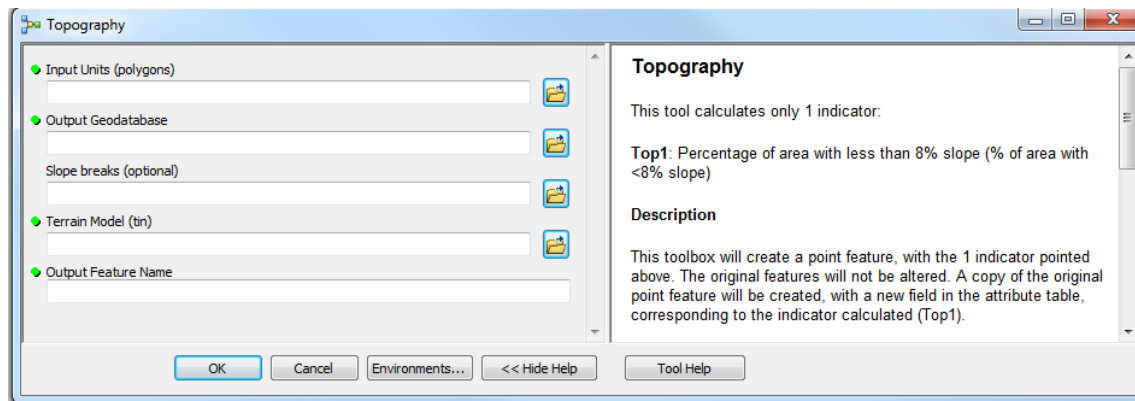


Figure 67 Topography AH tool user interface.

This tool calculates only **1** indicator:

**Top1:** Percentage of area with less than 8% slope (% of area with <8% slope)

### 15.1. Description

This toolbox will create a point feature, with the **1** indicator pointed above. The original features will not be altered. A copy of the original point feature will be created, with a new field in the attribute table, corresponding to the indicator calculated (Top1).

### 15.2. Toolbox Inputs

**ATTENTION:** This toolbox will not run successfully unless all the indications described below are established.

- 1) **Input Units:** a polygon feature is required with predefined area units (homogeneous areas)
- 2) **Terrain Model:** A tin model is required (See page 37).

- 3) **Slope breaks:** An excel file is required with the slope break at 8% like the example: (**All Caps**)

CLASS_BREAK	CODE
8	8

- 4) **Output Geodatabase:** Location where the output feature will be saved. It can be the same Geodatabase in which the input units and input buildings are saved.

- 5) **Output Feature Name:** The name of the output feature to be created by the toolbox

### 15.3. Calculating the topography indicator with our test files

If you are using our files, the toolbox should look like this:

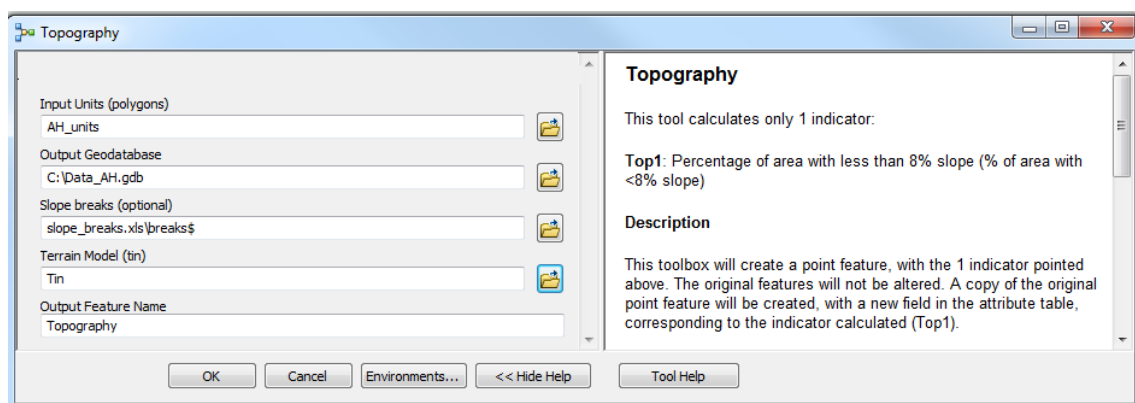


Figure 68 Topography AH tool user interface with our test files.

## Results

Table					
Topography					
OBJECTID *	Shape *	NRESIDENT	Shape Length	Shape Area	Top1
1	Polygon ZM	139	509,866494	13768,23657	54,457392
2	Polygon ZM	138	465,804231	11675,875169	52,057149
3	Polygon ZM	0	369,662102	1256,118395	100
4	Polygon ZM	43	1498,561191	80326,163646	21,811691
5	Polygon ZM	36	348,335773	6332,044949	50,072343
6	Polygon ZM	0	374,86391	1132,3657	94,839999
7	Polygon ZM	77	285,992103	4076,69282	47,142165
8	Polygon ZM	314	501,572009	12528,519486	79,839201
9	Polygon ZM	415	572,836093	10911,488199	62,05655
10	Polygon ZM	172	401,26807	6166,80026	63,443472
11	Polygon ZM	52	308,150613	4469,251597	100
12	Polygon ZM	94	1285,169704	56986,514198	9,710625
13	Polygon ZM	261	1082,712839	33163,623957	29,981955
14	Polygon ZM	86	297,762761	3882,004772	88,825596
15	Polygon ZM	313	986,726705	52940,579737	9,039443
16	Polygon ZM	439	486,740987	13052,558382	82,559143
17	Polygon ZM	139	244,286905	3065,064025	59,837607
18	Polygon ZM	12	175,454716	1928,211125	88,409855
19	Polygon ZM	18	275,793771	4622,675592	81,002375
20	Polygon ZM	87	326,73301	4510,122402	100

Figure 69 Attribute table of the calculated indicators.

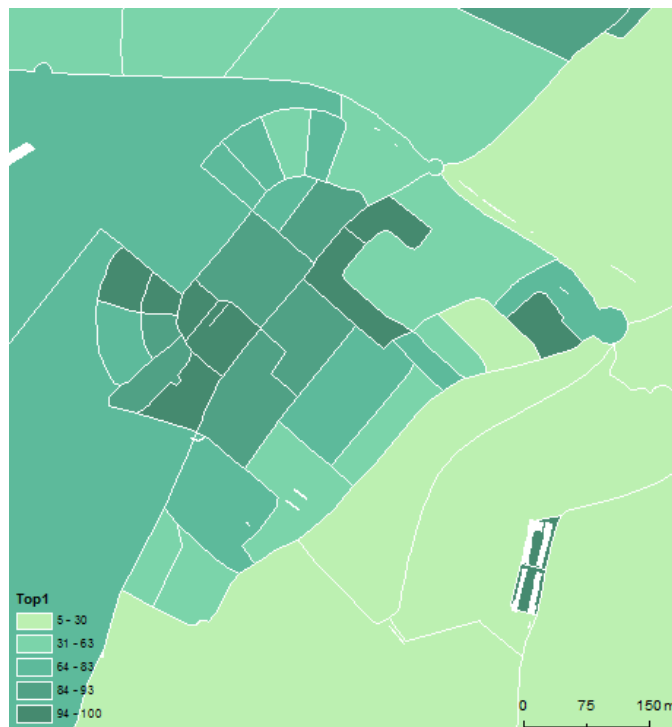


Figure 70 Representation of the values of Topography (Top 1)

**VOL.III Measuring the built environment Detailed indicators  
description**



## Accessibility

### Acc1 Distance to the closest transit stop

**Objectivo:** avaliar a proximidade ao transporte público.

*Goal: evaluate the proximity to public transit.*

**Escala de Análise:**

*Analysis scale*

☐ **Área homogénea**

*Homogeneous area*

☒ **Área de influência do ponto**

*Floating catchment area*

**Fórmula de Cálculo**

*Formula*

Distância à paragem mais próxima

*Distance to the closest transit stop*

**Unidade**

*Unit*

Distância metros

*Distance in meters*

### Acc2 Transit supply in the closest transit stop

**Objectivo:** avaliar oferta de transporte público na paragem mais próxima

*Goal: evaluate the public transit service offer in the closest public transit stop*

**Escala de Análise:**

*Analysis scale*

☐ **Área homogénea**

*Homogeneous area*

☒ **Área de influência do ponto**

*Floating catchment area*

**Fórmula de Cálculo**

*Formula*

Oferta de transporte público na paragem mais próxima  
(número total de autocarros que serve a paragem)

*Transit supply in the closest transit stop (total number of buses that serve that stop)*

**Unidade**

*Unit*

Oferta/dia

*offer/day*

**Notas:** O número total de autocarros é dado pelo somatório do total de autocarros de cada linha por dia que serve a paragem em questão.

*Notes: The total number of buses is given by the sum of the total of buses of each line per day that serve the stop in question.*

Acc3 **Transit frequency****Objetivo:** avaliar a oferta de transporte público.*Goal: evaluate the offer of public transit***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo***Formula*

$$\frac{\text{Total oferta TP (Total offer of public transport)}}{\text{total de paragens na área analisada (total number of public transit stops)}}$$
**Unidade***Unit*

Oferta por dia por paragem

*Offer by day by public transit stop*

**Notas:** A oferta total de TP é dada pelo somatório do total de autocarros de cada linha por dia que servem cada paragem dentro da área de estudo. Se o mesmo autocarro serve duas paragens dentro da área, contará duas vezes, uma em cada paragem.

**Notes:** The total offer of public transport is given by the sum of the total number of buses of each line per day that serve each transit stop inside the study area. If the same bus serves two different stops inside the study area it will count twice, one per each stop.

Acc4 **Distance to the closest activity****Objetivo:** avaliar a proximidade à actividade mais próxima.*Goal: evaluate the proximity to the closest activity.***Escala de Análise:***Analysis scale*☐ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo***Formula*

Distância à actividade mais próxima

*Distance to the closest activity***Unidade***Unit*

Distância em metros

*Distance in meters*

**Acc5 Average distance to n closest activities****Objetivo:** avaliar a proximidade a várias actividades mais próximas.*Goal: evaluate the proximity to several closest activities.***Escala de Análise:***Analysis scale*☐ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo***Formula*

Distância média a várias actividades mais próximas

*Average distance to several closest activities***Unidade***Unit*

Distância média em metros

*Average distance in meters***Acc6 Number of activities****Objectivo:** analisar a intensidade funcional de acordo com o número de actividades existentes na área de estudo*Goal: analyze the functional intensity according to the number of activities in the study area***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo***Formula* $\sum$  Número de Actividades (*N.º of activities*)**Unidade***Unit*

N.º de actividades

*N.º of activities***Notas:** Cada unidade comercial conta como uma actividade distinta. No caso dos centros comerciais o mesmo se aplica.*Notes: Each commercial units counts as a distinct activity. In the case of shopping centers the same applies.*

Acc7 **Commercial continuity****Objectivo:** analisar a distribuição funcional.*Goal: analyze the distribution of activities***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Unidade***Unit***Fórmula de Cálculo***Formula*

$$\frac{\text{N.º de actividades (N.º of activities)}}{\text{metros de via (meters of road)}} * 100$$

$$\frac{\text{N.º de actividades}}{100\text{m}}$$
  
*Activities/100m*
Acc8 **Number of bus lines****Objetivo:** quantificar o número de carreiras urbanas existentes na área de estudo.*Goal: quantify the number of urban bus lines for the study area.***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☐ **Área de influência do ponto***Floating catchment area***Unidade***Unit***Fórmula de Cálculo***Formula*

Número de carreiras urbanas que servem a área de estudo

*number of urban bus lines for the study area*

Número de carreiras

*Number of bus services*

## Acc9 *Number of bus stops*

**Objetivo:** quantificar o número de paragens de autocarro existentes na área de estudo.

*Goal: quantify the number of bus stops for the study area.*

**Escala de Análise:**

*Analysis scale*

☒ **Área homogénea**

*Homogeneous area*

☐ **Área de influência do ponto**

*Floating catchment area*

**Unidade**

*Unit*

**Fórmula de Cálculo**

*Formula*

Número de paragens de autocarro na área de estudo

*number of bus stops in the study area*

Número de paragens

*Number of bus stops*

## Acc10 *Kilometers of bus lines*

**Objetivo:** quantificar o número de paragens de autocarro existentes na área de estudo.

*Goal: quantify the number of bus stops for the study area.*

**Escala de Análise:**

*Analysis scale*

☒ **Área homogénea**

*Homogeneous area*

☐ **Área de influência do ponto**

*Floating catchment area*

**Unidade**

*Unit*

**Fórmula de Cálculo**

*Formula*

Extensão das linhas de transporte público (autocarro)

*Extension of bus lines*

Km

*Km*

**Connectivity:****Con1 Node density**

**Objectivo:** Identificar a quantidade de intersecções com três ou mais arcos na área de intervenção.

*Goal: Identify the number of intersections with three or more links in the study area*

**Escala de Análise:**  
*Analysis scale*

☒ **Área homogénea**  
*Homogeneous area*

☒ **Área de influência do ponto**  
*Floating catchment area*

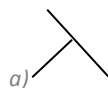
**Fórmula de Cálculo:**  
*Formula*

$$\frac{\text{N.º de nós (number of nodes)}}{\text{Superfície de análise (surface of analysis)}}$$

**Unidade**  
*Unit*  
N.º nós /ha  
*Nodes /ha*

**Notas:** para o cálculo do índice considera-se nós as intersecções do tipo a) e b) e exceptua-se as do tipo c)

*Notes: to calculate the index the intersections of type a) and b) are considered while the intersections of type c) are excluded*

**Con2 Pedestrian shed ratio**

**Objectivo:** analisar o rácio entre a área alcançada medida em linha recta e área medida na rede.

*Goal: analyze the ratio between the reached area, measured as the crow flies and reached area measured through the network.*

**Escala de Análise:**  
*Analysis scale*

☐ **Área homogénea**  
*Homogeneous area*

☒ **Área de influência do ponto**  
*Floating catchment area*

**Fórmula de Cálculo:**  
*Formula*

$$\frac{\text{Área de influência medida na rede (Network distance)}}{\text{área de influência medida em linha recta (Euclidean distance)}}$$

**Unidade**  
*Unit*  
Índice ]0-1]  
*Index ]0-1]*

**Notas:** o cálculo da área em rede é feito através da ferramenta do arcgis “service area” com a opção “detailed” para a definição dos polígonos. Área medida em linha recta é feita com base na fórmula da área do círculo ( $A = \pi r^2$ ).

*Notes: the calculation of the index is made using the “service area” tool from ArcGIS, with the option “detailed” selected in ‘generate polygons’ menu. The Euclidean area is calculated using the formula for the area of a circle ( $A = \pi r^2$ ).*

Con3 **Straightness****Objectivo:** analisar o impacto da morfologia na distância pedonal*Goal: analyze the impact of morphology on the pedestrian distance***Escala de Análise:***Analysis scale*☐ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*
$$\frac{\text{distância euclidiana (Euclidean distance)}}{\text{Distancia na rede (Network distance)}}$$
**Unidade***Unit***Rácio***Ratio*Con4 **Average link length****Objectivo:** analisar o impacto da morfologia na conectividade pedonal*Goal: analyze the impact of morphology on pedestrian connectivity***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*
$$\frac{\sum \text{comprimento de cada arco (link length)}}{\text{Nº. total de arcos (total number of links)}}$$
**Unidade***Unit***metros***meters***Notas:** no cálculo do indicador foi considerada a rede pedonal*Notes: the pedestrian network is considered to calculate the indicator*

Con5 **Link node ratio (Gamma index)****Objectivo:** analisar o nível de conectividade da rede*Goal: analyze the level of network connectivity***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☐ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*

$$\frac{e}{3(v-2)}$$

**Unidade***Unit*

Índice ]0-1]

*Index ]0-1]***Parâmetros***Parameters***Fonte***Source***e = número de arcos***N.º of links*

SIG

GIS

**v = número de nós***N.º of nodes*

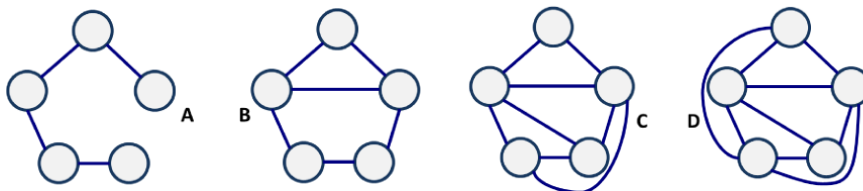
SIG

GIS

**Notas:** Medida de conectividade que considera relação entre as possíveis ligações observadas e as que efectivamente existem. O valor do indicador varia entre 0 e 1 em que 1 significa uma rede totalmente conectada. Garantir que na rede a analisar existem no mínimo 3 nós, caso contrário assumir valor 0 para o indicador.

*Notes: A measure of connectivity that considers the relationship between the number of observed links and the number of possible links. The value of gamma is between 0 and 1 where a value of 1 indicates a completely connected network. Ensure that the analyzed network has more than 3 nodes, otherwise assume a value of 0 for the index*

$$\gamma = \frac{e}{3(v-2)}$$



	e	3(v-2)	Gamma
A	4	9	0.44
B	6	9	0.66
C	8	9	0.88
D	9	9	1.0



**Density:****Den1 Housing density**

**Objectivo:** Identificar a distribuição espacial da ocupação habitacional na área de intervenção.

*Goal: Identify the spatial distribution of dwellings in the study area*

**Escala de Análise:**

*Analysis scale*

☒ **Área homogénea**

*Homogeneous area*

☒ **Área de influência do ponto**

*Floating catchment area*

**Fórmula de Cálculo**

*Formula*

$$\left( \frac{\text{N.º fracções habitacionais (N.º of dwellings)}}{\text{Superfície de análise (surface of analysis)}} \right) * 10000$$

**Unidade**

*Unit*

N.º de fracções/ha

*Dwellings/ha*

**Notas:** Fracções habitacionais são calculadas, para cada edifício, como a diferença entre o n.º de fracções totais e as fracções de diferentes usos, ou seja, não habitacionais

*Notes: the number of dwellings is calculated, for each building, as the difference between the total number of subdivisions and the subdivisions allocated for non-housing use*

**Den2 Building Density**

**Objectivo:** identificar a distribuição espacial dos edifícios

*Goal: Identify the spatial distribution of buildings*

**Escala de Análise:**

*Analysis scale*

☒ **Área homogénea**

*Homogeneous area*

☒ **Área de influência do ponto**

*Floating catchment area*

**Fórmula de Cálculo:**

*Formula*

$$\frac{\text{N.º edifícios (N.º of buildings)}}{\text{superfície de análise (surface of analysis)}}$$

**Unidade**

*Unit*

N.º de edifícios/ha

*Buildings/ha*

Den3 **Gross Floor Area Ratio****Objectivo:** analisar aos níveis de ocupação do solo na área de estudo.*Goal: analyze the construction density in the study area***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*Área bruta de construção (*Gross floor area*)Superfície de análise (*Surface of analysis*)**Unidade***Unit***Índice***Index***Parâmetros***Parameters***Fonte***Source***Área de construção****ABC = Área implantação do edifício X N pisos***Construction area. ABC = building plant area X N floors***SIG***GIS*Den4 **Housing gross floor area ratio****Objectivo:** analisar aos níveis de ocupação por habitação na área de estudo.*Goal: analyze the construction house density in the study area***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*

Área bruta de construção de Habitação

*(Gross floor area of housing)*Superfície de análise (*Surface of analysis*)**Unidade***Unit***Índice***Index***Parâmetros***Parameters***Fonte***Source***Área de construção**

$$ABC_{hab} \left( \frac{\text{Área de implantação do edifício} \times N \text{ pisos}}{\text{Número de Frações Totais}} \right) \times \text{Número de Frações de Habitação}$$
*Floor area of the building \* N floors**total number of fractions**\*(Total number of dwelling)***SIG***GIS*

Den5 **Services and retail gross floor area ratio**

**Objectivo:** analisar aos níveis de ocupação de comércio e serviços na área de estudo.

*Goal: analyze the construction density of commerce and services in the study area*

**Escala de Análise:**

*Analysis scale*

☒ **Área homogénea**

*Homogeneous area*

☒ **Área de influência do ponto**

*Floating catchment area*

**Fórmula de Cálculo:**

*Formula*

Área bruta de construção de Comércio e Serviços  
(*Gross floor area of services and retail*)

Superfície de análise (*Surface of analysis*)

**Unidade**

*Unit*

**Índice**

*Index*

**Parâmetros**

*Parameters*

**Fonte**

*Source*

**Área de construção**

**SIG**

*GIS*

$$ABC_{hab} \left( \frac{\text{Área de implantação do edifício} \cdot N \text{ pisos}}{\text{Número de Frações Totais}} \right) \cdot \text{Número de Frações de Comércio e serviços}$$

*\* (total number of fractions of services and commerce)*

Den6 **Population Density**

**Objectivo:** Identificar a distribuição espacial da população na área de intervenção.

*Goal: Identify the spatial distribution of the population in the study area*

**Escala de Análise:**

*Analysis scale*

☒ **Área homogénea**

*Homogeneous area*

**Fórmula de Cálculo:**

*Formula*

$$\left( \frac{N.^{\circ} \text{ residentes (N.^{\circ} of inhabitants)}}{\text{Superfície de análise (surface of analysis)}} \right) \cdot 10000$$

**Unidade**

*Unit*

**N.º de residents/ha**

*Inhabitants/ha*

**Parâmetros**

*Parameters*

**Fonte**

*Source*

**N.º de residentes**

**Censos**

*N.º of inhabitants*

*Census*

## Design:

### Dsg1 *Surface of buildings*

**Objectivo:** quantificar a área ocupada por edifícios.

*Goal: quantify the surface of buildings*

**Escala de Análise:**

*Analysis scale*

☒ **Área homogénea**

*Homogeneous area*

☒ **Área de influência do ponto**

*Floating catchment area*

**Fórmula de Cálculo:**

*Formula*

$$\left( \frac{\text{Área ocupada por edifícios} \quad (Surface \ of \ buildings)}{\text{Superfície de análise} \quad (Surface \ of \ analysis)} \right) * 100$$

**Unidade**

*Unit*

% area de edifícios

*% of buildings area*

### Dsg2 *Surface of motorized circulation*

**Objectivo:** quantificar a área ocupada por circulação motorizada.

*Goal: quantify the surface of motorized circulation.*

**Escala de Análise:**

*Analysis scale*

☒ **Área homogénea**

*Homogeneous area*

☒ **Área de influência do ponto**

*Floating catchment area*

**Fórmula de Cálculo:**

*Formula*

$$\left( \frac{\text{Área ocupada por circulação motorizada} \quad (Surface \ of \ motorized \ circulation)}{\text{Superfície de análise} \quad (Surface \ of \ analysis)} \right) * 100$$

**Unidade**

*Unit*

% area de circulação

motorizada

*% of motorized circulation*

Dsg3 **Surface of parking****Objectivo:** quantificar a área ocupada por estacionamento.*Goal: quantify the surface of parking.***Escala de Análise:***Analysis scale***Fórmula de Cálculo:***Formula*

$$\left( \frac{\begin{array}{c} \text{Área ocupada por estacionamento} \\ \text{(Surface of parking)} \end{array}}{\begin{array}{c} \text{Superfície de análise} \\ \text{(Surface of analysis)} \end{array}} \right) * 100$$

**Unidade***Unit*% area ocupada por  
estacionamento*% of Surface of parking*Dsg4 **Surface of facilities****Objectivo:** quantificar a área ocupada por equipamentos.*Goal: quantify the surface of facilities.***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*

$$\left( \frac{\begin{array}{c} \text{Área ocupada por equipamentos} \\ \text{(Surface of facilities)} \end{array}}{\begin{array}{c} \text{Superfície de análise} \\ \text{(Surface of analysis)} \end{array}} \right) * 100$$

**Unidade***Unit*% area ocupada por  
equipamentos*% of Surface of facilities*

**Dsg5 Surface of patios****Objectivo:** quantificar a área livre de logradouros.*Goal: quantify the surface free private space.***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*

$$\left( \frac{\text{Área ocupada por logradouros} \quad (Surface \ of \ patios)}{\text{Superfície de análise} \quad (Surface \ of \ analysis)} \right) * 100$$

**Unidade***Unit*

% area ocupada por logradouros

*% of Surface of patios***Dsg6 Percentage of pedestrian area****Objectivo:** analisar a percentagem da área pedonal na área de estudo.*Goal: analyze the proportion of pedestrian area in the study area***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*

$$\left( \frac{\text{Área de circulação pedonal} \quad (Surface \ of \ pedestrian \ circulation)}{\text{Superfície de análise} \quad (Surface \ of \ analysis)} \right) * 100$$

**Unidade***Unit*

% area pedonal

*% of pedestrian area***Notas:** \*Área de circulação pedonal corresponde à área ocupada por passeios e vias pedonais.*Notes: \* Surface of pedestrian circulation is the area corresponding to the footpaths and the pedestrian roads*

**Dsg7 Average width of the pedestrian path****Objectivo:** analisar a largura média do passeio.*Goal: analyze the proportion of pedestrian area in the study area***Escala de Análise:***Analysis scale*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*

$$\frac{\text{Área do passeio (Area of the pedestrian path)}}{\text{Comprimento da via (road length)}}$$
**Unidade***Unit*

metros (largura do passeio)

*meters (pedestrian width)***Notas:** \*Área de circulação pedonal corresponde à área ocupada por passeios e vias pedonais.*Notes: \* Surface of pedestrian circulation is the area corresponding to the footpaths and the pedestrian roads***Dsg8 Green space area ratio****Objectivo:** analisar a oferta de espaços verdes na área de estudo*Goal: analyze the offer of green spaces in the study area***Escala de Análise:***Analysis scale*☒ **Cidade***City*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo***Formula*

$$\left( \frac{\text{Área de espaços verdes (Green space area)}}{\text{Superfície de análise (Surface of analysis)}} \right) * 100$$
**Unidade***Unit*

% espaços verdes

*% green spaces***Notas:** Área de espaços verdes inclui espaços verdes de fruição, mas exclui zonas ajardinadas de rotundas e afins.*Notes: Green spaces area do not include green spaces contained within traffic elements – roundabouts and so on.*

Dsg9 **Parking spaces per dwelling****Objectivo:** oferta de estacionamento total*Goal: availability of public parking spaces.***Escala de Análise:***Analysis scale*☒ **Cidade***City*☒ **Área homogénea***Homogeneous area*☒ **Área de influência do ponto***Floating catchment area***Fórmula de Cálculo:***Formula*N.º de lugares estacionamento (*Number of parking spaces*)Total de fracções (*Total number of dwellings*)**Unidade***Unit*

N.º de Lugares

*N.º of parking spaces***Parâmetros***Parameters***Fonte***Source***N.º de lugares estacionamento total\****Number of public parking spaces*

SIG

GIS

**Área de bolsa de estacionamento em bolsa ao ar livre = 20m<sup>2</sup>***Area of parking lot in outsider park = 20m<sup>2</sup>***Número de fracções na escala de análise***Total number of dwellings in the unit scale*

SIG

GIS

**Notas:** \*Valor aproximado de área ocupada por um veículo ligeiro. Contabiliza-se todos os lugares de estacionamento tanto públicos como privado.*Notes:* \*Estimated area per car. For parking space count every parking offer, all public and private parking



DiversityDiv1 **Percentage of single family buildings**

**Objectivo:** Identificar zonas de baixa densidade habitacional, ocupadas por edifícios unifamiliares

*Goal: Identify low density zones, occupied by single-family houses.*

**Escala de Análise:**  
*Analysis scale*

☒ **Área homogénea**  
*Homogeneous area*

☒ **Área de influência do ponto**  
*Floating catchment area*

**Fórmula de Cálculo:**  
*Formula*

$$\left( \frac{\text{N.º edifícios unifamiliares} \\ \text{(Number of single family buildings)}}{\text{Total de edifícios} \\ \text{(Total number of buildings)}} \right) * 100$$

**Unidade**  
*Unit*  
% de edifícios  
*% of Buildings*

Div2 **Percentage of residential dwellings**

**Objectivo:** analisar a diversidade funcional

*Goal: analyze the functional diversity*

**Escala de Análise:**  
*Analysis scale*

☒ **Área homogénea**  
*Homogeneous area*

☒ **Área de influência do ponto**  
*Floating catchment area*

**Fórmula de Cálculo**  
*Formula*

$$\frac{\text{N.º fracções habitacionais} \\ \text{(Number of residential dwellings)}}{\text{total de fracções} \\ \text{(total number of fractions)}} * 100$$

**Unidade**  
*Unit*  
% de fracções  
*% of dwellings*

Div3 **Percentage of area occupied by activities**

**Objectivo** analisar a intensidade funcional de acordo com área afecta às actividades existentes na área de estudo

*Goal: analyze the functional intensity according to the area allocated to each activity in the study area*

**Escala de Análise:**

*Analysis scale*

☐ **Área homogénea**

*Homogeneous area*

☒ **Área de influência do ponto**

*Floating catchment area*

**Fórmula de Cálculo**

*Formula*

$$\left( \frac{\text{Área total de funções} \quad (Total \text{ area of activities})}{\sum \text{Área total das actividades existentes em toda a AI} \quad (total \text{ area for all activities in all IA})} \right) * 100$$

**Unidade**

*Unit*

% de área de cada actividade  
*% of area of each activity*

**Notas:** A área de cada função corresponde à área ocupada pelo edifício. Caso o mesmo edifício tem várias funções divide-se a área de edifício pelo número de funções aí existentes.

No caso dos centros comerciais:  $\frac{ABC \text{ do edifício do centro comercial}}{N^{\circ} \text{ de lojas existentes}}$

*Notes: The area of each activity is given by the area of the building. When the building has more than one activity, its area is divided equally by the number of activities therein. In the case of a shopping center the area is given by:  $\frac{\text{gross construction area of the shopping center}}{N^{\circ} \text{ of shops}}$*

Div4 **Urban complexity**

**Objectivo:** analisar a diversidade de usos existentes na área de estudo

*Goal: analyze the land-use diversity in the study area*

**Escala de Análise:**

*Analysis scale*

☒ **Área homogénea**

*Homogeneous area*

☒ **Área de influência do ponto**

*Floating catchment area*

**Fórmula de Cálculo**

*Formula*

$$-1 * \sum_{i=1}^n P_i \log_2 P_i$$

$P_i = N_i/N$  é a abundância relativa de cada categoria  
 *$P_i = N_i/N$  is the relative abundance of each category*

$N_i$  é número de indivíduos da categoria "i"  
 *$N_i$  is the number of individuals of each category i*

"N" é o número total de indivíduos  
*N is the total number of individuals*

**Unidade**

*Unit*

Índice de complexidade  $\geq 0$   
*Index of complexity  $\geq 0$*

**Topography:**

Top1 **Percentage of area with < 8% slope**

**Objectivo:** identificar características morfológicas

*Goal: identify morphological characteristics*

**Escala de Análise:**

*Analysis scale*

☐ Cidade

*City*

☒ Área homogénea

*Homogeneous area*

☒ Área de influência do ponto

*Floating catchment area*

**Fórmula de Cálculo:**

*Formula*

$$\frac{\text{Área com declive} < 8\% \text{ (Area with slope} > 8\%) }{\sum \text{Área total (Total area)}}$$

**Unidade**

*Unit*

% Área ocupada por declive  
<8%

*% of area with <8% slope*

**Notas:** Classes de declive superior a 8%

*Notes: Categories of slope superior of 8%*