MEASURING THE BUILT ENVIRONMENT WITH GIS

Toolbox for ArcGIS 10 | 10.1 and latest versions
Instructions Manual
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Measuring the built environment with GIS

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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:
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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.

![Network Analyst Extension](image)

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.](image)

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

![Figure 3 Built Environment Tools](image)
Measuring the built environment with GIS

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.](image)

**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 xls 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.](image)
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 requirements for the built environment characterization. Two different approaches were considered, first for floating catchment areas of each building 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 landmark 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.
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.

Figure 6 Indicators calculated in InLUT project, with the InLUT toolbox
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 *.dwf 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.

![Creating a New Network Dataset from a polyline shapefile in ArcMap 10.1](image)

Figure 7 Creating a New Network Dataset from a polyline shapefile in ArcMap 10.1
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)**

<table>
<thead>
<tr>
<th>CODE_TYPE</th>
<th>Type of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS1</td>
<td>Diário/ Diary</td>
</tr>
<tr>
<td>CS2</td>
<td>Ocasional/ Occasional</td>
</tr>
<tr>
<td>CS3</td>
<td>Excepcional/ Exceptional</td>
</tr>
<tr>
<td>E1</td>
<td>Equipamentos de Ensino/ Facilities</td>
</tr>
<tr>
<td>E2</td>
<td>Outros Equipamentos / Other Facilities</td>
</tr>
<tr>
<td>O</td>
<td>Outros/ Other</td>
</tr>
<tr>
<td>V</td>
<td>Vago/ Unoccupied</td>
</tr>
</tbody>
</table>
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:

![Accessibility tool user interface with our test files](image)

Figure 9 Accessibility tool user interface with our test files
Results:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
<th>Value 5</th>
<th>Value 6</th>
<th>Value 7</th>
<th>Value 8</th>
<th>Value 9</th>
<th>Value 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC6</td>
<td>0.621</td>
<td>0.621</td>
<td>0.621</td>
<td>0.621</td>
<td>0.621</td>
<td>0.621</td>
<td>0.621</td>
<td>0.621</td>
<td>0.621</td>
<td>0.621</td>
</tr>
</tbody>
</table>

Figure 10 Attribute table of the calculated indicators

Figure 11 Representation of the values of Commercial continuity (ACC6)
3.2. Accessibility to Facilities

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 and 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**).

<table>
<thead>
<tr>
<th>CODE_TYPE</th>
<th>Type of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS1</td>
<td>Diário/ Diary</td>
</tr>
<tr>
<td>CS2</td>
<td>Ocasional/ Occasional</td>
</tr>
<tr>
<td>CS3</td>
<td>Excepcional/ Exceptional</td>
</tr>
<tr>
<td>E1</td>
<td>Equipamentos de Ensino/ Facilities</td>
</tr>
<tr>
<td>E2</td>
<td>Outros Equipamentos / Other Facilities</td>
</tr>
<tr>
<td>O</td>
<td>Outros/ Other</td>
</tr>
<tr>
<td>V</td>
<td>Vago/ Unoccupied</td>
</tr>
</tbody>
</table>
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:

![Accessibility to Facilities tool user interface with our test files](image)

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

| Access & Function | Name | ACC1 | ACC2 | ACC3 | ACC4 | ACC5 | ACC6 | ACC7 | ACC8 | ACC9 | ACC10 | ACC11 | ACC12 | ACC13 | ACC14 | ACC15 | ACC16 | ACC17 | ACC18 | ACC19 | ACC20 |
|-------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1                 | Stad | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 |
| 2                 | Zone | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 |
| 3                 | Area | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 |
| 4                 | Zone | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 |
| 5                 | Area | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 | 9012 | 3456 | 7890 | 1234 | 5678 |

Figure 14 Attribute table of the calculated indicators

Figure 15 Representation of the values of Distance to the closest activity (ACC4)
4. Connectivity Tool

![Connectivity tool user interface.](image)

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](image-url)
Results:

Table

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>AREA</th>
<th>MFLOOR AG</th>
<th>MFLOOR IG</th>
<th>MFAC TOT</th>
<th>RESIDENTIAL</th>
<th>NACTIVITY</th>
<th>FacilitD</th>
<th>Con2</th>
<th>Con3</th>
<th>Con4</th>
<th>Con5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Point</td>
<td>211,2603</td>
<td>8</td>
<td>1</td>
<td>17</td>
<td>17</td>
<td>0</td>
<td>1</td>
<td>5.319594</td>
<td>43.910279</td>
<td>3.425704</td>
<td>0.049204</td>
</tr>
<tr>
<td>2 Point</td>
<td>255,0019</td>
<td>8</td>
<td>1</td>
<td>19</td>
<td>16</td>
<td>4</td>
<td>2</td>
<td>5.342151</td>
<td>43.949184</td>
<td>3.785703</td>
<td>0.038804</td>
</tr>
<tr>
<td>3 Point</td>
<td>257,2449</td>
<td>9</td>
<td>1</td>
<td>17</td>
<td>17</td>
<td>0</td>
<td>2</td>
<td>5.274124</td>
<td>43.726930</td>
<td>2.579463</td>
<td>0.021099</td>
</tr>
<tr>
<td>4 Point</td>
<td>285,0372</td>
<td>8</td>
<td>1</td>
<td>17</td>
<td>17</td>
<td>0</td>
<td>4</td>
<td>3.301242</td>
<td>43.373214</td>
<td>3.553983</td>
<td>0.028083</td>
</tr>
<tr>
<td>5 Point</td>
<td>247,1500</td>
<td>8</td>
<td>1</td>
<td>17</td>
<td>17</td>
<td>0</td>
<td>5</td>
<td>3.327923</td>
<td>43.238574</td>
<td>3.416929</td>
<td>0.054873</td>
</tr>
<tr>
<td>6 Point</td>
<td>299,8529</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>6</td>
<td>3.786594</td>
<td>43.851871</td>
<td>2.892986</td>
<td>0.045908</td>
</tr>
<tr>
<td>7 Point</td>
<td>247,5469</td>
<td>8</td>
<td>1</td>
<td>12</td>
<td>10</td>
<td>2</td>
<td>5</td>
<td>3.568546</td>
<td>43.160161</td>
<td>2.761661</td>
<td>0.005542</td>
</tr>
<tr>
<td>8 Point</td>
<td>209,9567</td>
<td>9</td>
<td>1</td>
<td>17</td>
<td>19</td>
<td>2</td>
<td>0</td>
<td>4.407512</td>
<td>42.852138</td>
<td>2.782703</td>
<td>0.087765</td>
</tr>
<tr>
<td>9 Point</td>
<td>239,0620</td>
<td>7</td>
<td>1</td>
<td>13</td>
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<td>0.048801</td>
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<td>2</td>
<td>10</td>
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<td>3.684738</td>
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<td>11</td>
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<td>0</td>
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<td>0.075613</td>
</tr>
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<td>38.750971</td>
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<td>0.271306</td>
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<td>0.070226</td>
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<td>0.769014</td>
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<td>0.088001</td>
</tr>
</tbody>
</table>

Figure 18 Attribute table of the calculated indicators

Figure 19 Representation of the values of Node density (Con1)
5. Density Tool

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:

![Density tool user interface with our test files](image)

Results:

![Attribute table of the calculated indicators](image)

![Representation of the values of Building density (Den2)](image)
6. Design inLut Tool

![Design inLut tool user interface](image)

**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)
Measuring the built environment with floating catchment areas

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:

![Design InLut tool user interface with our test files](image-url)
Results:

Table

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>Shape</th>
<th>AREA</th>
<th>SURF.</th>
<th>LVL/3</th>
<th>DSG3</th>
<th>DSG4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Point</td>
<td>211</td>
<td>0.01</td>
<td>1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>3</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Figure 26 Attribute table of the calculated indicators

Figure 27 Representation of the values of Surface of parking (Dsg3)
6.2 Design Tool

![Design tool user interface](image)

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. Is recommend that 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.

### 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 allows the user 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:

![Design tool user interface with our test files](image)

*Figure 29 Design tool user interface with our test files*
Results:

Figure 30 Attribute table of the calculated indicators

Figure 31 Representation of the area values of Green spaces (Espaços verdes)
7. Diversity Tool

![Diversity Tool User Interface](image)

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 ≥ 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)*

<table>
<thead>
<tr>
<th>CODE_TYPE</th>
<th>Type of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS1</td>
<td>Diário/ Diary</td>
</tr>
<tr>
<td>CS2</td>
<td>Ocasional/ Occasional</td>
</tr>
<tr>
<td>CS3</td>
<td>Excepcional/ Exceptional</td>
</tr>
<tr>
<td>E1</td>
<td>Equipamentos de Ensino/ Facilities</td>
</tr>
<tr>
<td>E2</td>
<td>Outros Equipamentos / Other Facilities</td>
</tr>
<tr>
<td>O</td>
<td>Outros/ Other</td>
</tr>
<tr>
<td>V</td>
<td>Vago/ Unoccupied</td>
</tr>
</tbody>
</table>

7.3. Calculating the diversity indicators with our test files

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

![Diversity tool user interface with our test files](image)

*Figure 33 Diversity tool user interface with our test files*
Results:

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
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:

![Topography tool user interface with our test files](image)

Figure 39 Topography tool user interface with our test files
Results:

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<th>OBJECTID</th>
<th>SHAPE</th>
<th>AREA</th>
<th>INFLOOR_AG</th>
<th>INFLOOR_UO</th>
<th>INFRAF_TOT</th>
<th>NBWELLING</th>
<th>NACTIVITY</th>
<th>NACTIVITY</th>
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<td>17</td>
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<td>6</td>
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<td></td>
</tr>
<tr>
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<td>Point</td>
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<td>6</td>
<td>58.912306</td>
<td></td>
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<tr>
<td>7</td>
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<td>247.3545</td>
<td>6</td>
<td>17</td>
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<td>6</td>
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<tr>
<td>8</td>
<td>Point</td>
<td>256.8659</td>
<td>9</td>
<td>17</td>
<td>17</td>
<td>6</td>
<td>58.912306</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Point</td>
<td>256.8659</td>
<td>9</td>
<td>17</td>
<td>17</td>
<td>6</td>
<td>58.912306</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
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<td></td>
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<td>239.8395</td>
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<td>6</td>
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<td></td>
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<td>17</td>
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</tr>
<tr>
<td>16</td>
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<td>232.2551</td>
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<td>17</td>
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<td>58.912306</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 stop. (**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:

![Accessibility AH tool user interface with our test files.](image)

Figure 44 Accessibility AH tool user interface with our test files.
Measuring the built environment for pre-defined areas or homogeneous areas

Results:

Figure 45 Attribute table of the calculated indicators.

Figure 46 Representation of the values of Accessibility (Acc 10)
10. Connectivity AH Tool

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.](image)
Results:

Table

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>Shape</th>
<th>Attribute</th>
<th>Shape Length</th>
<th>Shape Area</th>
<th>Cont.</th>
<th>Cont.</th>
<th>Cont.</th>
<th>Cont.</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>139</td>
<td>509.86494</td>
<td>13768.23657</td>
<td>0.6</td>
<td>109.983171</td>
<td></td>
<td></td>
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<td>2</td>
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<td>11675.875169</td>
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<td>1.142837</td>
<td>52.098326</td>
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<td>7.841033</td>
<td>3.8</td>
<td>8.752227</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Polygon ZM</td>
<td>36</td>
<td>345.82272</td>
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<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Polygon ZM</td>
<td>35</td>
<td>346.85272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>6</td>
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<td>36</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>7</td>
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<td>37</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Polygon ZM</td>
<td>38</td>
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<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Polygon ZM</td>
<td>39</td>
<td>345.82272</td>
<td>12532.94494</td>
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<td>0.424259</td>
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<tr>
<td>10</td>
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<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>11</td>
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<td>41</td>
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<td></td>
</tr>
<tr>
<td>12</td>
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<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Polygon ZM</td>
<td>43</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>14</td>
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<td>44</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Polygon ZM</td>
<td>45</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Polygon ZM</td>
<td>46</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Polygon ZM</td>
<td>47</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Polygon ZM</td>
<td>48</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Polygon ZM</td>
<td>49</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Polygon ZM</td>
<td>50</td>
<td>345.82272</td>
<td>12532.94494</td>
<td>1.574294</td>
<td>0.424259</td>
<td>82.960304</td>
<td></td>
</tr>
</tbody>
</table>

Figure 49 Attribute table of the calculated indicators.

Figure 50 Representation of the values of Connectivity (Con4)
11. Density AH Tool

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)
Measuring the built environment for pre-defined areas or homogeneous areas

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:

![Density AH tool user interface with our test files.](image)

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

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. º 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).
Measuring the built environment for pre-defined areas or homogeneous areas

**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:

![Design inLut AH tool user interface with our test files.](image)

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

Figure 57 Attribute table of the calculated indicators.

Figure 58 Representation of the values of Design_InLUT (Dsg 6)
13. Design AH Tool

![Design AH tool user interface](image)

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 the network dataset. (see page 11)
Measuring the built environment for pre-defined areas or homogeneous areas

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.](image-url)
Measuring the built environment for pre-defined areas or homogeneous areas

Results

![Figure 61 Attribute table of the calculated indicators.](image)

![Figure 62 Representation of the values of Design](image)
14. Diversity AH Tool

This tool calculates 3 indicators:

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

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

**Div4**: Urban complexity (Index ≥ 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.

<table>
<thead>
<tr>
<th>CODE_TYPE</th>
<th>Type of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS1</td>
<td>Diário/ Diary</td>
</tr>
<tr>
<td>CS2</td>
<td>Ocasional/ Occasional</td>
</tr>
<tr>
<td>CS3</td>
<td>Excepcional/ Exceptional</td>
</tr>
<tr>
<td>E1</td>
<td>Equipamentos de Ensino/ Facilities</td>
</tr>
<tr>
<td>E2</td>
<td>Outros Equipamentos / Other Facilities</td>
</tr>
<tr>
<td>O</td>
<td>Outros/ Other</td>
</tr>
<tr>
<td>V</td>
<td>Vago/ Unoccupied</td>
</tr>
</tbody>
</table>
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.](image)
Measuring the built environment for pre-defined areas or homogeneous areas

Results

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 more 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).
Measuring the built environment for pre-defined areas or homogeneous areas

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.](image-url)

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

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*

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

*Goal*: evaluate the proximity to public transit.

**Escala de Análise**: 
- [ ] Área homogénea
- ✔ Área de influência do ponto

**Fórmula de Cálculo**

<table>
<thead>
<tr>
<th>Formula</th>
<th>Distância à paragem mais próxima</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance to the closest transit stop</td>
</tr>
</tbody>
</table>

**Unidade**
- Distância metros

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

**Notas**: 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.

---

**Acc2**  *Transit supply in the closest transit stop*

**Objective**: 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**: 
- [ ] Área homogénea
- ✔ Área de influência do ponto

**Fórmula de Cálculo**

<table>
<thead>
<tr>
<th>Formula</th>
<th>Oferta de transporte público na paragem mais próxima</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(número total de autocarros que serve a paragem)</td>
</tr>
<tr>
<td></td>
<td>Transit supply in the closest transit stop (total number of buses that serve that stop)</td>
</tr>
</tbody>
</table>

**Unidade**
- Oferta/dia

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

**Notas**: 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:**  
- Área homogénea (Homogeneous area)  
- Área de influência do ponto (Floating catchment area)  

**Fórmula de Cálculo:**

\[
\text{Total oferta TP} \quad (\text{Total offer of public transport})  \\
\text{total de paragens na área analisada} \quad (\text{total number of public transit stops})
\]

**Unidade:** 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:**  
- Área homogénea (Homogeneous area)  
- Área de influência do ponto (Floating catchment area)  

**Fórmula de Cálculo:**

\[
\text{Distância à actividade mais próxima} \quad (\text{Distance to the closest activity})
\]

**Unidade:** Distância em metros (Distance in meters)
### Acc5  *Average distance to n closest activities*

**Objective:** evaluate the proximity to several closest activities.

**Escala de Análise:**

- Homogeneous area
- Floating catchment area

<table>
<thead>
<tr>
<th>Fórmula de Cálculo</th>
<th>Analysis scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distância média a várias actividades mais próximas</td>
<td>Average distance to several closest activities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unidade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distância média em metros</td>
</tr>
</tbody>
</table>

### Acc6  *Number of activities*

**Objective:** analyze the functional intensity according to the number of activities in the study area

**Escala de Análise:**

- Homogeneous area
- Floating catchment area

<table>
<thead>
<tr>
<th>Fórmula de Cálculo</th>
<th>Analysis scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sum \text{Número de Actividades} )</td>
<td>( N.º \text{ of activities} )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unidade</th>
</tr>
</thead>
<tbody>
<tr>
<td>( N.º \text{ of activities} )</td>
</tr>
</tbody>
</table>

**Notas:** Each commercial unit counts as a distinct activity. In the case of shopping centers the same applies.
### Acc7 Commercial continuity

**Objective:** analisar a distribuição funcional.  
*Goal:* analyze the distribution of activities

**Escala de Análise:** Analysis scale

<table>
<thead>
<tr>
<th>Área homogénea</th>
<th>Área de influência do ponto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homogeneous area</td>
<td>Floating catchment area</td>
</tr>
</tbody>
</table>

**Fórmula de Cálculo**  
*Formula*

\[
\frac{N.º de actividades}{metros de via} \times 100
\]

*Activities/meters of road*  
*Activities/100m*

### Acc8 Number of bus lines

**Objective:** 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

<table>
<thead>
<tr>
<th>Área homogénea</th>
<th>Área de influência do ponto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homogeneous area</td>
<td>Floating catchment area</td>
</tr>
</tbody>
</table>

**Fórmula de Cálculo**  
*Formula*

\[
\text{Número de carreiras urbanas que servem a área de estudo}
\]

*Number of urban bus lines for the study area*
### 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.

<table>
<thead>
<tr>
<th>Escala de Análise:</th>
<th>Área homogénea</th>
<th>Área de influência do ponto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis scale</td>
<td>Homogeneous area</td>
<td>Floating catchment area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fórmula de Cálculo</th>
<th>Número de paragens de autocarro na área de estudo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula</td>
<td>number of bus stops in the study area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unidade</th>
<th>Número de paragens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>Number of bus stops</td>
</tr>
</tbody>
</table>

### 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.

<table>
<thead>
<tr>
<th>Escala de Análise:</th>
<th>Área homogénea</th>
<th>Área de influência do ponto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis scale</td>
<td>Homogeneous area</td>
<td>Floating catchment area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fórmula de Cálculo</th>
<th>Extensão das linhas de transporte público (autocarro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula</td>
<td>Extension of bus lines</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unidade</th>
<th>Extensão das linhas de transporte público (autocarro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>Km</td>
</tr>
<tr>
<td></td>
<td>Km</td>
</tr>
</tbody>
</table>
Connectivity:

Con 1  **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:**
- Área homogénea
- Área de influência do ponto

**Fórmula de Cálculo:**
\[
\text{N.º de nós (number of nodes)} / \text{Superfície de análise (surface of analysis)}
\]

**Unidade:**
- N.º nós / 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

\[
\begin{align*}
\text{a)} & \quad \text{b)} \\
\text{c)} &
\end{align*}
\]

Con 2  **Pedestrian shed ratio**

**Objectivo:** analisar o ráció 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:**
- Área homogénea
- Área de influência do ponto

**Fórmula de Cálculo:**
\[
\frac{\text{Área de influência medida na rede (Network distance)}}{\text{Área de influência medida em linha recta (Euclidean distance)}}
\]

**Unidade:**
- Índice [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 circulo \(A = \pi r^2\).

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:**

- [ ] Área homogénea (Homogeneous area)
- [x] Área de influência do ponto (Floating catchment area)

**Fórmula de Cálculo:**

\[ \text{distância euclidiana} (\text{Euclidean distance}) \]

\[ \text{Distancia na rede} (\text{Network distance}) \]

**Unidade**

- [ ] Unit
- [x] Rácio (Ratio)

**Notas:** no cálculo do indicador foi considerada a rede pedonal

*Notes: the pedestrian network is considered to calculate the indicator*

---

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:**

- [x] Área homogénea (Homogeneous area)
- [x] Área de influência do ponto (Floating catchment area)

**Fórmula de Cálculo:**

\[ \frac{\sum \text{comprimento de cada arco} (\text{link length})}{\text{Nº. total de arcos} (\text{total number of links})} \]

**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*

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

**Parâmetros**
*Parameters*

- \(e\) = número de arcos  
  *N.º of links*
- \(v\) = número de nós  
  *N.º of nodes*

**Fonte**
*Source*

- 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.*
**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:**

- **Área homogénea**
- **Área de influência do ponto**

**Fórmula de Cálculo**

\[
\text{N.º de fracções/ha} = \left( \frac{\text{N.º fracções habitacionais (N.º of dwellings)}}{\text{Superfície de análise (surface of analysis)}} \right) \times 10000
\]

**Unidade**

- **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:**

- **Área homogénea**
- **Área de influência do ponto**

**Fórmula de Cálculo**

\[
\text{N.º de edifícios/ha} = \frac{\text{N.º edifícios (N.º of buildings)}}{\text{Superfície de análise (surface of analysis)}}
\]

**Unidade**

- **N.º de edifícios/ha**
- **Buildings/ha**
### Den3  Gross Floor Area Ratio

**Objective:** analisar aos níveis de ocupação do solo na área de estudo.

*Goal: analyze the construction density in the study area*

<table>
<thead>
<tr>
<th>Analysis scale</th>
<th>Homogeneous area</th>
<th>Floating catchment area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fórmula de Cálculo:</strong></td>
<td>Área bruta de construção (Gross floor area)</td>
<td>Superfície de análise (Surface of analysis)</td>
</tr>
<tr>
<td><strong>Parameters</strong></td>
<td><strong>Parameters</strong></td>
<td><strong>Source</strong></td>
</tr>
<tr>
<td>Área de construção</td>
<td>ABC = Área implantação do edifício X N pisos</td>
<td>SIG</td>
</tr>
<tr>
<td><em>Construction area, ABC = building plant area X N floors</em></td>
<td></td>
<td>GIS</td>
</tr>
</tbody>
</table>

### Den4  Housing gross floor area ratio

**Objective:** analisar aos níveis de ocupação por habitação na área de estudo.

*Goal: analyze the construction house density in the study area*

<table>
<thead>
<tr>
<th>Analysis scale</th>
<th>Homogeneous area</th>
<th>Floating catchment area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fórmula de Cálculo:</strong></td>
<td>Área bruta de construção de Habitação (Gross floor area of housing)</td>
<td>Superfície de análise (Surface of analysis)</td>
</tr>
<tr>
<td><strong>Parameters</strong></td>
<td><strong>Parameters</strong></td>
<td><strong>Source</strong></td>
</tr>
<tr>
<td>Área de construção</td>
<td>ABC_	ext{hab} = \left( \frac{\text{Número de Frações Totais}}{\text{Total number of fractions}} \right) \times \text{Número de Frações de Habitação}</td>
<td>SIG</td>
</tr>
<tr>
<td><em>Total number of dwelling</em></td>
<td></td>
<td>GIS</td>
</tr>
</tbody>
</table>
### Den5  *Services and retail gross floor area ratio*

**Objective**: 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**:
- Área homogénea
- Área de influência do ponto

**Fórmula de Cálculo**:
\[
\text{Área bruta de construção de Comércio e Serviços} / \text{Superfície de análise (Surface of analysis)}
\]

**Parâmetros**
- ABC\textsubscript{hub} (Plant area of the building; N floors)
- Número de Frações Totais (total number of fractions)
- Número de Frações de Comércio e serviços (total number of fractions of services and commerce)

**Fonte**
- SIG (GIS)

### Den6  *Population Density*

**Objective**: 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**:
- Área homogénea

**Fórmula de Cálculo**:
\[
(\text{N.º residentes (N.º of inhabitants)} / \text{Superfície de análise (surface of analysis)}) \times 10000
\]

**Parâmetros**
- N.º de residentes (N.º of inhabitants)

**Fonte**
- Censos (Census)
**Design:**

<table>
<thead>
<tr>
<th><strong>Dsg1</strong></th>
<th><strong>Surface of buildings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td>Quantificar a área ocupada por edifícios.</td>
</tr>
<tr>
<td><strong>Goal:</strong></td>
<td>Quantify the surface of buildings</td>
</tr>
<tr>
<td><strong>Analysis scale:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Área homogénea</td>
</tr>
<tr>
<td></td>
<td>Área de influência do ponto</td>
</tr>
</tbody>
</table>
| **Formula of Calculation:** | \[
\left( \frac{\text{Superfície de análise}}{\text{Área ocupada por edifícios}} \right) \times 100
\]
| **Unit:** | % area of buildings |

<table>
<thead>
<tr>
<th><strong>Dsg2</strong></th>
<th><strong>Surface of motorized circulation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td>Quantificar a área ocupada por circulação motorizada.</td>
</tr>
<tr>
<td><strong>Goal:</strong></td>
<td>Quantify the surface of motorized circulation.</td>
</tr>
<tr>
<td><strong>Analysis scale:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Área homogénea</td>
</tr>
<tr>
<td></td>
<td>Área de influência do ponto</td>
</tr>
</tbody>
</table>
| **Formula of Calculation:** | \[
\left( \frac{\text{Superfície de análise}}{\text{Área ocupada por circulação motorizada}} \right) \times 100
\]
| **Unit:** | % 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*

\[
\left( \frac{\text{Área ocupada por estacionamento}}{\text{Superfície de análise}} \right) \times 100
\]

**Unidade**
*Unit*

% área 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*

\[
\left( \frac{\text{Área ocupada por equipamentos}}{\text{Superfície de análise}} \right) \times 100
\]

**Unidade**
*Unit*

% área ocupada por equipamentos  
% of Surface of facilities
**Dsg5  Surface of patios**

**Objective:** quantificar a área livre de logradouro.

*Goal: quantify the surface free private space.*

<table>
<thead>
<tr>
<th>Escala de Análise:</th>
<th>Área homogénea</th>
<th>Área de influência do ponto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis scale</td>
<td>Homogeneous area</td>
<td>Floating catchment area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fórmula de Cálculo:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula</td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

\[
\left( \frac{\text{Superfície de análise} \cdot \text{Area ocupada por logradouro}}{\text{Superfície de análise} \cdot \text{Surface of patios}} \right) \cdot 100
\]

**Dsg6  Percentage of pedestrian area**

**Objective:** analisar a percentagem da área pedonal na área de estudo.

*Goal: analyze the proportion of pedestrian area in the study area*

<table>
<thead>
<tr>
<th>Escala de Análise:</th>
<th>Área homogénea</th>
<th>Área de influência do ponto</th>
</tr>
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<tbody>
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</tbody>
</table>

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<thead>
<tr>
<th>Fórmula de Cálculo:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula</td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>

\[
\left( \frac{\text{Superfície de análise} \cdot \text{Área de circulação pedonal}}{\text{Superfície de análise} \cdot \text{Surface of pedestrian circulation}} \right) \cdot 100
\]

**Notes:** *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:**

- Área homogénea
- Área de influência do ponto

**Fórmula de Cálculo:**

\[
\text{Área do passeio (Area of the pedestrian path)} \div \text{Comprimento da via (road length)}
\]

*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:**

- Cidade
- Área homogénea
- Área de influência do ponto

**Fórmula de Cálculo:**

\[
\left( \frac{\text{Área de espaços verdes (Green space area)}}{\text{Superfície de análise (Surface of analysis)}} \right) \times 100
\]

*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*

<table>
<thead>
<tr>
<th>Parâmetros</th>
<th>Fonte</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nº de lugares estacionamento total</strong>*</td>
<td>SIG</td>
</tr>
<tr>
<td>Number of public parking spaces</td>
<td>GIS</td>
</tr>
<tr>
<td><strong>Área de bolsa de estacionamento em bolsa ao ar livre = 20m²</strong></td>
<td></td>
</tr>
<tr>
<td>Area of parking lot in outsider park = 20m²</td>
<td></td>
</tr>
</tbody>
</table>

| Número de fracções na escala de análise | SIG   |
| Total number of dwellings in the unit scale | 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.*
## Measuring the built environment: Detailed indicators description

### Diversity

#### Div1  Percentage of single family buildings

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

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

**Escala de Análise**: Analysis scale

<table>
<thead>
<tr>
<th><strong>Unidade</strong></th>
<th><strong>% de edifícios</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area homogénea</strong></td>
<td>Homogeneous area</td>
</tr>
<tr>
<td><strong>Área de influência do ponto</strong></td>
<td>Floating catchment area</td>
</tr>
</tbody>
</table>

**Fórmula de Cálculo**: 

\[
\text{Number of single family buildings} \times 100 \\
\text{Total number of buildings}
\]

**Unidade**: % of Buildings

#### Div2  Percentage of residential dwellings

**Objective**: Analyze the functional diversity

**Goal**: Analyze the functional diversity

**Escala de Análise**: Analysis scale

<table>
<thead>
<tr>
<th><strong>Unidade</strong></th>
<th><strong>% de fracções</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area homogénea</strong></td>
<td>Homogeneous area</td>
</tr>
<tr>
<td><strong>Área de influência do ponto</strong></td>
<td>Floating catchment area</td>
</tr>
</tbody>
</table>

**Fórmula de Cálculo**: 

\[
\text{Number of residential dwellings} \times 100 \\
\text{Total number of fractions}
\]

**Unidade**: % of dwellings
## Div3  *Percentage of area occupied by activities*

**Objective** 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
- [x] Área de influência do ponto

### Fórmula de Cálculo: Formula

\[
\left( \frac{\text{Área total de funções}}{\text{总面积 of activities}} \right) \times 100
\]

\[
\sum \text{Área total das actividades existentes em toda a AI} \quad \text{(total area for all activities in all IAs)}
\]

### 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:

\[
\frac{ABC \ do \ edifício \ do \ centro \ comercial}{\text{No of shops}}
\]

**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:

\[
\text{gross construction area of the shopping center}
\]

## Div4  *Urban complexity*

**Objective:** 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
- [x] Área homogénea
- [ ] Área de influência do ponto

### Fórmula de Cálculo: Formula

\[
-1 \times \sum_{i=1}^{N} P_i \log_2 P_i
\]

\[
P_i = \frac{N_i}{N} \quad \text{is the relative abundance of each category}
\]

\[
N_i \quad \text{is the number of individuals of each category } i
\]

\[
N \quad \text{is the total number of individuals}
\]

### Unidade: Unit
- Índice de complexidade ≥ 0
- Index of complexity ≥ 0
Topography:

**Top1 Percentage of area with more than 8% slope**

**Objective:** identify morphological characteristics

Goal: identify morphological characteristics

<table>
<thead>
<tr>
<th>Analysis scale</th>
<th>City</th>
<th>Homogeneous area</th>
<th>Floating catchment area</th>
</tr>
</thead>
</table>

**Formula:**

\[
\frac{\text{Area with slope} > 8\%}{\sum \text{Total area}}
\]

**Notes:** Categories of slope superior of 8%


% area occupied by slope > 8%

% of area with >8% slope