

Methodology to produce a **URBAN SYSTEM** map using GIS desktop

By PhD student:

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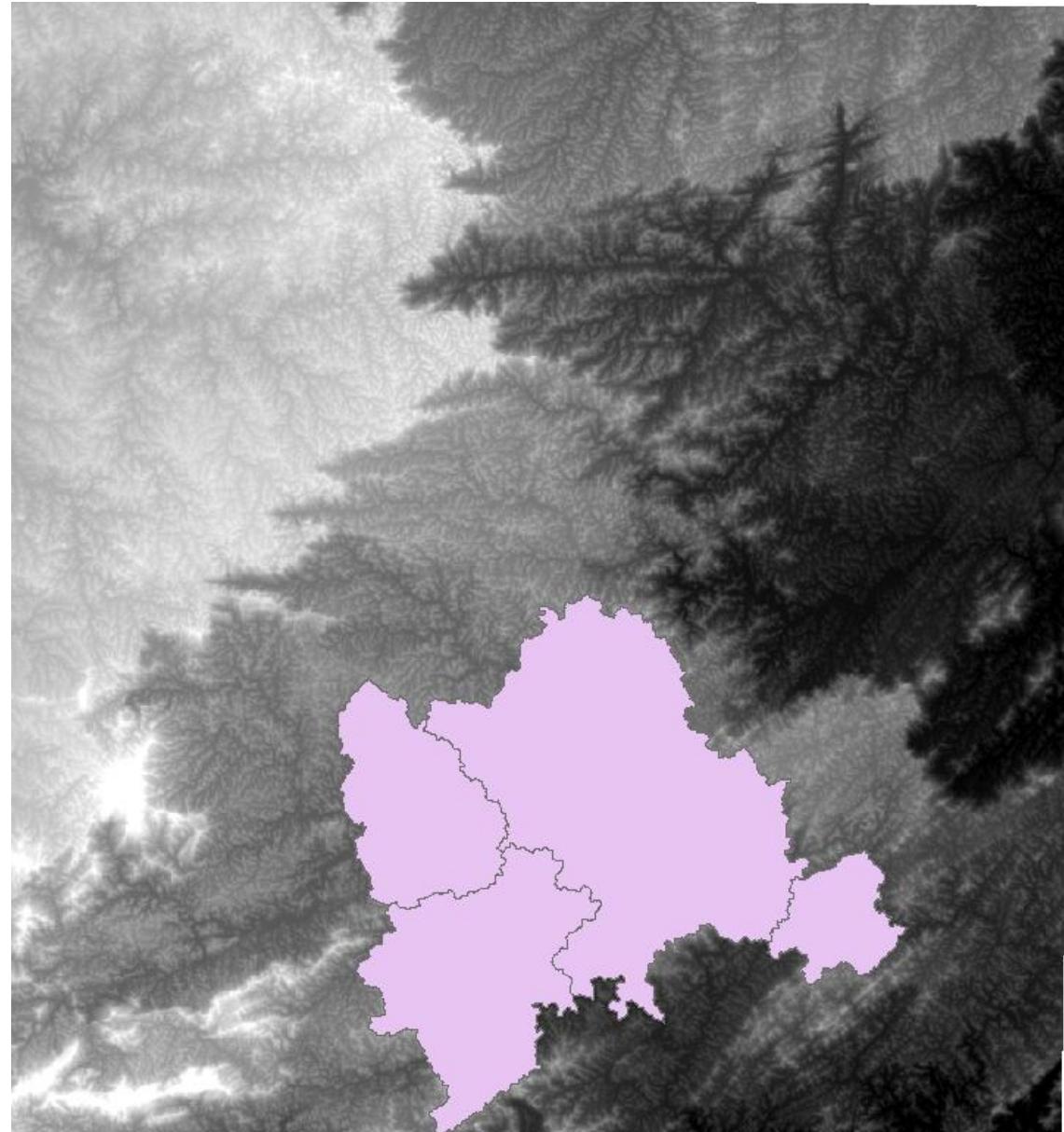
Introduction

- To construct the urban system, we used two partial maps, combined to create a third map. The first maps were slope and land use, and they together composed the “urban system”, mapping areas there are indicated to receive urban growth or urban use.
- We are considering that we have no date and must begin from the beginning.
 - Slope map
 - Land use map
 - Urban map using combinatorial analysis

SLOPE

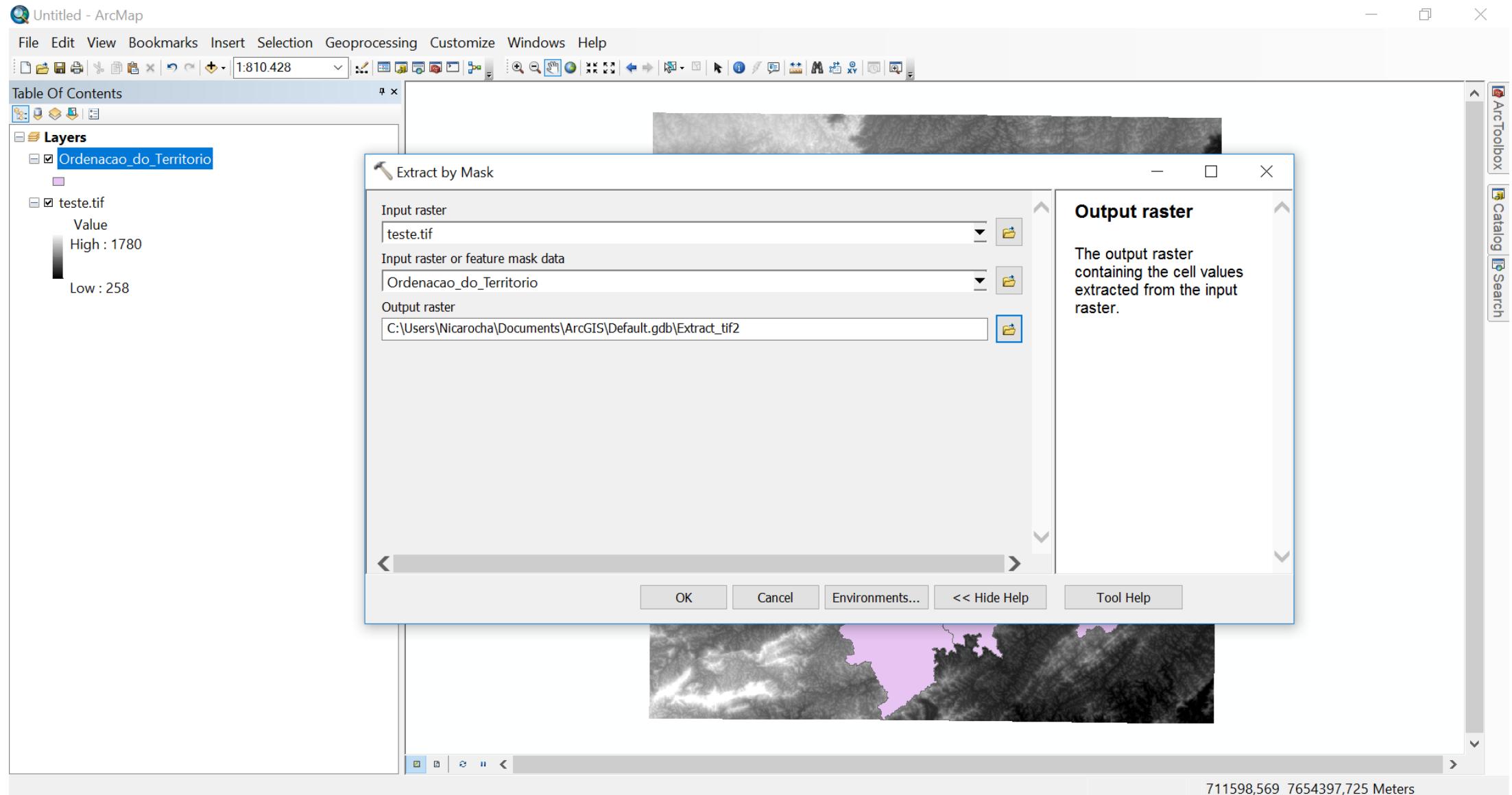
Download the SRTM

- You need: SRTM image (resolution of 30 m) + a boundary to define the area of the case study (we used the municipality of Juiz de Fora in Brazil).
- SRTM convert from WGS84 geographic to WGS84 UTM
- To calculate slope the first step is to interpolate contours (isolines of topography), and using the contours we construct the TIN (Triangular Irregular Network). To the resolution of 30 meters we are using contours of 5 meters.

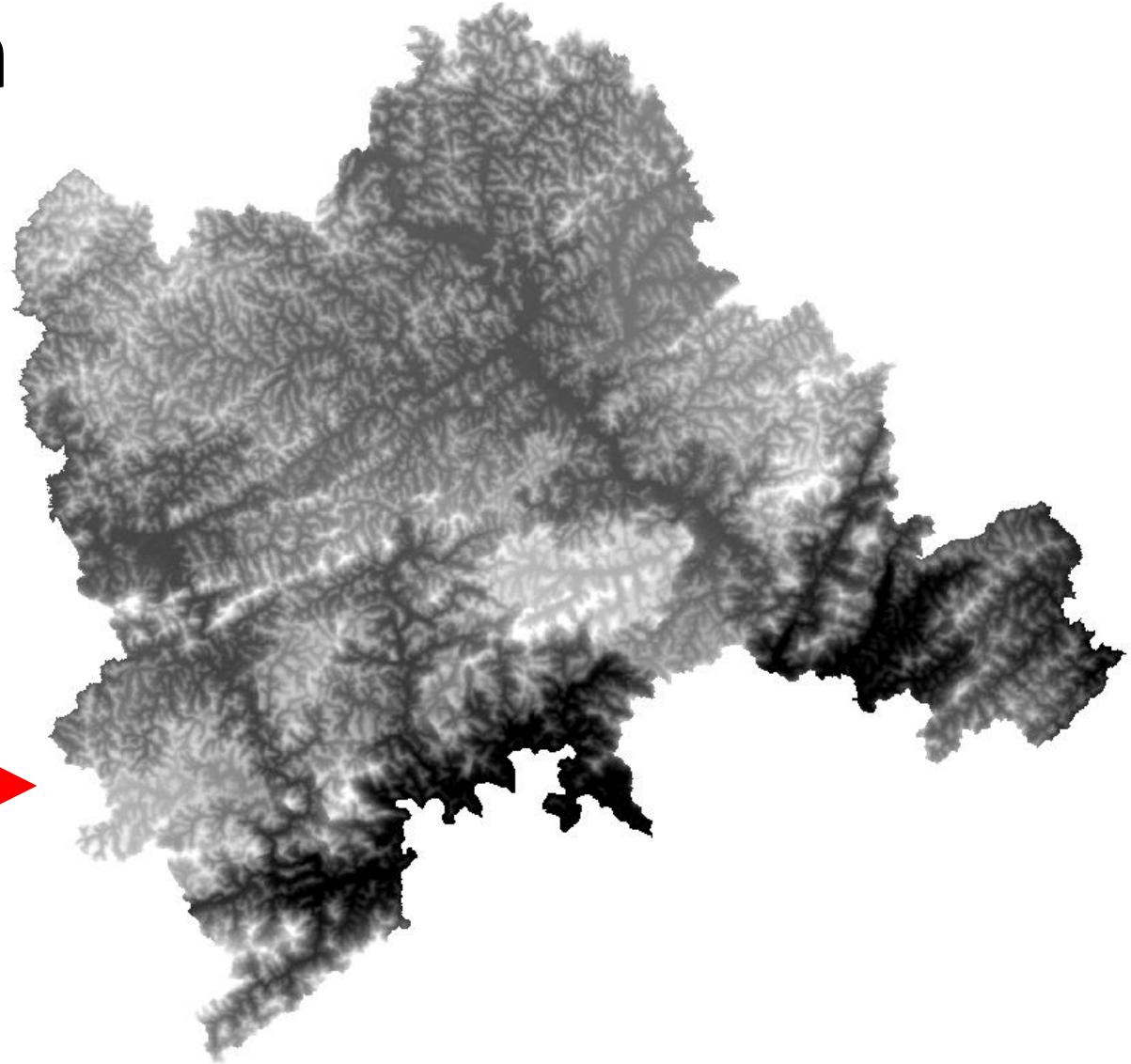
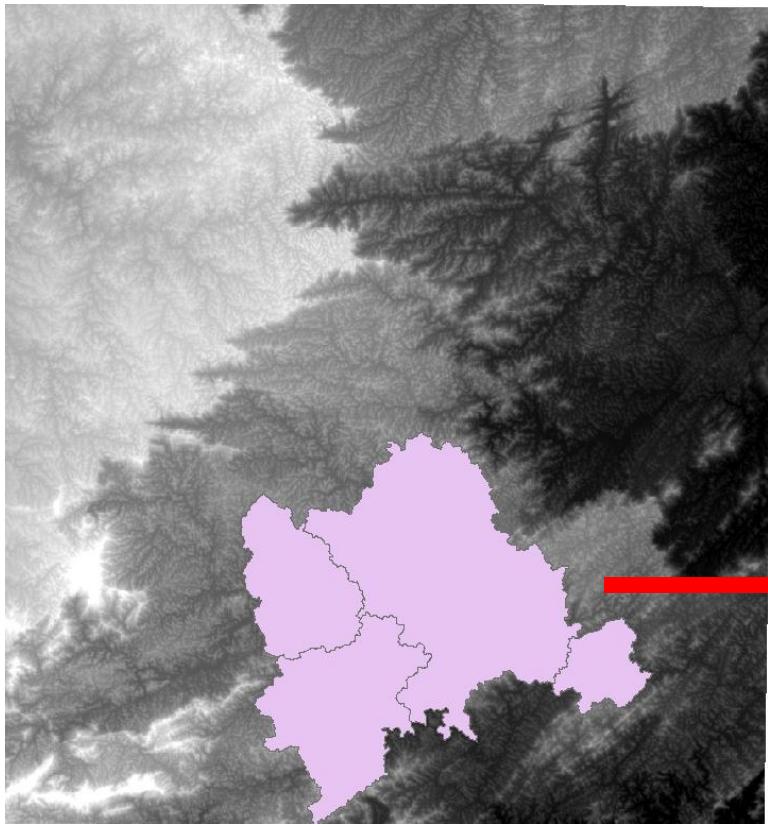


SRTM image source: <http://dwtkns.com/srtm30m/>

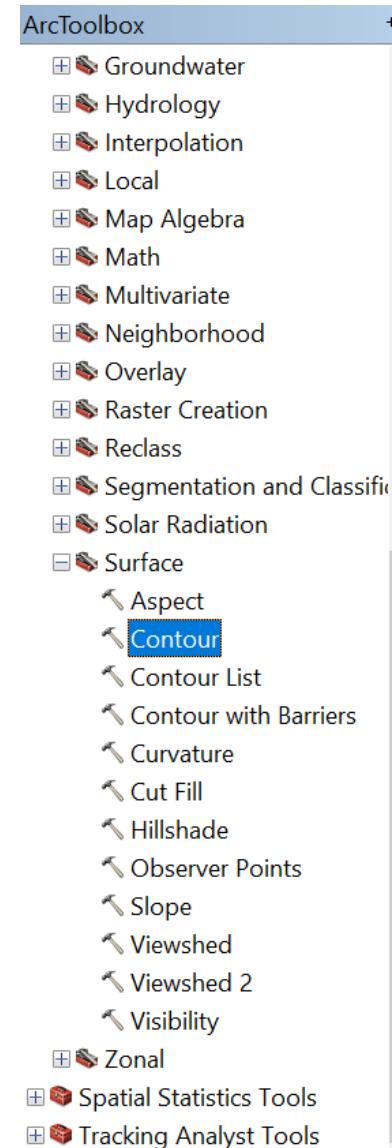
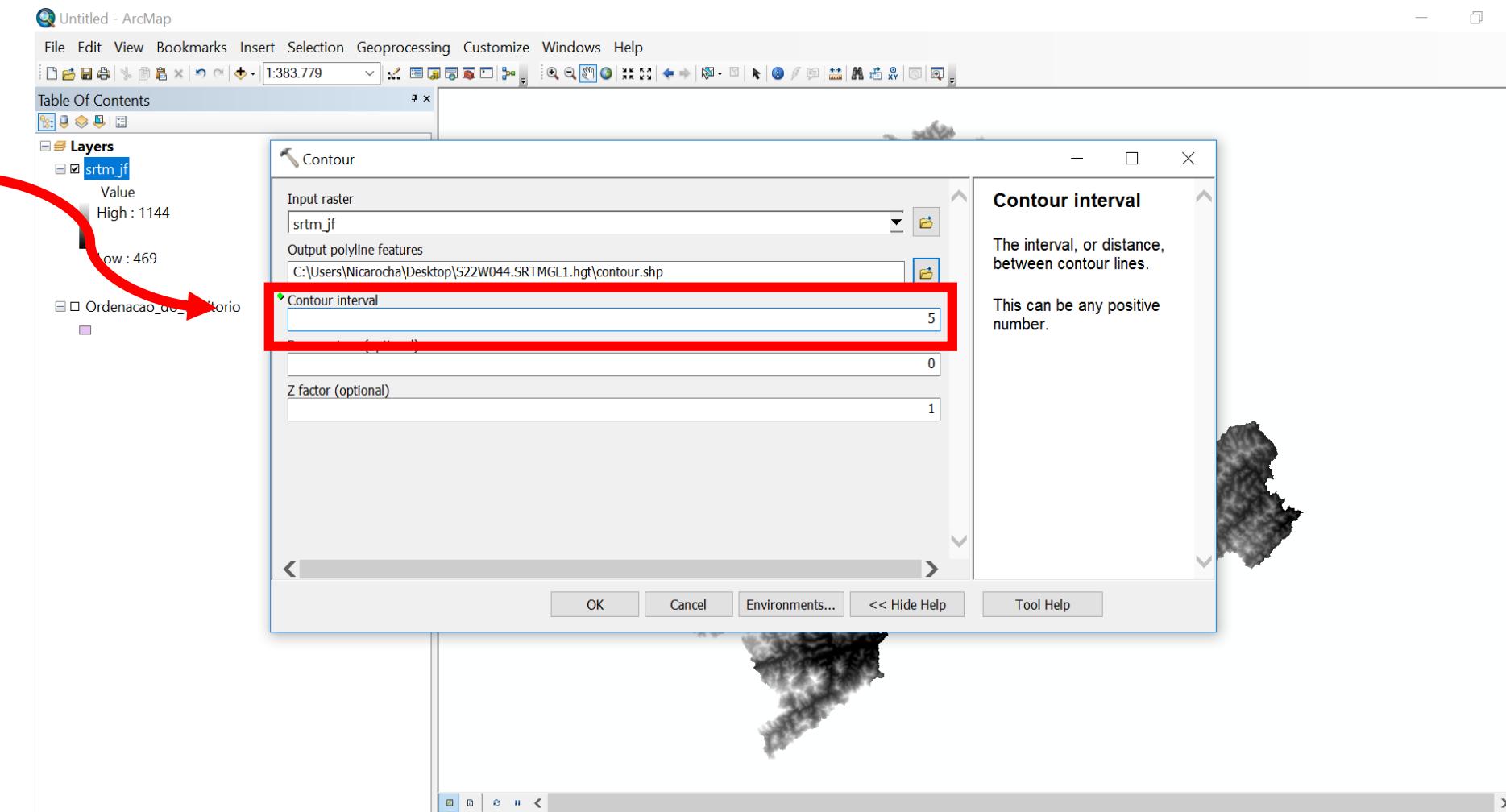
- Cut the SRTM according to the boundary (using Extract by mask)



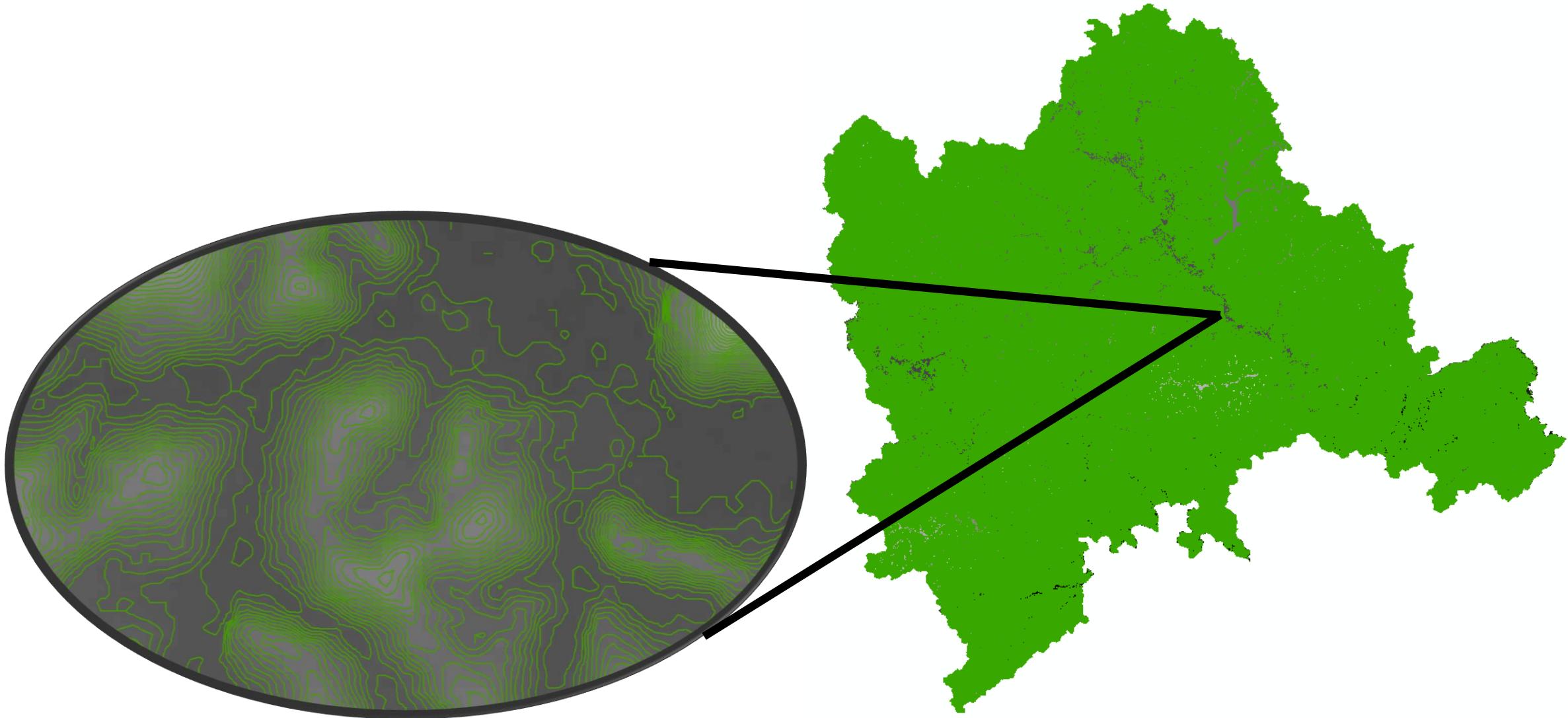
Result of the extraction



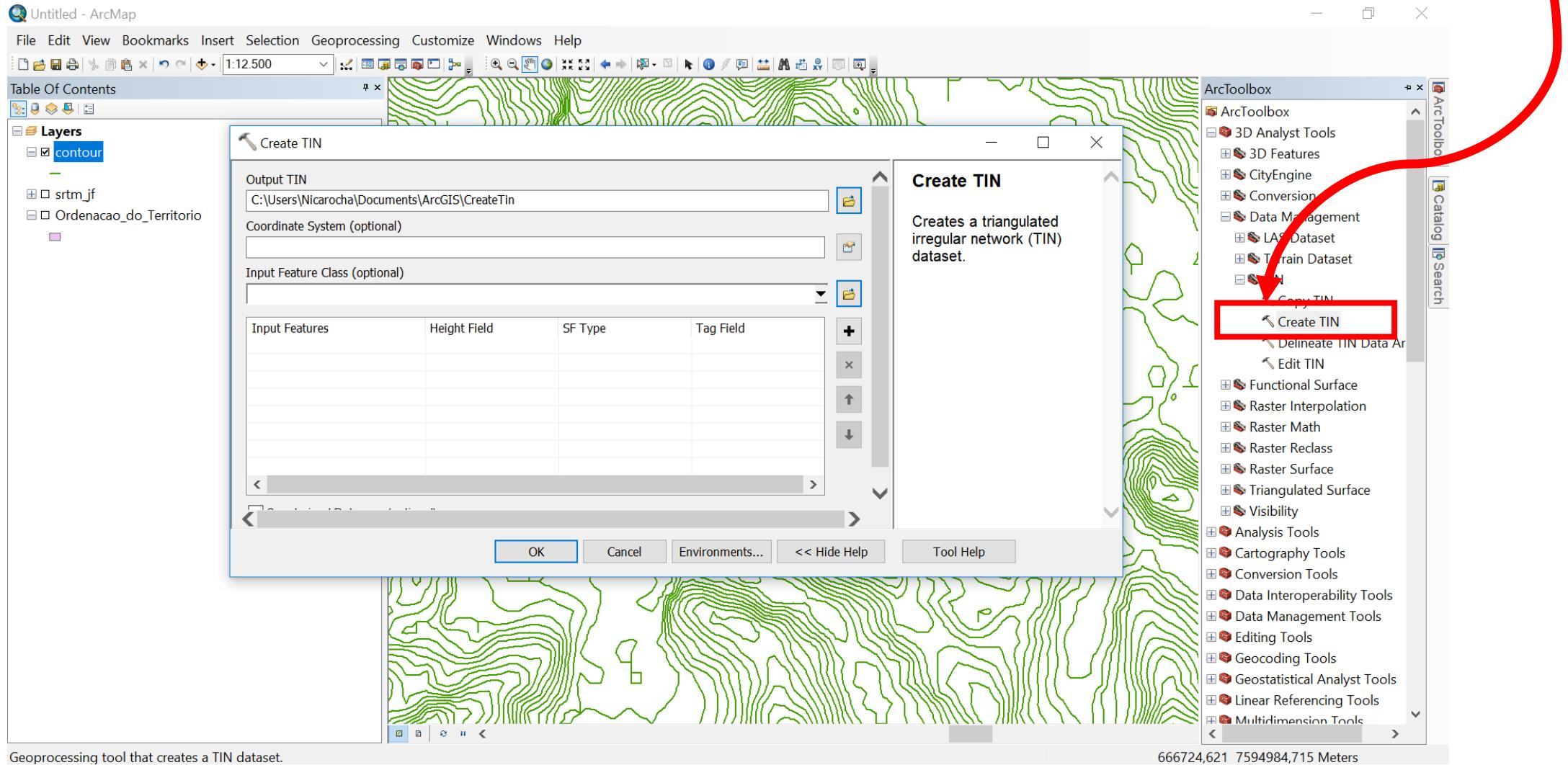
- From SRTM raster, the “contour” command is used to interpolate the isolines of topography.
- Interpolate topographic lines (contour)
- Define (contour interval) = 5m



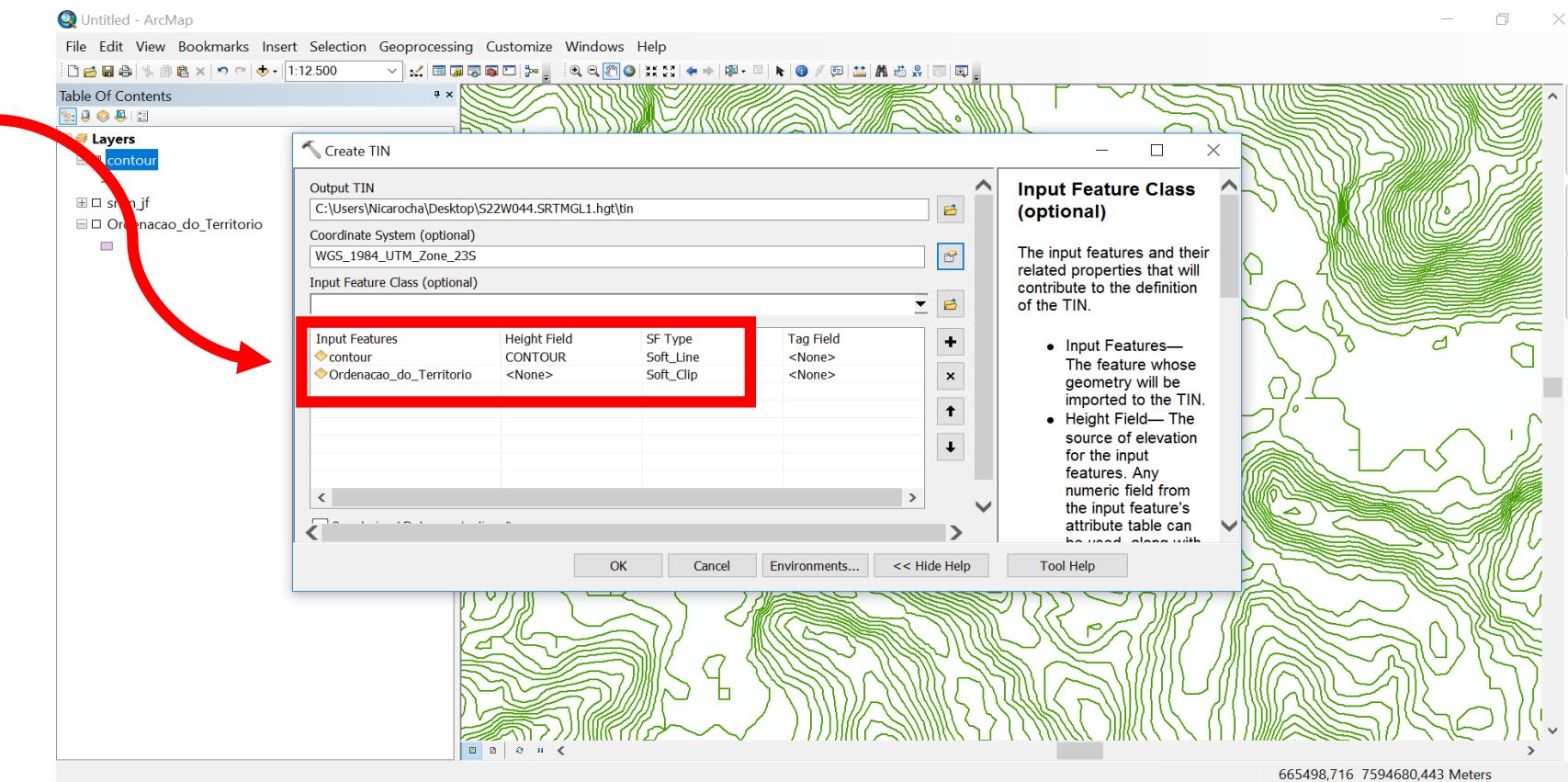
Result of the interpolation of contours 5m



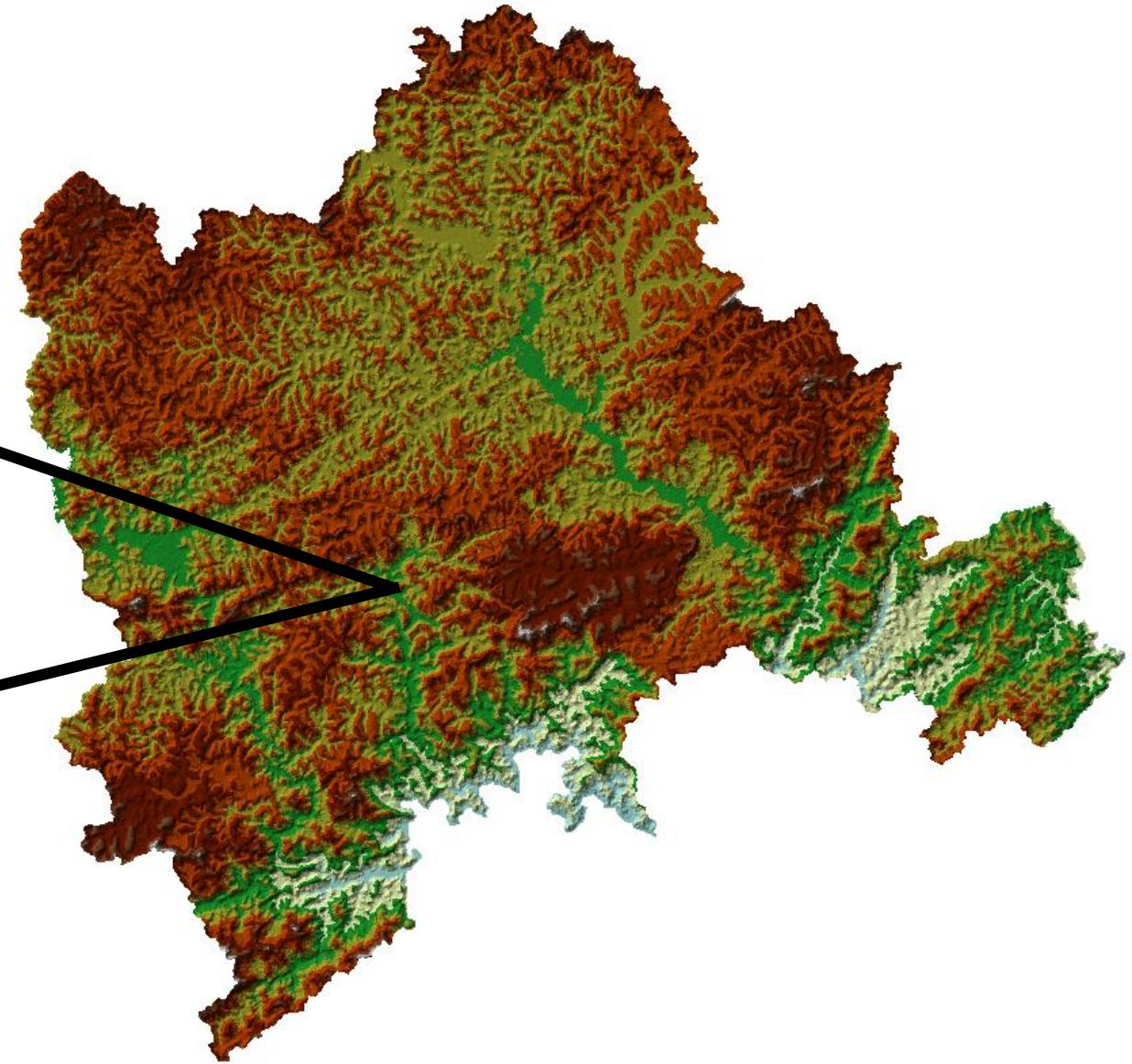
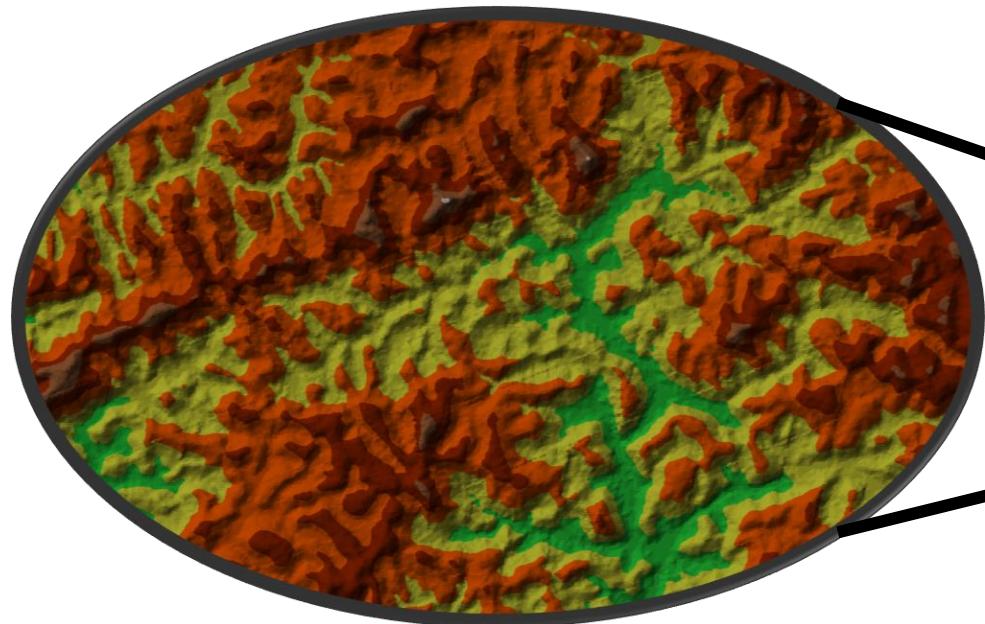
Creating TIN data to produce the slope map



- Use two layers: the contour layer, from which the application is going to get the information about the height, and the boundary, that will work as a delimitation to construct the TIN surface
- From the layer contour, define it's going to be “soft line” and indicate from which field he is going to get the attribute about height.
- From the layer boundary, define it's going to be “soft clip” and that it has no height field.



Result of the TIN (triangular irregular network)



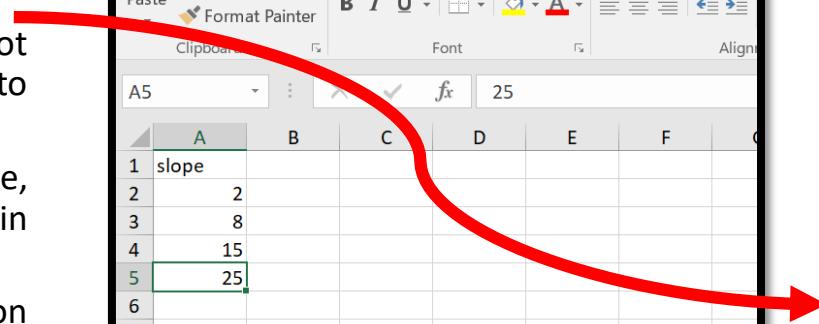
Set the slope percentage ranges

- In a excel file (avoid xlsx format if you are using ArcGis) define the breaks of the ranges. In Brazil, as we have a very rough surface and big slopes, we generally work with the ranges:

- Less than 5% - allowed to urban use, but it's not the best condition, as it results in difficulties to drain water and to project sewage network.
- From 5 to 13% - excellent condition to urban use, and it's the limit to use mechanization in agriculture.
- From 13 to 30% - not possible to use mechanization in agriculture, but it's still good to urban use (not the best, but ok).
- From 30 – 47% - can be accepted to urban use only if it presents a plan to correct geotechnical risks.
- More than 47% - area of protection

- We received an indication to use other ranges in Europe:

- Less than 2%
- From 2 to 8%
- From 8 to 15%
- From 15 to 25%
- More than 25%



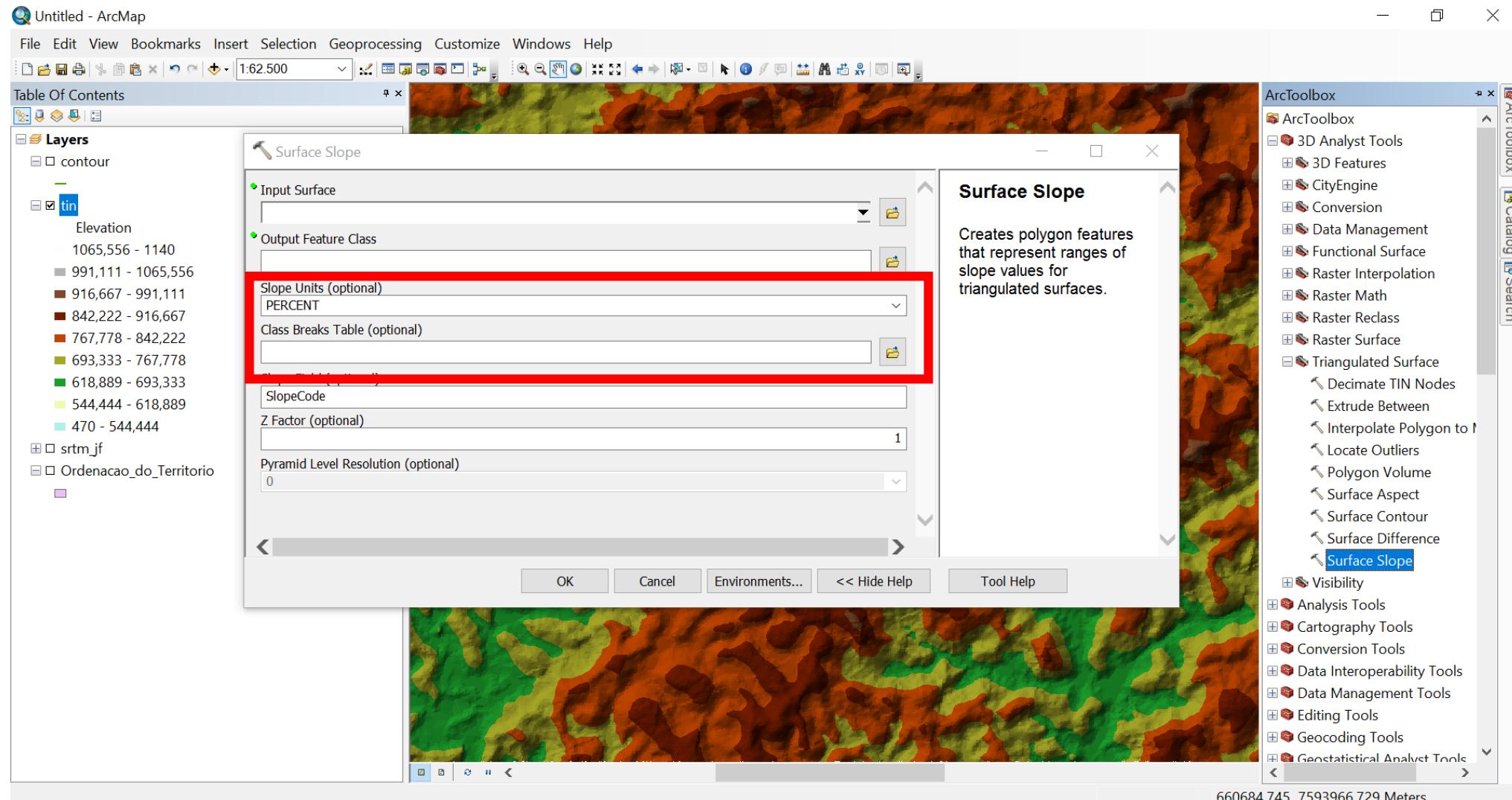
A	B	C	D	E	F
1 slope					
2	2				
3	8				
4	15				
5	25				
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

Czech reality (to be analysed according to each country)

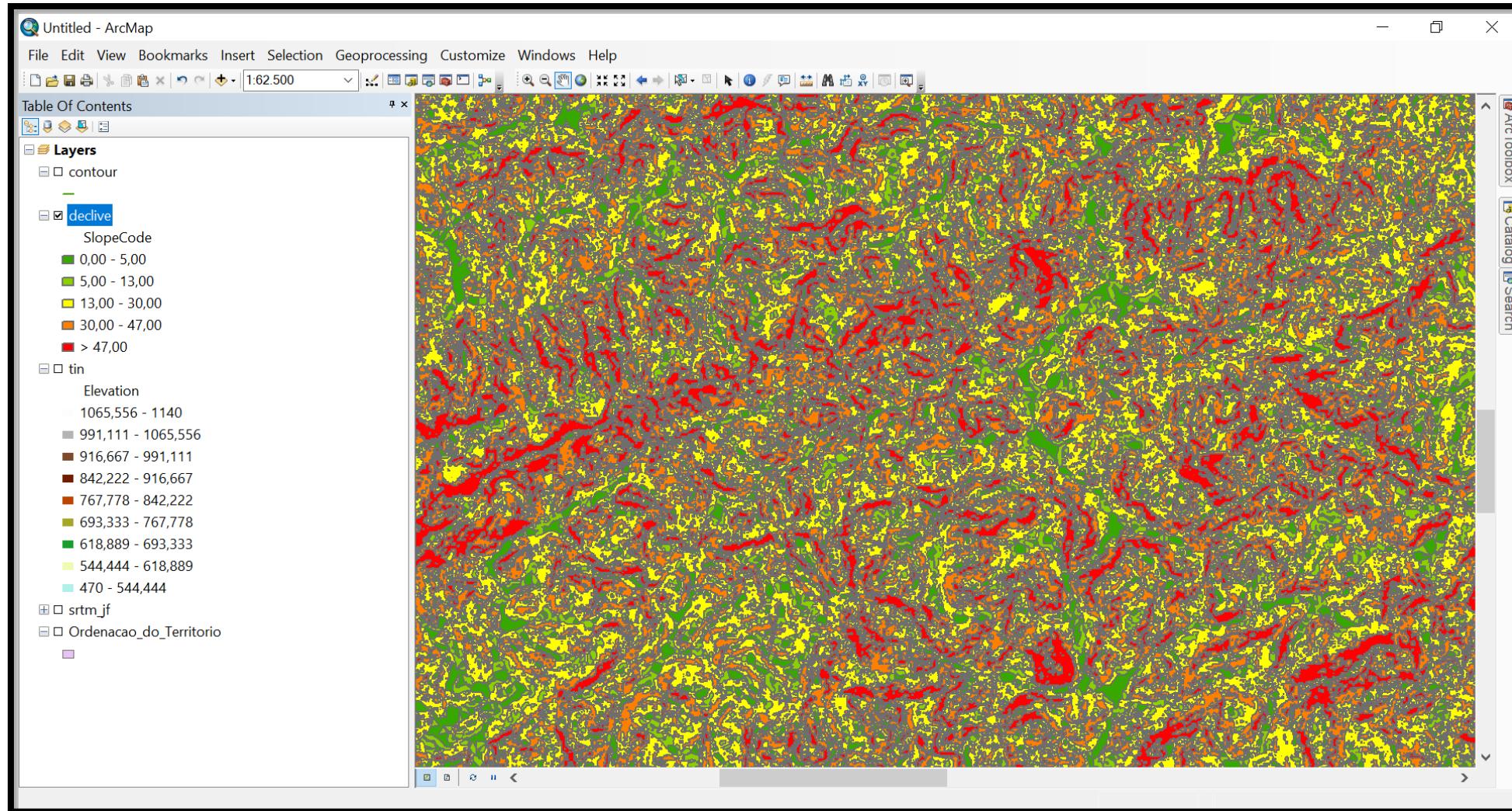
A	B	C	D	E	F
1 slope					
2	5				
3	13				
4	30				
5	47				
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

Brazilian reality

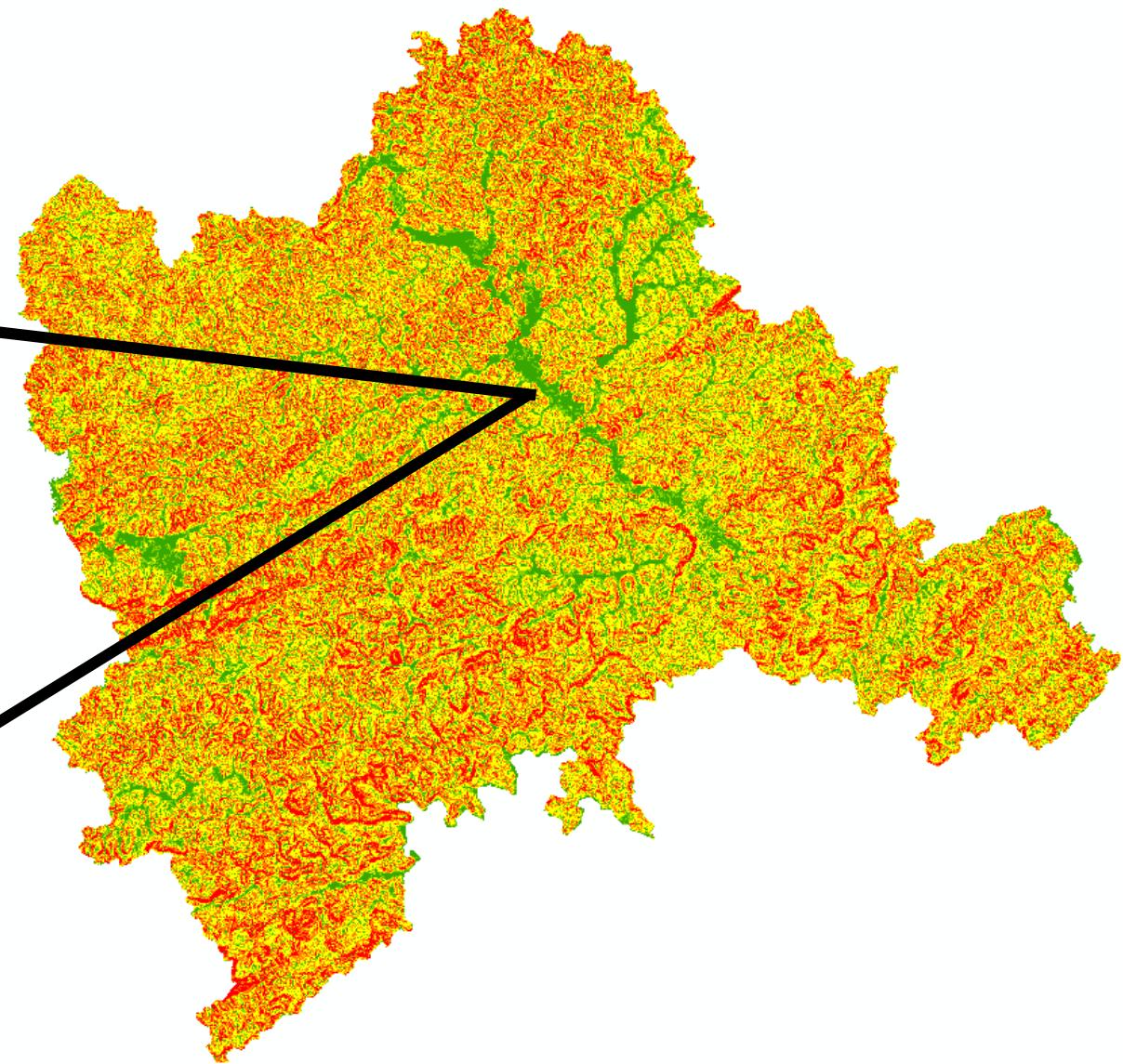
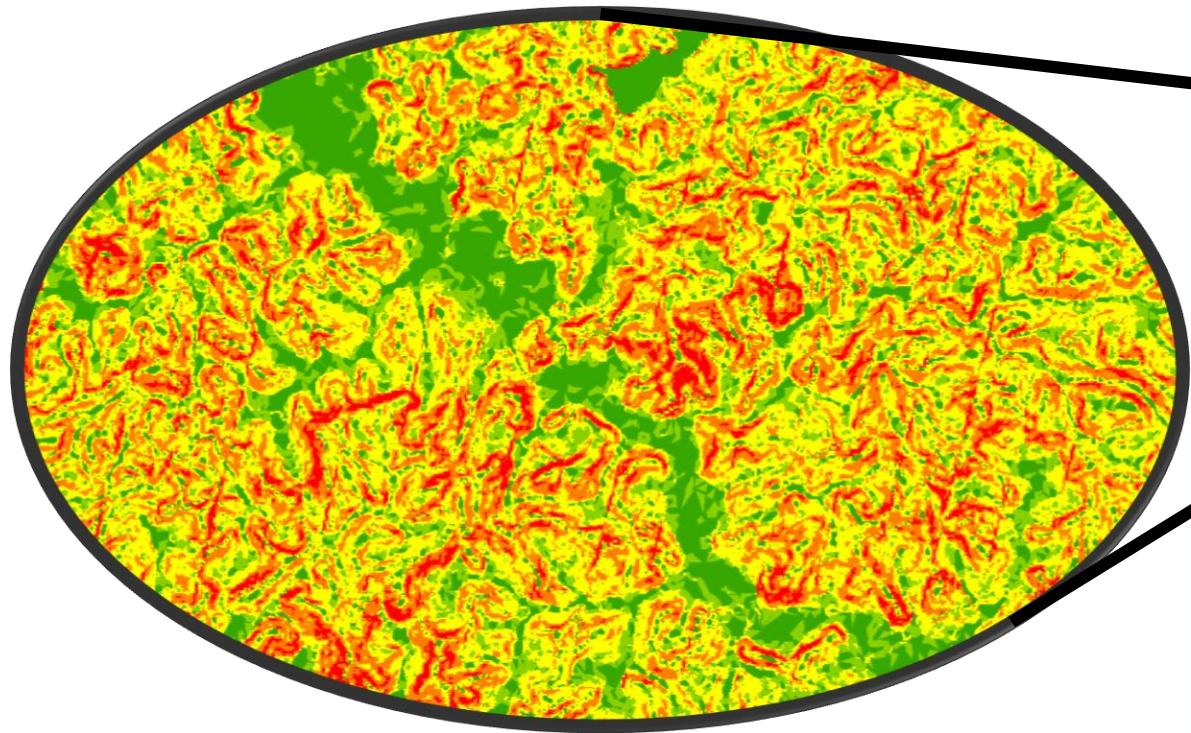
- With the TIN and the excel file with the ranges of slope (that is the “Class Break Table”), calculate slope.



Result of the Slope according to Brazilian Laws:

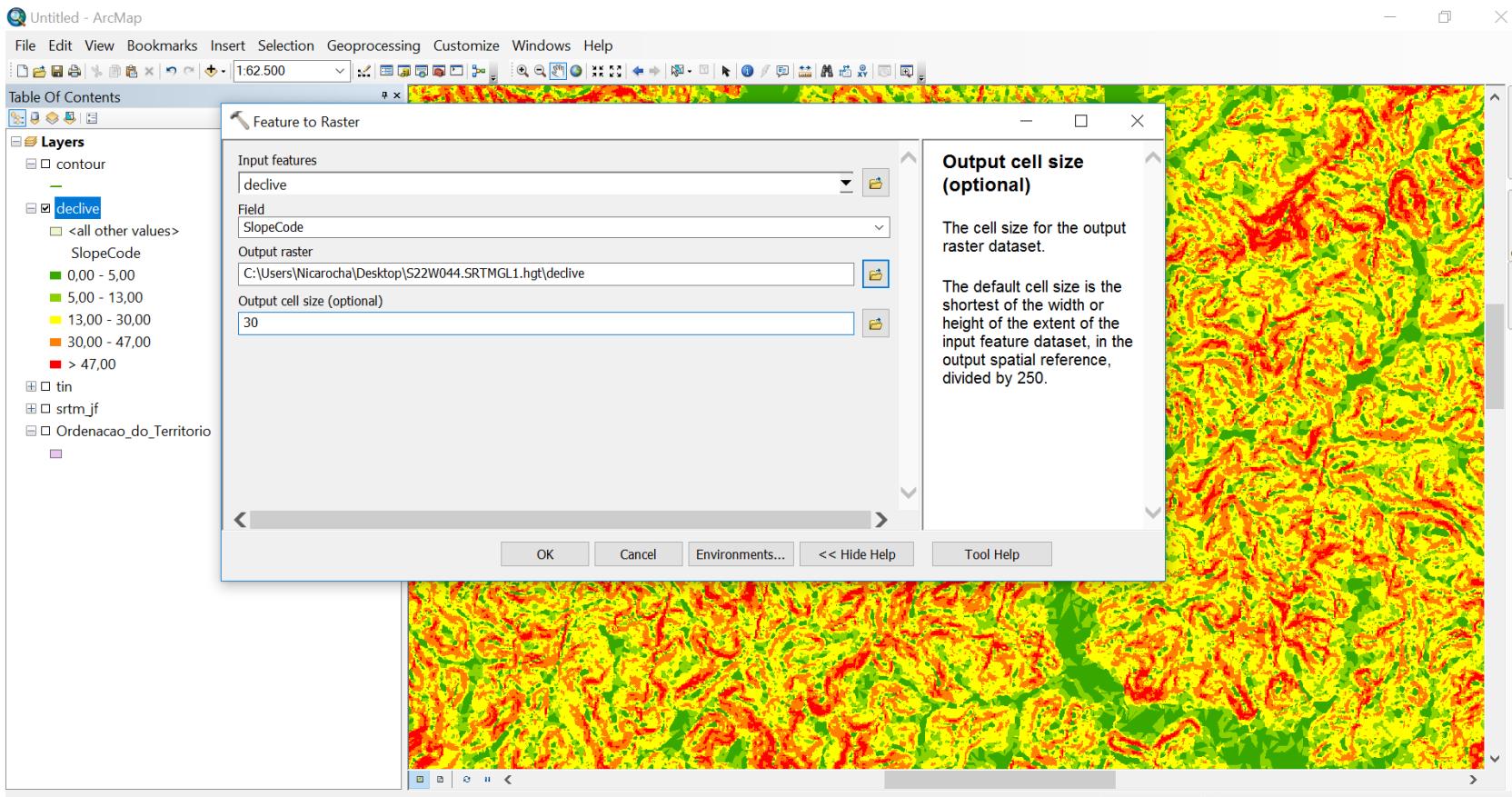


Result of the Slope according to Brazilian Laws:

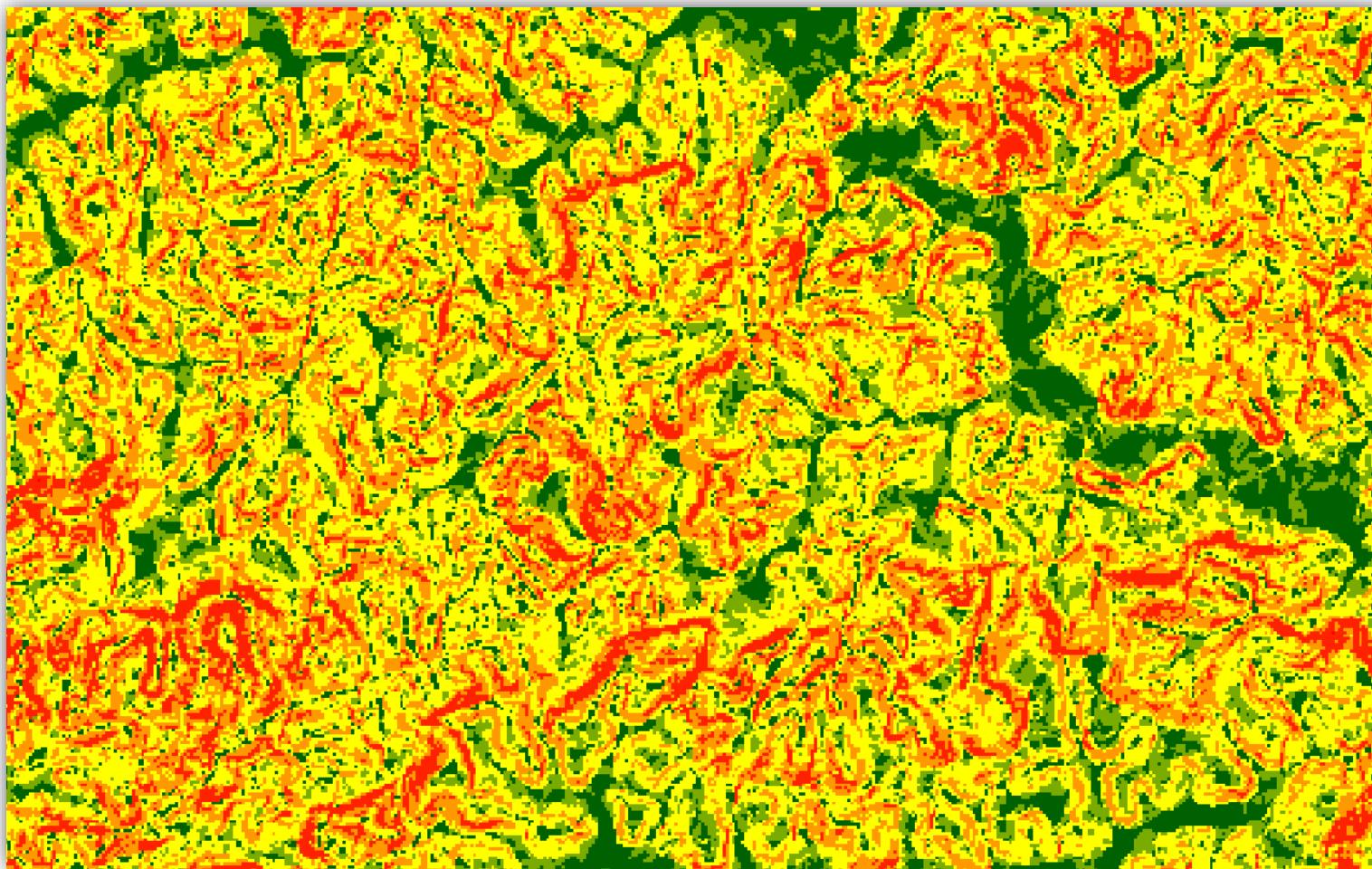


To compose the raster map with the 5 classes of slope.

- As the result is a feature map, and we will need to combine it with land use map, it's indicated to convert it to raster.



Result

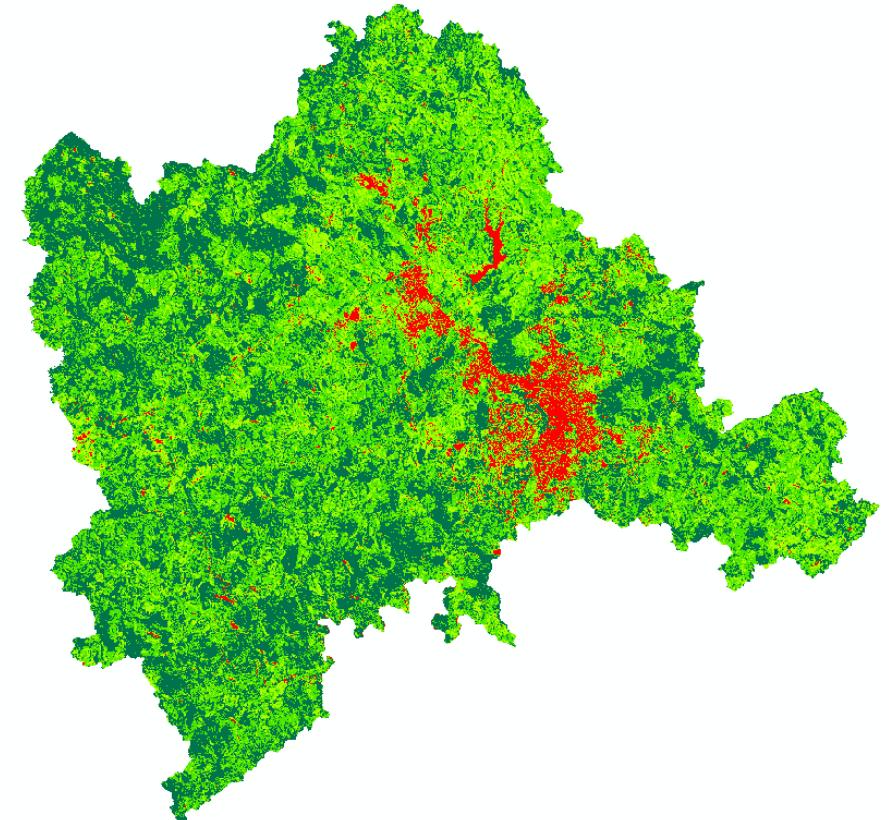


- 1 Flooding areas
- 2 Low slope
- 3 Low to Medium slope
- 4 Medium to High slope
- 5 High slope

LAND USE

NDVI

- We can use NDVI data that was already calculated in the study of green areas.



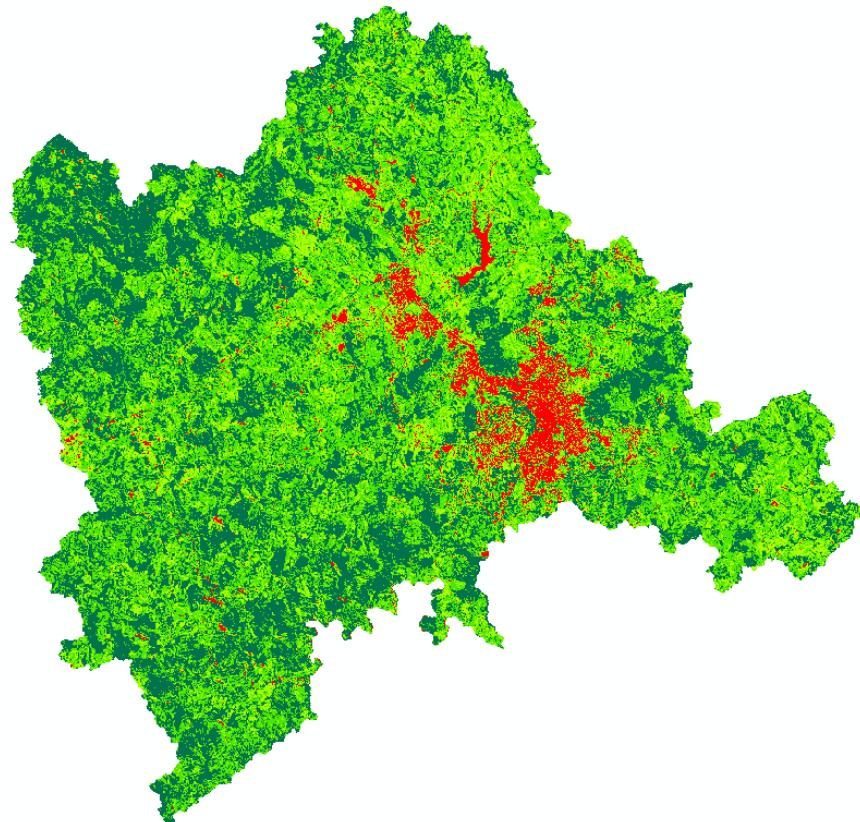
- Impervious/ Exposed soil / Water or shadow
- Grassy
- Shrubby
- Robust vegetation

URBAN SYSTEM MAP

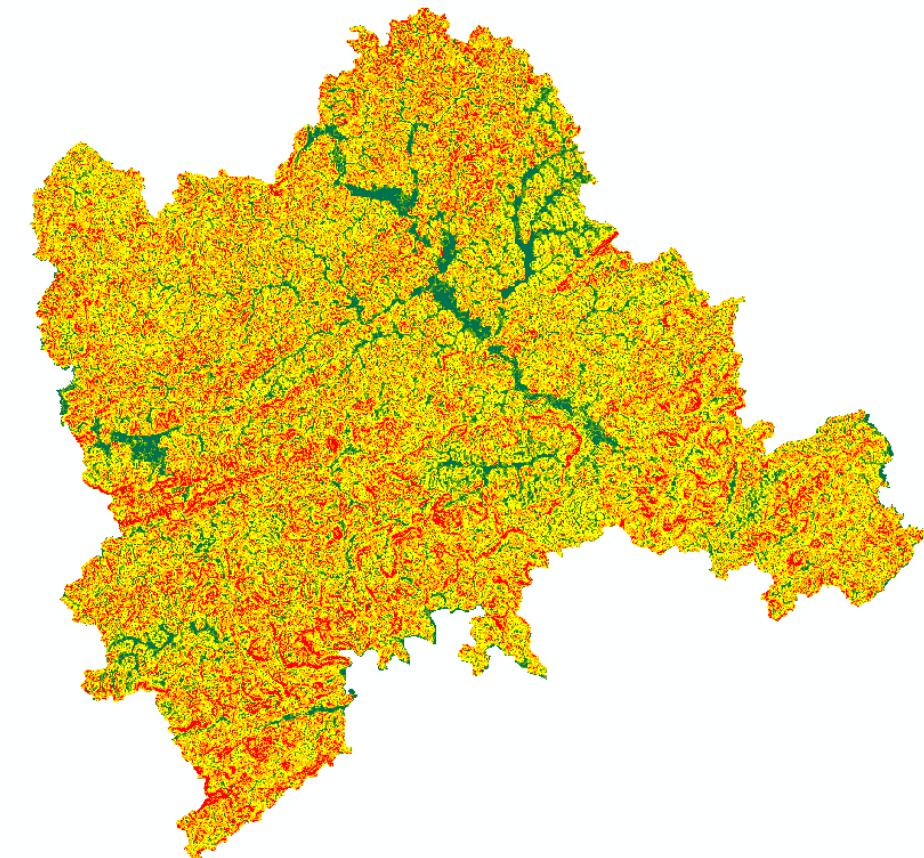
Urban map

- To produce the Urban map we need sum the two maps using combinatorial analysis.

NDVI MAP



SLOPE MAP



■ Impervious/ Exposed soil / Water or shadow
■ Grassy
■ Shrubby
■ Robust vegetation

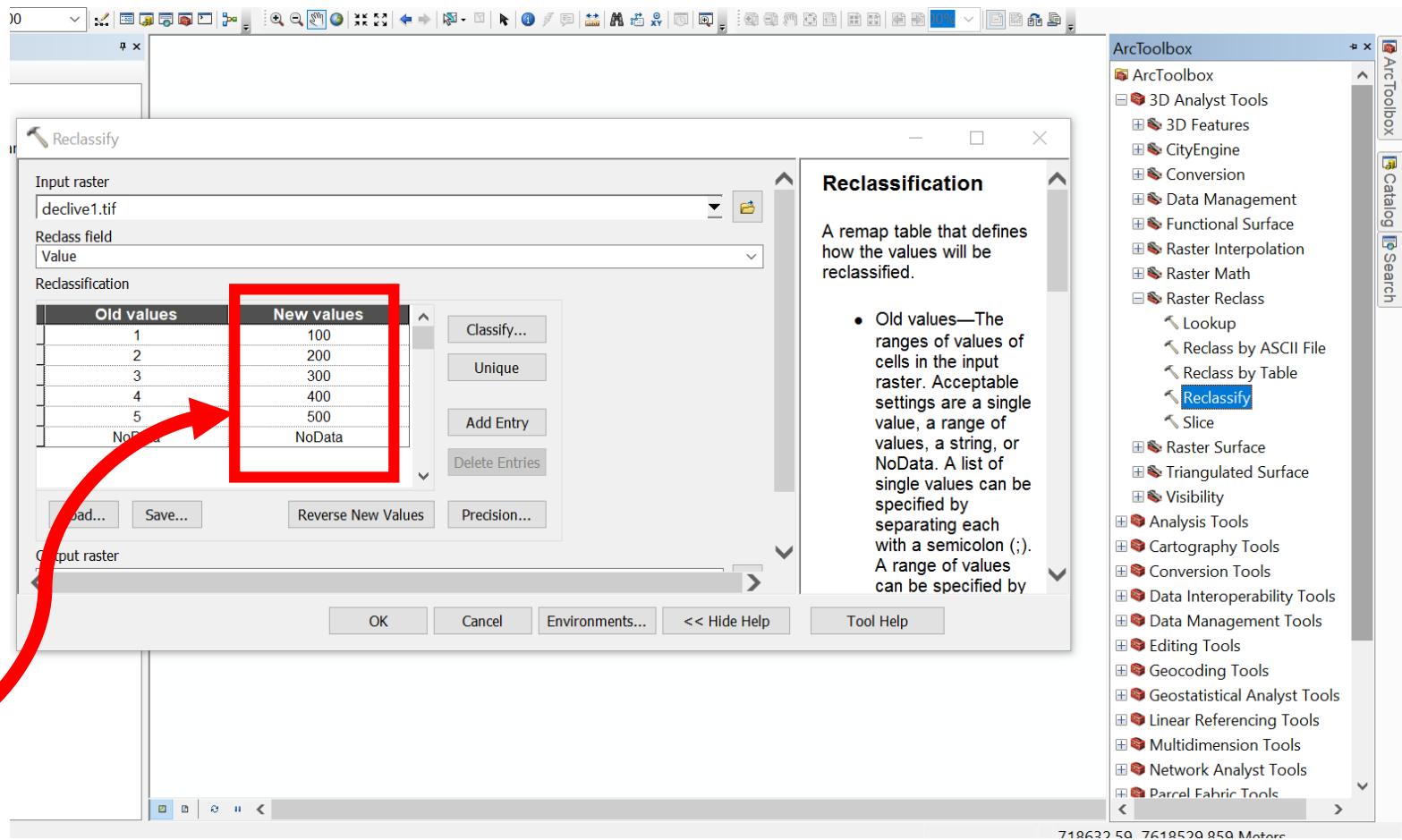
■ Flooding areas
■ Low slope
■ Low to Medium slope
■ Medium to High slope
■ High slope

The logic about combinatorial analysis

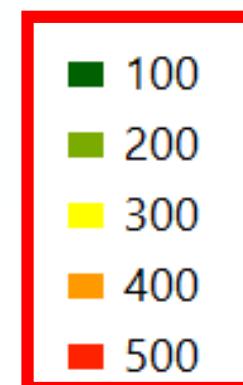
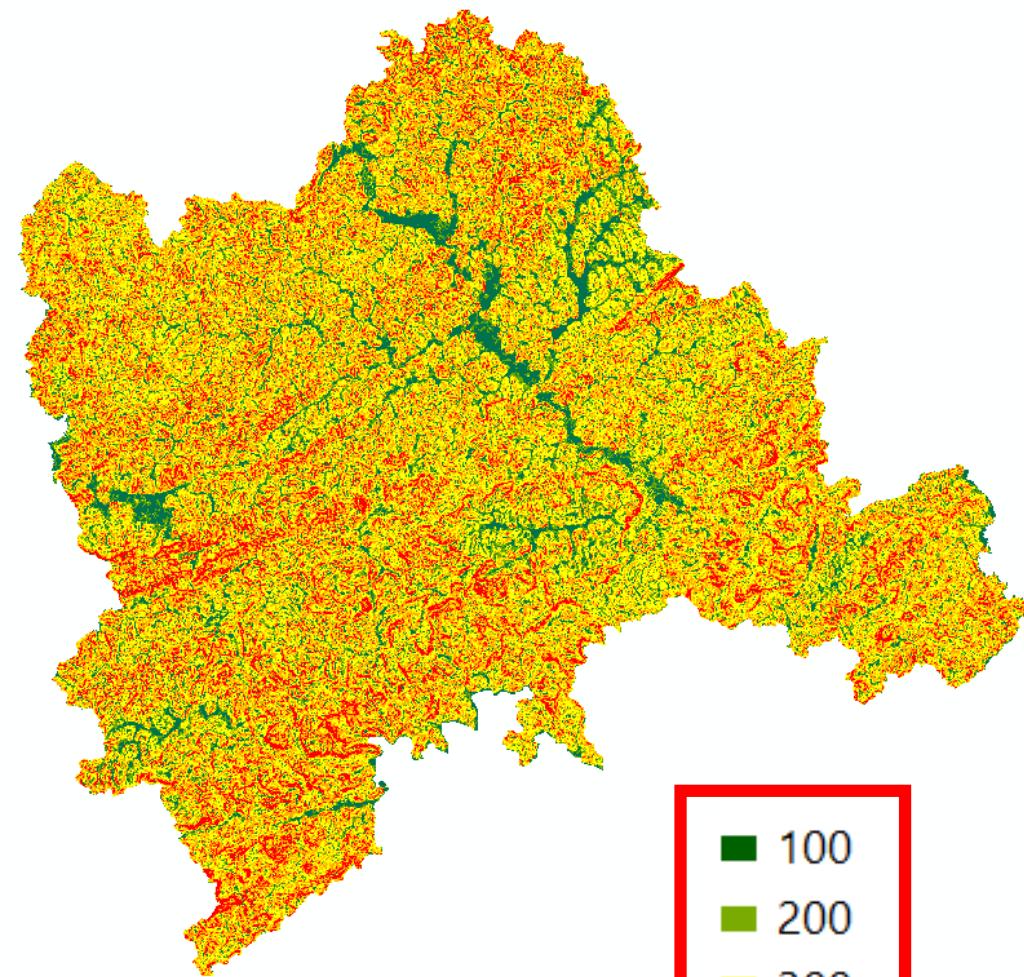
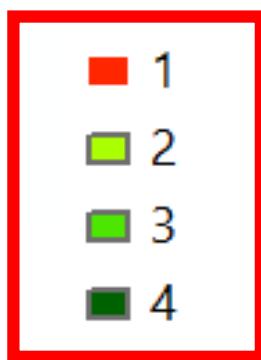
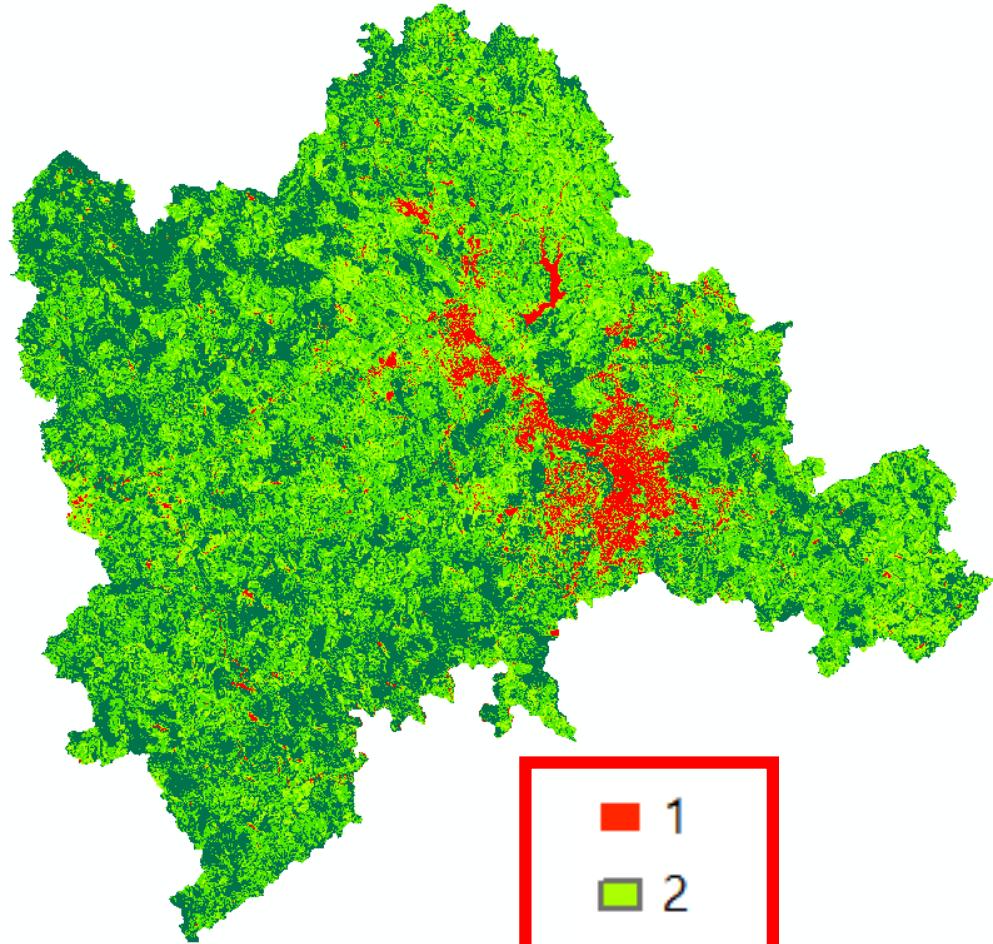
- According Groenwald *et al.* (2009), "*Combinatory Analysis is the part of Mathematics that studies and develops methods for solving problems involving counting or existence, in general, it can be said that it is the part of Mathematics that analyzes discrete structures and relations*".
- The Combinatory Analysis matrix, we divided the land use in 4 categories: (1) Impervious areas/ Exposed soil/ water and shadow; (2) Grassy; (3) Shrubby; and (4) Robust vegetation. The Slope was divided in five categories: 0-5%, represent flooding areas; 5-13% represents low slope (good areas to build); 13-30% medium slope (suitable area to build); 30-47% medium slope (areas suitable to build with restrictions); and above 47% protected areas.
- When applying combinatorial analysis, we can get 4 classes:
 - (1) Flooding areas;
 - (2) Suitable to urban growth;
 - (3) Suitable to urban growth + Impervious areas;
 - (4) To be protected, not suitable to urban use.

Reclassing the class

- To do the combinatorial analysis is important to reclassify each layer that is going to be combined, in order to identify the results in the final sum. We decided to use values from 100 to 500 in slope (100, 200, 300, 400 and 500), and values from 1 to 4 in land use (1, 2, 3 and 4). Doing the sum of the layers we can identify all the combinations.



Result reclass

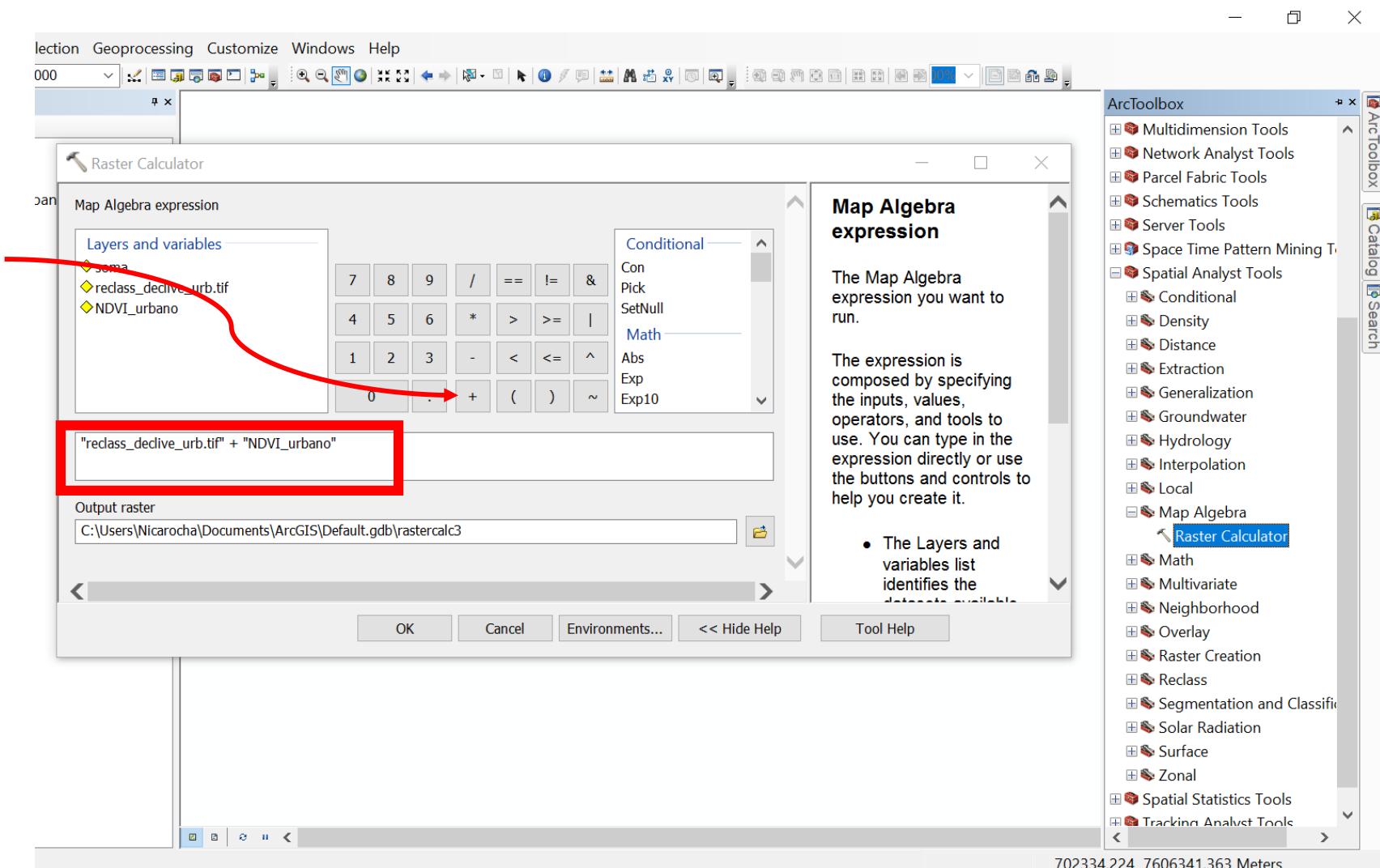


Combinatoryal analysis matrix

SLOPE	LAND USE	Impervious areas/ Exposed soil/ water and shadow			
		Grassy	Shrubby	Robust vegetation	
		1	2	3	4
0-5 %	100	101	102	103	104
5-13%	200	201	202	203	204
13-30%	300	301	302	303	304
30-47%	400	401	402	403	404
> 47%	500	501	502	503	504

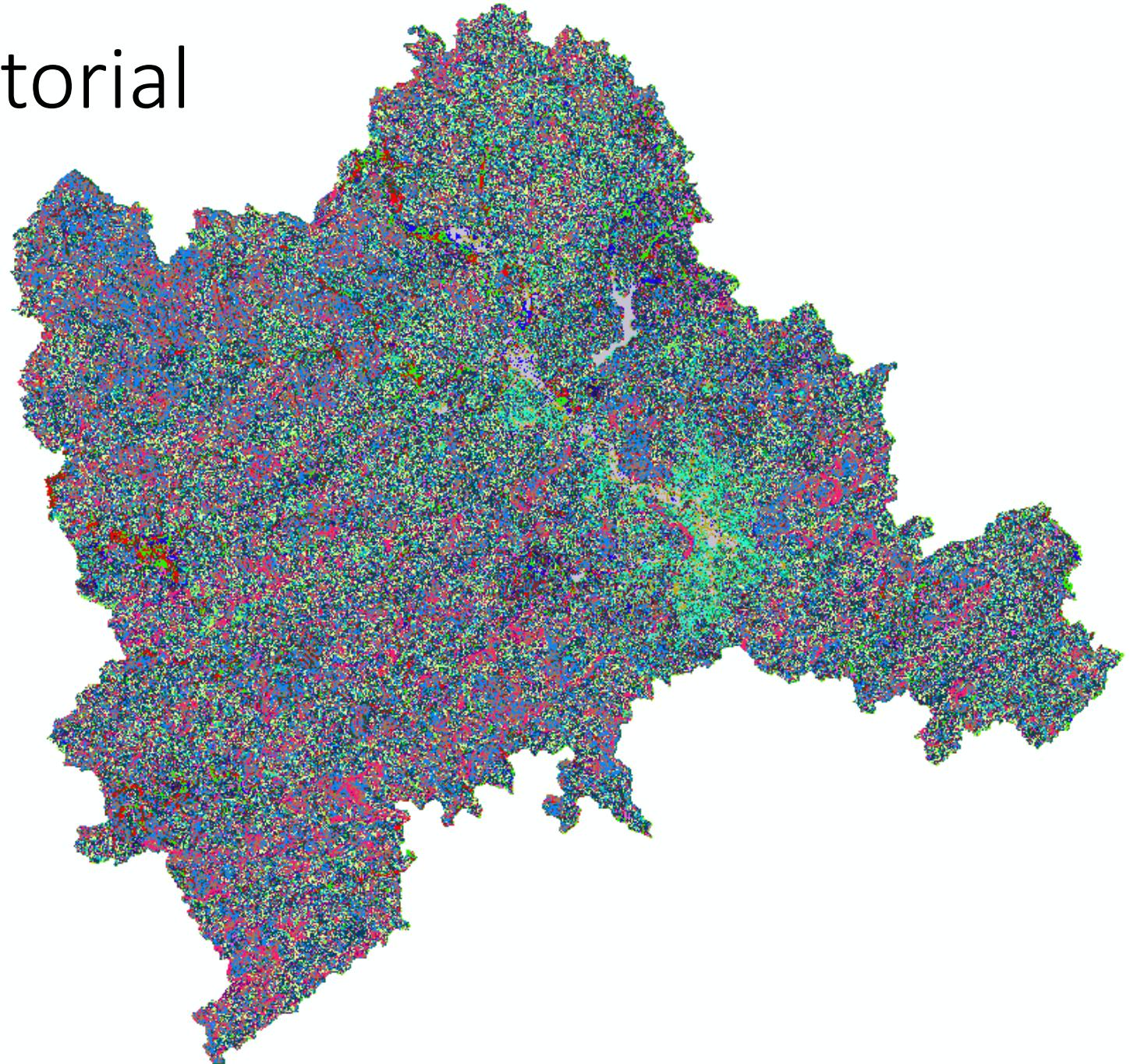
Sum the two maps (slope + land use)

- Using raster calculator, sum the maps the were reclassified in the new values.



Result of Combinatorial Analysis

- 101
- 102
- 103
- 104
- 201
- 202
- 203
- 204
- 301
- 302
- 303
- 304
- 401
- 402
- 403
- 404
- 501
- 502
- 503
- 504



Interpretation of result of Combinatory Analysis

- Protection of height slope and/or robust vegetation: 501, 502, 503, 504, 104, 204, 304, 404.
- Not suitable to urban growth: 101, 201, 301, 401
- Suitable to agriculture, but risk of flood to urban use: 102, 103
- Suitable to urban use and agriculture: 202, 203
- Suitable to urban use: 302, 303
- Urban use conditioned to controlling geotechnical risks: 402, 403.

SLOPE	LAND USE	Impervious areas/ Land exposed/ water and shadow			Robust
		Grassy	Shrubby		
0-5 %	100	101	102	103	104
5-13%	200	201	202	203	204
13-30%	300	301	302	303	304
30-47%	400	401	402	403	404
> 47%	500	501	502	503	504

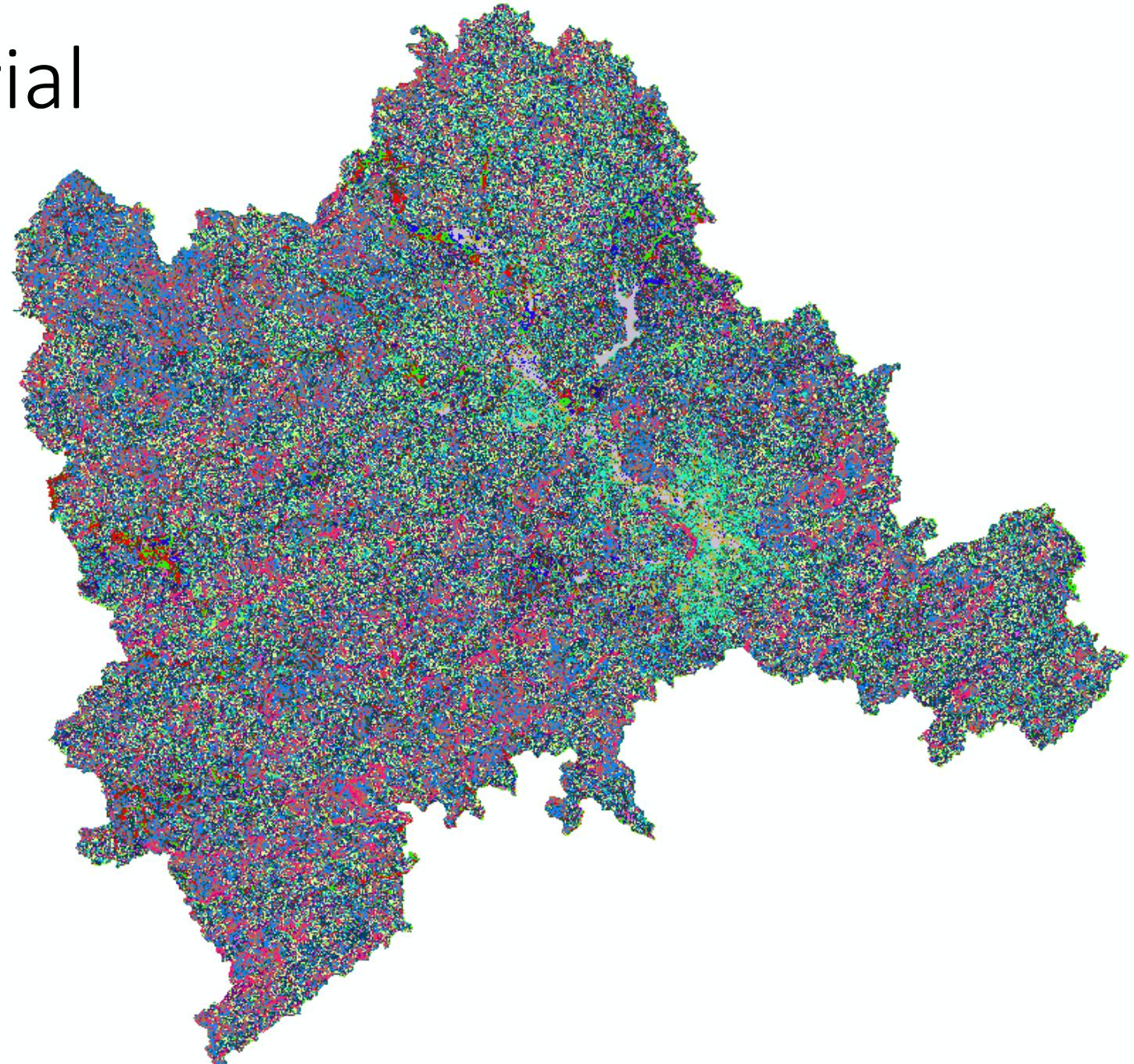
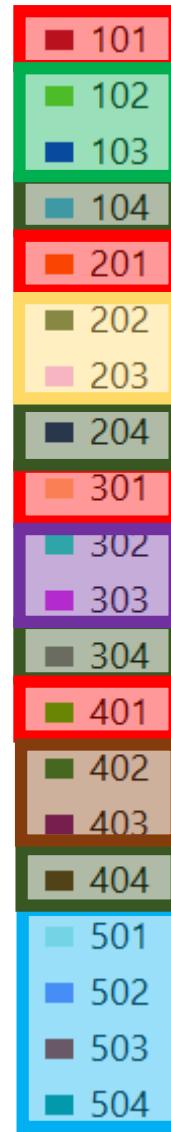
Interpretation of result of Combinatory Analysis

If you want more simplified results, it can also be:

- **URBAN System:**
 - Not suitable/inappropriate to urban growth: 501, 502, 503, 504, 104, 204, 304, 404, 101, 201, 301, 401
 - Capable to urban growth: 402, 403
 - Suitable to urban growth: 102, 103
 - Feasible to urban growth: 201, 203, 302, 303

Result combinatorial Analysis

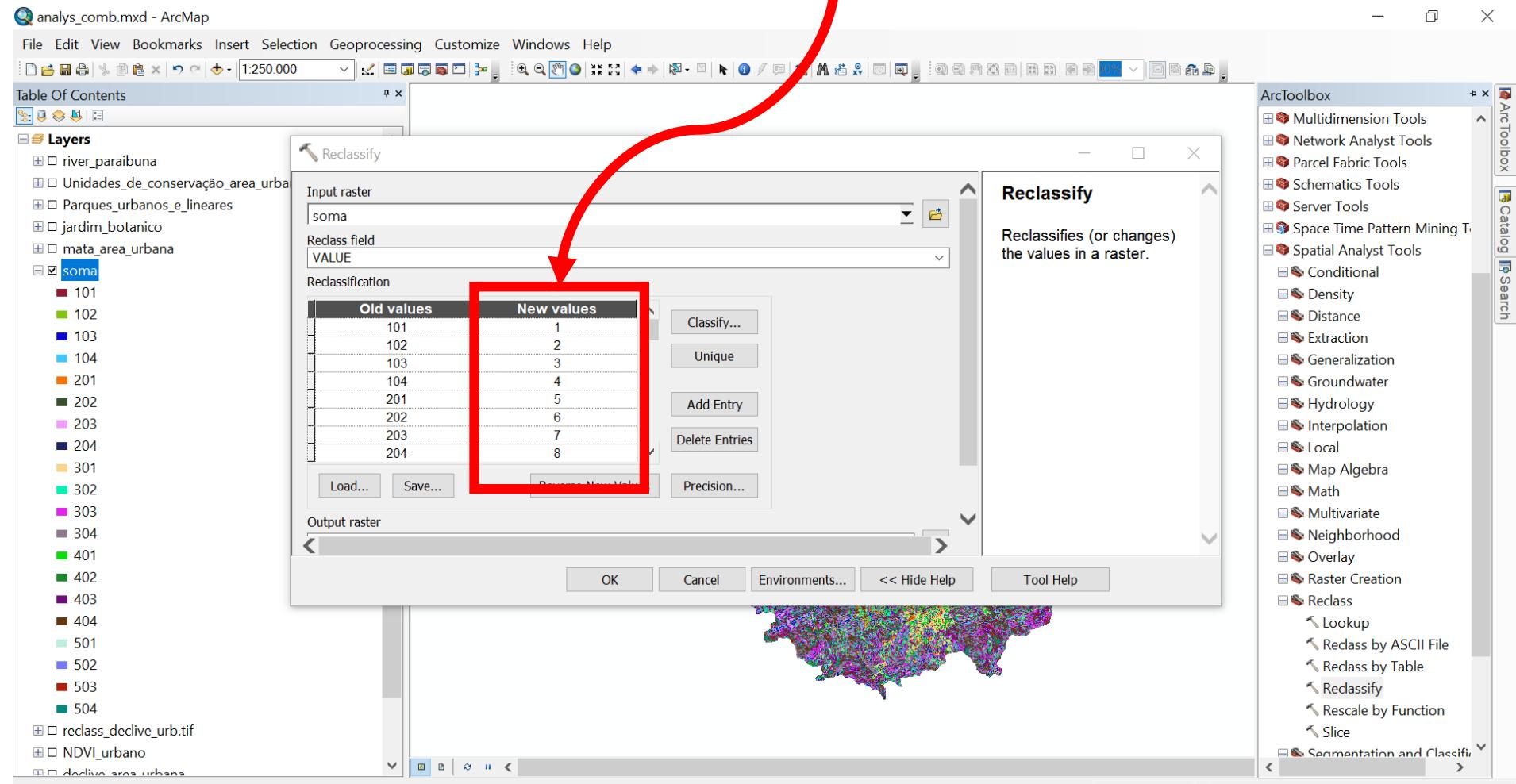
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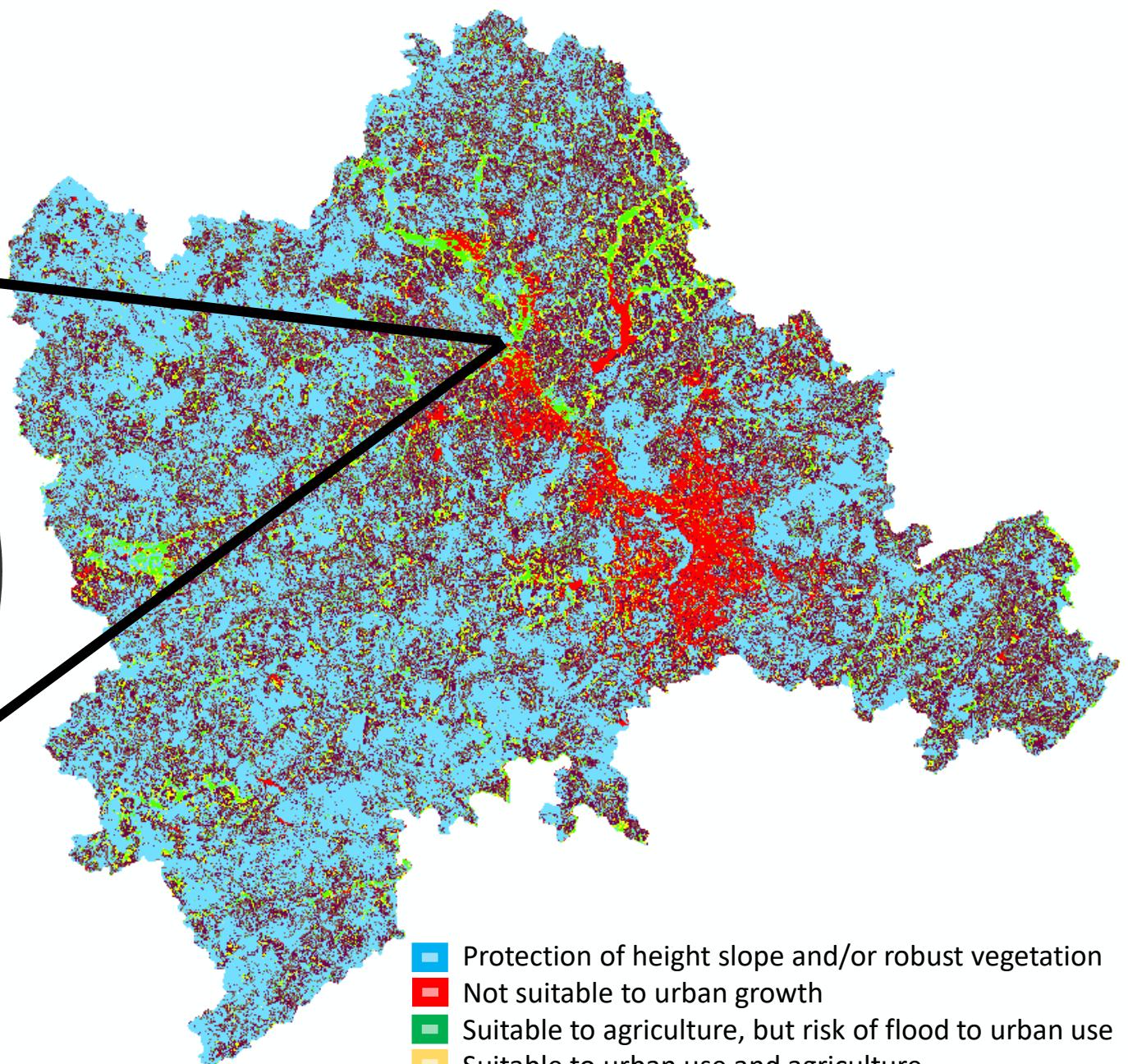
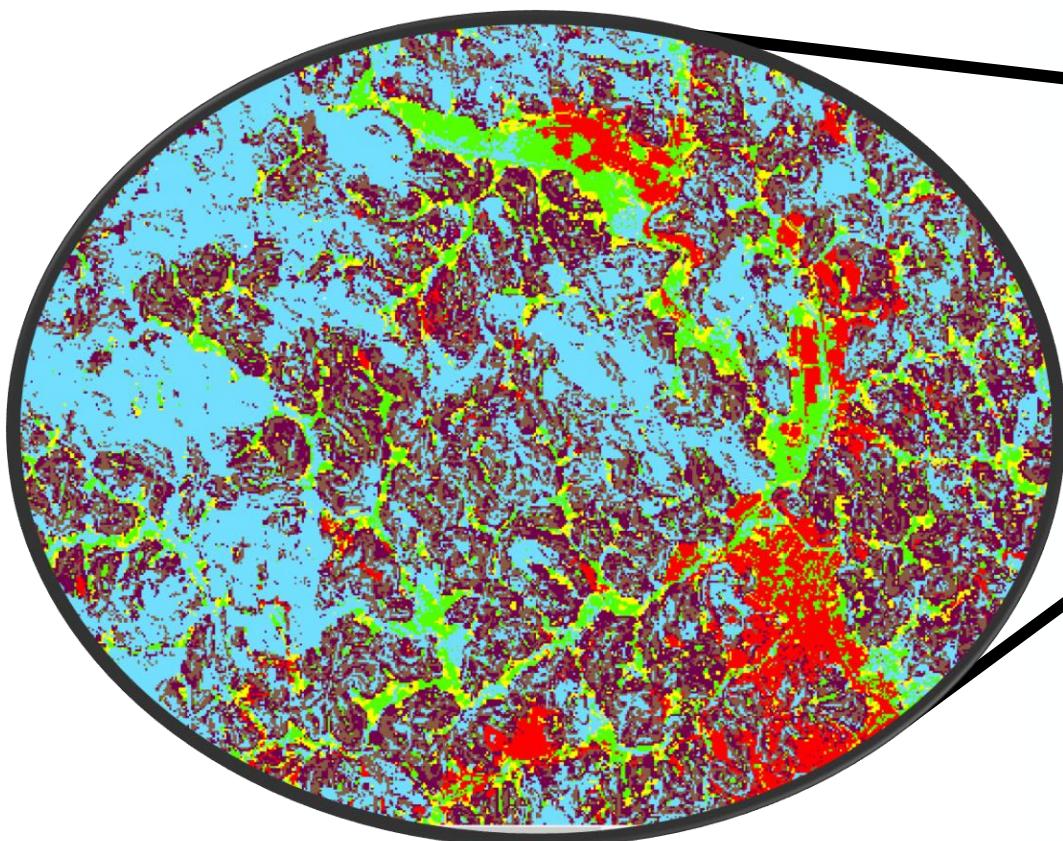
Reclassify the groups

- We need in this moment reclassify the class according to new class.

RECLASSIFY IN HERE THE NEW VALUES



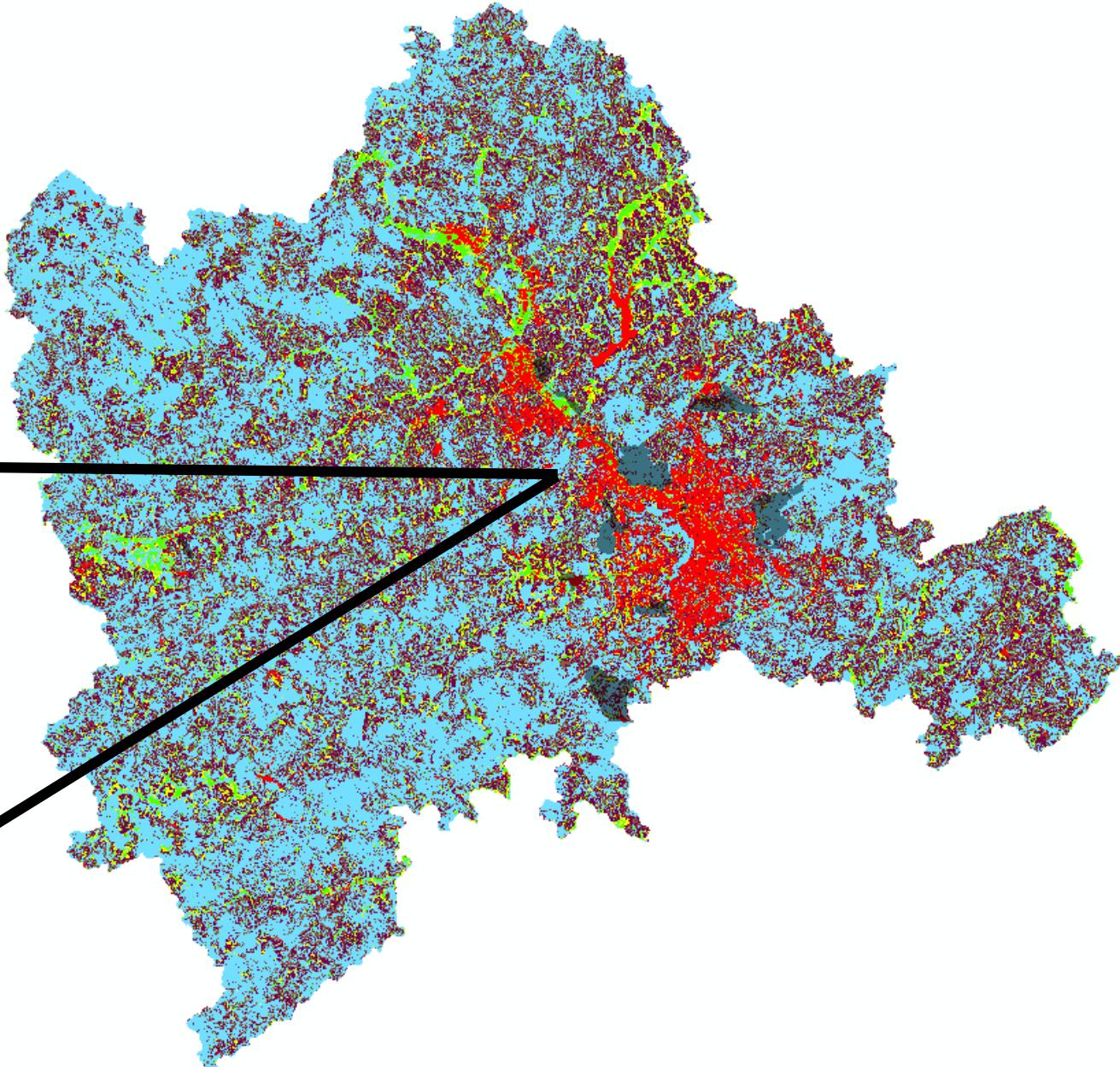
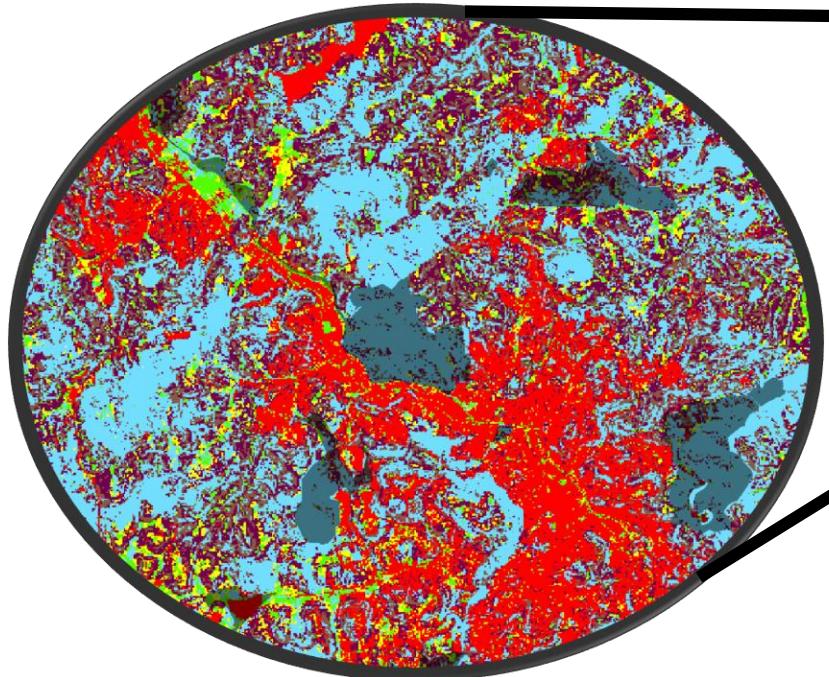
Result reclass



- Protection of height slope and/or robust vegetation
- Not suitable to urban growth
- Suitable to agriculture, but risk of flood to urban use
- Suitable to urban use and agriculture
- Suitable to urban use
- Urban use conditioned to controlling geotechnical risks

Result combinatorial analysis + Units conservation

- It's interesting add the shape about the units conservation to increase understanding of place

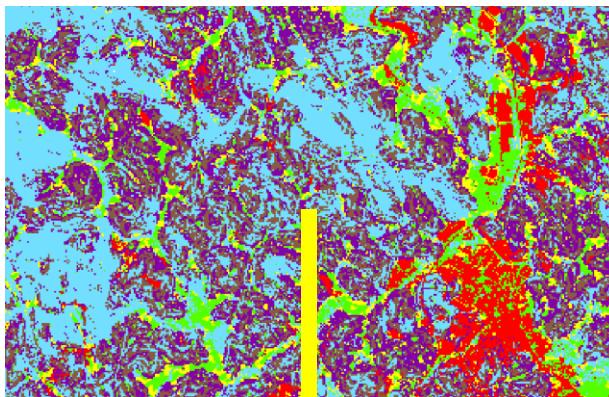


To improve the map visualization

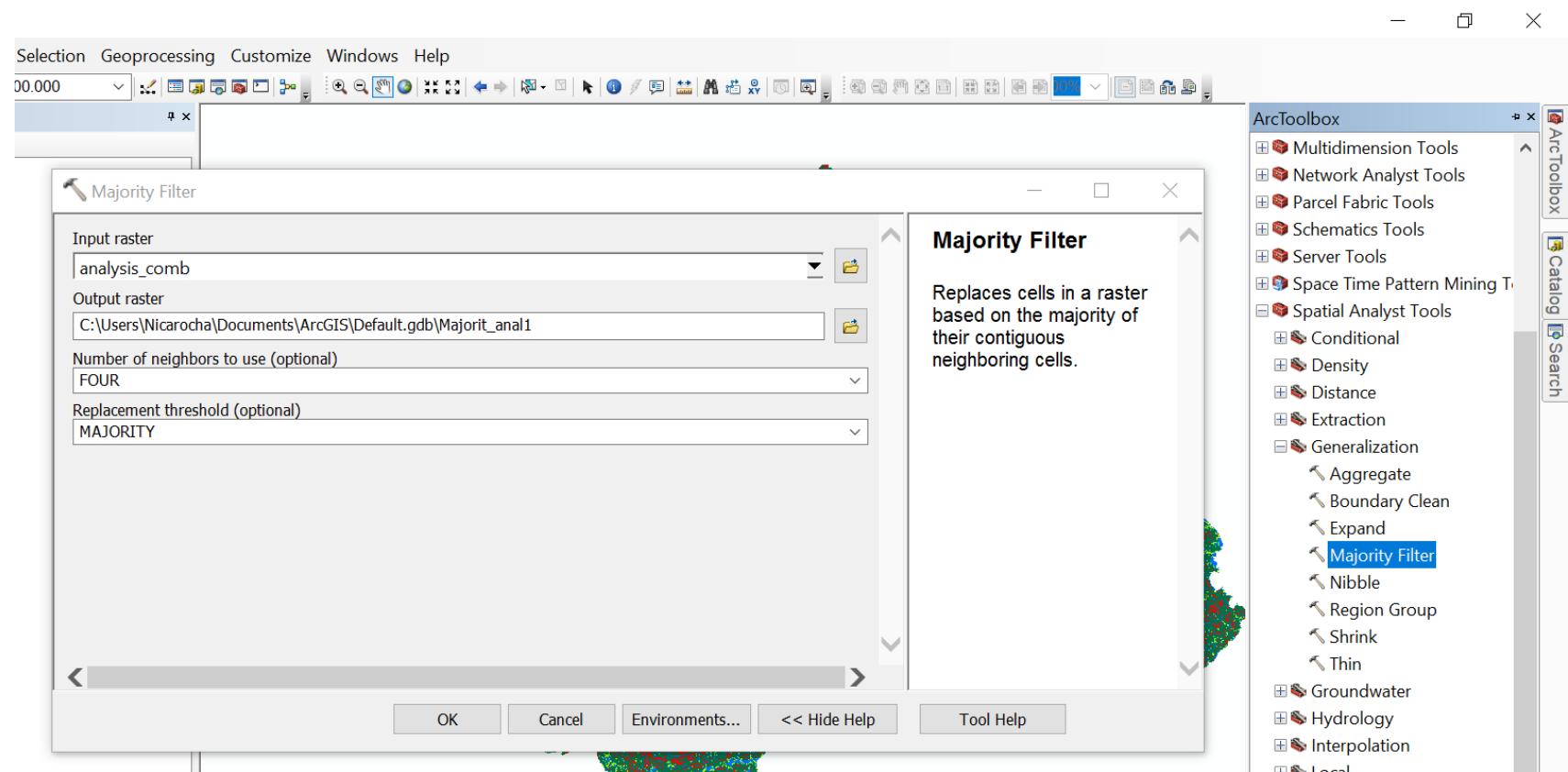
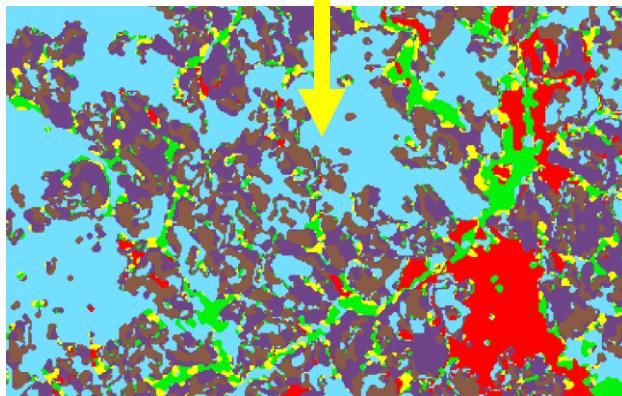
DEVELOPMENTS – to improve the map

- Image processing to eliminate the “pixel effect” use the majority filter command as many times as necessary

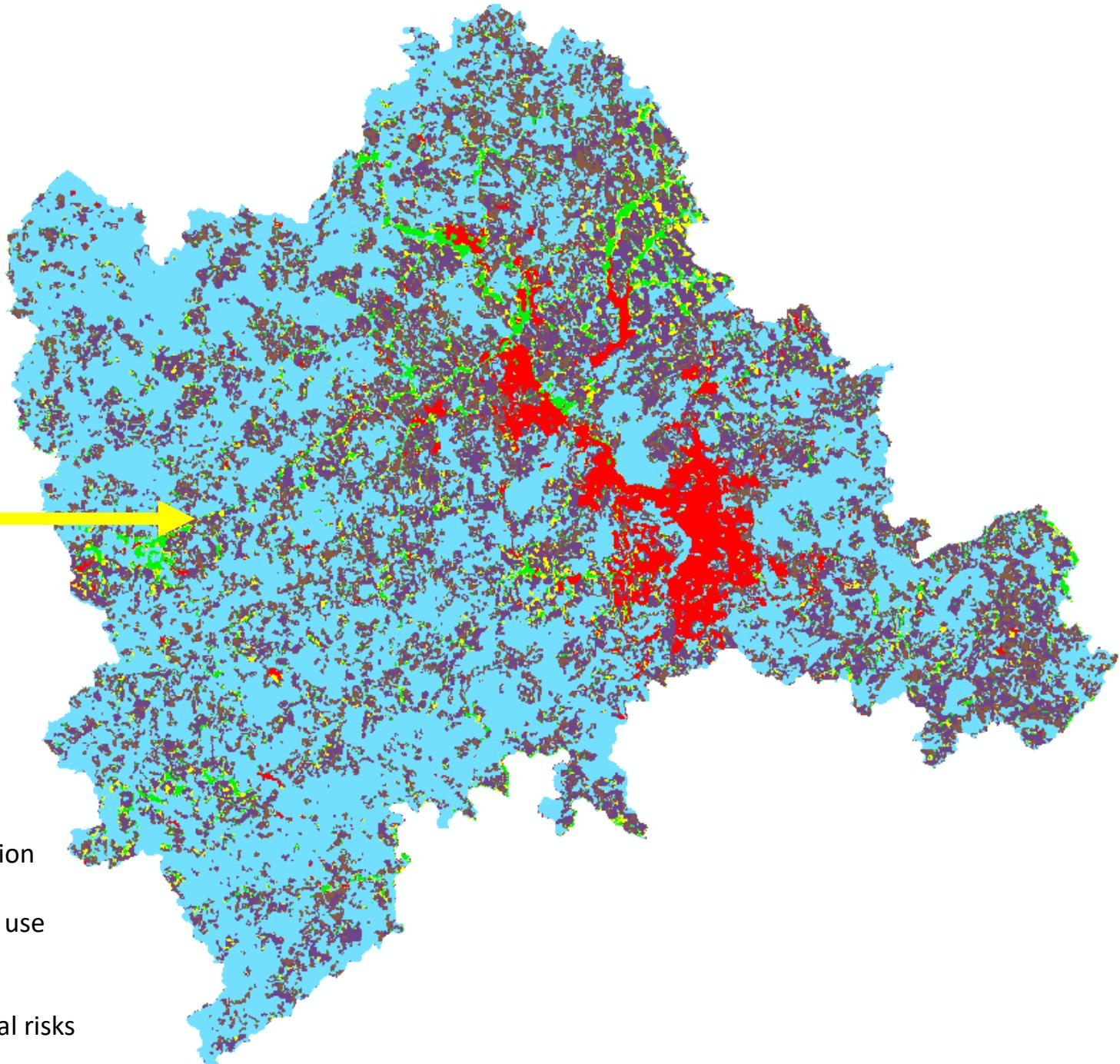
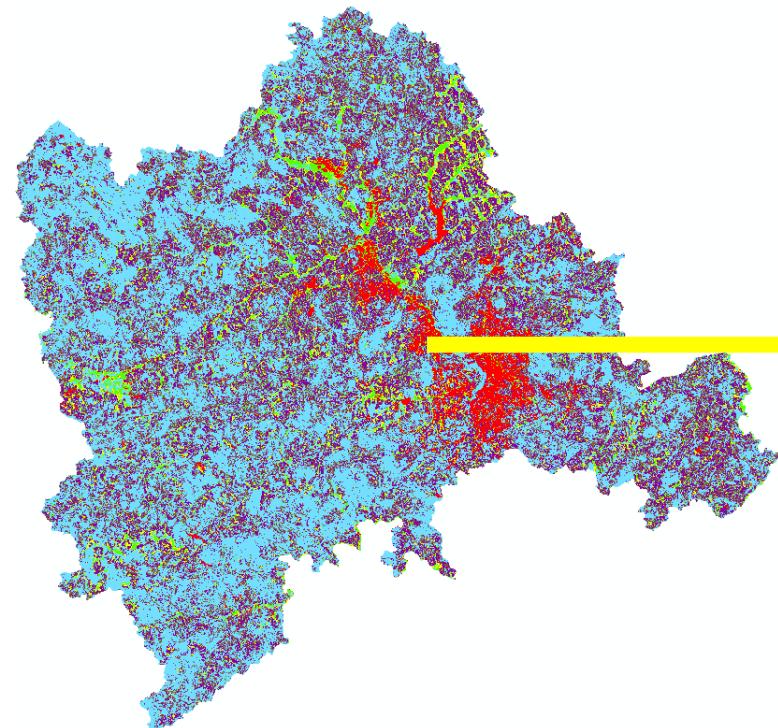
Before



After



Result



- Protection of height slope and/or robust vegetation
- Not suitable to urban growth
- Suitable to agriculture, but risk of flood to urban use
- Suitable to urban use and agriculture
- Suitable to urban use
- Urban use conditioned to controlling geotechnical risks