

Methodology to produce the AGRICULTURE and/or HYDROLOGY SYSTEM map using GIS desktop

By PhD student:

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- Head Teacher: Ana Clara Mourão Moura

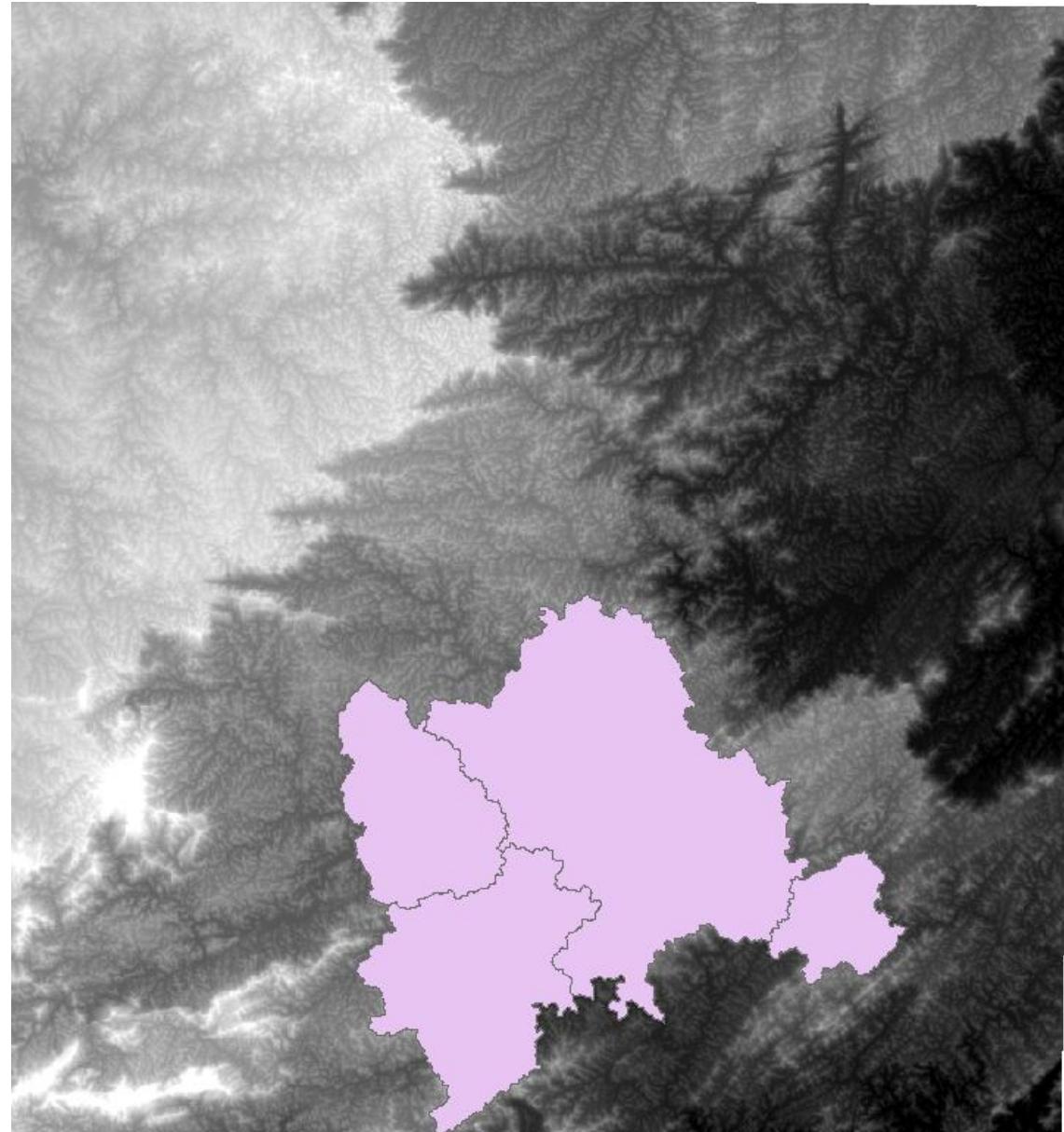
Introduction

- To construct the agriculture system, we used three partial maps, combined to create a fourth map. The first maps were slope and land use, add the watershed and they together composed the “Agriculture system and/ or Hydrology map”, mapping areas there are indicated to agriculture.
- We are considering that we have no date and must begin from the beginning.
 - Slope map
 - Land use map
 - Watershed
 - Urban map using combinatorial analysis

SLOPE TO AGRICULTURE

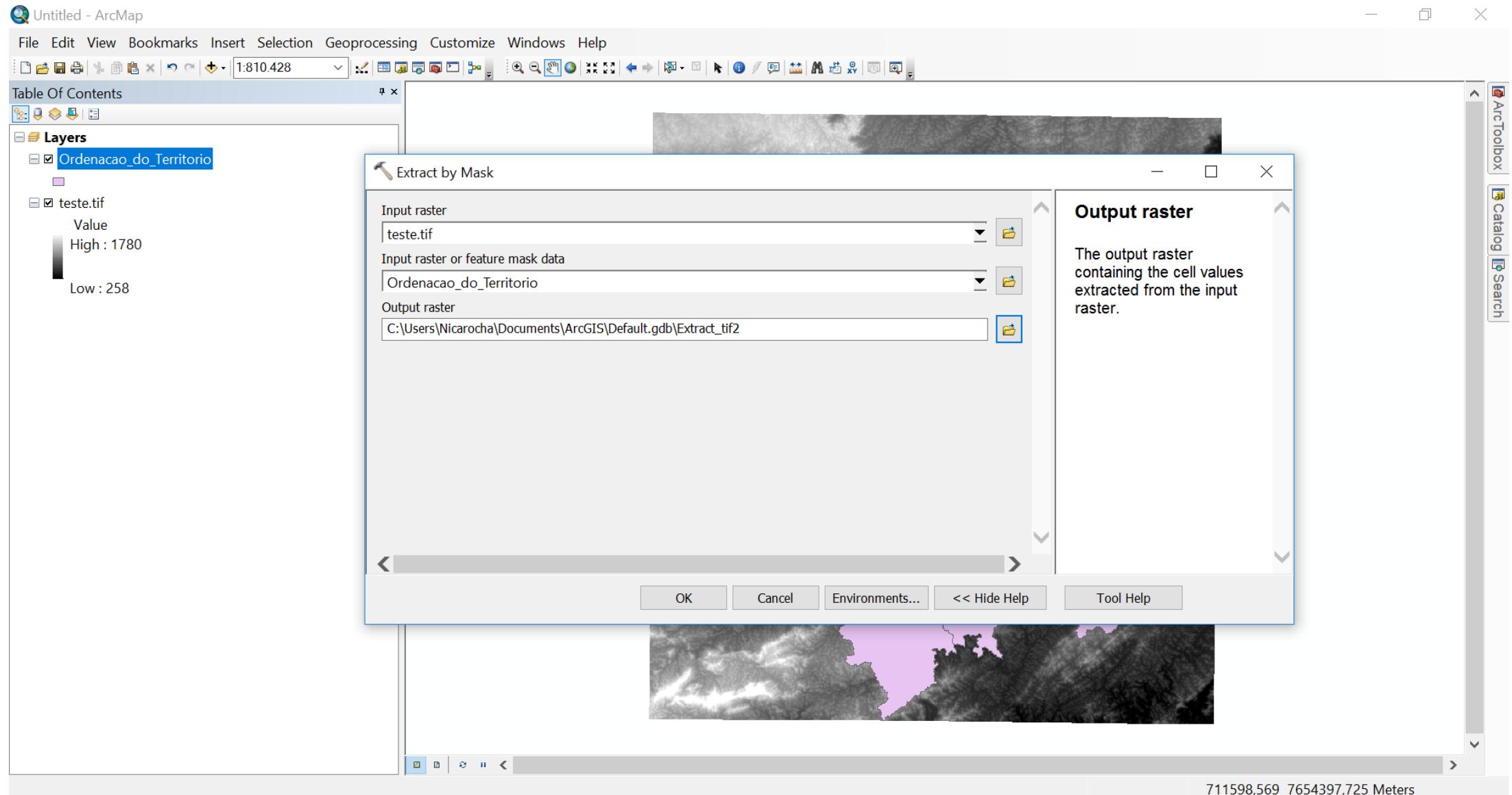
Download the SRTM

- 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.

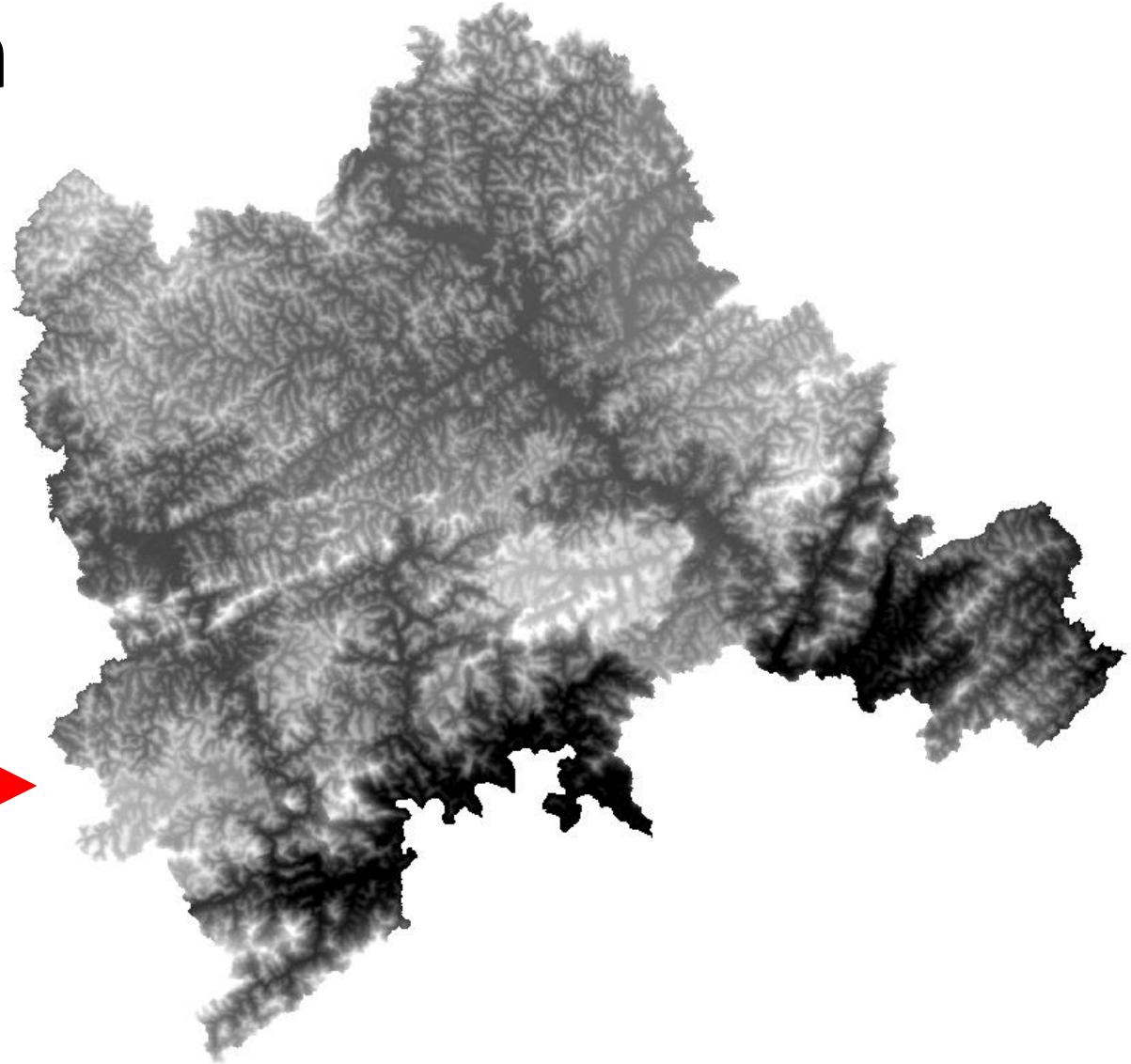
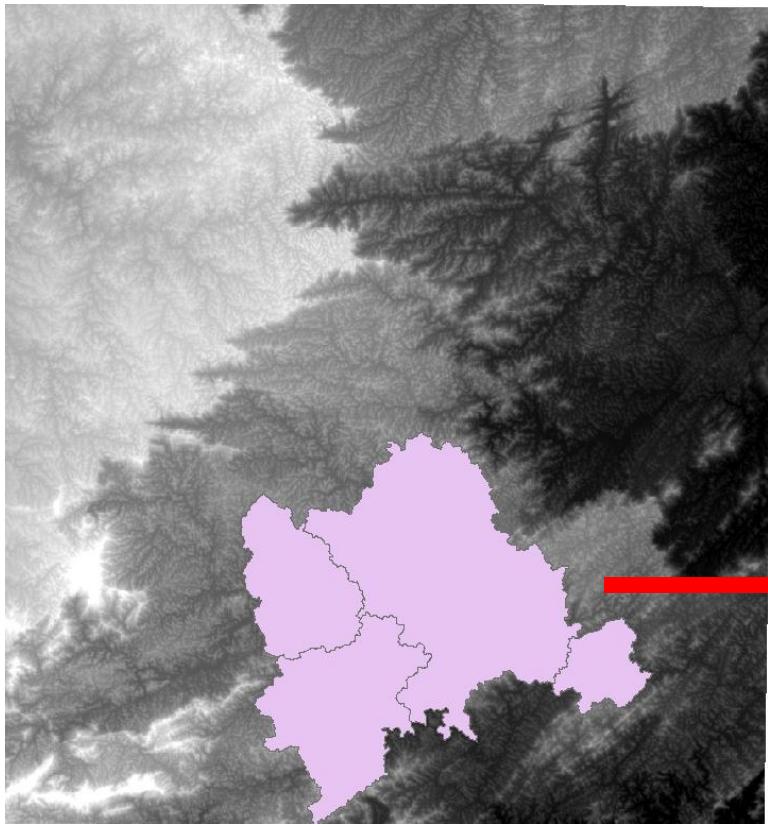


SRTM image source: <http://dwtkns.com/srtm30m/>

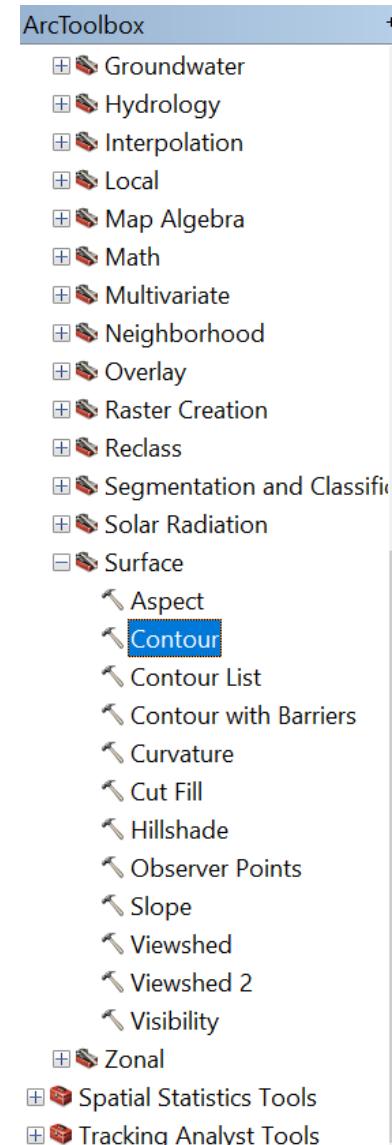
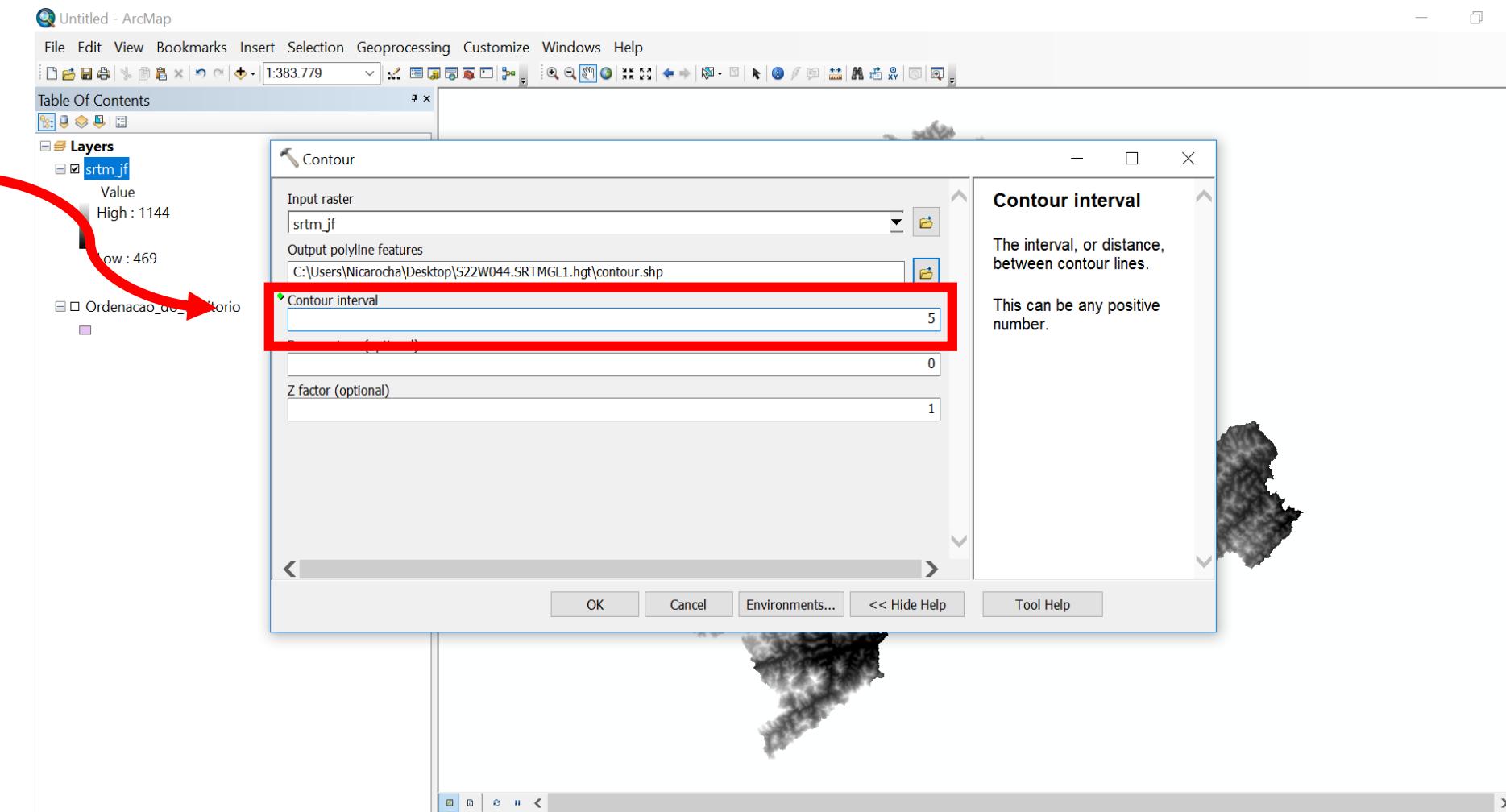
- Cut the SRTM according to the boundary (using Extract by mask)



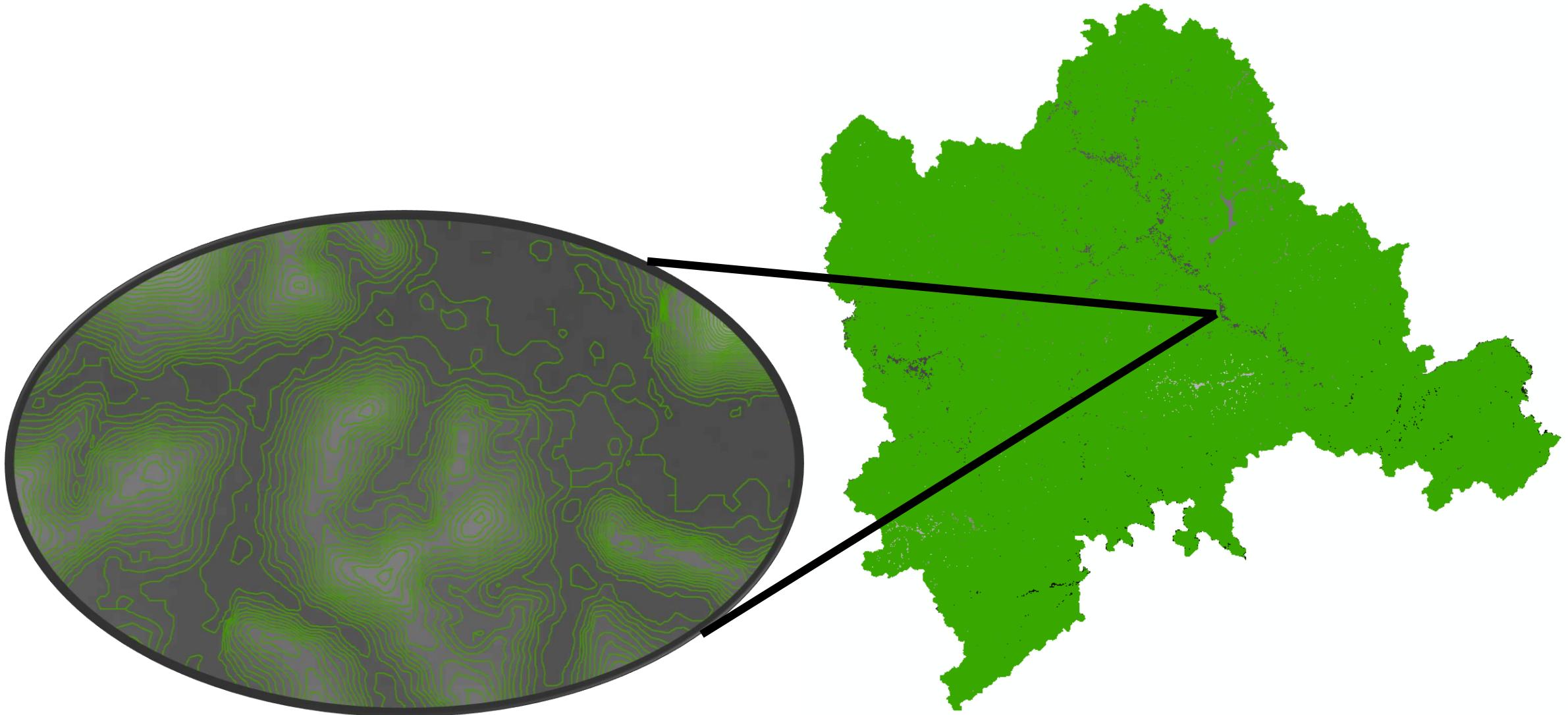
Result of the extraction



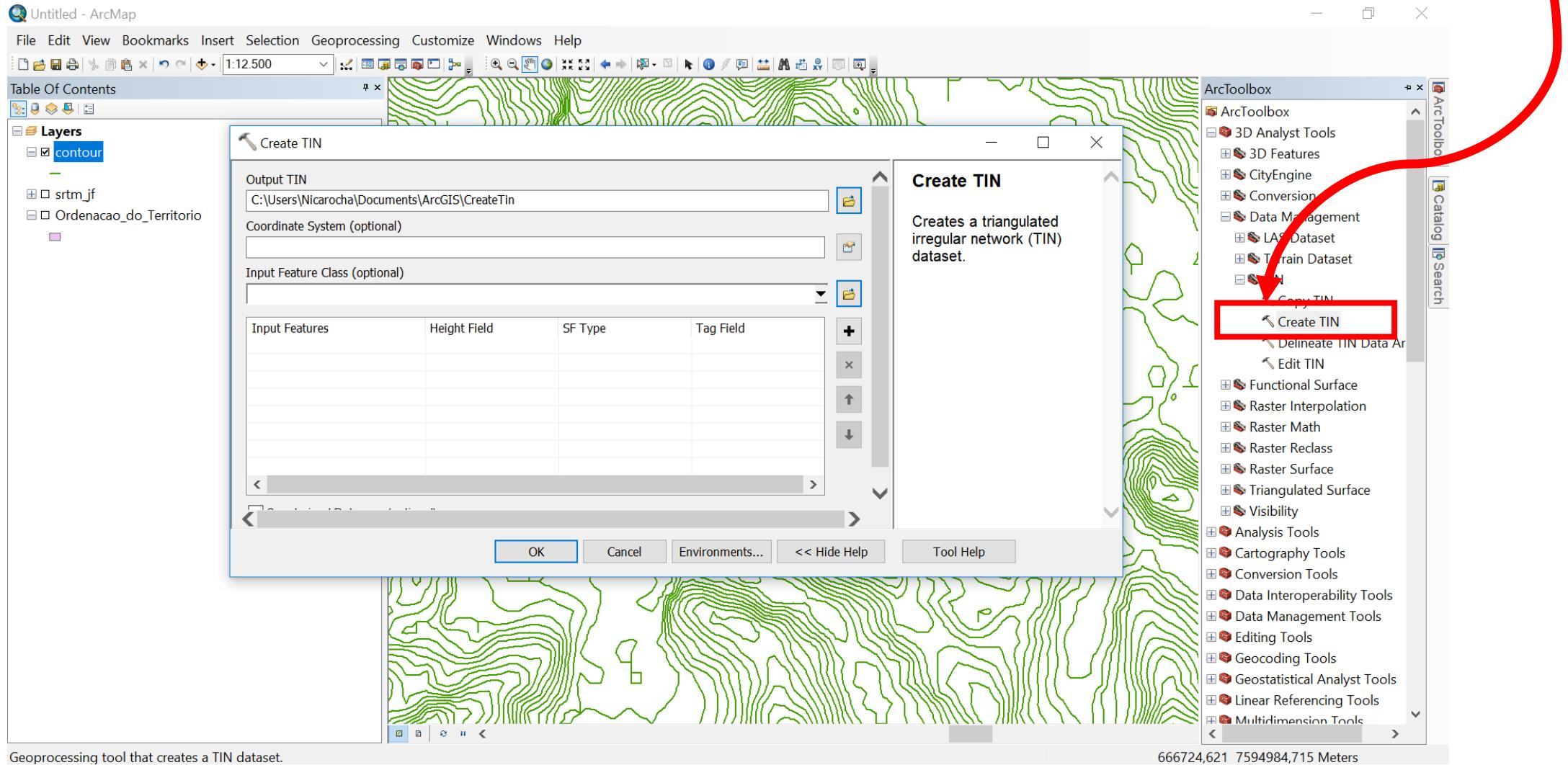
- From SRTM raster, the “contour” command is used to interpolate the isolines of topography.
- Interpolate topographic lines (contour)
- Define (contour interval) = 5m



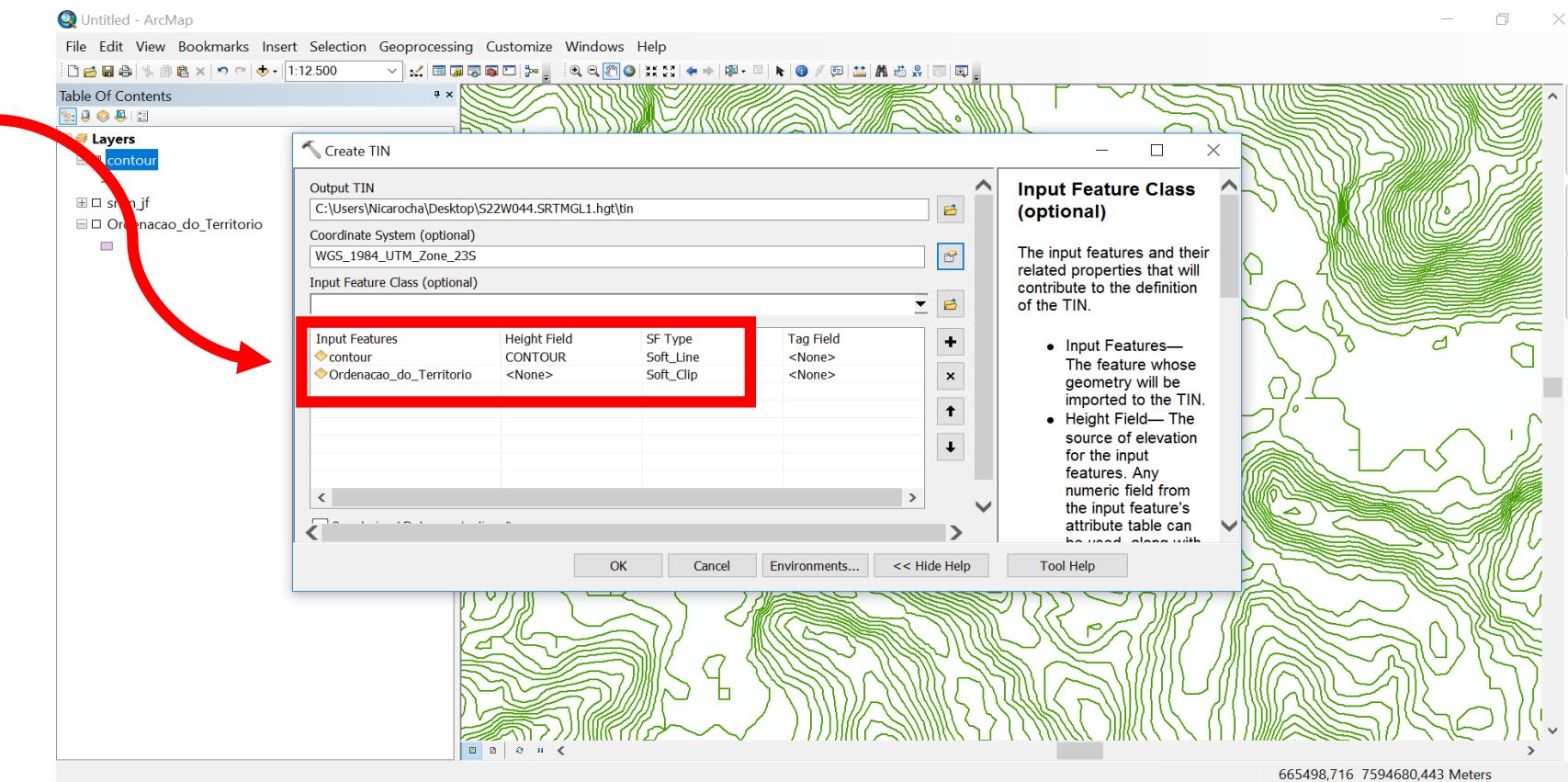
Result of the interpolation of contours 5m



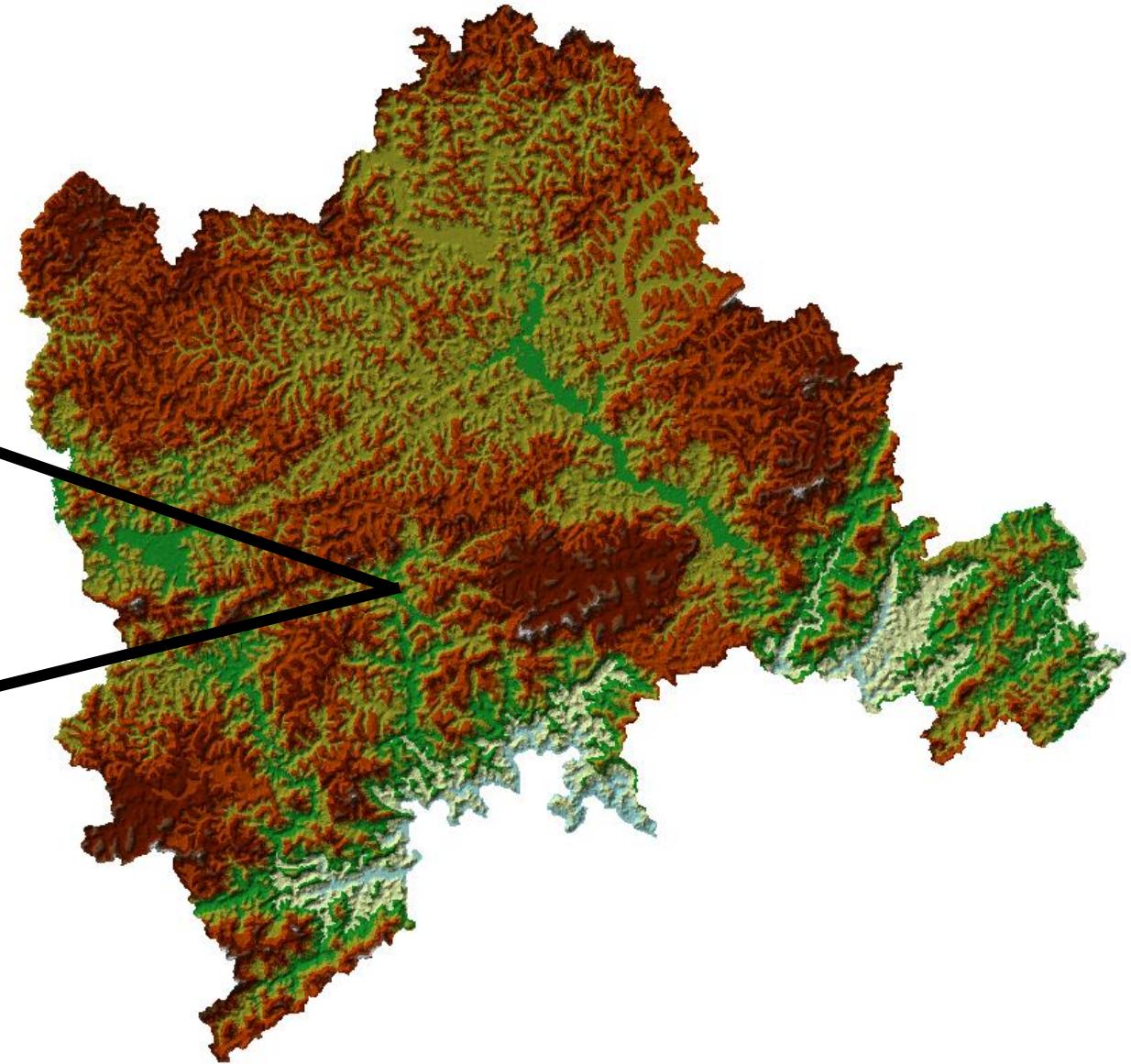
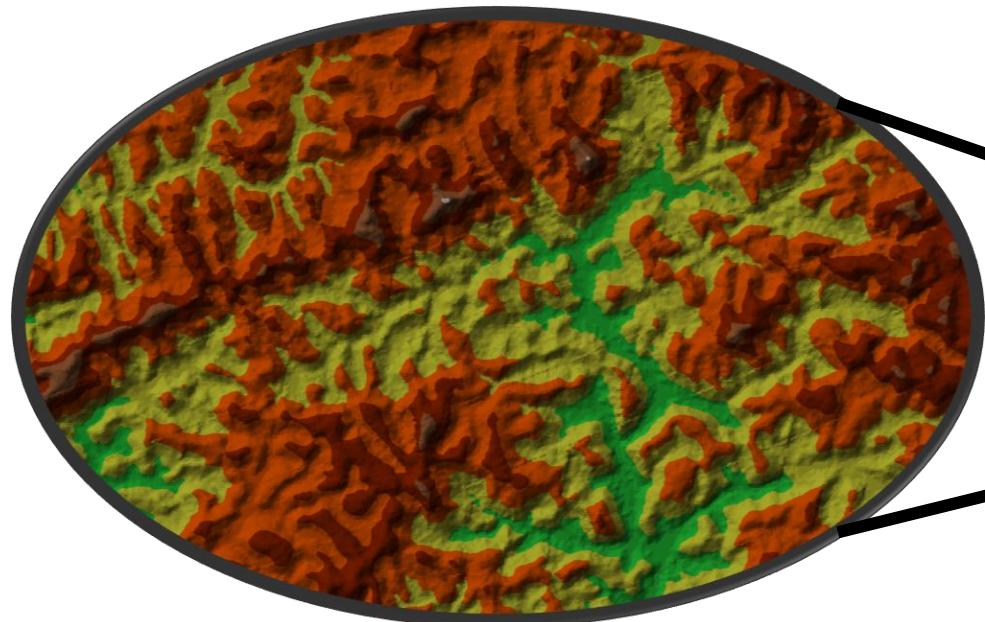
Creating TIN data to produce the slope map



- 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.

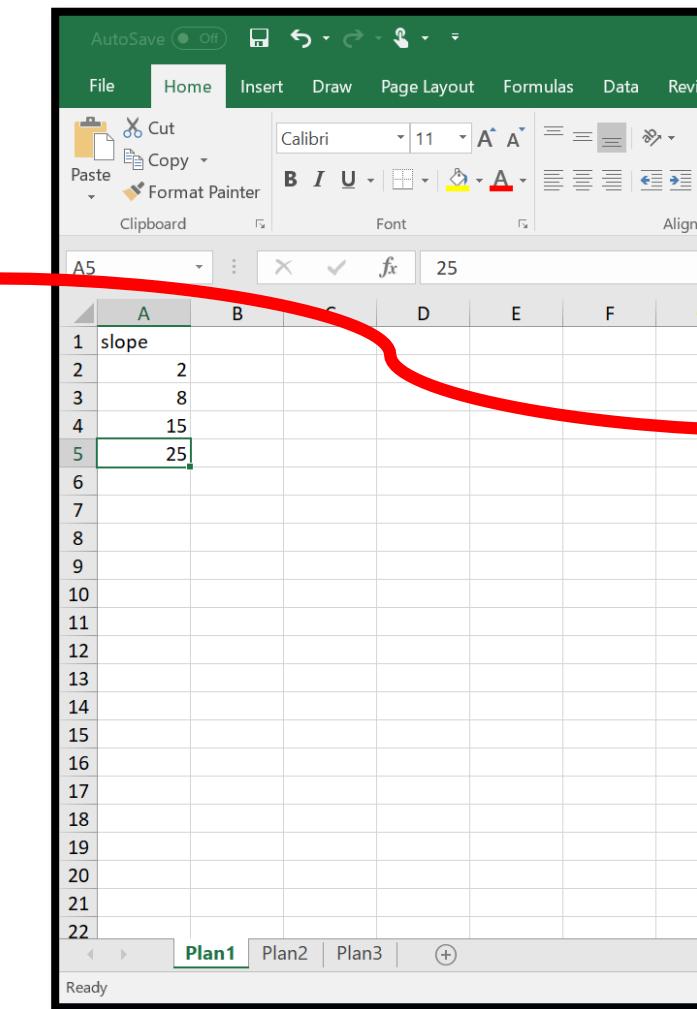


Result of the TIN (triangular irregular network)



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 0 to 13% - allowed to mechanized agriculture;
 - From 13% to 100% - family farming
 - From 100% - Permanent protection Area according to Brazilian's forest code.
- 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%



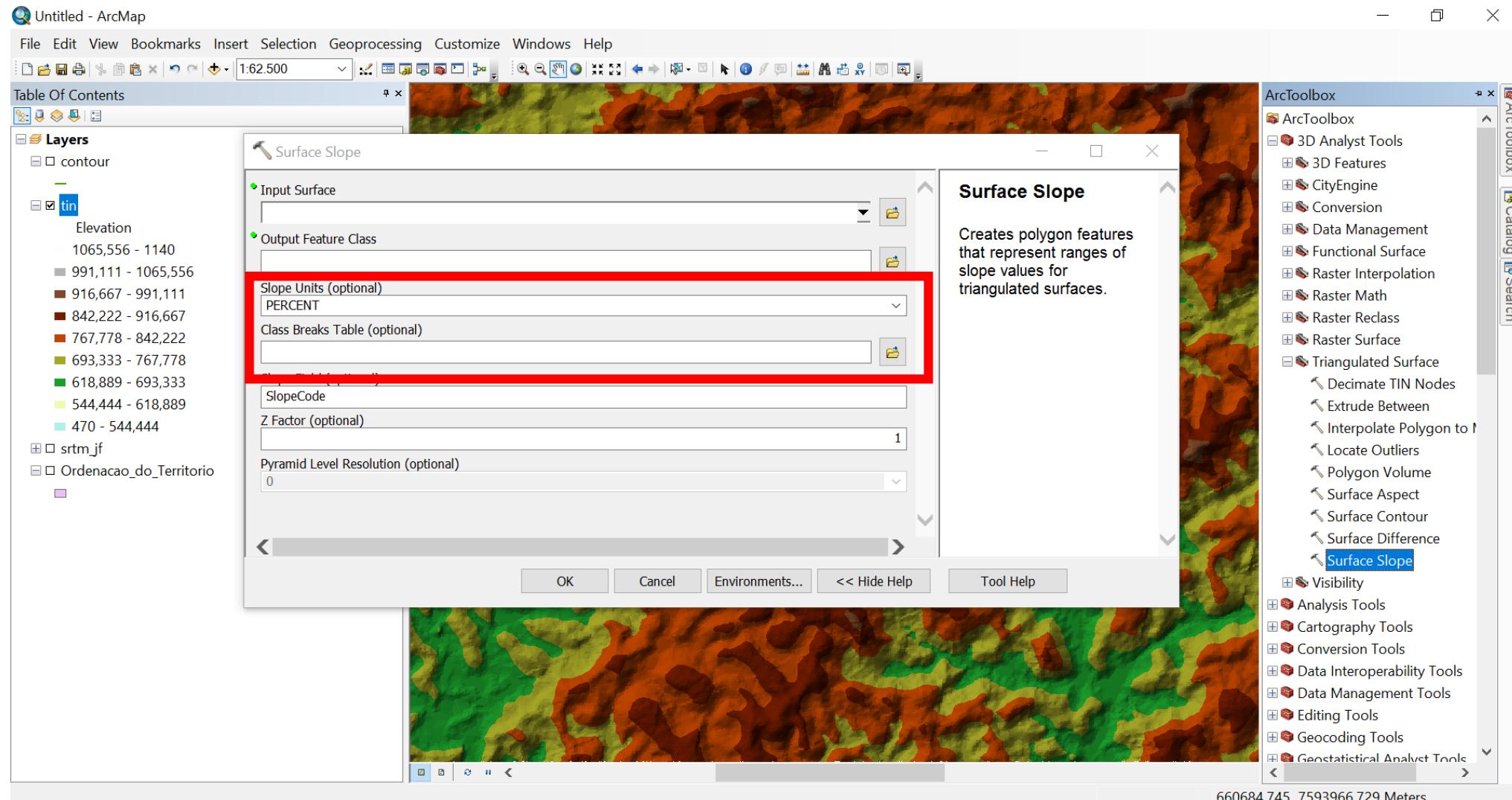
Plan1					
A	B	C	D	E	F
1 slope					
2	2				
3	8				
4	15				
5	25				
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

Czech reality (you need check this information to others contexts)

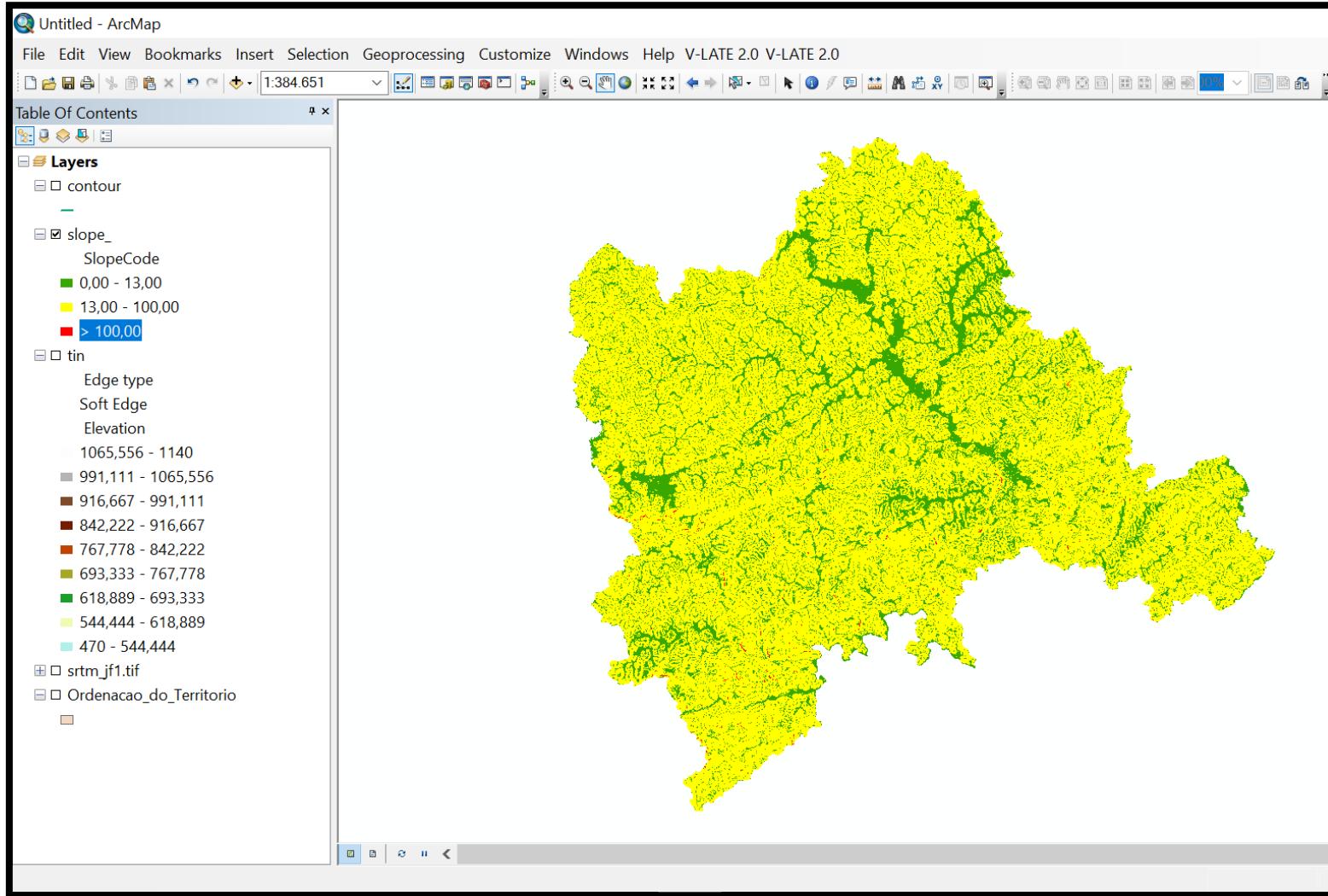
Sheet1					
A	B	C	D	E	F
1 Slope					
2	13				
3	100				
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

Brazilian reality

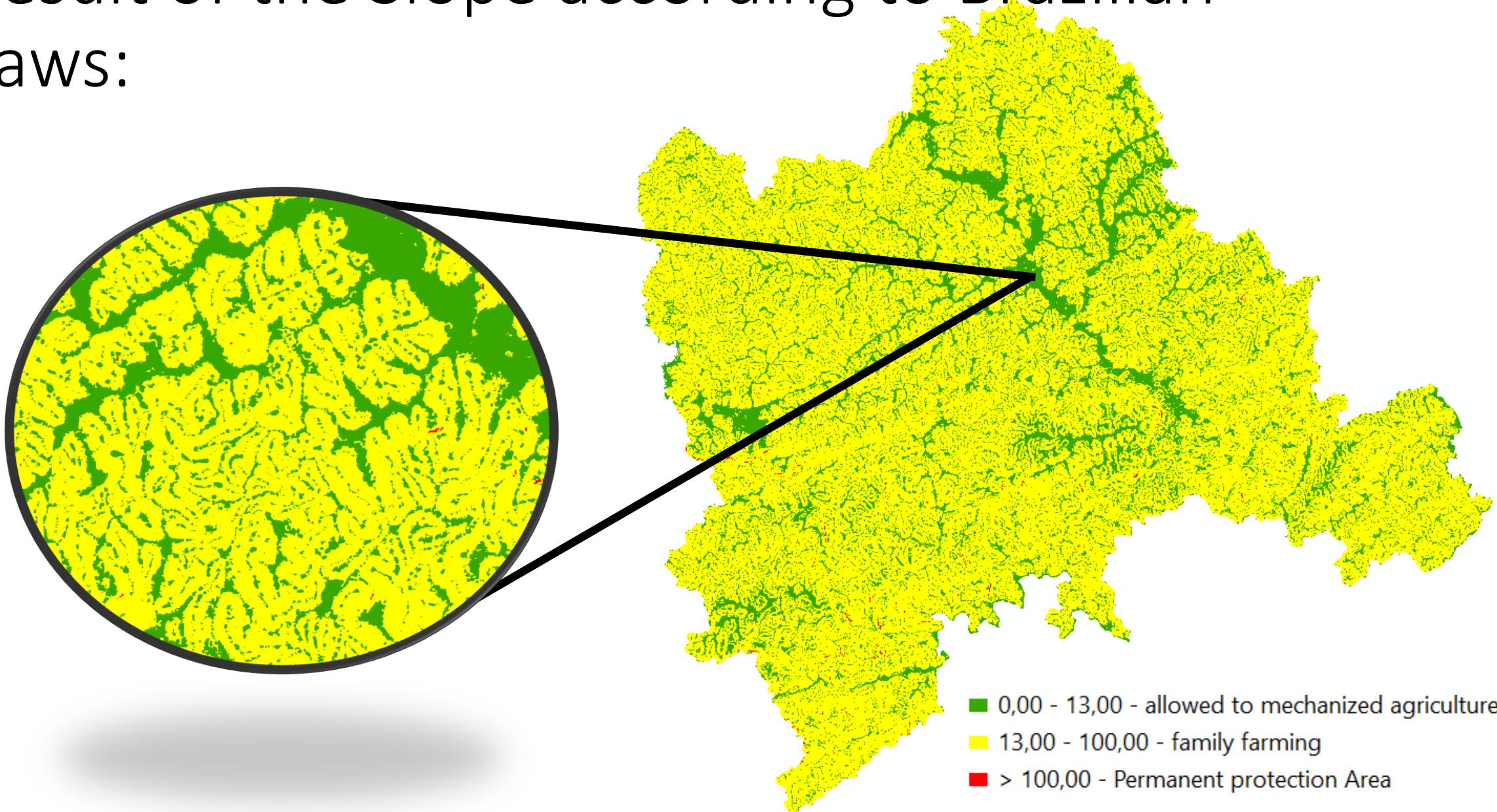
- With the TIN and the excel file with the ranges of slope (that is the “Class Break Table”), calculate slope.



Result of the Slope according to Brazilian Laws:

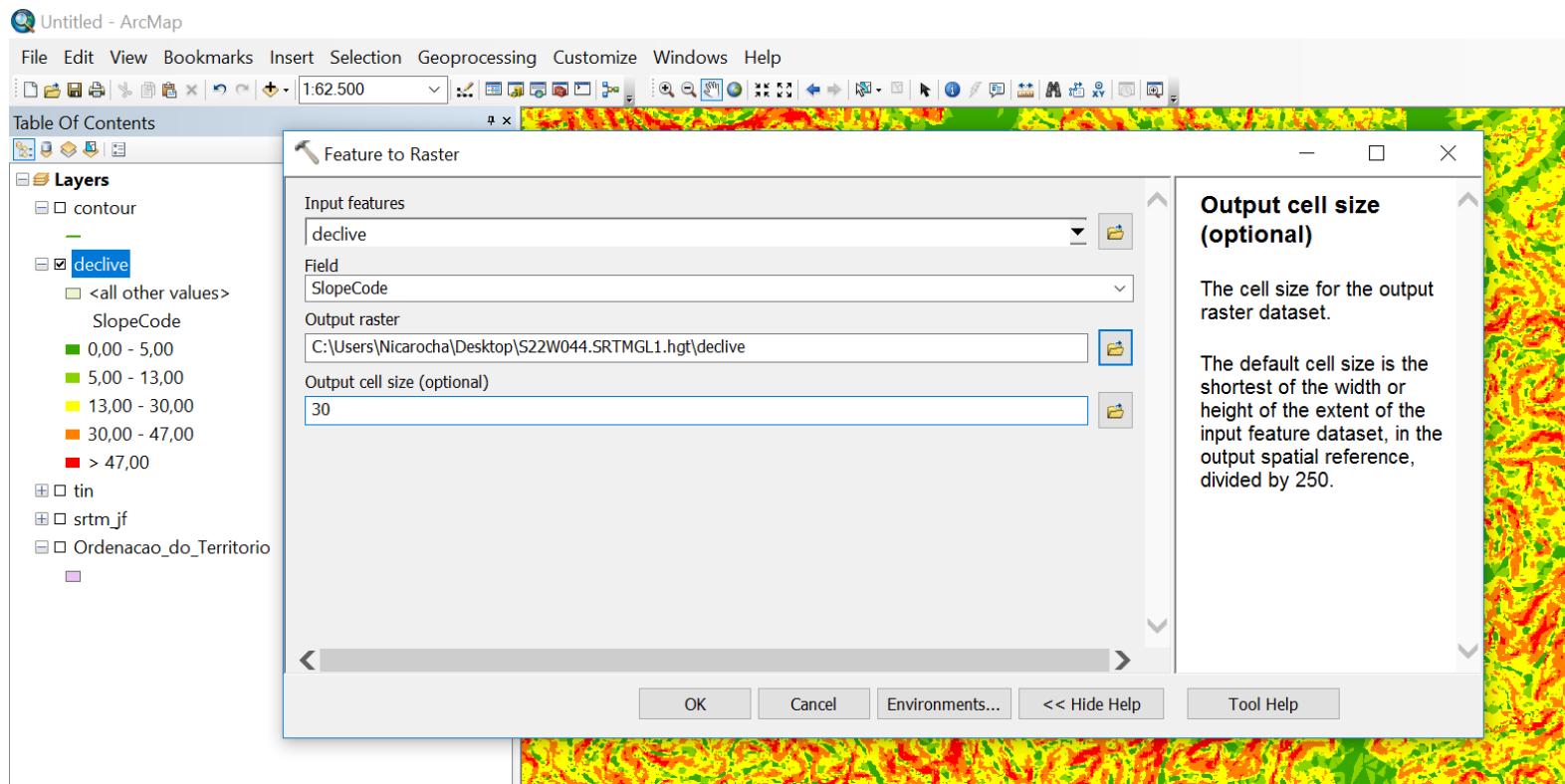


Result of the Slope according to Brazilian Laws:

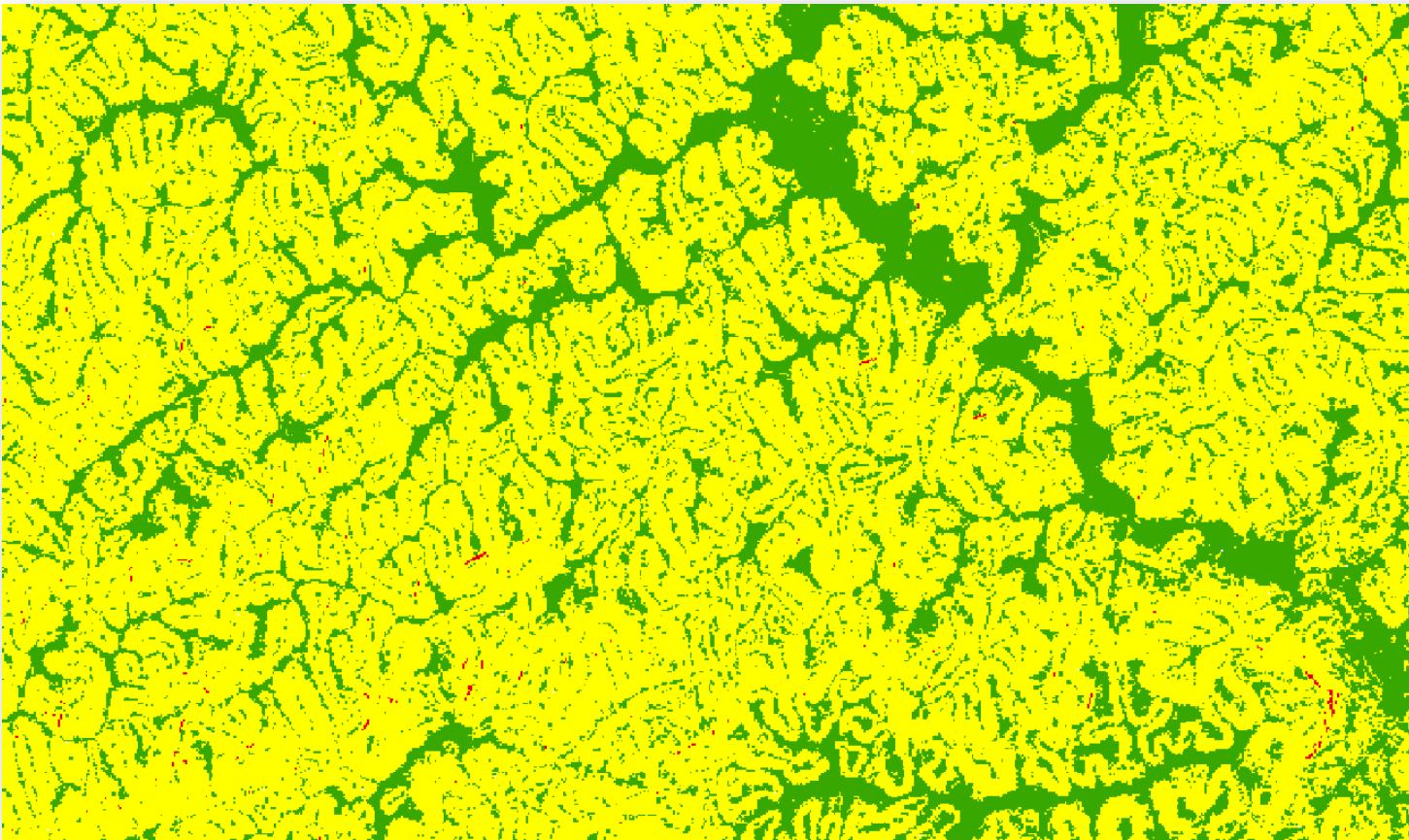


To compose the raster map with the 5 classes of slope.

- 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

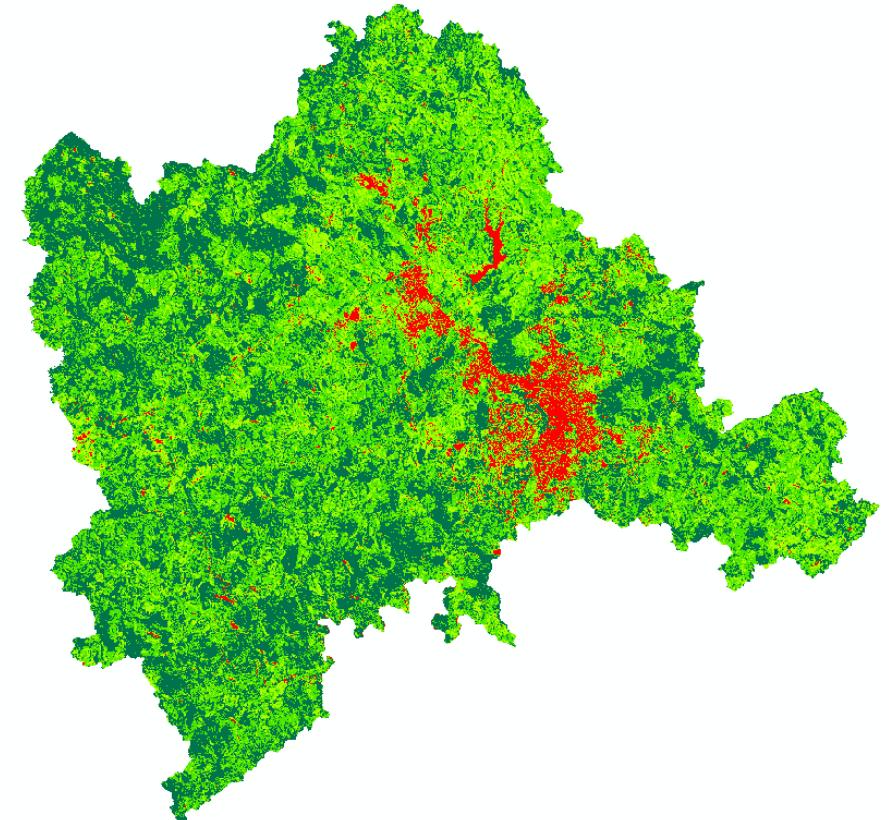


- 1 0,00 - 13,00 - allowed to mechanized agriculture
- 2 13,00 - 100,00 - family farming
- 3 > 100,00 - Permanent protection Area

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

Hydrologic map
to be considered according to the decision of researcher or
local conditions

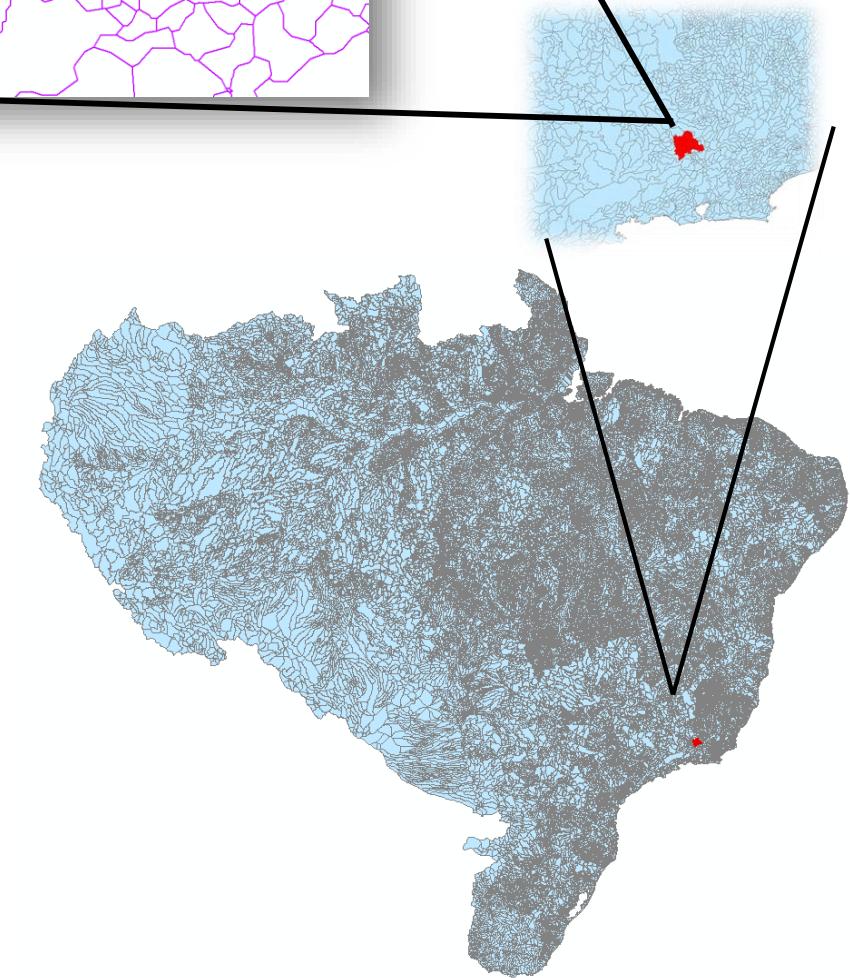
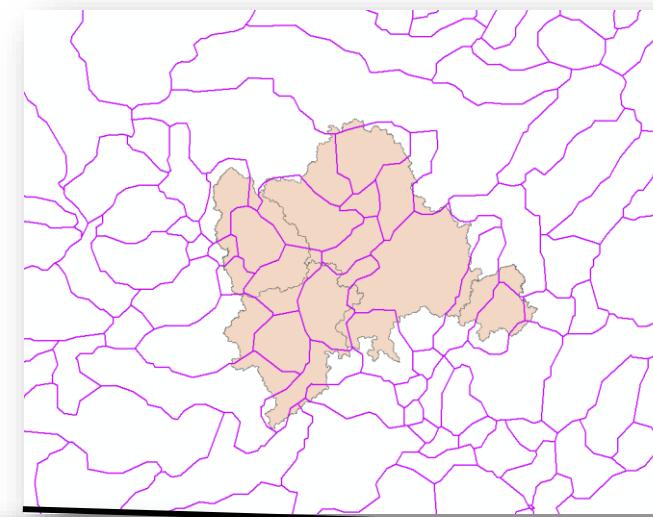
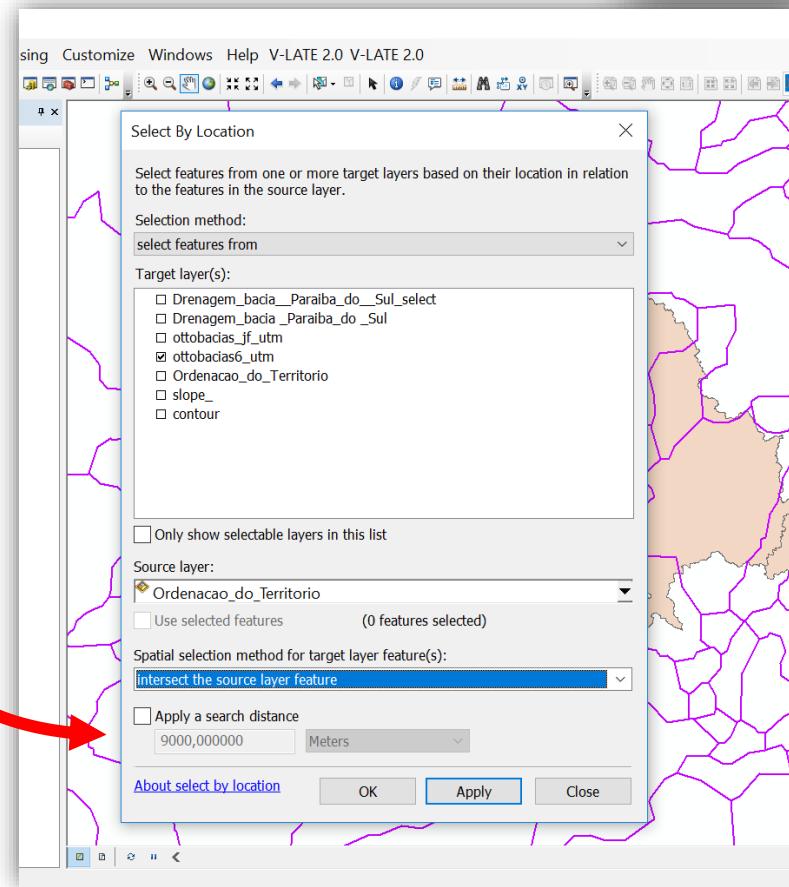
If the country has an open source data base that provides polylines of rivers and polygons of watershed:

E.g. In Brazil: To use the open source data from ANA (*Agência Nacional das Águas* (National Water Agency))

- Polygons of Watershed “Ottobacias” level 6 (ANA):
 - <http://www.ana.gov.br/bibliotecavirtual/solicitacaoBaseDados.asp>
- Polylines of rivers from “Paraíba do Sul” (case study):
 - <http://metadados.ana.gov.br/geonetwork/srv/pt/main.home>
 - <http://metadados.ana.gov.br/geonetwork/srv/pt/metadata.show?id=121&currTab=distribution>
- Just in case: if the country doesn’t’ have a data base infrastructure if this information we suggest the user to construction watersheds and rivers from SRTM
 - <http://geopoea.arq.ufmg.br/+/dmFront/downloadContent?u=eyJtZWRpYV9pZCI6IjQwNyIsInRpbWVzdGFtcCI6MTUwNzAwMTE5NH0%3D>
 - <http://support.esri.com/en/technical-article/000012346>

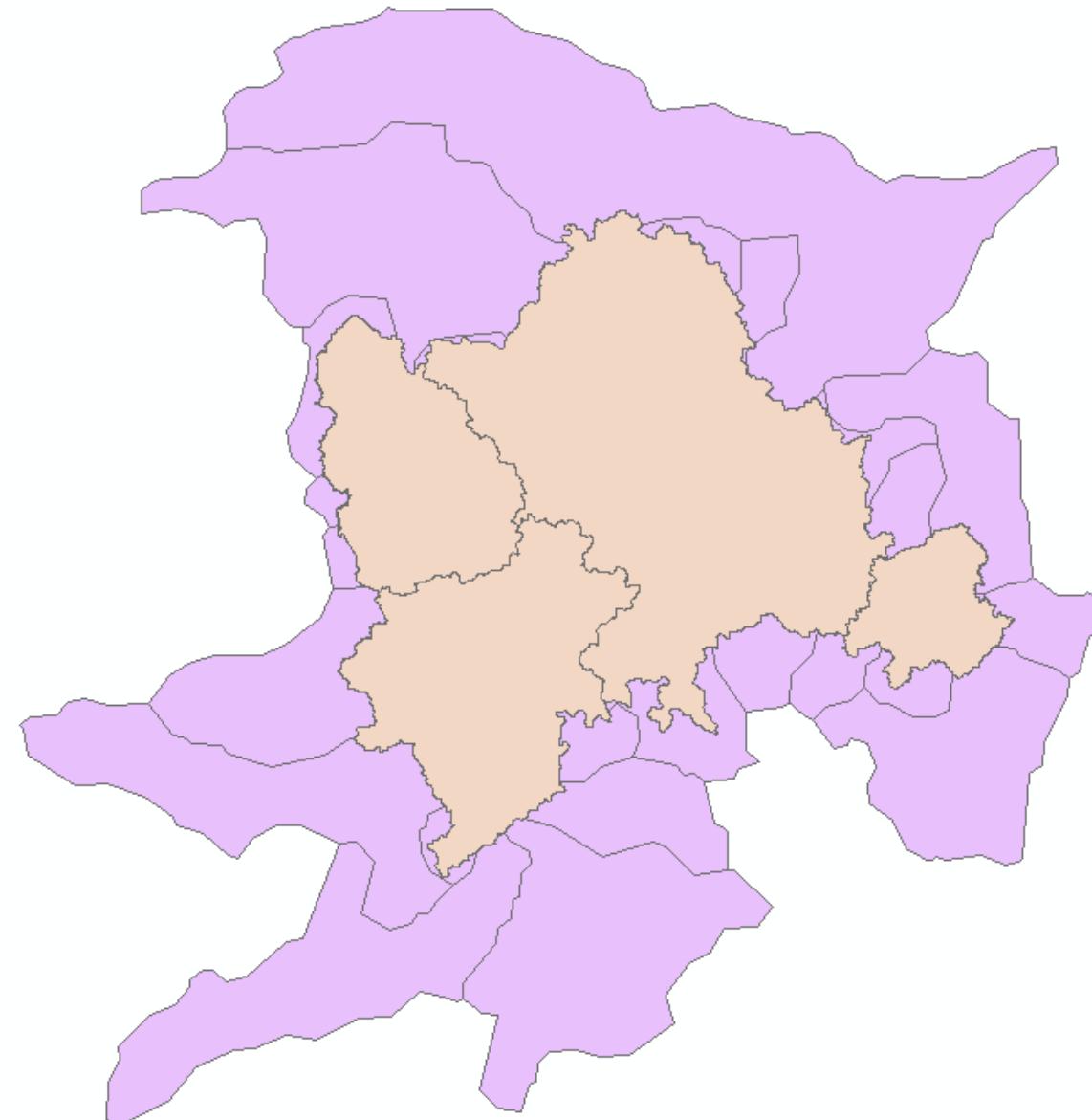
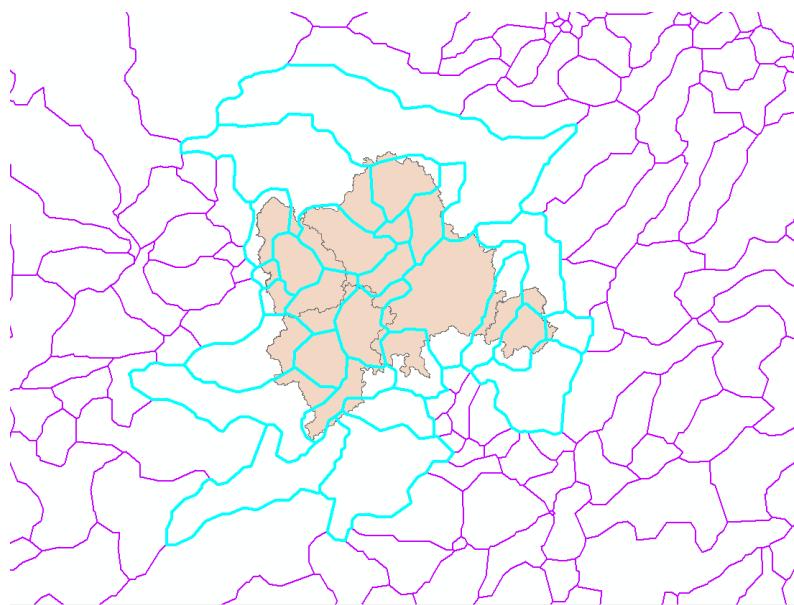
Download of watershed

- We downloaded Brazilian data and selected all the watershed from municipality of Juiz de Fora (case study).
- After that, we need select the watershed that supply the city (using select by tool “select by location”)



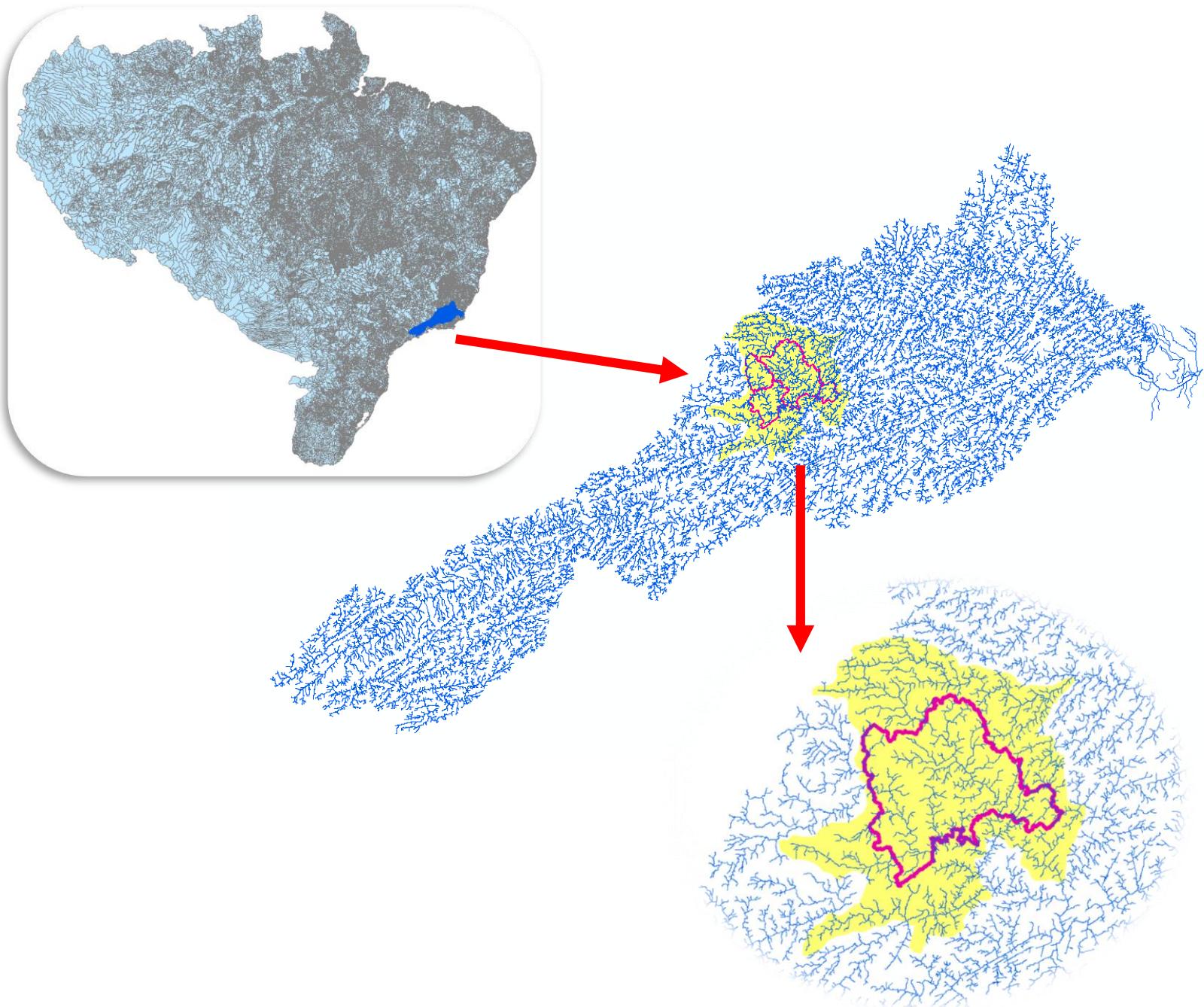
Selection of watershed

- The selection of watershed must avoid to cut the polygons in the line of the municipality, and must choose all the polygons that are inside or are touched by the boundary line (selection by location: inside and interception)

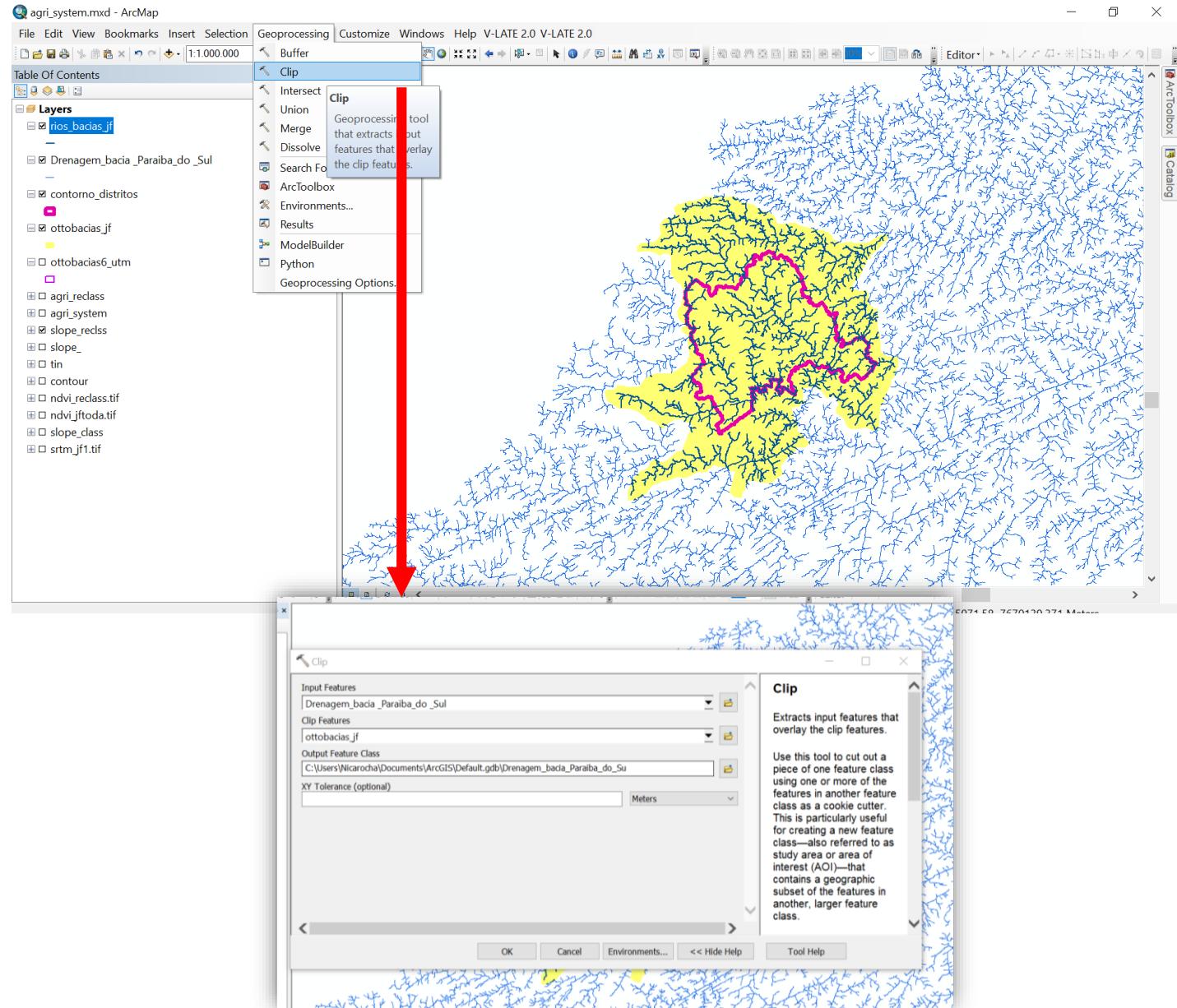


Download of rivers

- We downloaded Brazilian data and selected all the rivers from municipality of Juiz de Fora (case study)
- The rivers are selected according to the limits of watershed and not only to the boundary of the municipality

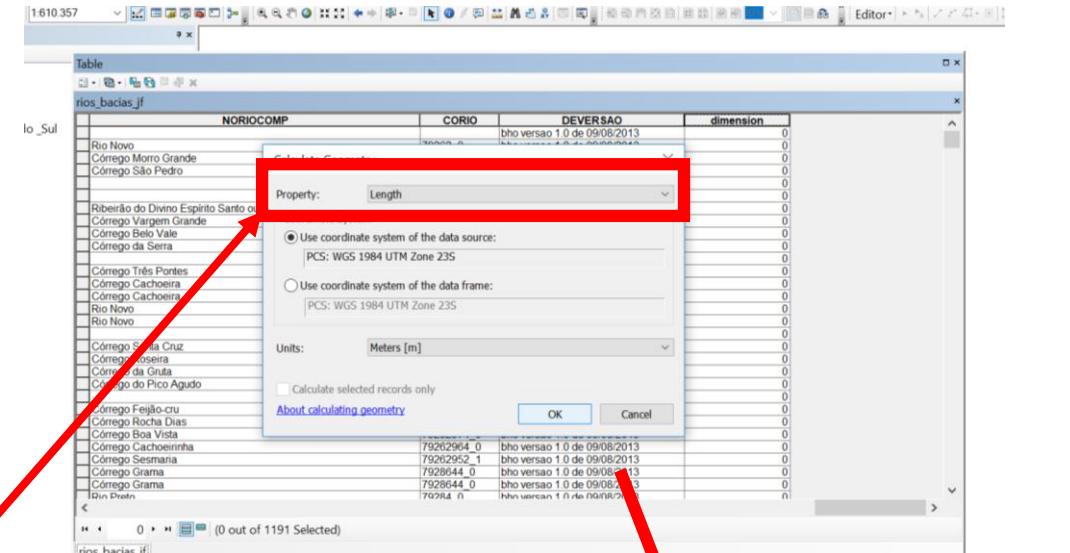
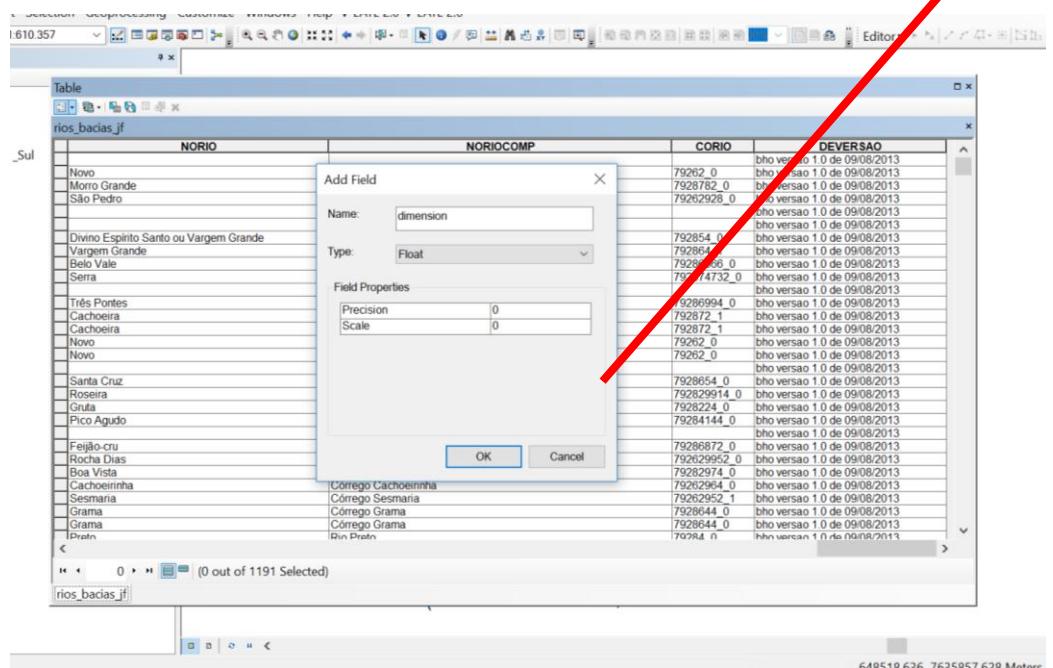


- Now, we need cut the polylines of rivers using the tool “clip”



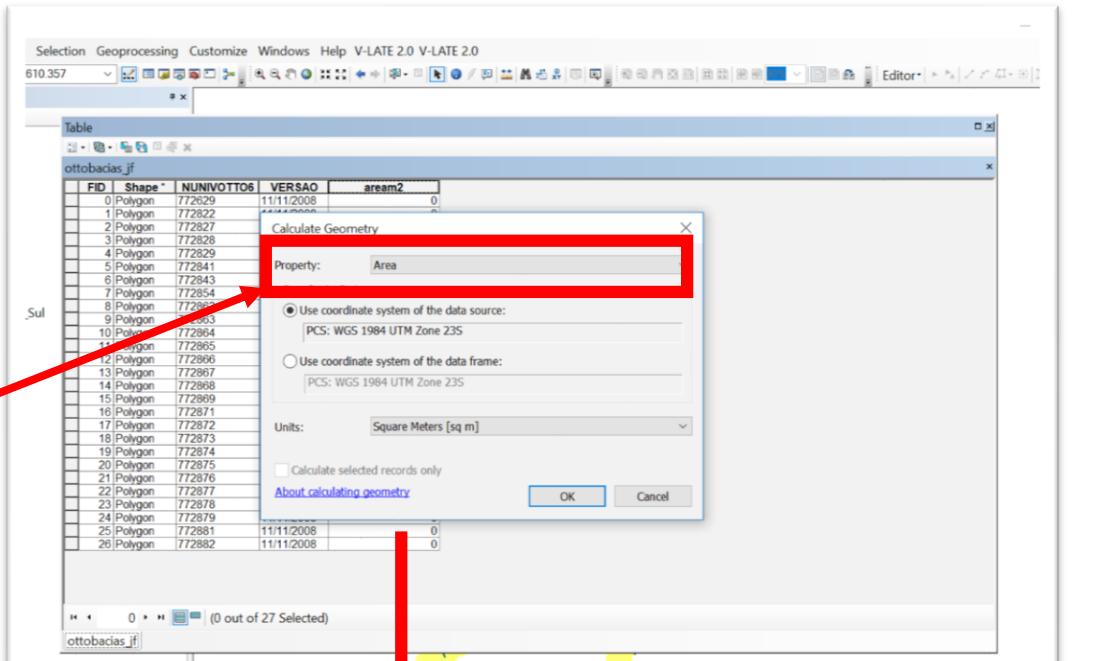
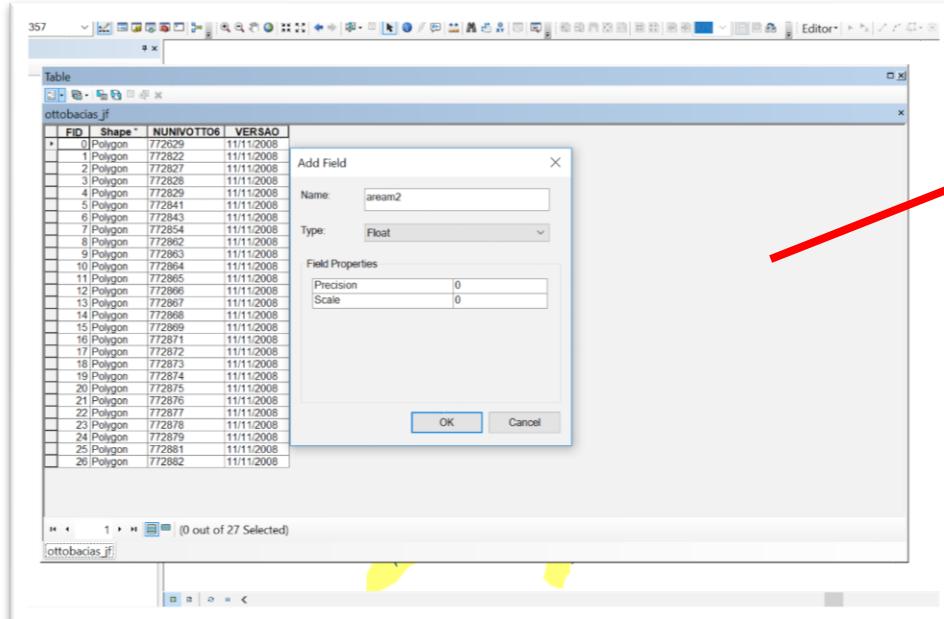
Treating the polylines of rivers

- Go to “open attribute table”
- Add the field, in this case we called “dimension” to obtain the length of each drain run – type: float
- After that, click on the new field created and select the “calculate geometry” to have the result



NORIO	NORIOCOMP	CORIO	DEVERSAO	dimension		
Novo		79262_0	bho versao 1.0 de 09/08/2013	1437.7		
Morro Grande		7928782_0	bho versao 1.0 de 09/08/2013	1298.49		
São Pedro		79282928_0	bho versao 1.0 de 09/08/2013	2629.1		
Ribeirão do Divino Espírito Santo ou Vargem Grande		792854_0	bho versao 1.0 de 09/08/2013	2871.94		
Vargem Grande		792864_0	bho versao 1.0 de 09/08/2013	285.764		
Belo Vale		792865_0	bho versao 1.0 de 09/08/2013	175.02		
Serra		7928672_0	bho versao 1.0 de 09/08/2013	1340.51		
Três Pontes		7928694_0	bho versao 1.0 de 09/08/2013	3036.7		
Cachoeira		792871_0	bho versao 1.0 de 09/08/2013	1282.52		
Cachoeira		792871_1	bho versao 1.0 de 09/08/2013	1762.07		
Novo		792872_0	bho versao 1.0 de 09/08/2013	124.07		
Novo		792872_0	bho versao 1.0 de 09/08/2013	1578.59		
Santa Cruz		7928654_0	bho versao 1.0 de 09/08/2013	853.26		
Roseira		792829914_0	bho versao 1.0 de 09/08/2013	585.777		
Gruta		7928224_0	bho versao 1.0 de 09/08/2013	725.779		
Pico Agudo		79284144_0	bho versao 1.0 de 09/08/2013	246.34		
Feijão-cru		79286872_0	bho versao 1.0 de 09/08/2013	2134.9		
Rocha Dias		792829952_0	bho versao 1.0 de 09/08/2013	7928224_0	bho versao 1.0 de 09/08/2013	1509.9
Boa Vista		79282974_0	bho versao 1.0 de 09/08/2013	7928224_0	bho versao 1.0 de 09/08/2013	204.65
Cachoeirinha	Córrego Cachoeirinha	79282964_0	bho versao 1.0 de 09/08/2013	7928224_0	bho versao 1.0 de 09/08/2013	3445.03
Sesmaria	Córrego Sesmaria	79282952_1	bho versao 1.0 de 09/08/2013	7928224_0	bho versao 1.0 de 09/08/2013	1027.87
Grama	Córrego Grama	7928644_0	bho versao 1.0 de 09/08/2013	7928224_0	bho versao 1.0 de 09/08/2013	3043.66
Grama	Córrego Grama	7928644_0	bho versao 1.0 de 09/08/2013	7928224_0	bho versao 1.0 de 09/08/2013	721.42
Pratin		7074_0	hhn versao 1.0 de 09/08/2013			

Treating the Polygons of Watershed



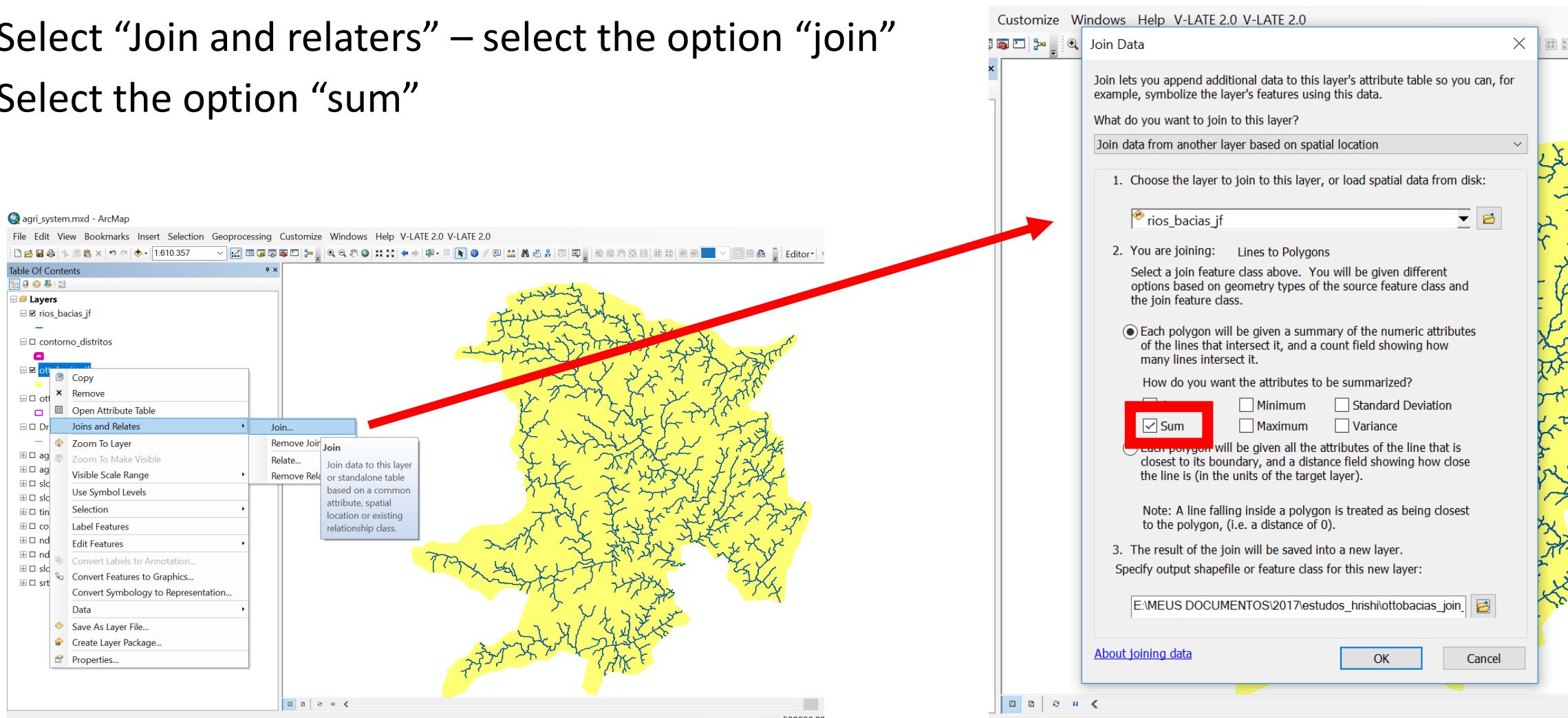
The screenshot shows the ArcGIS application interface with a table window titled 'ottobacias.jf'. The table includes columns 'FID', 'Shape *', 'NUNIVOTTO6', 'VERSAO', and 'aream2'. The 'aream2' column now contains numerical values representing the area of each polygon. A red box highlights the 'aream2' column. A red arrow points from the 'aream2' field in the table below to the 'aream2' field in the table above.

FID	Shape *	NUNIVOTTO6	VERSAO	aream2
0	Polygon	772629	11/11/2008	740196000
1	Polygon	772822	11/11/2008	196608000
2	Polygon	772827	11/11/2008	47944600
3	Polygon	772828	11/11/2008	71877400
4	Polygon	772829	11/11/2008	151039000
5	Polygon	772841	11/11/2008	290947000
6	Polygon	772843	11/11/2008	261597000
7	Polygon	772854	11/11/2008	93609800
8	Polygon	772863	11/11/2008	110156000
9	Polygon	772864	11/11/2008	320760000
10	Polygon	772865	11/11/2008	96645200
11	Polygon	772866	11/11/2008	51834800
12	Polygon	772867	11/11/2008	142969000
13	Polygon	772868	11/11/2008	24653100
14	Polygon	772869	11/11/2008	104985000
15	Polygon	772870	11/11/2008	396907000
16	Polygon	772871	11/11/2008	102362000
17	Polygon	772872	11/11/2008	115509000
18	Polygon	772873	11/11/2008	93353900
19	Polygon	772874	11/11/2008	276525000
20	Polygon	772875	11/11/2008	74825000
21	Polygon	772876	11/11/2008	187122000
22	Polygon	772877	11/11/2008	91539300
23	Polygon	772878	11/11/2008	68854500
24	Polygon	772879	11/11/2008	27834600
25	Polygon	772881	11/11/2008	17962100
26	Polygon	772882	11/11/2008	80410900

- Go to “open attribute table”
- Add the field, in this case we called “aream2” – type: float
- After that, click on the new field created and select the “calculate geometry” to have the result

Join the polylines of rivers and Polygons of Watershed

- Select “Join and relaters” – select the option “join”
- Select the option “sum”



Working with the sum the datas

- After sum the datas, we have the data with area (m^2) + lenght
- Now, we need creat a new field, we called “density”.

The screenshot shows the ArcGIS V-LATE 2.0 interface with two tables and a 'density' field creation dialog.

Table 1: A list of 27 polygons with columns: FID, Shape, rios_bacias_if_FID, NUNIVOTTO6, aream2, and Sum_dimens. The Sum_dimens column contains values such as 446833.997414, 981300.000000, 95888.0604, etc.

FID	Shape	rios_bacias_if_FID	NUNIVOTTO6	aream2	Sum_dimens
0	Polygon	0	772029	740196000	446833.997414
1	Polygon	1	772030	189000000	981300.000000
2	Polygon	2	772827	47944600	95888.0604
3	Polygon	3	772828	71877400	46758.358185
4	Polygon	4	772829	151039000	113975.18858
5	Polygon	5	772841	290947000	162777.83576
6	Polygon	6	772843	261597000	103492.474086
7	Polygon	7	772851	393600000	58842.499865
8	Polygon	8	772852	110156000	3705.59407
9	Polygon	9	772863	320760000	172740.51759
10	Polygon	10	772864	96645200	46484.442139
11	Polygon	11	772865	51834800	41912.562645
12	Polygon	12	772866	142969000	81126.230957
13	Polygon	13	772867	24653100	23177.388749
14	Polygon	14	772868	183600000	38300.13913
15	Polygon	15	772869	396907000	20432.89535
16	Polygon	16	772871	102362000	7465.091324
17	Polygon	17	772872	115509000	70563.331314
18	Polygon	18	772873	9335900	62664.527313
19	Polygon	19	772874	276525000	118040.066742
20	Polygon	20	772875	746522000	46058.499786
21	Polygon	21	772876	18122000	
22	Polygon	22	772877	91539300	
23	Polygon	23	772878	68854500	
24	Polygon	24	772879	27834600	
25	Polygon	25	772881	17962100	
26	Polygon	26	772882	80410900	

Table 2: A list of 27 polygons with columns: FID, Shape, rios_bacias_if_FID, NUNIVOTTO6, aream2, and Sum_dimens. This table is identical to Table 1.

FID	Shape	rios_bacias_if_FID	NUNIVOTTO6	aream2	Sum_dimens
0	Polygon	0	772029	740196000	446833.997414
1	Polygon	1	7726	Add Field	
2	Polygon	2	7726	Name: density	
3	Polygon	3	7726	Type: Float	
4	Polygon	4	7726	Precision: 0	
5	Polygon	5	7726	Scale: 0	
6	Polygon	6	7726		
7	Polygon	7	7726		
8	Polygon	8	7726		
9	Polygon	9	7726		
10	Polygon	10	7726		
11	Polygon	11	7726		
12	Polygon	12	7726		
13	Polygon	13	7726		
14	Polygon	14	7726		
15	Polygon	15	7726		
16	Polygon	16	7726		
17	Polygon	17	7726		
18	Polygon	18	7726		
19	Polygon	19	7726		
20	Polygon	20	7726		
21	Polygon	21	7726		
22	Polygon	22	7726		
23	Polygon	23	7726		
24	Polygon	24	7726		
25	Polygon	25	772881	17962100	12842.190064
26	Polygon	26	772882	80410900	42117.232635

Working with the sum the datas

The screenshot shows the ArcGIS Field Calculator interface. A red arrow points from the text instructions below to the calculator window. Another red box highlights the expression being entered.

In the field "density" Select the command "field calculation" and calculate aream²/sum_dimension

Field Calculator expression:

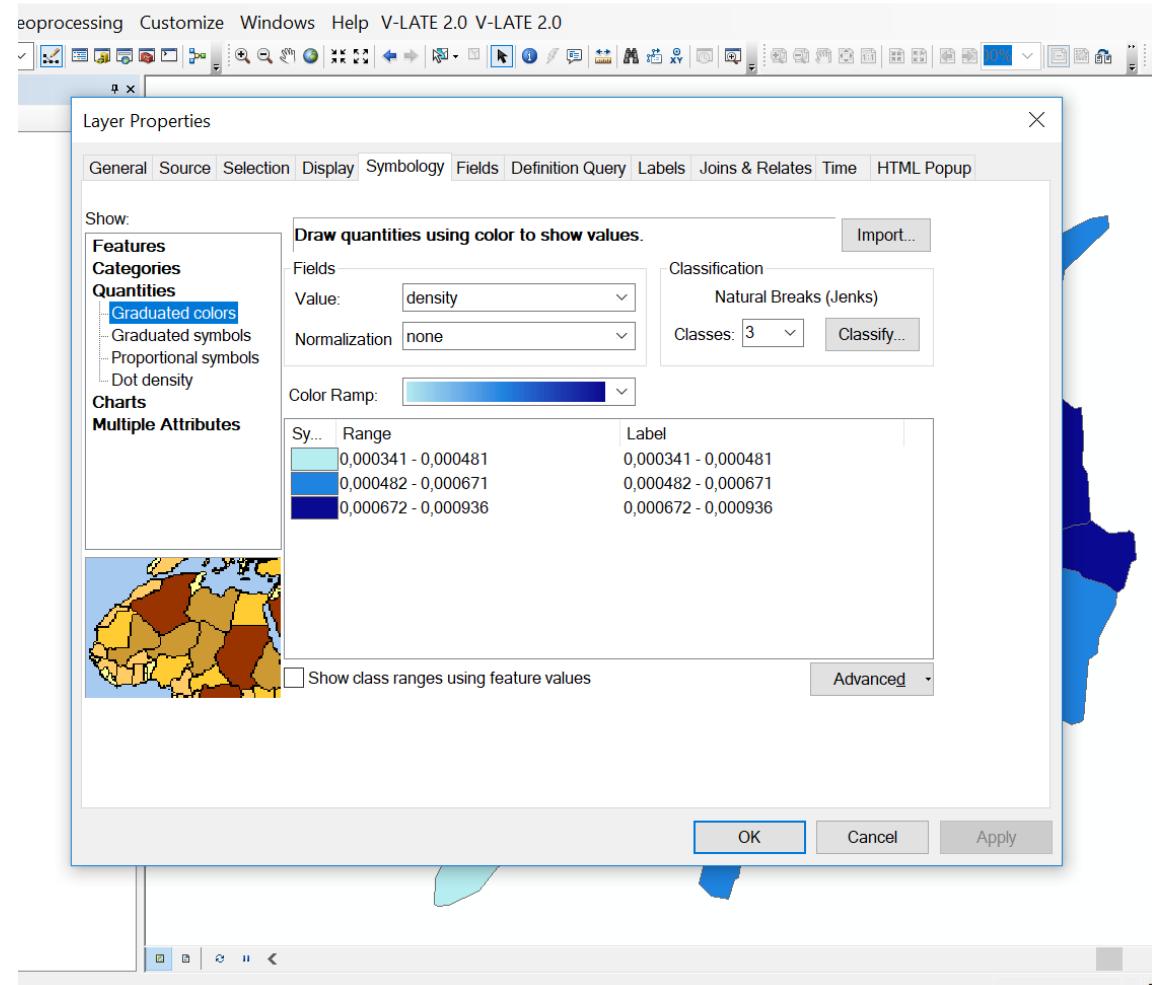
```
[aream2] / [Sum_dimens]
```

Resulting table (density column highlighted with a red box):

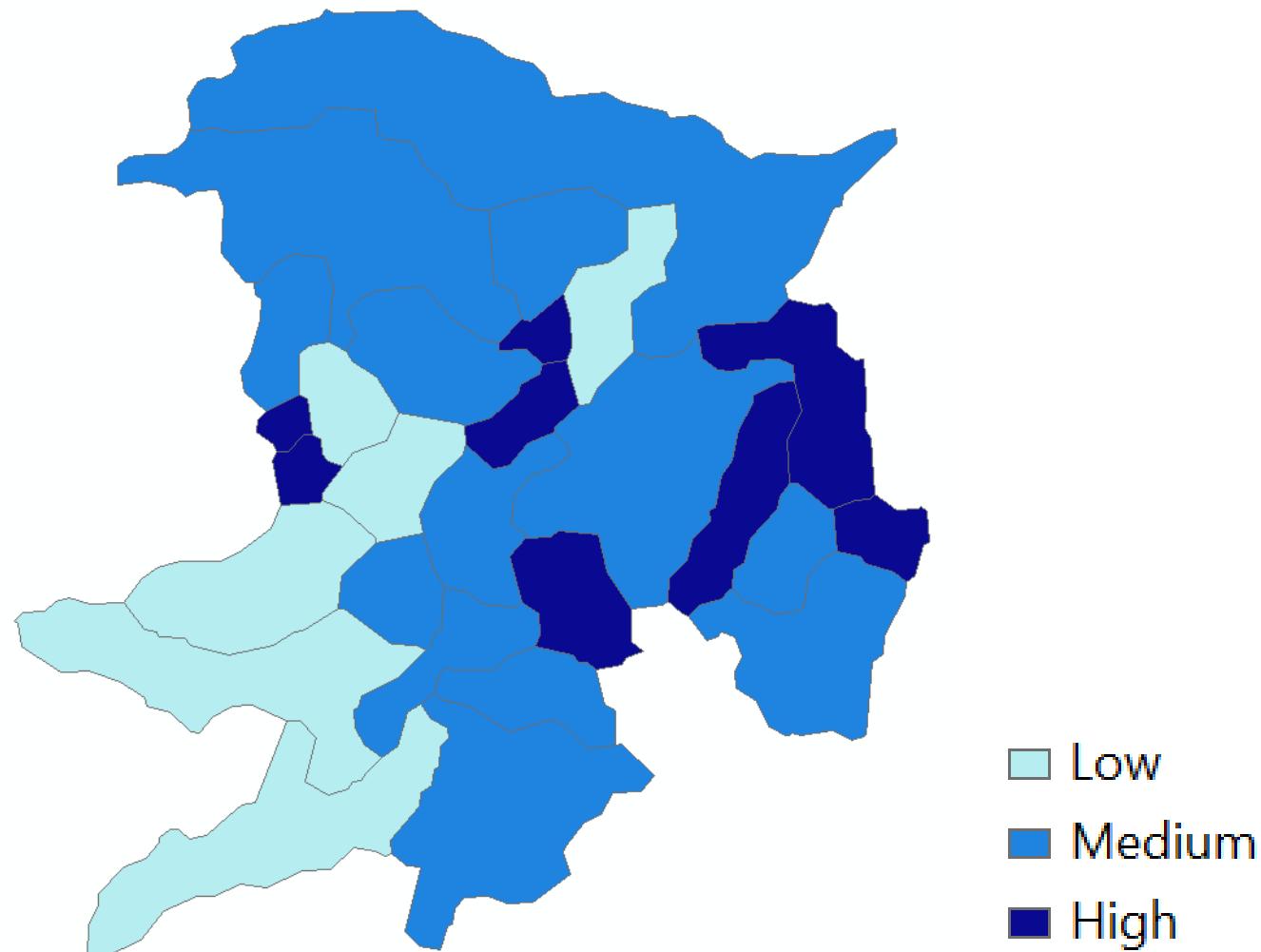
FID	Shape	rios_bacias_if_FID	NUNIVOTTO6	aream2	Sum_dimens	density
0	Polygon	0	772629	7401960000	446833.997414	0.000604
1	Polygon	1	772822	1966080000	99136.536339	0.000504
2	Polygon	2	772827	479446000	35888.06604	0.000749
3	Polygon	3	772828	718774000	46758.358185	0.000629
4	Polygon	4	772829	151039000	113975.118858	0.000535
5	Polygon	5	772841	290947000	162677.835876	0.000611
6	Polygon	6	772843	261597000	103492.474686	0.000567
7	Polygon	7	772854	936098000	58839.240265	0.000625
8	Polygon	8	772862	110156000	87805.59407	0.000635
9	Polygon	9	772863	320760000	172749.517559	0.000535
10	Polygon	10	772864	96645200	46484.442139	0.000539
11	Polygon	11	772865	51834800	41912.562645	0.000615
12	Polygon	12	772866	142969000	81126.230957	0.000609
13	Polygon	13	772867	24653100	23077.386749	0.000567
14	Polygon	14	772868	104985000	53839.685913	0.000535
15	Polygon	15	772869	396907000	207432.895355	0.000539
16	Polygon	16	772871	102362000	74625.091324	0.000539
17	Polygon	17	772872	115509000	70563.331314	0.000527
18	Polygon	18	772873	93353900	62664.527313	0.000527
19	Polygon	19	772874	276525000	118046.066742	0.000427
20	Polygon	20	772875	74825000	46058.499786	0.000616
21	Polygon	21	772876	18712000	65484.338623	0.00035
22	Polygon	22	772877	91539300	40938.935745	0.000447
23	Polygon	23	772878	68854500	23494.249023	0.000341
24	Polygon	24	772879	27834600	23429.437317	0.000842
25	Polygon	25	772881	17962100	12842.190064	0.000715
26	Polygon	26	772882	80410900	42117.232635	0.000524

To produce the Hydrologic density per watershed

- Go to “layer properties”
- In “quantities” select the layer density
- The classification Natural breaks, choose 3 classes: low, medium and high hydrology



Hydrologic density per watershed

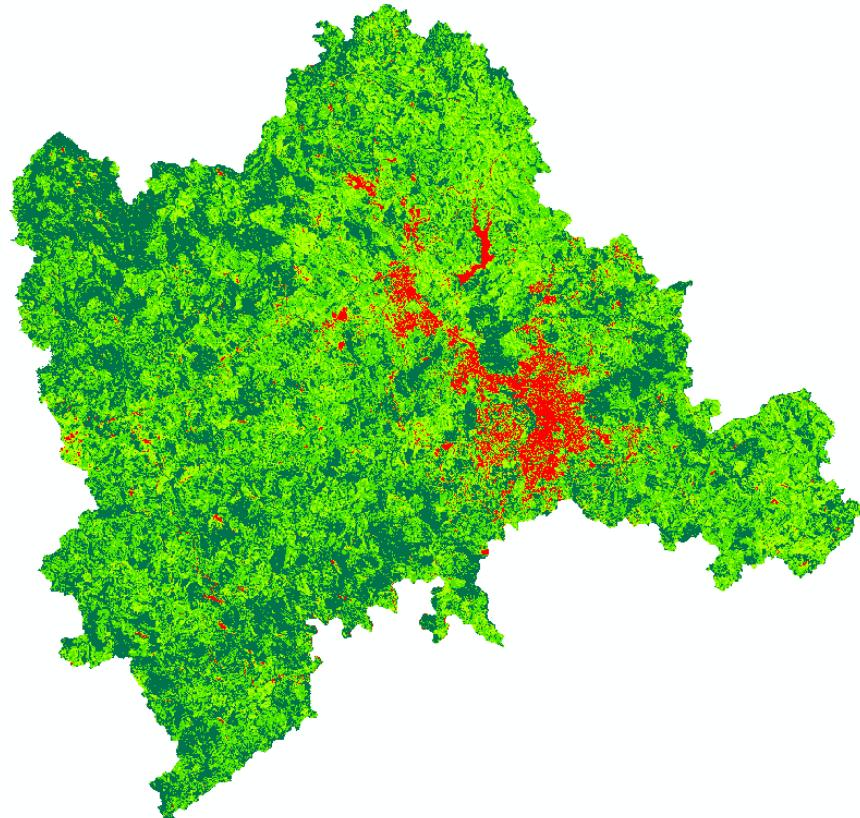


AGRICULTURE and HYDROLOGY SYSTEM MAP

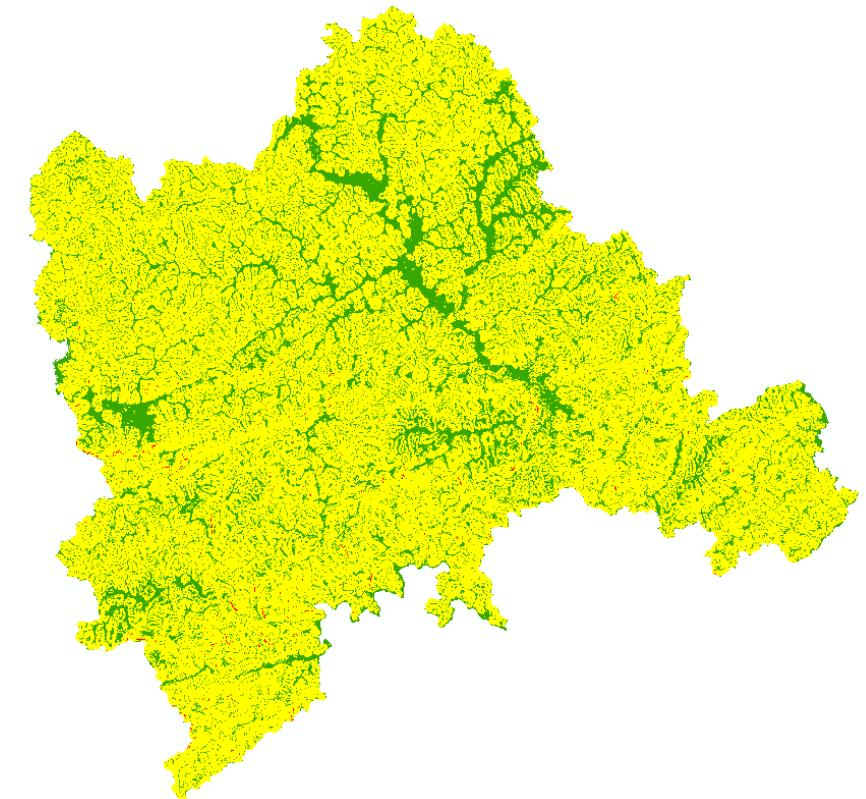
Combinatorial analysis

- To produce the Agriculture map we need the two maps using combinatorial analysis.
- After, add the waterway to identify the water

NDVI MAP



SLOPE MAP - Agriculture



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

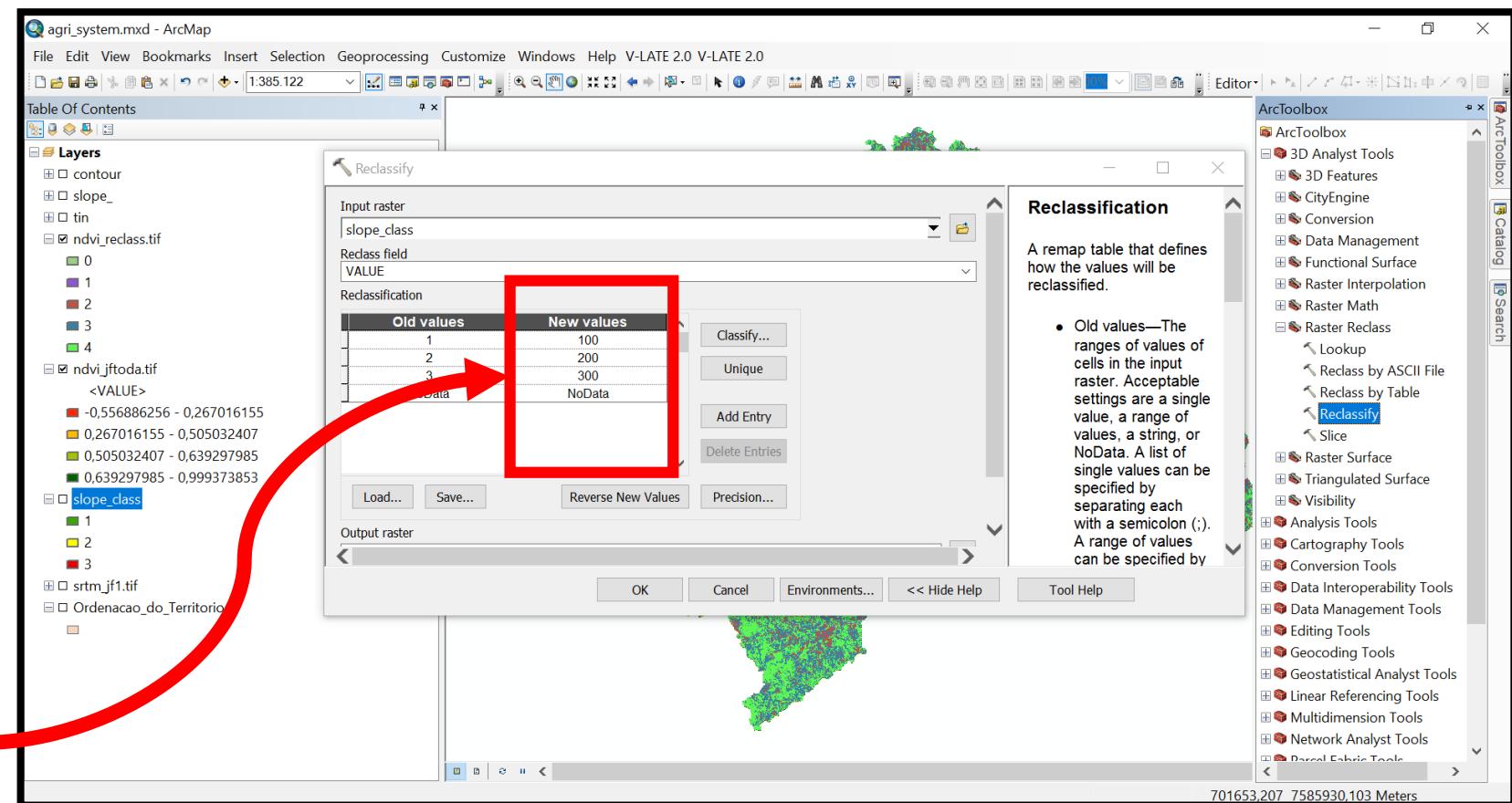
■ 0,00 - 13,00 - allowed to mechanized agriculture
■ 13,00 - 100,00 - family farming
■ > 100,00 - Permanent protection Area

The logic about combinatorial analysis

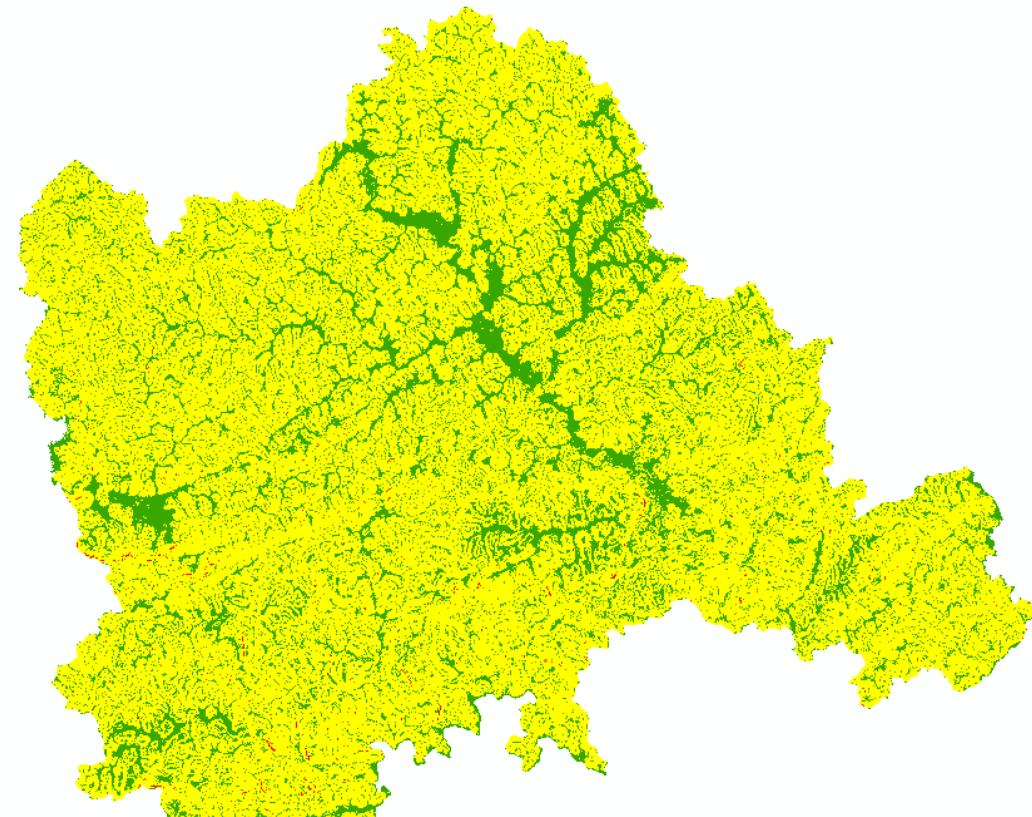
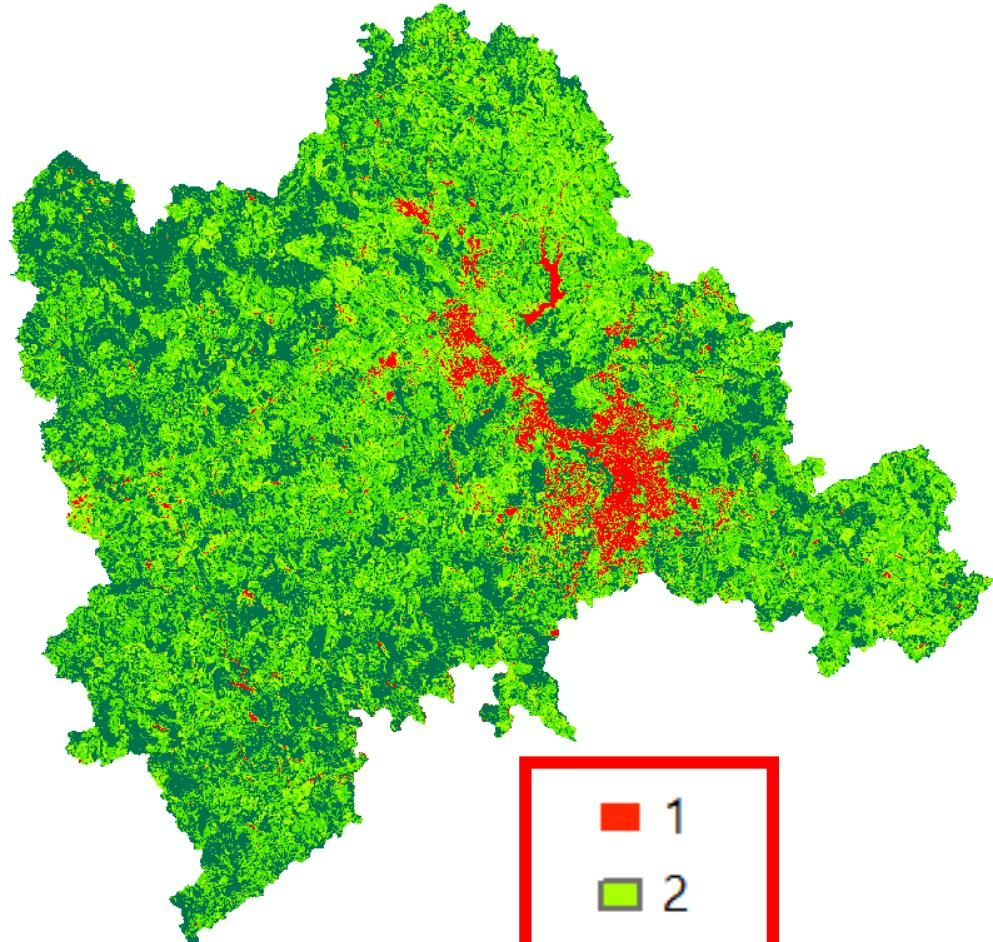
- According Groenwald *et al.* (2009), "*Combinatory Analysis is the part of Mathematics that studies and develops methods for solving problems involving counting or existence, in general, it can be said that it is the part of Mathematics that analyzes discrete structures and relations*".
- The Combinatory 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: Less than 0 to 13% - allowed to mechanized agriculture; From 13 to 100 % family farming ; From 100% Permanent protection Area according to Brazilian's forest code.

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 300 in slope (100, 200, 300), 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

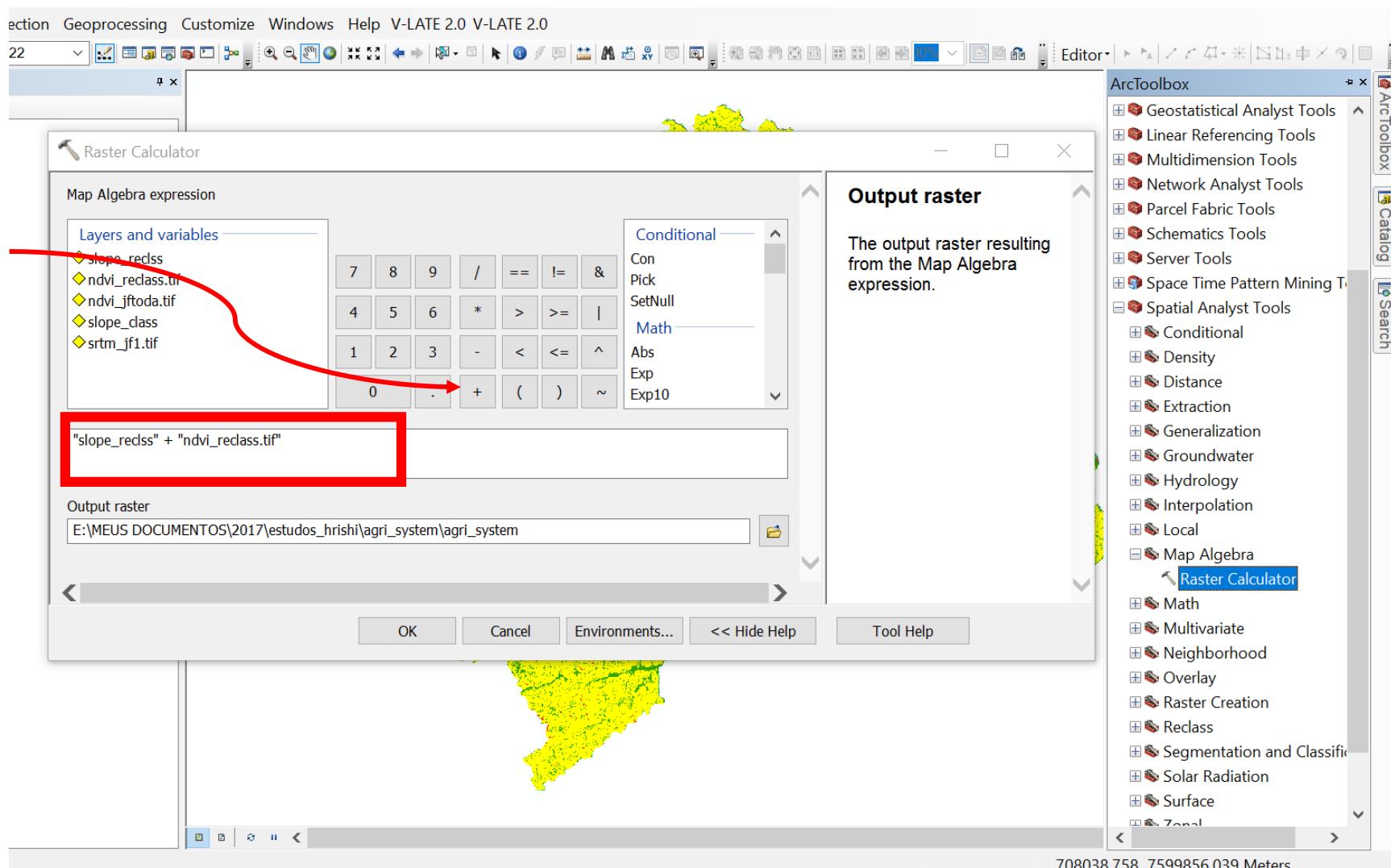


Combinatorial analysis matrix

LAND USE		Impervious areas/ Exposed soil/ water and shadow	Grassy	Shrubby	Robust vegetation
SLOPE		1	2	3	4
0-13 %	100	101	102	103	104
13 -100%	200	201	202	203	204
100%	300	301	302	303	304

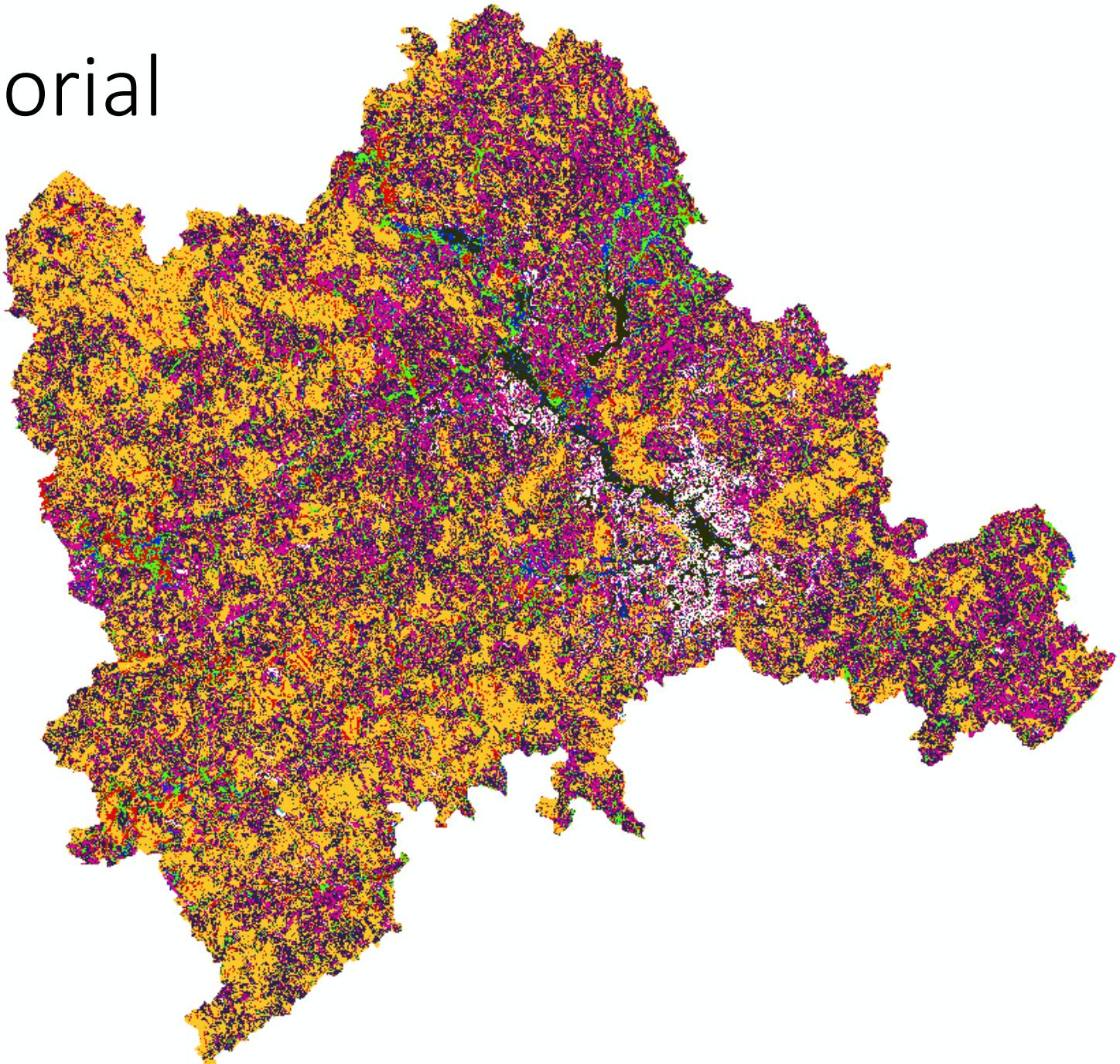
Sum the two maps (slope + land use)

- 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



Interpretation of result of Combinatory Analysis

- Not suitable /inappropriate to agriculture growth: 101, 104, 201, 204, 301, 302, 303, 304.
- Capable to agriculture (specific methods to plant): 102, 103
- Suitable to agriculture growth: 202, 203

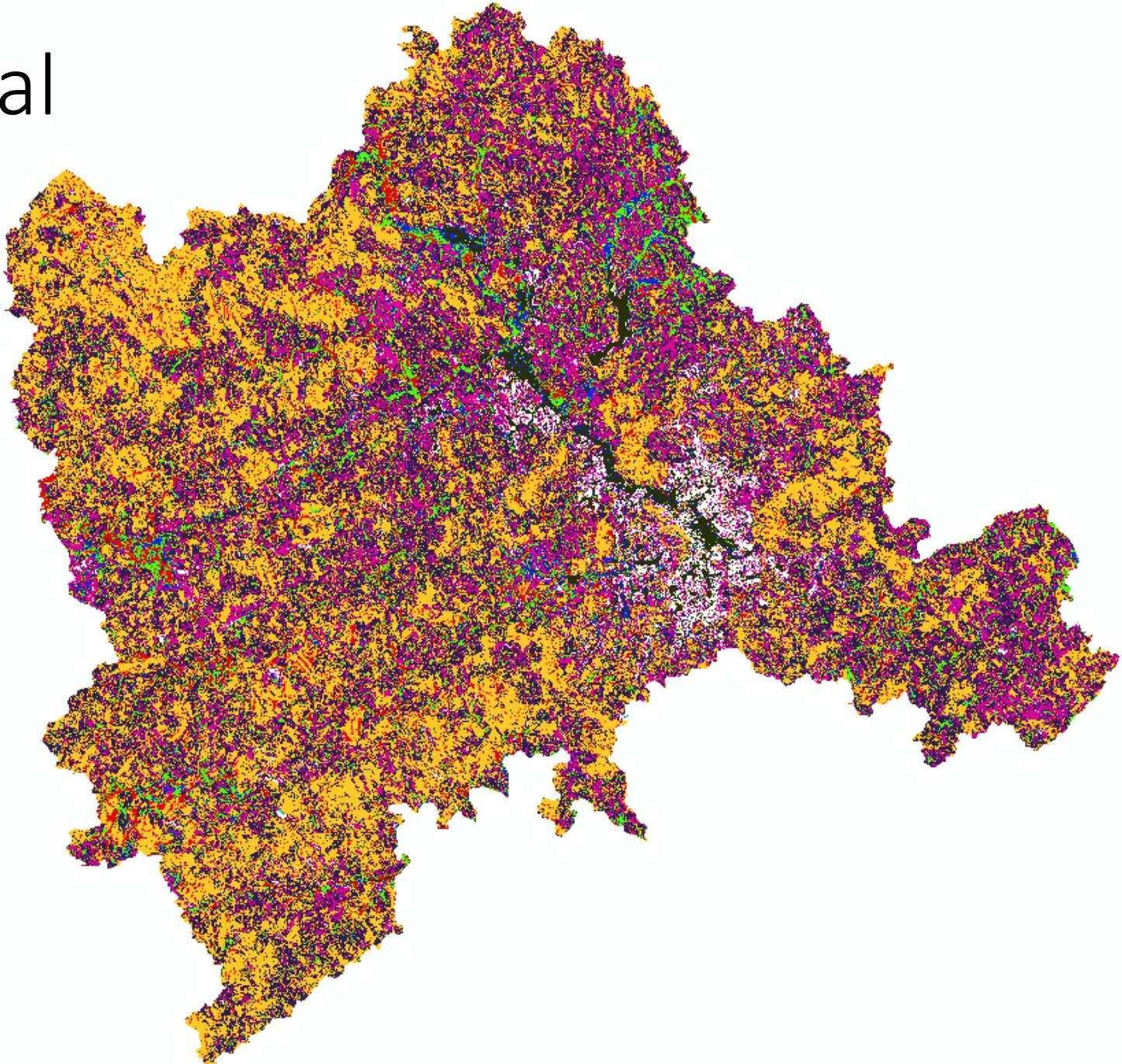
LAND USE SLOPE	Impervious areas/ Exposed soil/ water and shadow	Grassy	Shrubby	Robust vegetation
0-13 %	1 101	2 102	3 103	4 104
13 -100%	200 201	202	203	204
100%	300 301	302	303	304

Interpretation of result of Combinatory Analysis

- AGRI System (considering land use and slope):
 - Not suitable /inappropriate to agriculture growth: 101, 104, 201, 201, 301, 302, 303, 304.
 - Capable to agriculture (specific methods to plant): 102, 103
 - Suitable to agriculture growth: 202, 203

Result combinatorial Analysis

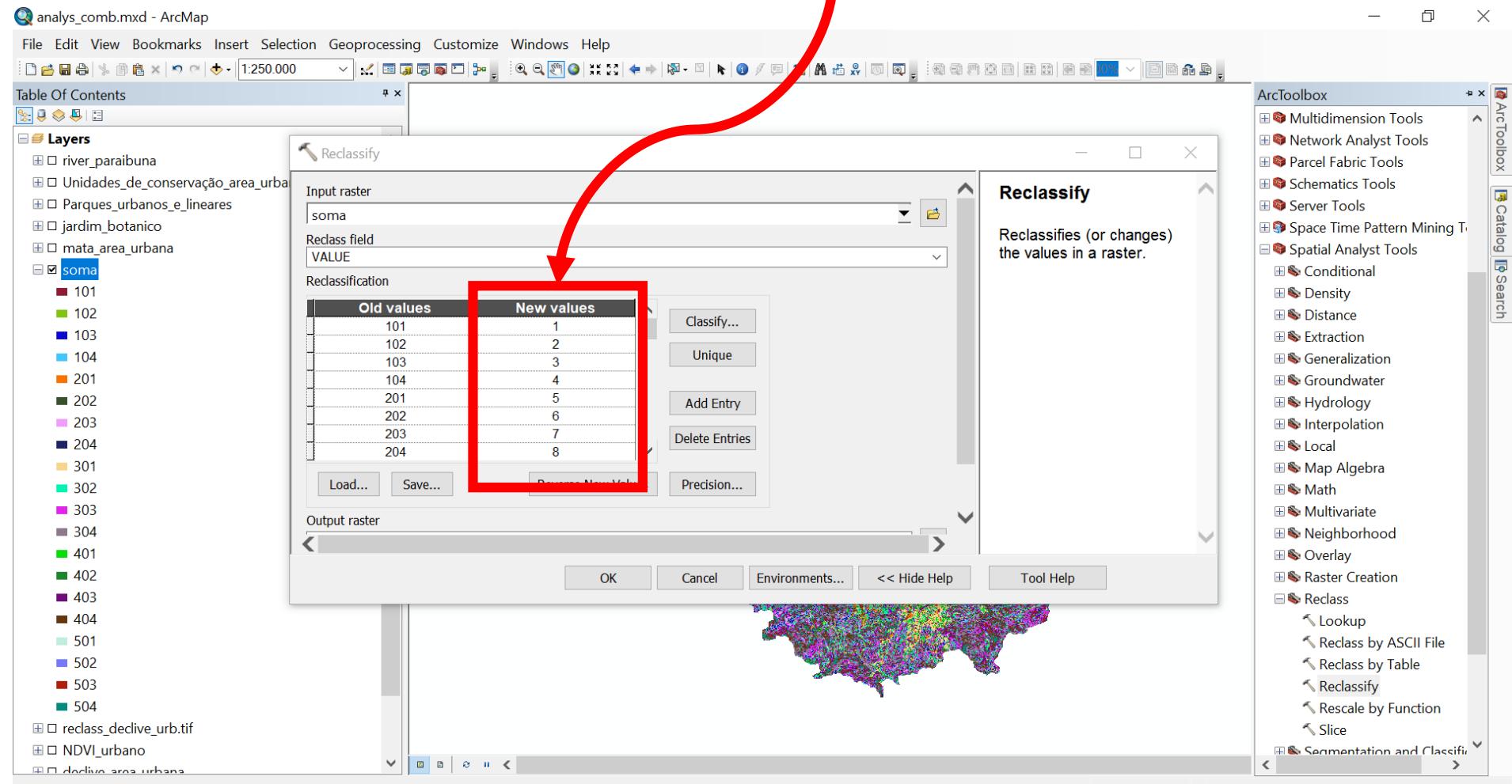
- Not suitable /inappropriate to agriculture growth: 101, 104, 201, 204, 301, 302, 303, 304.
- Capable to agriculture (specific methods to plant): 102, 103
- Suitable to agriculture growth: 202, 203



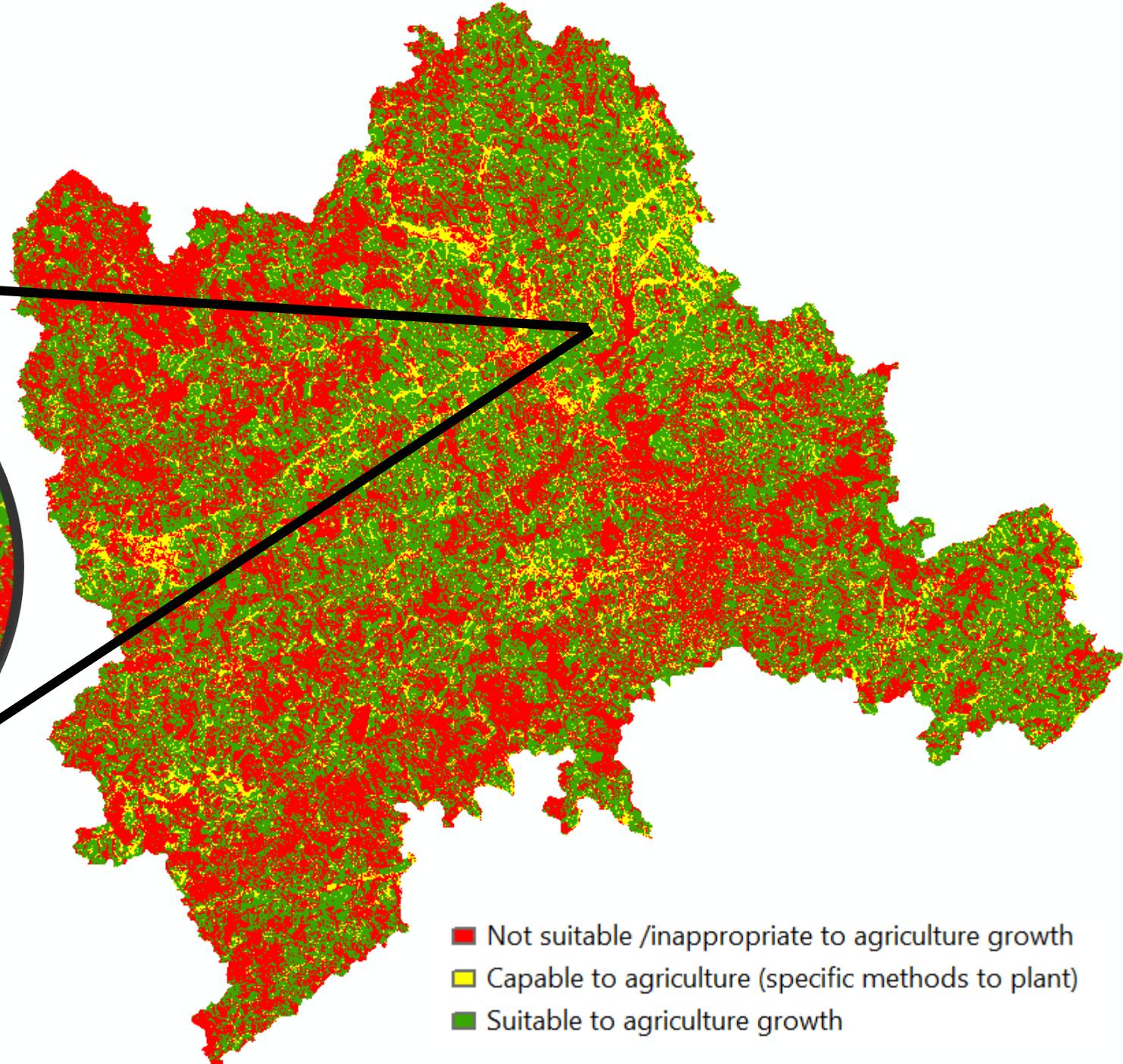
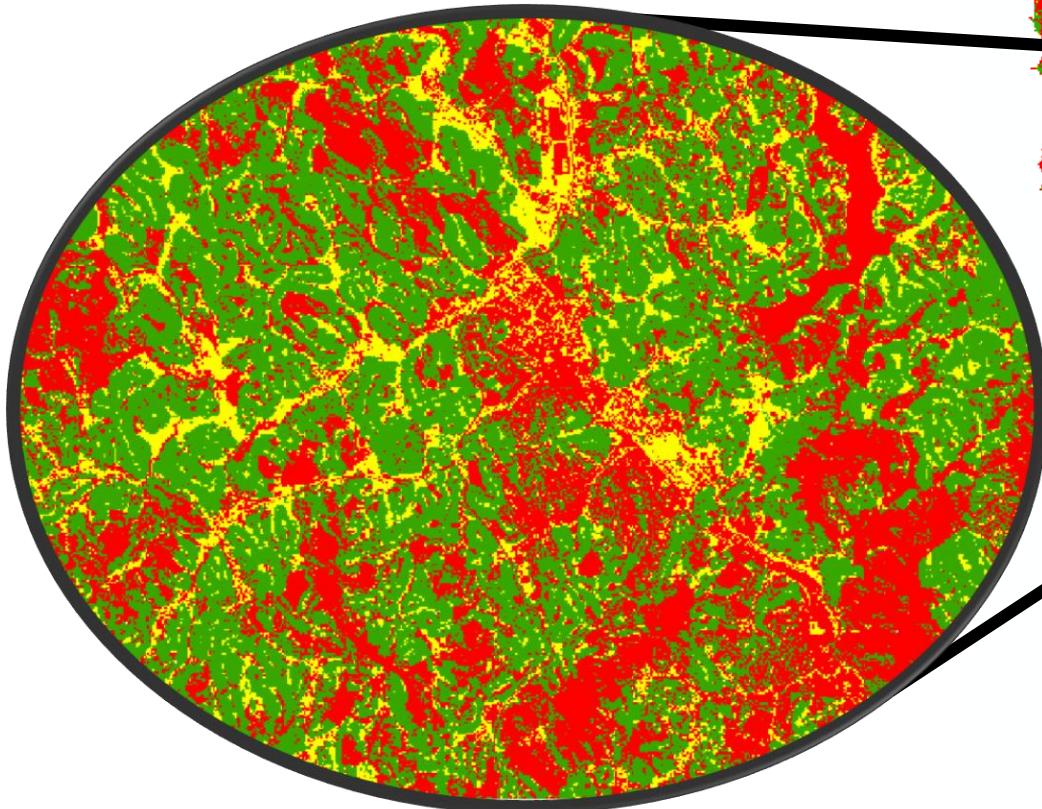
Reclassify the groups

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

RECLASSIFY IN HERE THE NEW VALUES



Result reclass

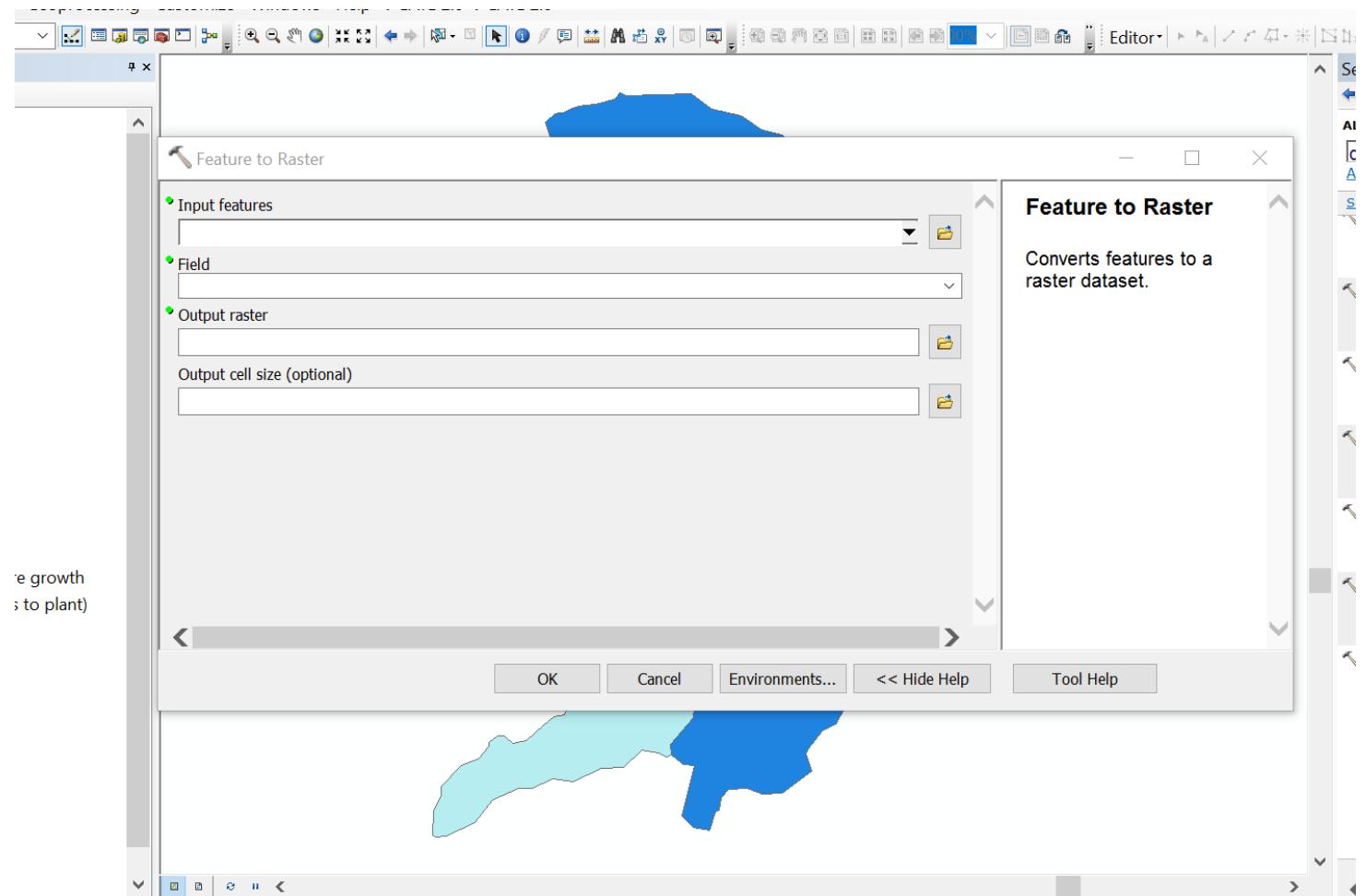


- Not suitable /inappropriate to agriculture growth
- Capable to agriculture (specific methods to plant)
- Suitable to agriculture growth

Add the variable presence of water
to be considered according to the decision of
researcher or local conditions

Preparing the water datas

- The vector was converted to raster using the tool “feature to raster”



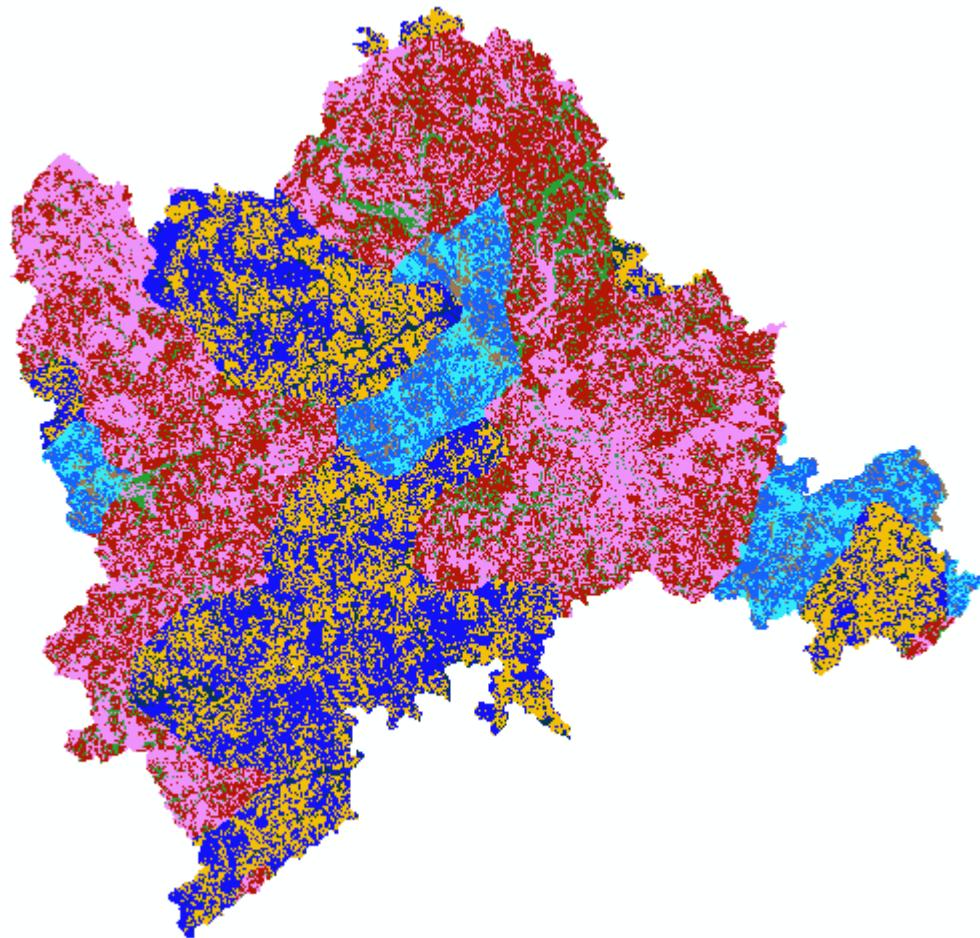
Combinatorial analysis matrix with the variable of water

WATER		Low	Medium	High
SLOPE/ LAND USE		100	200	300
Not suitable	1	101	102	103
Capable	2	201	202	203
Suitable	3	301	302	303

Combinatoryal analysis matrix

- Not suitable /inappropriate to agriculture growth considering water:101, 102, 201.
- Capable to agriculture (specific methods to plant) considering water: 103, 202, 301.
- Suitable to agriculture growth considering water: 203, 302, 303.

- 101
- 102
- 103
- 201
- 202
- 203
- 301
- 302
- 303



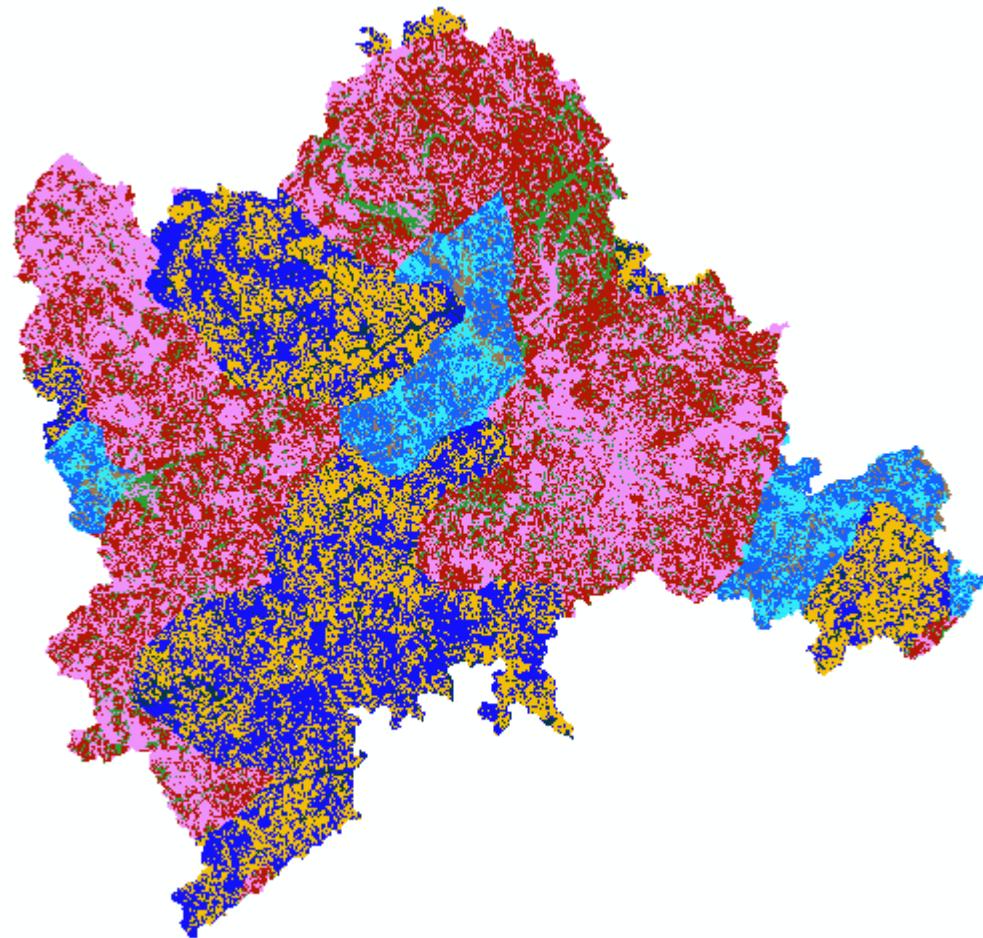
Combinatoryal analysis matrix

- Not suitable /inappropriate to agriculture growth considering water: 101, 102, 201.
- Capable to agriculture (specific methods to plant) considering water: 103, 202, 301.
- Suitable to agriculture growth considering water: 203, 302, 303.

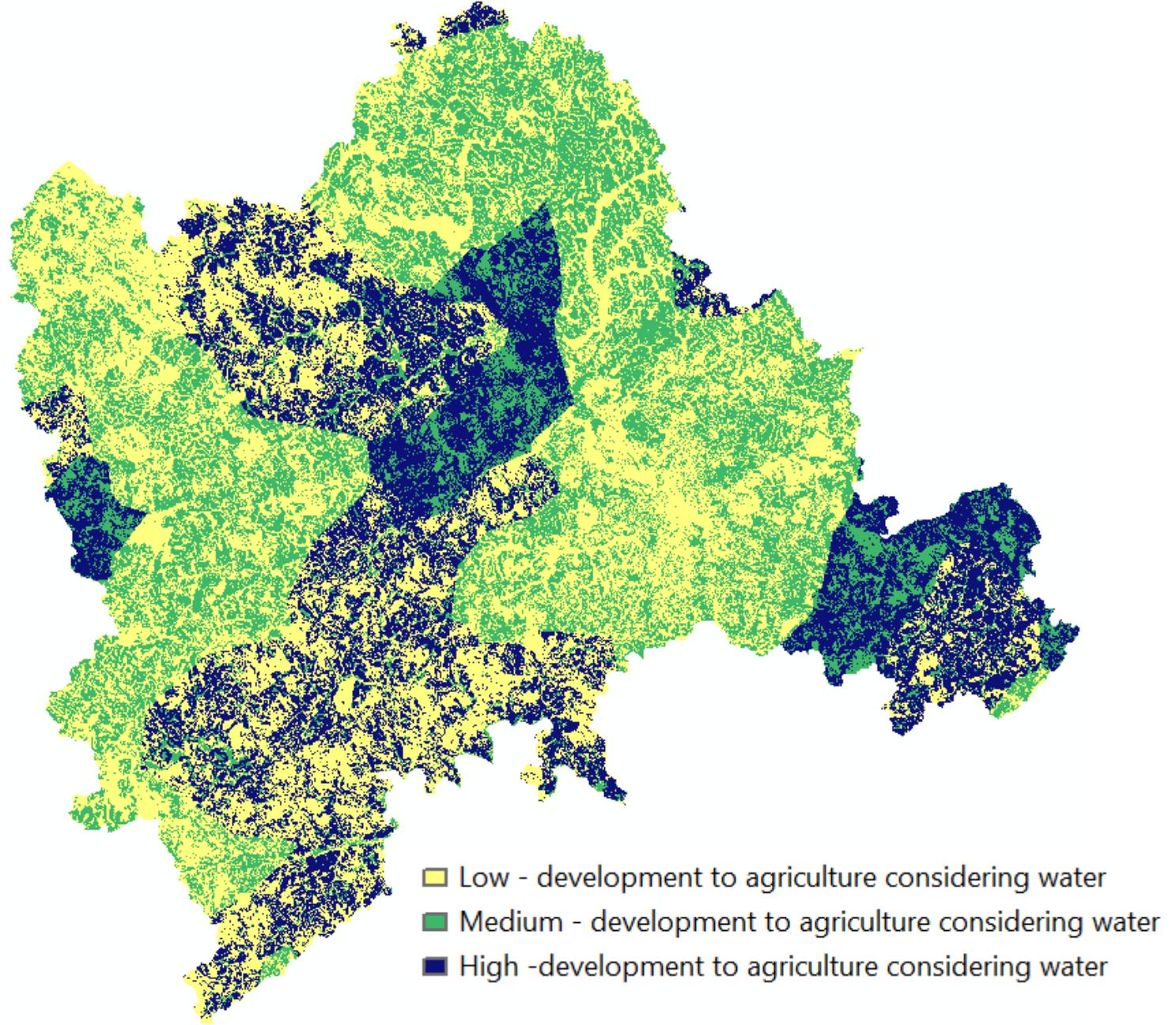
		WATER		
		Low	Medium	High
SLOPE/ LAND USE		100	200	300
Not suitable	1	101	102	103
Capable	2	201	202	203
Suitable	3	301	302	303

Combinatoryal analysis matrix

- Not suitable /inappropriate to agriculture growth considering water:101, 102, 201.
- Capable to agriculture (specific methods to plant) considering water: 103, 202, 301.
- Suitable to agriculture growth considering water: 203, 302, 303.



Result map with variable water

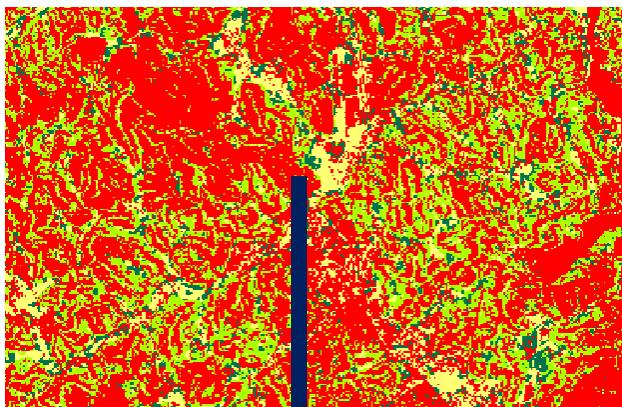


To improve the map visualization

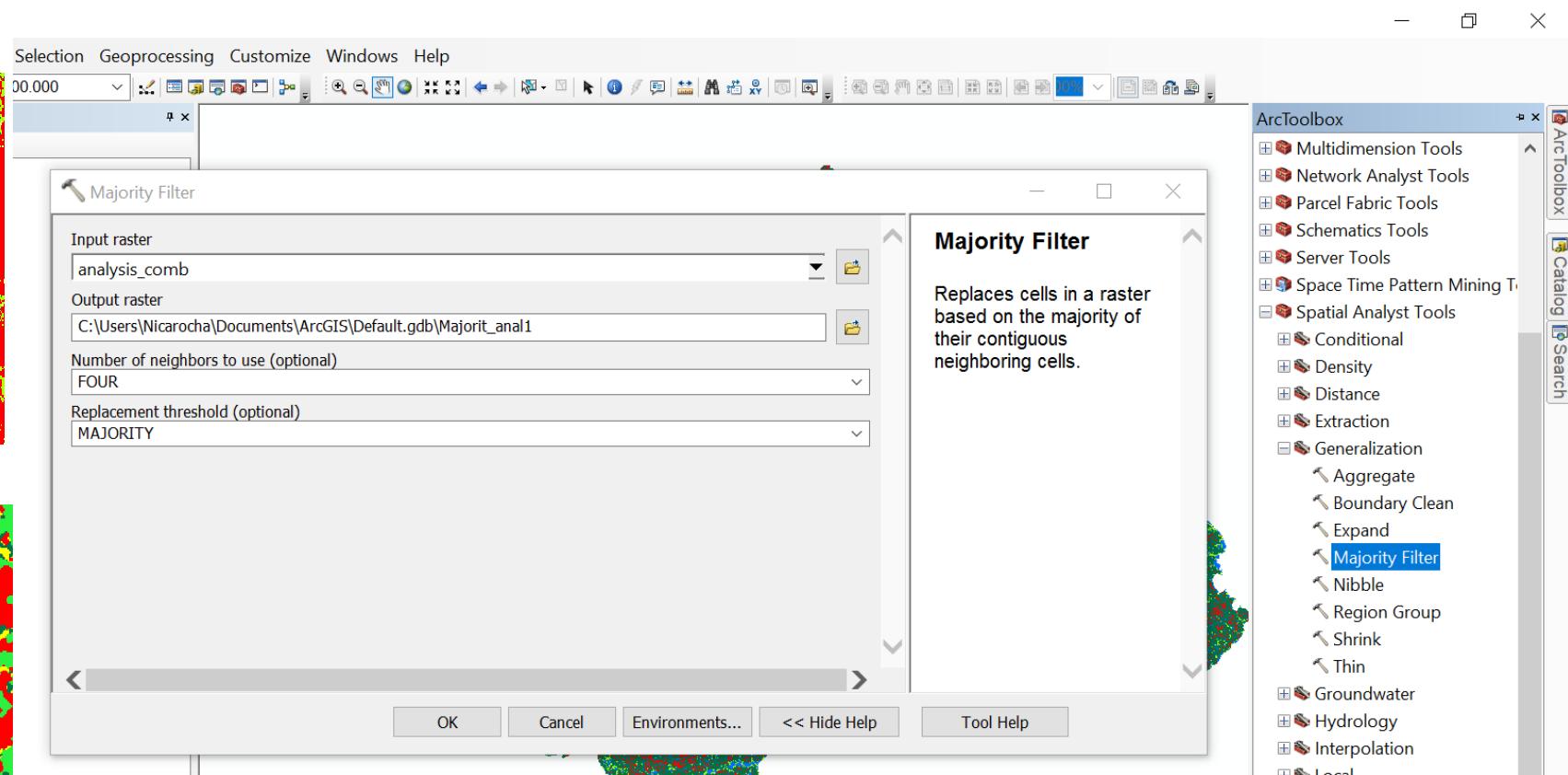
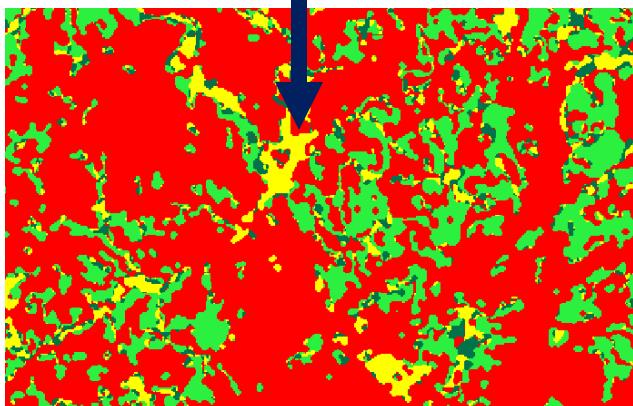
DEVELOPMENTS – to improve the map

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

Before

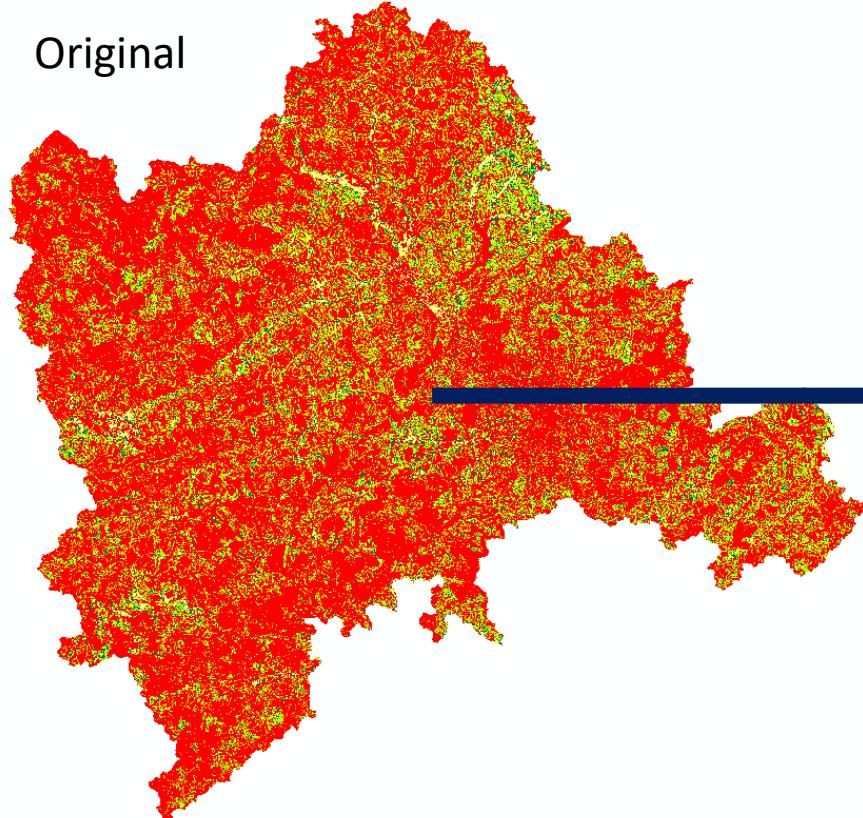


After

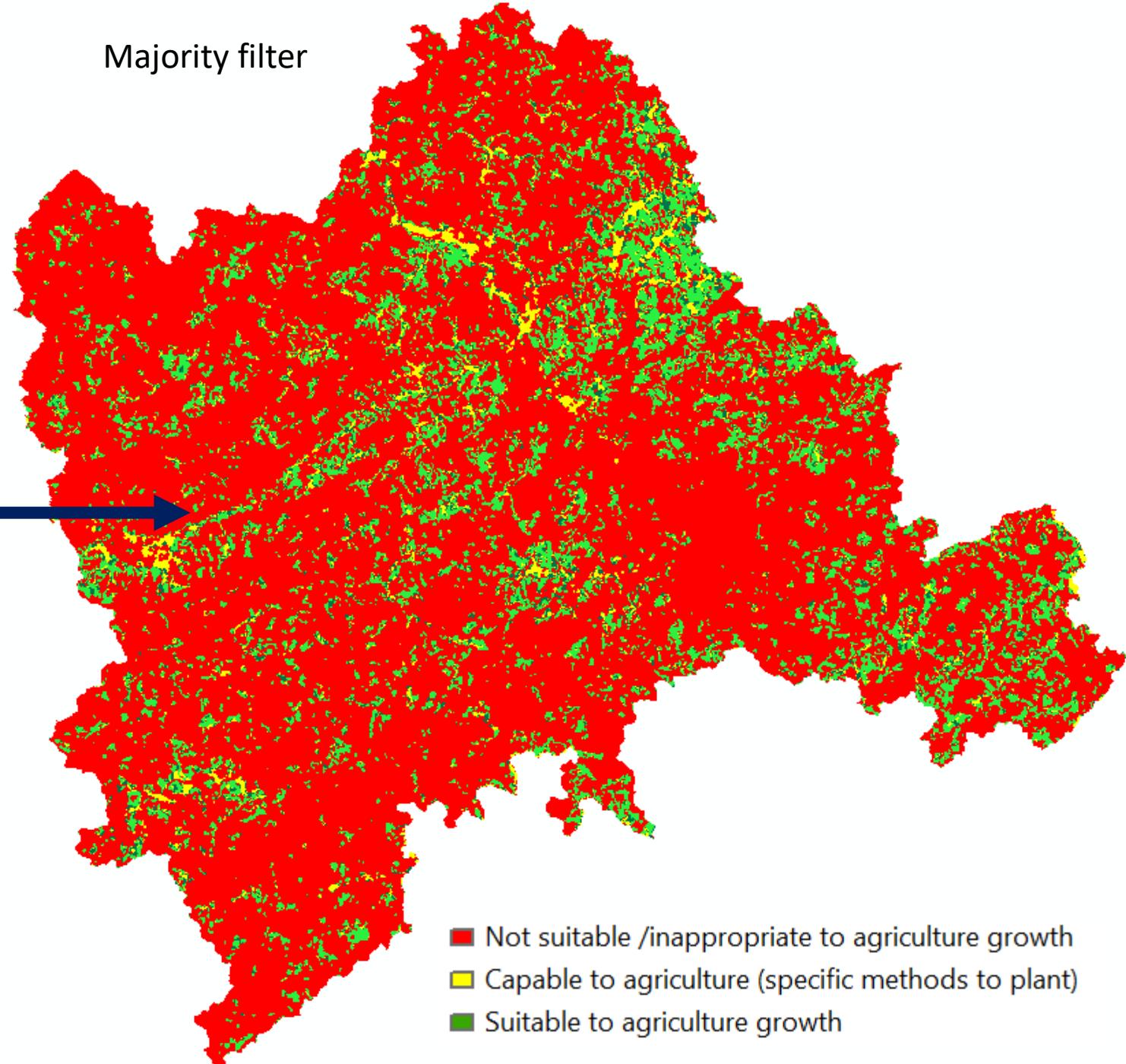


Result

Original

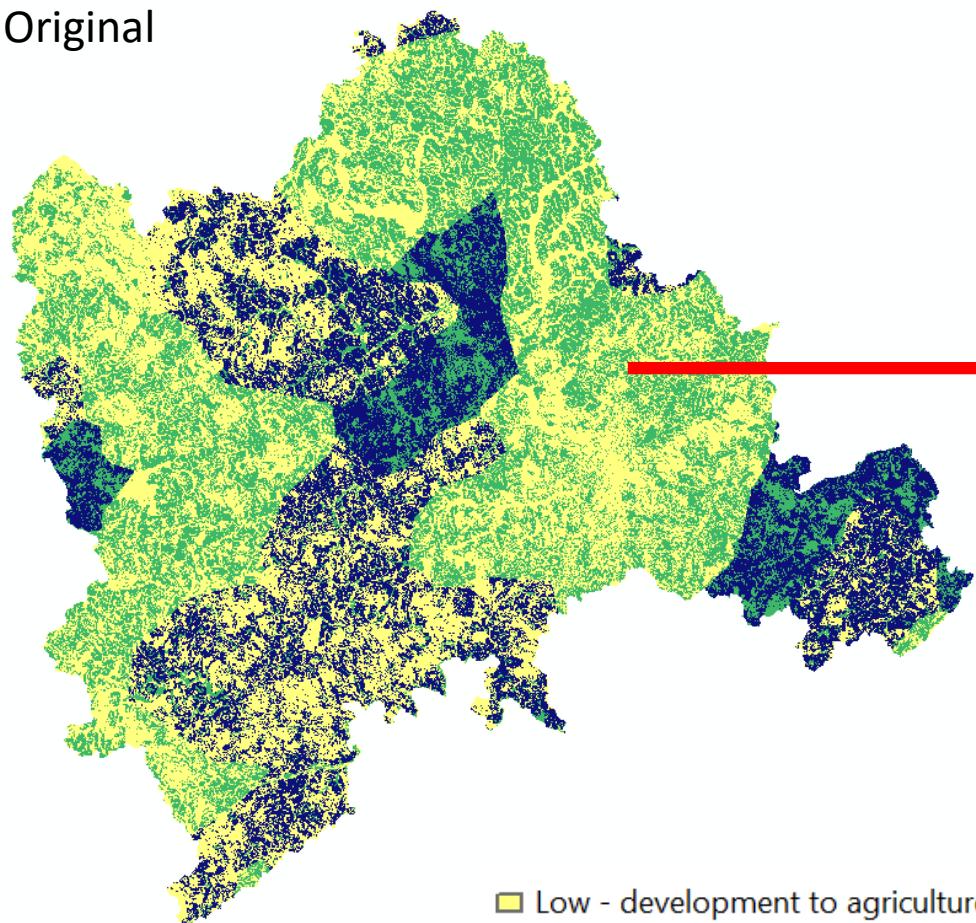


Majority filter



To improve the map visualization using the
“majority filter”

Original



Majority filter

