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

By PhD student:

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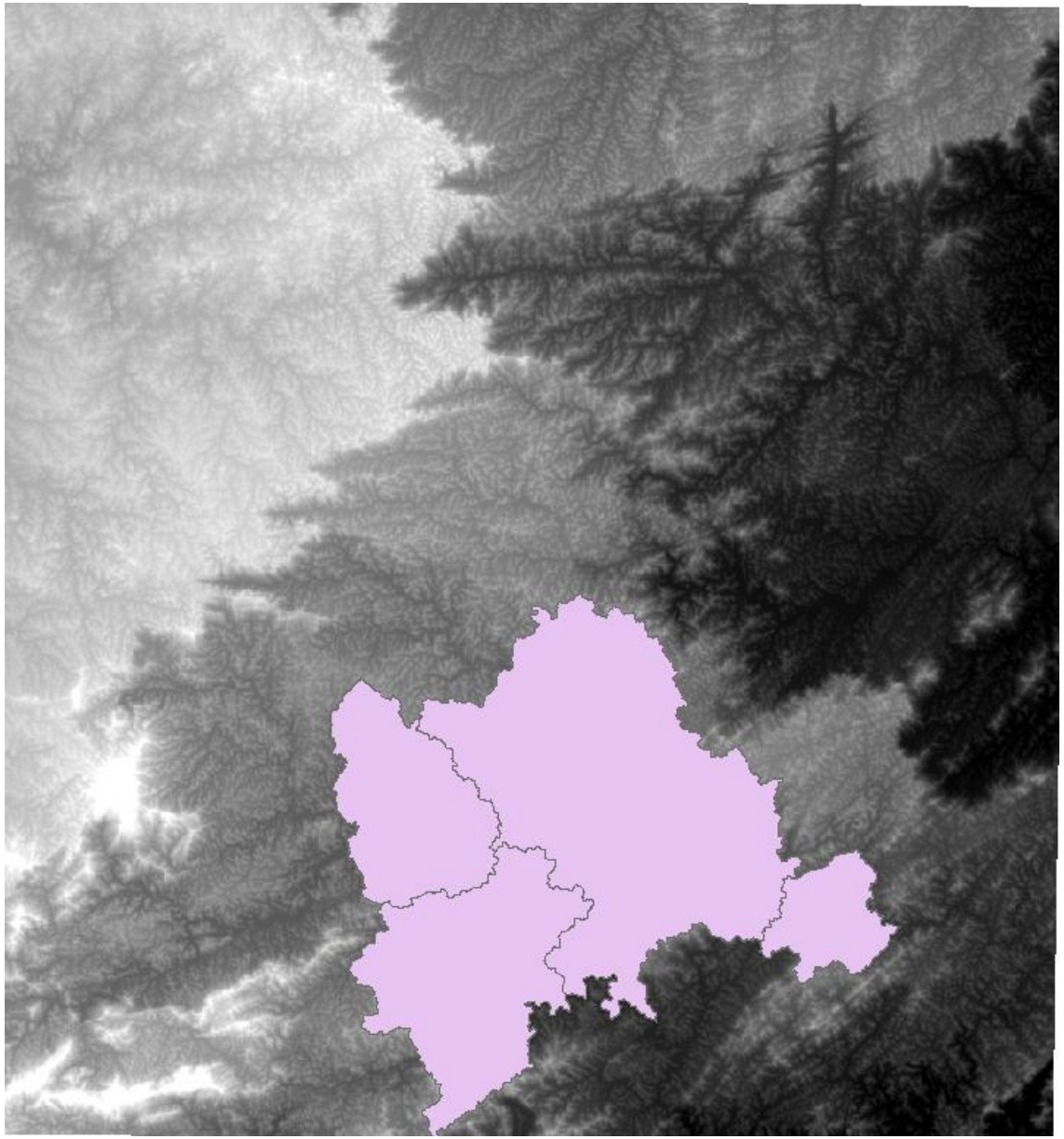
Introduction

- 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

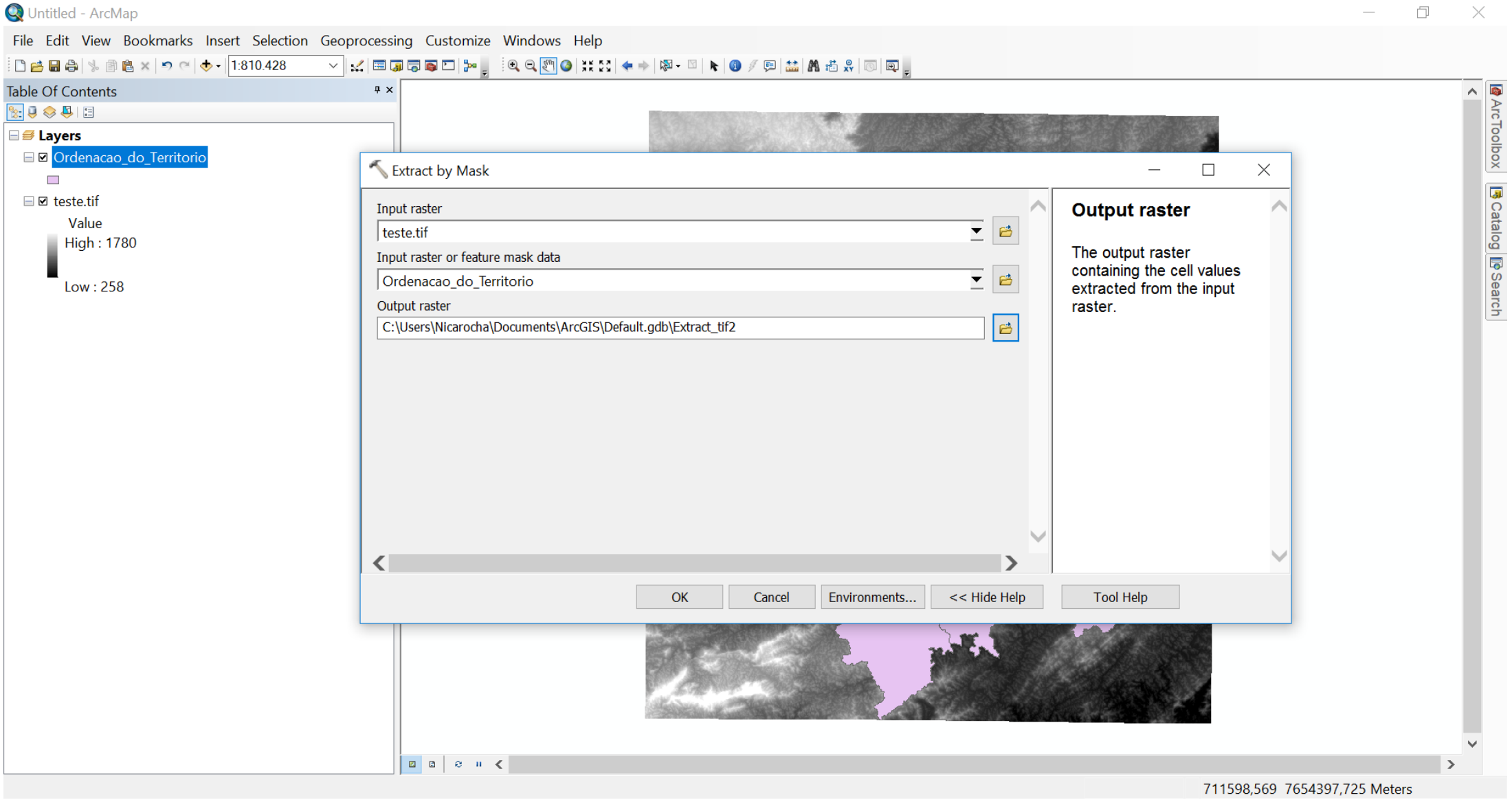
Download the SRTM

- 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.

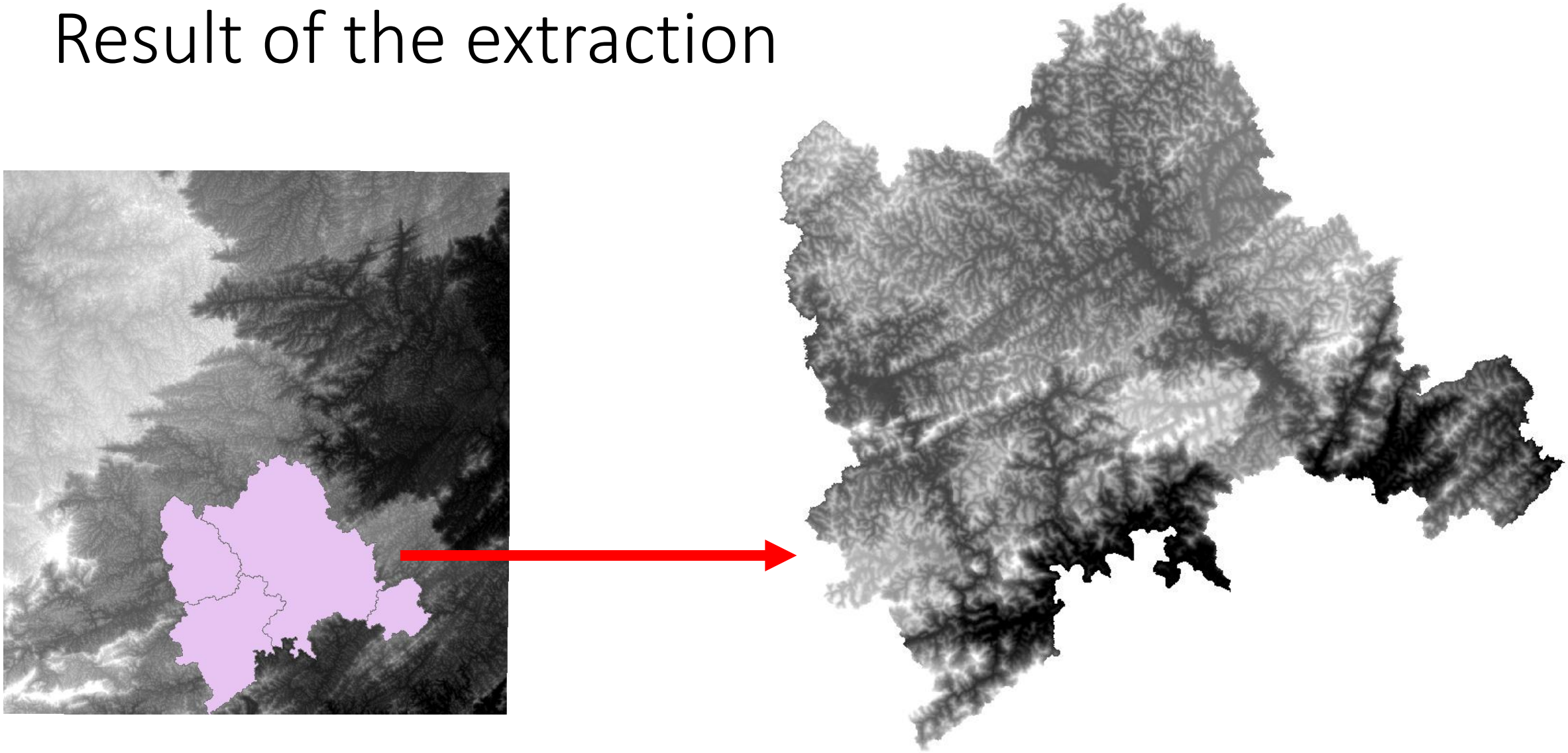


SRTM image source: http://dwtkns.com/srtm30m/

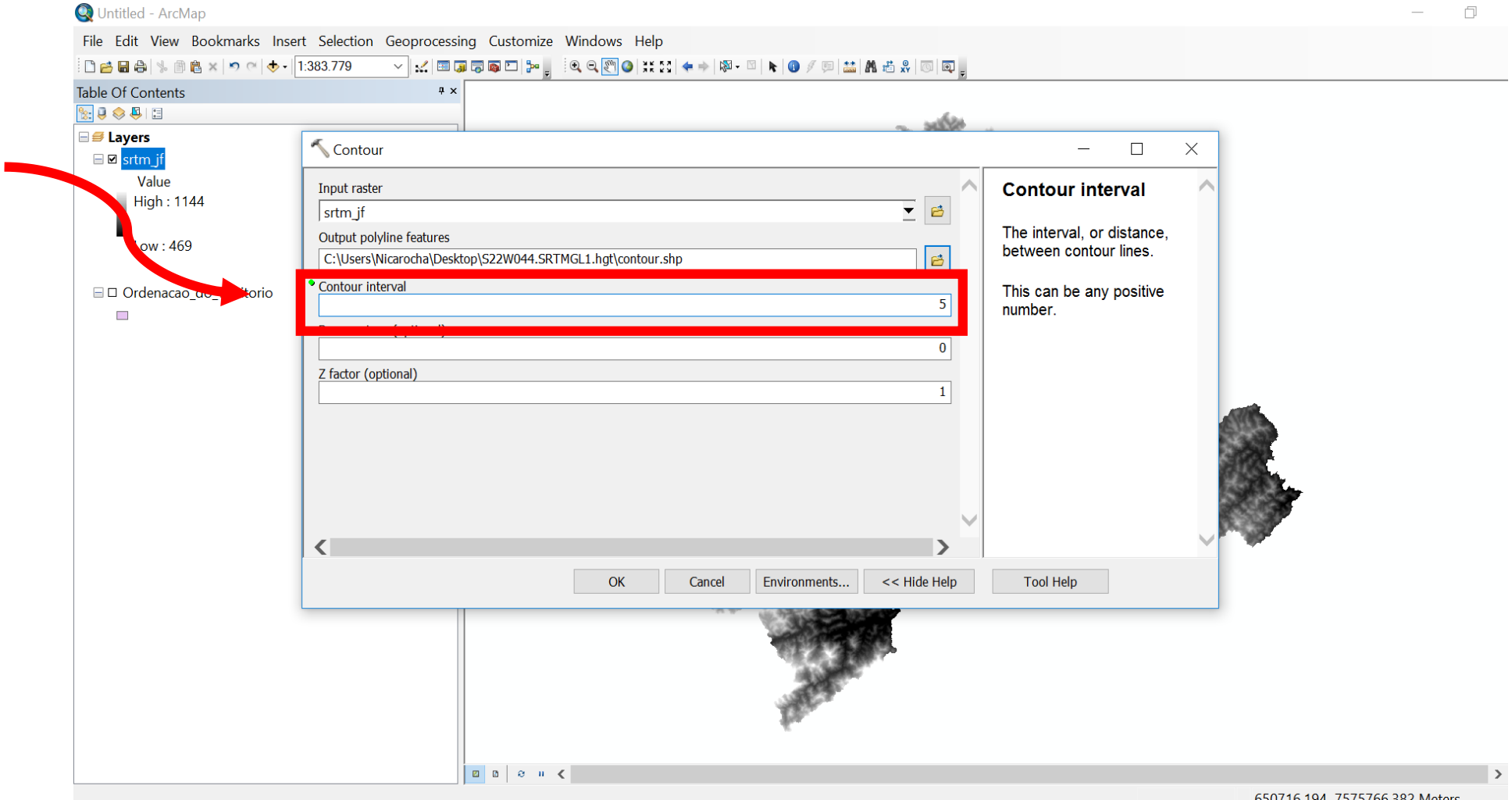
- Cut the SRTM according to the boundary (using Extract by mask)

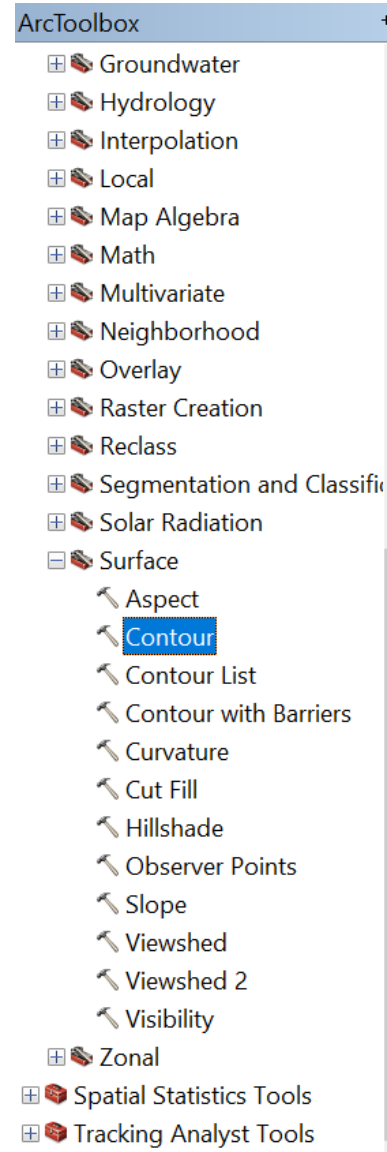


Result of the extraction

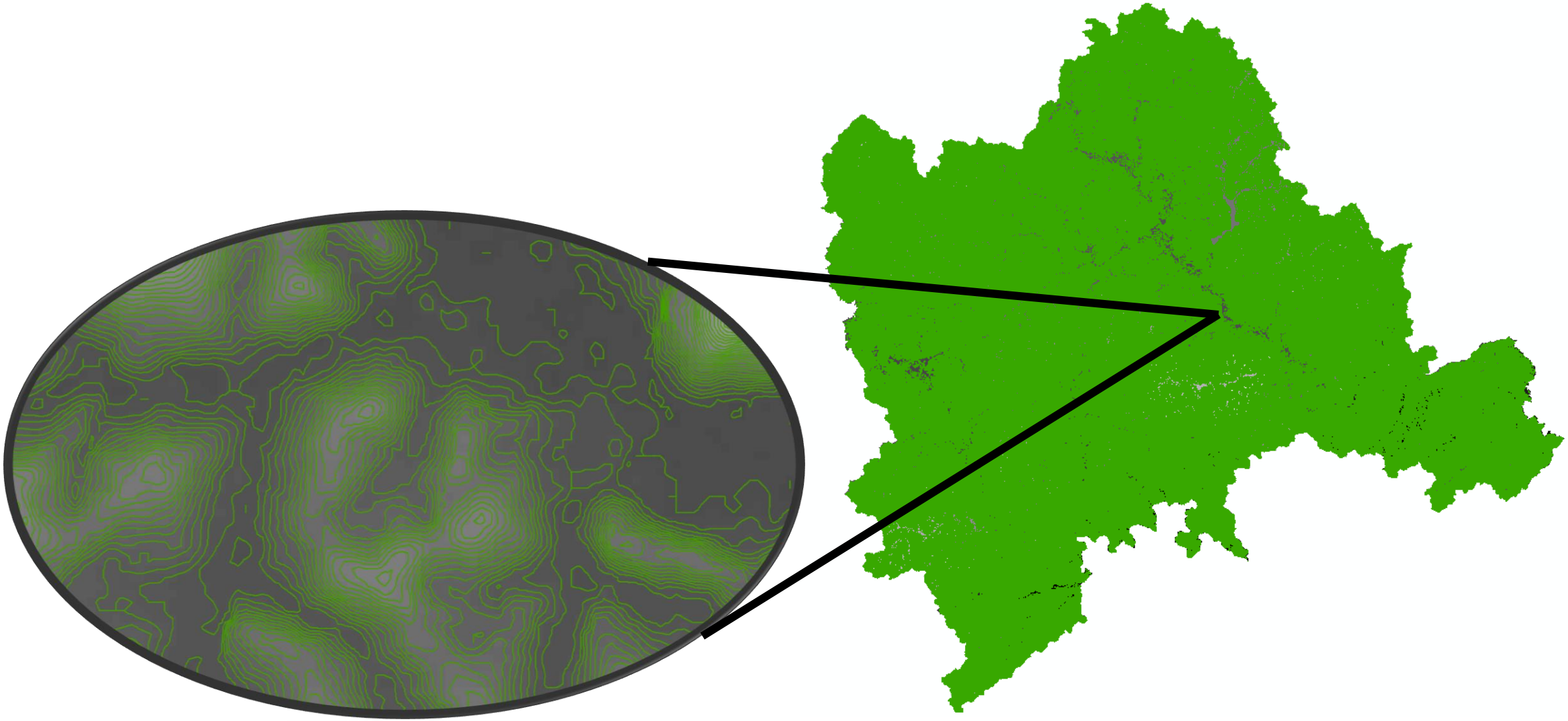


- From SRTM raster, the “contour” command is used to interpolate the isolines of topography.
- Interpolate topografic lines (contour)
- Define (contour interval) = 5m

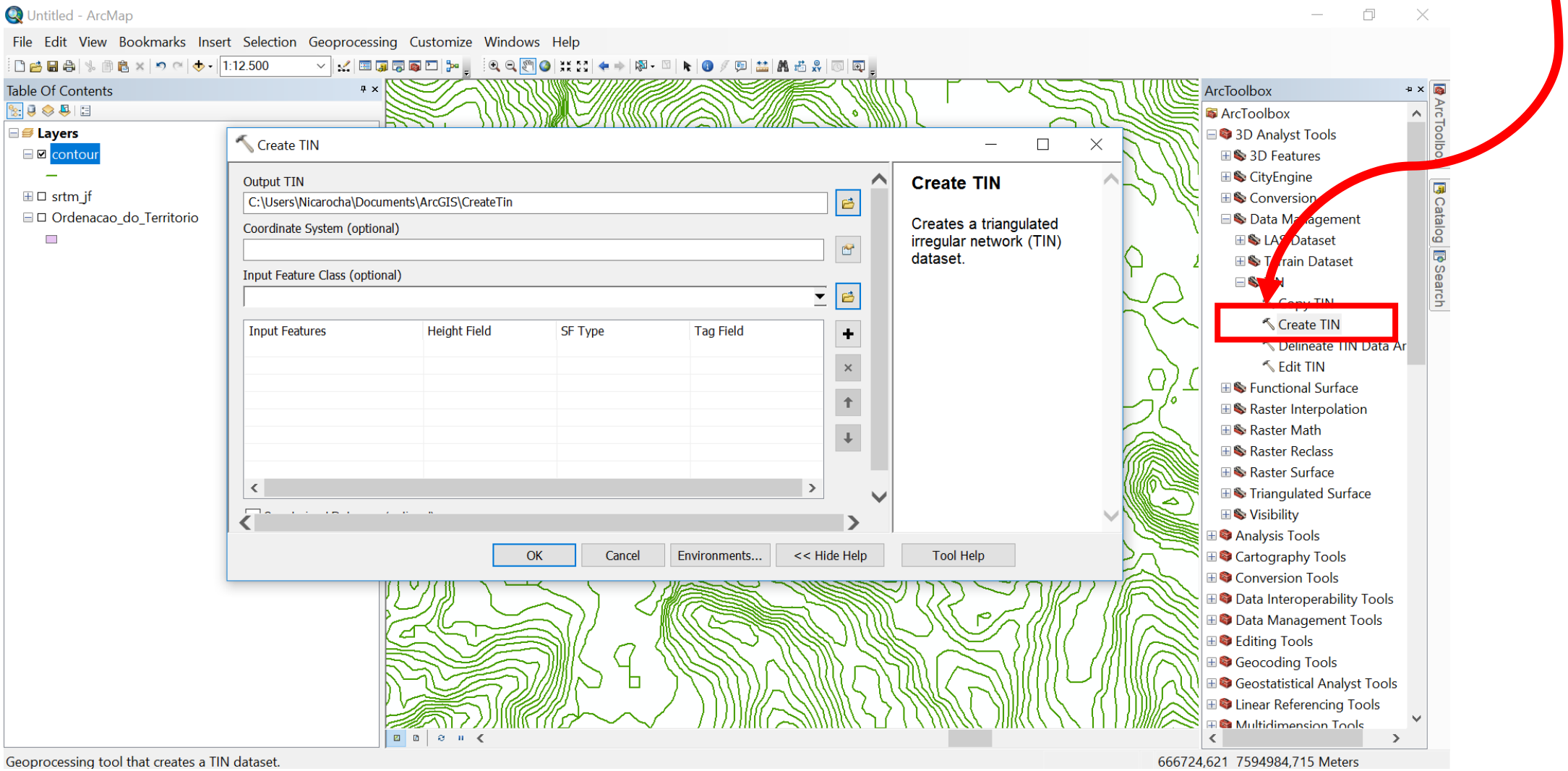




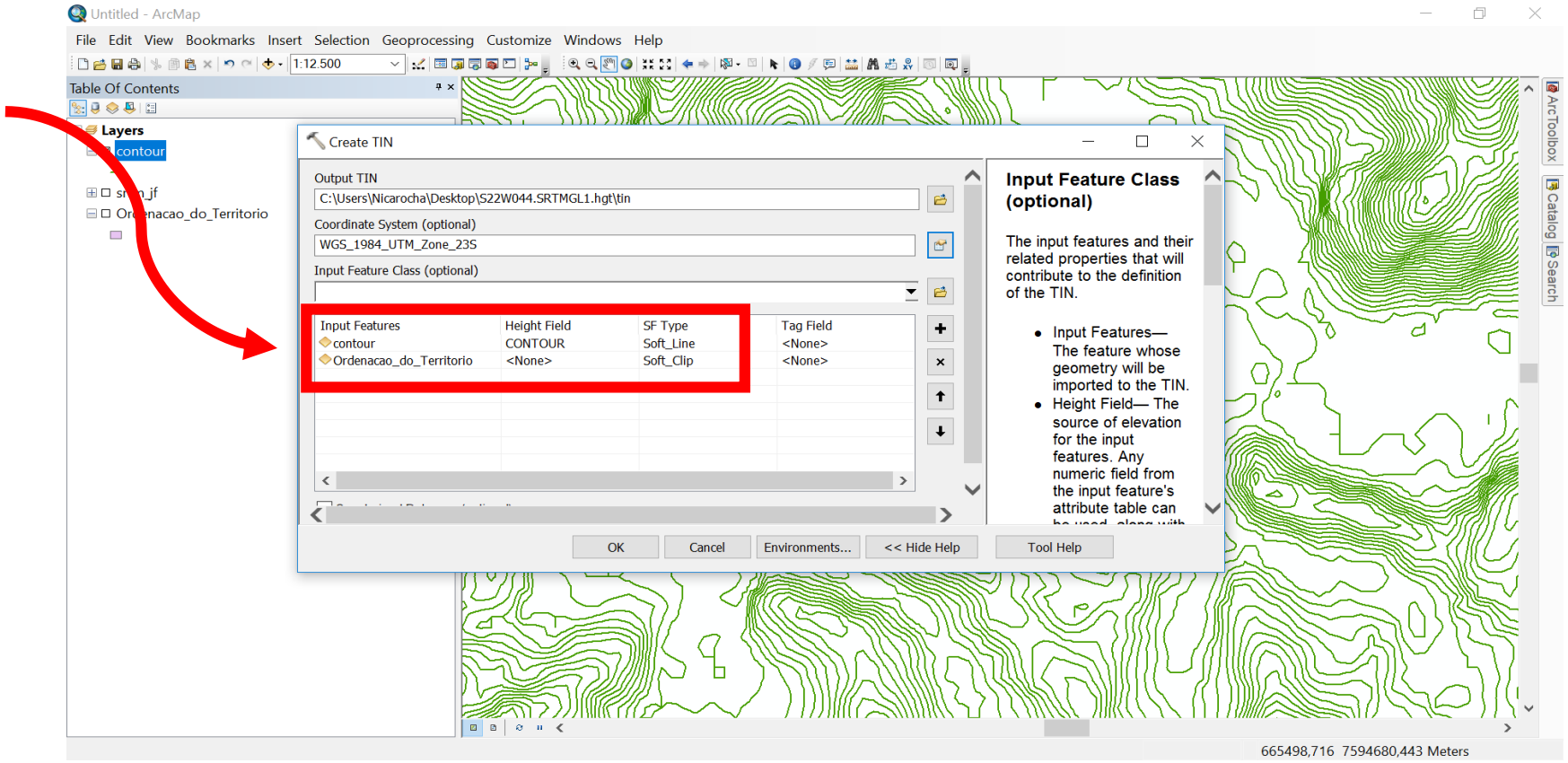
Result of the interpolation of contours 5m



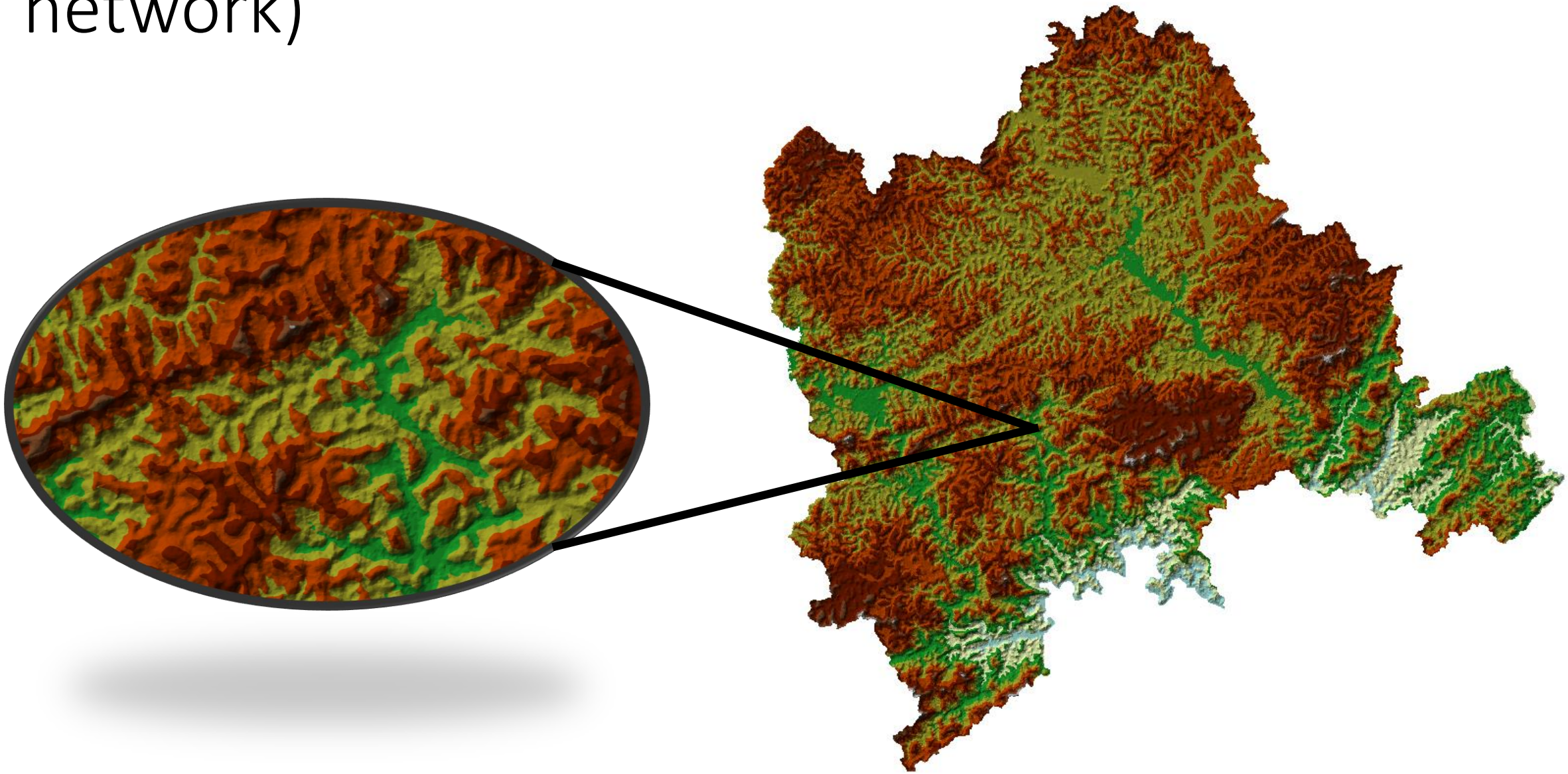
Creating TIN data to produce the slope map



- 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.

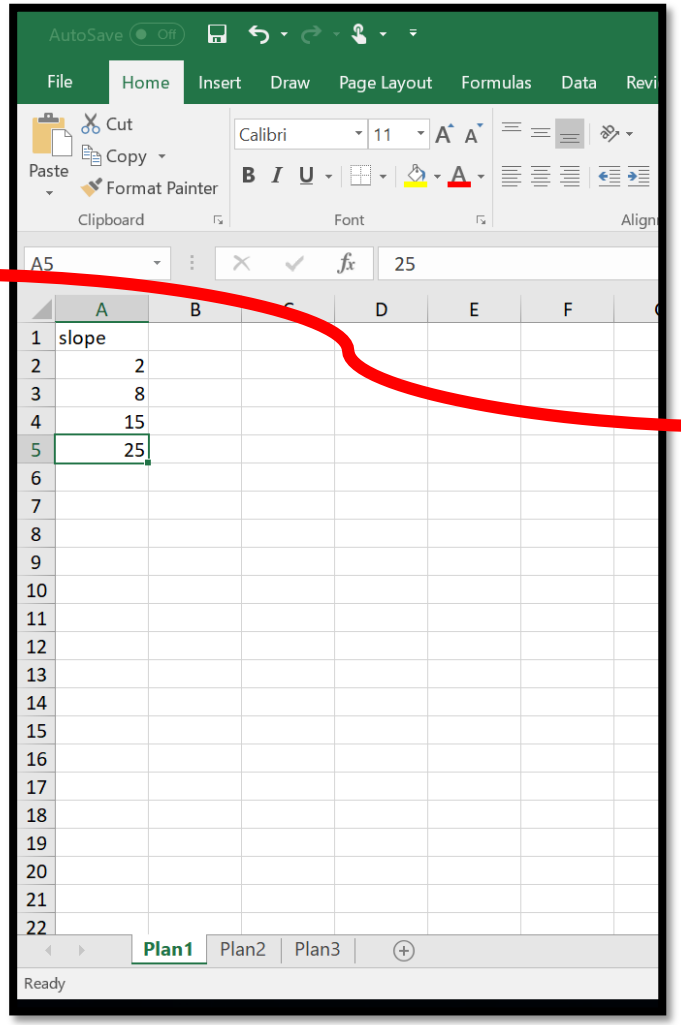


Result of the TIN (triangular irregular network)

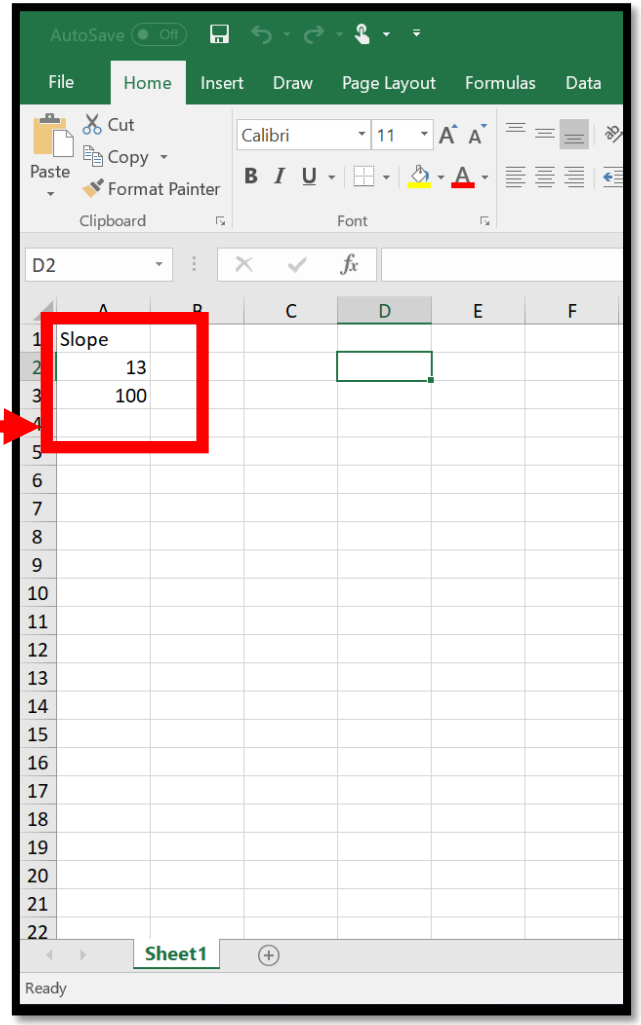


Set the slope percentage ranges

- 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%

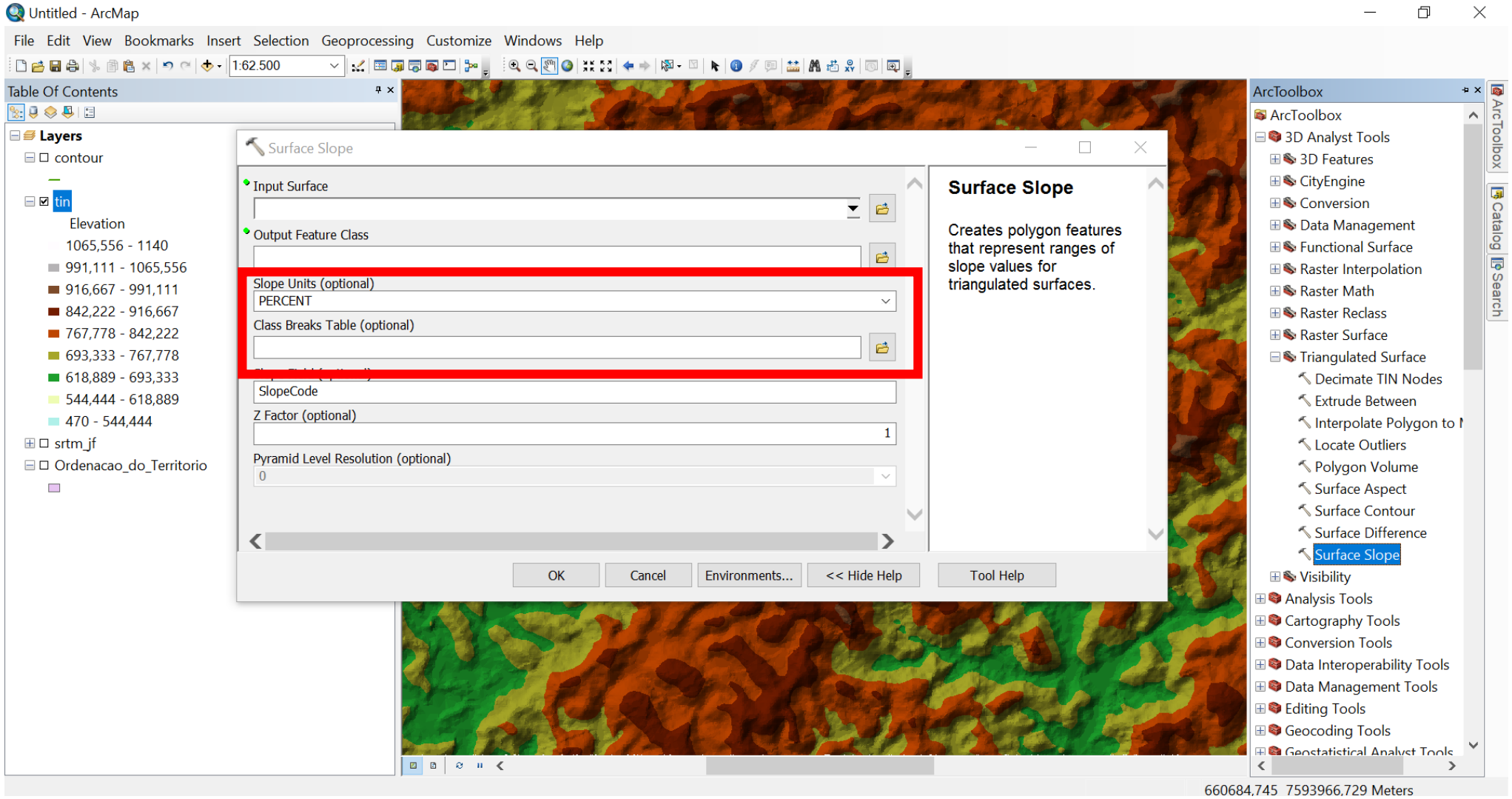


Czech reality (you need check this information to others contexts)

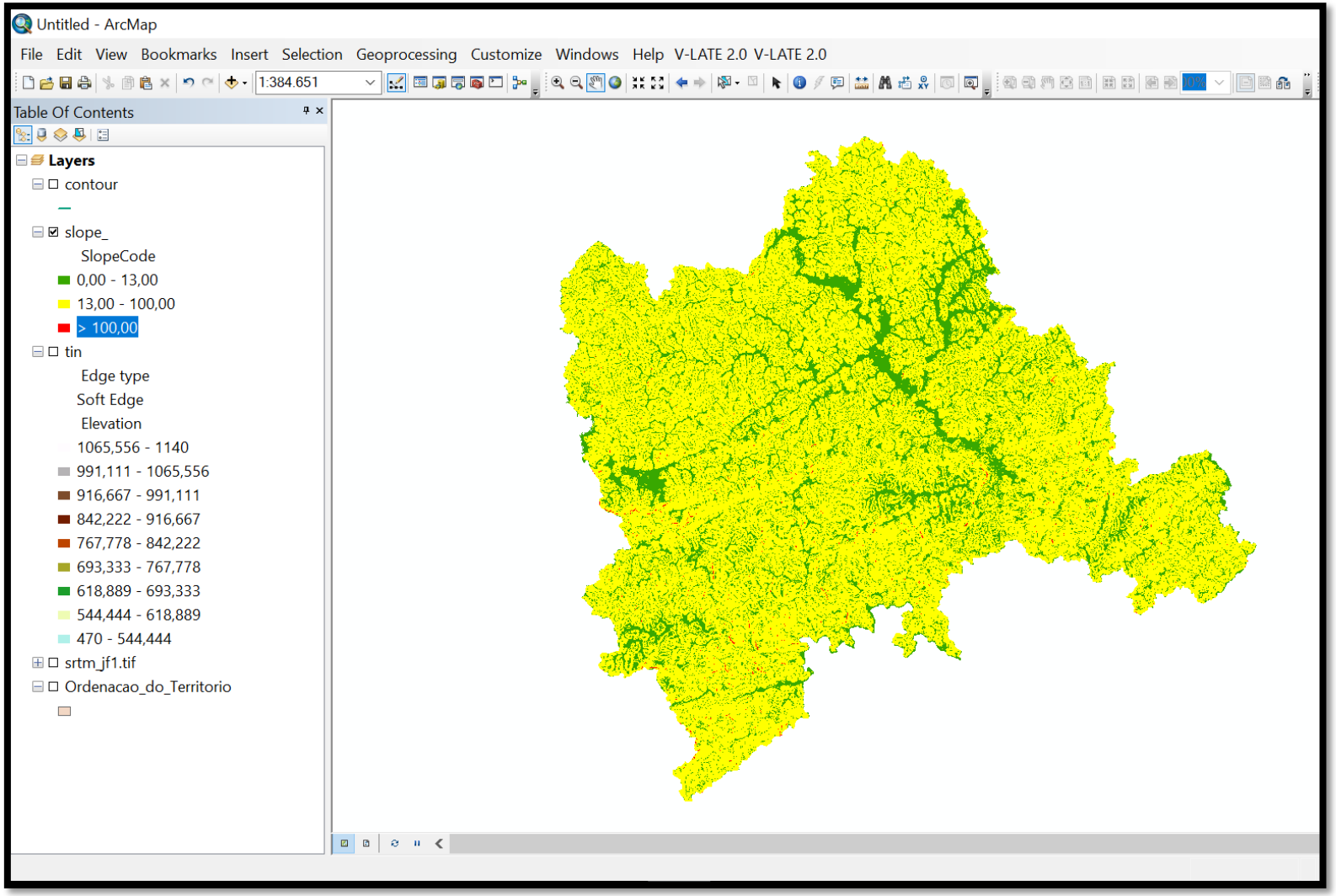


Brazilian reality

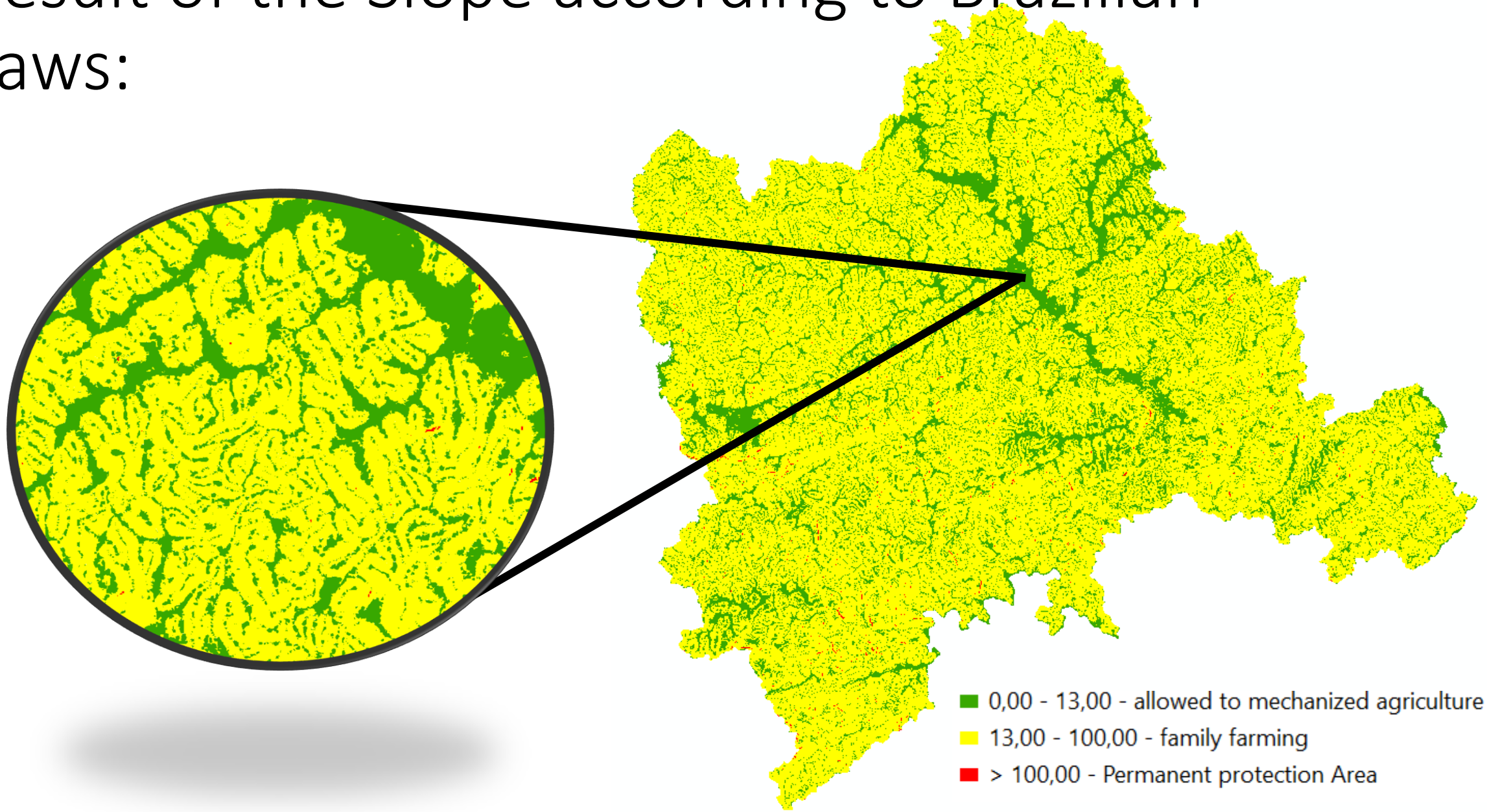
- With the TIN and the excel file with the ranges of slope (that is the “Class Break Table”), calculate slope.



Result of the Slope according to Brazilian Laws:

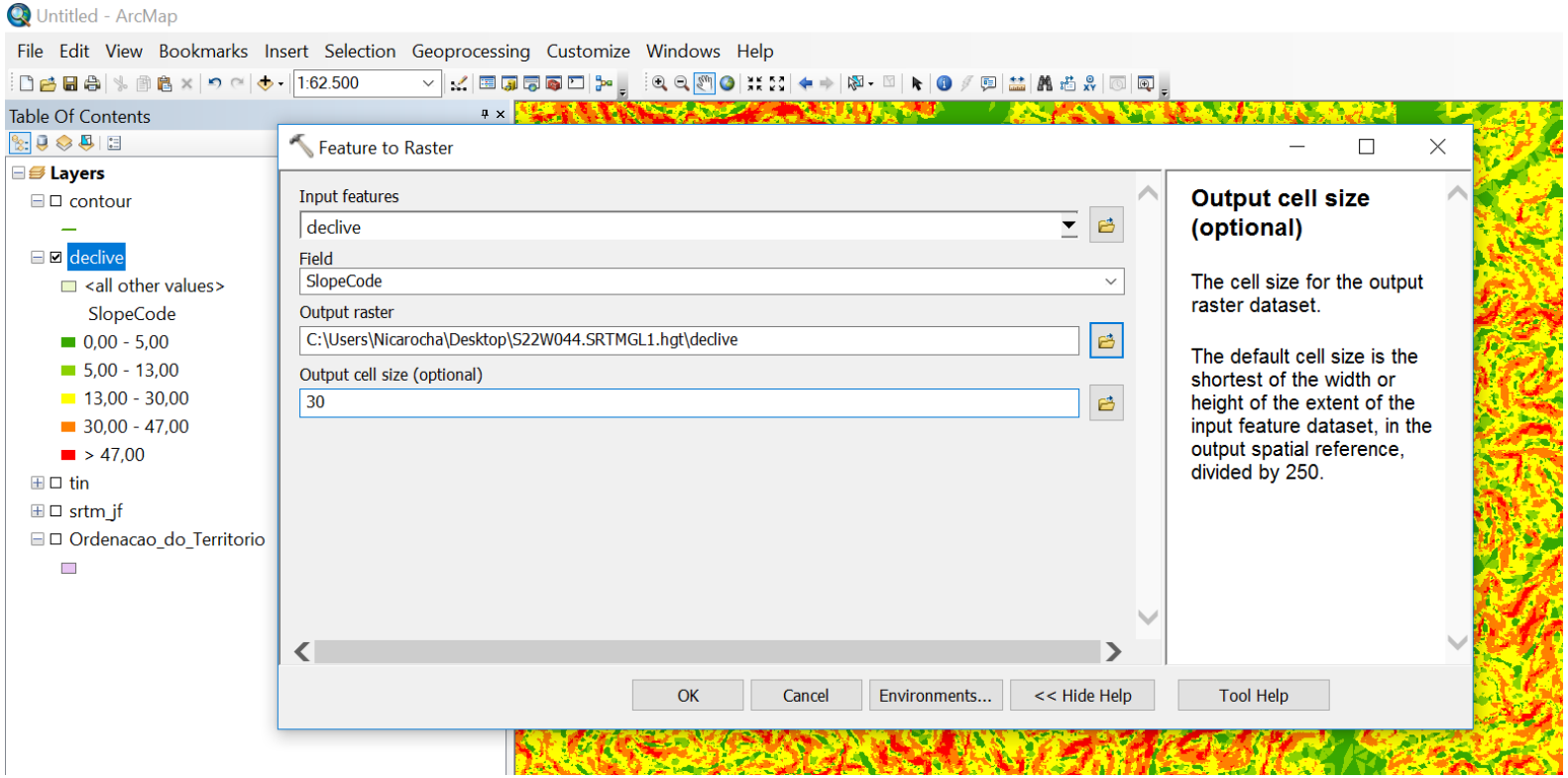


Result of the Slope according to Brazilian Laws:

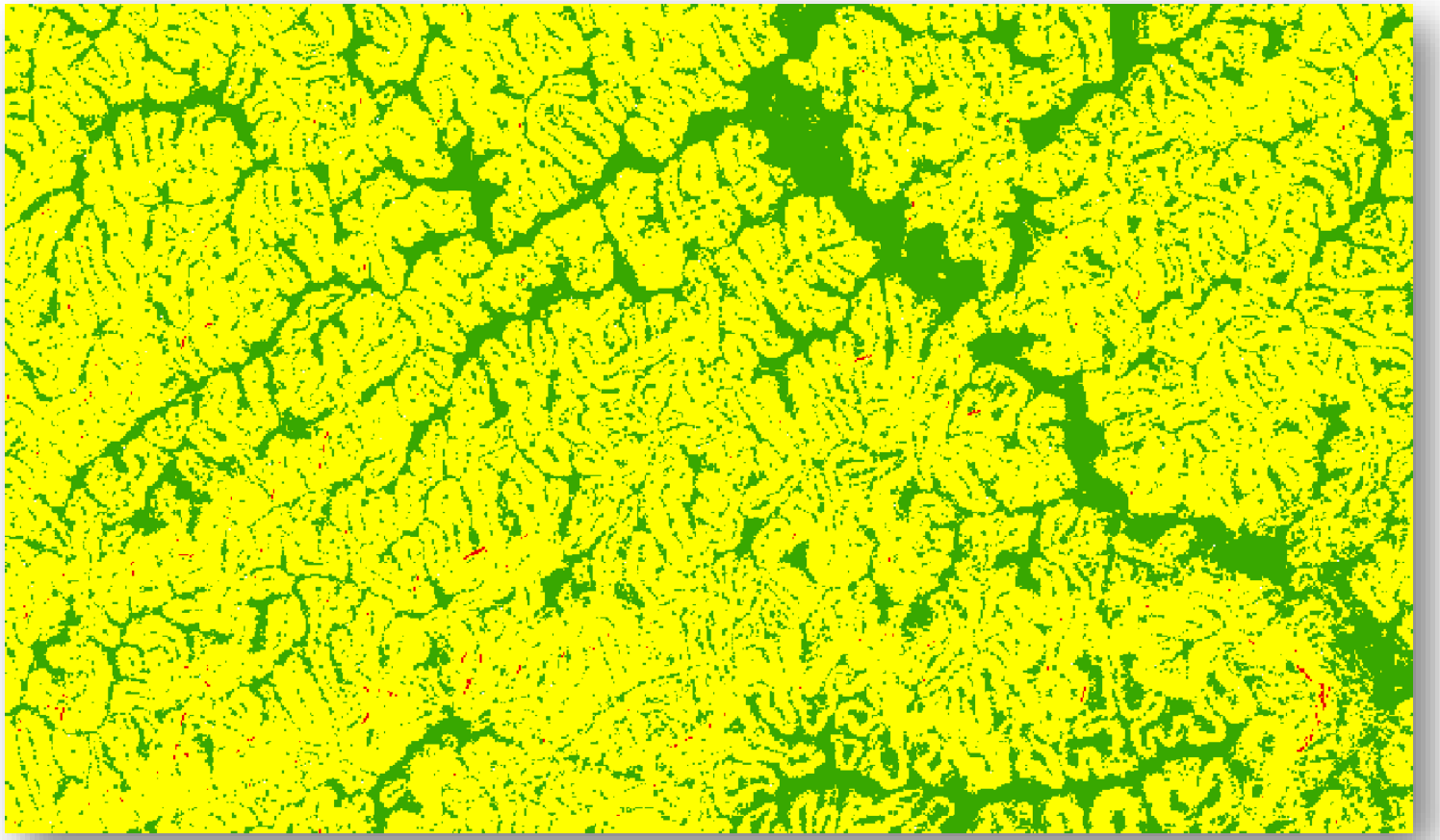


To compose the raster map with the 5 classes of slope.

- 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

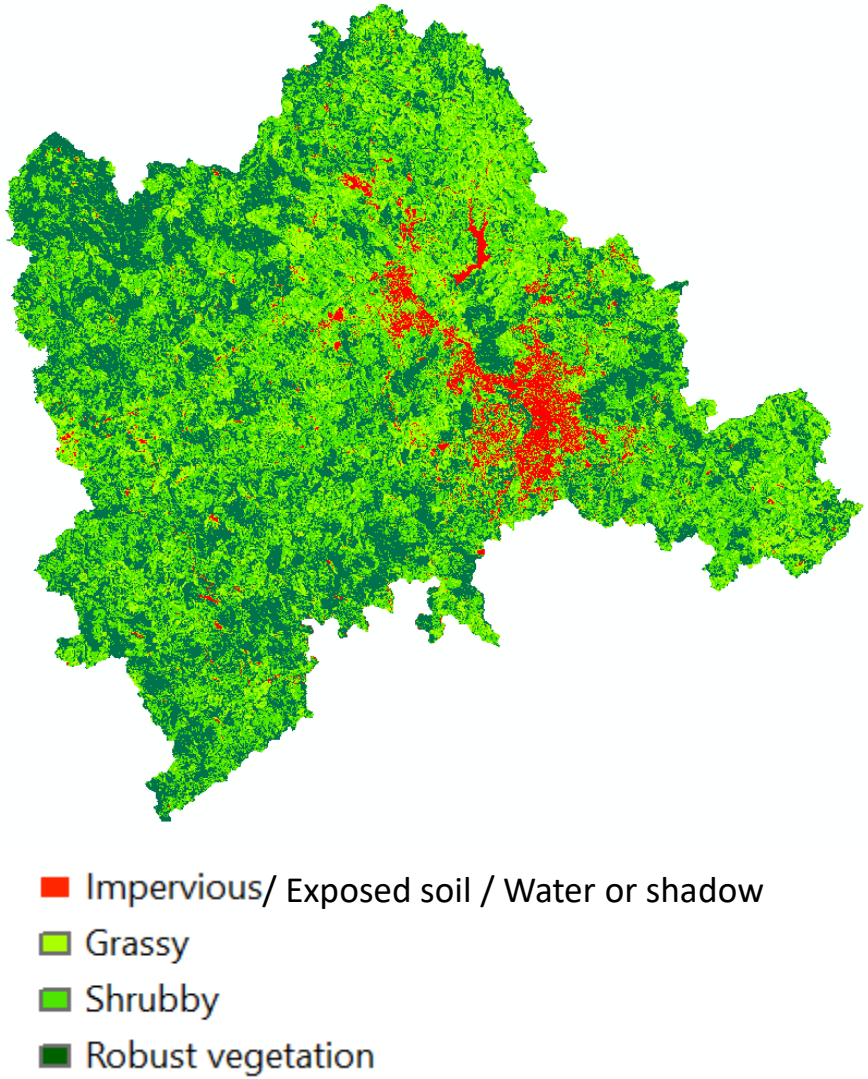


1 0,00 - 13,00 - allowed to mechanized agriculture
2 13,00 - 100,00 - family farming
3 > 100,00 - Permanent protection Area

LAND USE

NDVI

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



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:

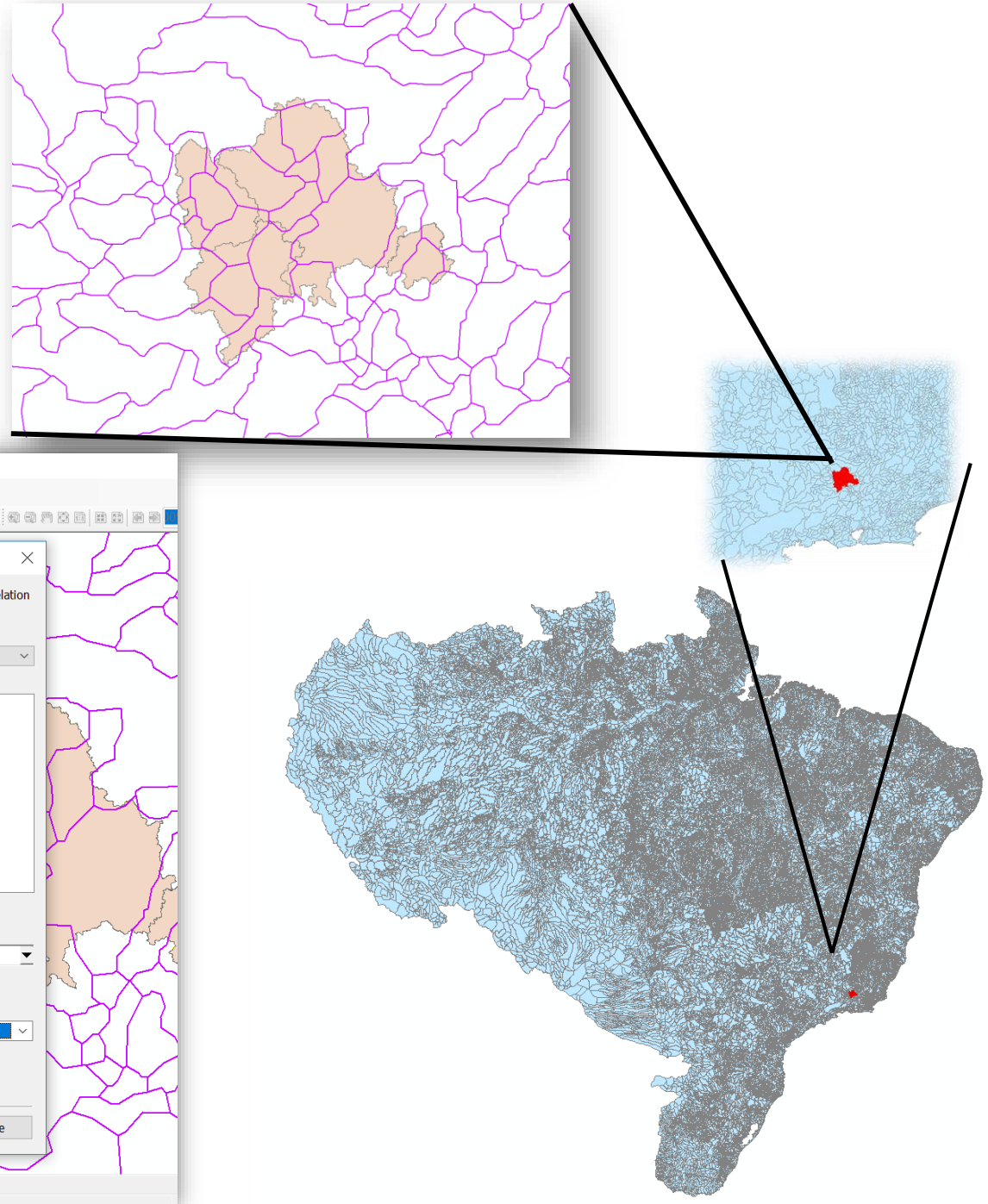
E.g. In Brazil: To use the open source data from ANA (*Agência Nacional das Águas (* National Water Agency))

- 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://geoproea.arq.ufmg.br/+/dmFront/downloadContent?u=eyJtZWRpYV9pZCI6IjQwNyIsInRpbWVzdGFtcCI6MTUwNzAwMTE5NH0%3D
    - http://support.esri.com/en/technical-article/000012346

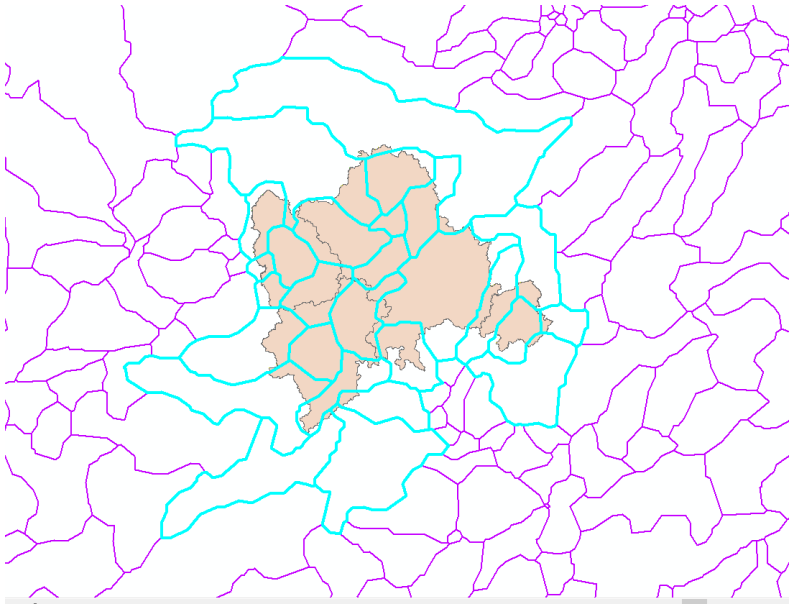
Download of watershed

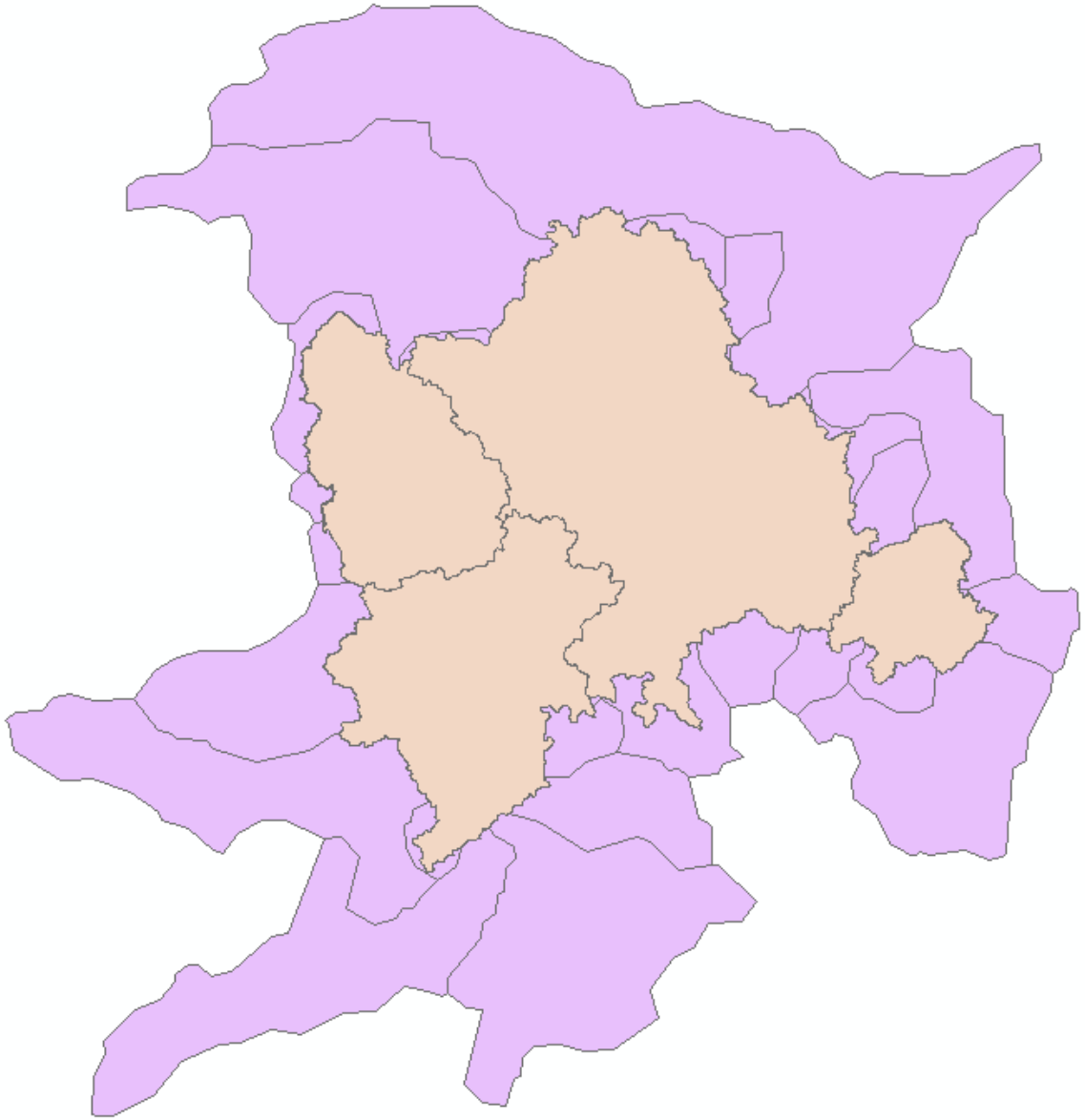
- We downloaded Brazilian data and selected all the watershed from municipality of Juiz de Fora (case study).
- After that, we need select the watershed that supply the city (using select by tool “select by location”)



Selection of watershed

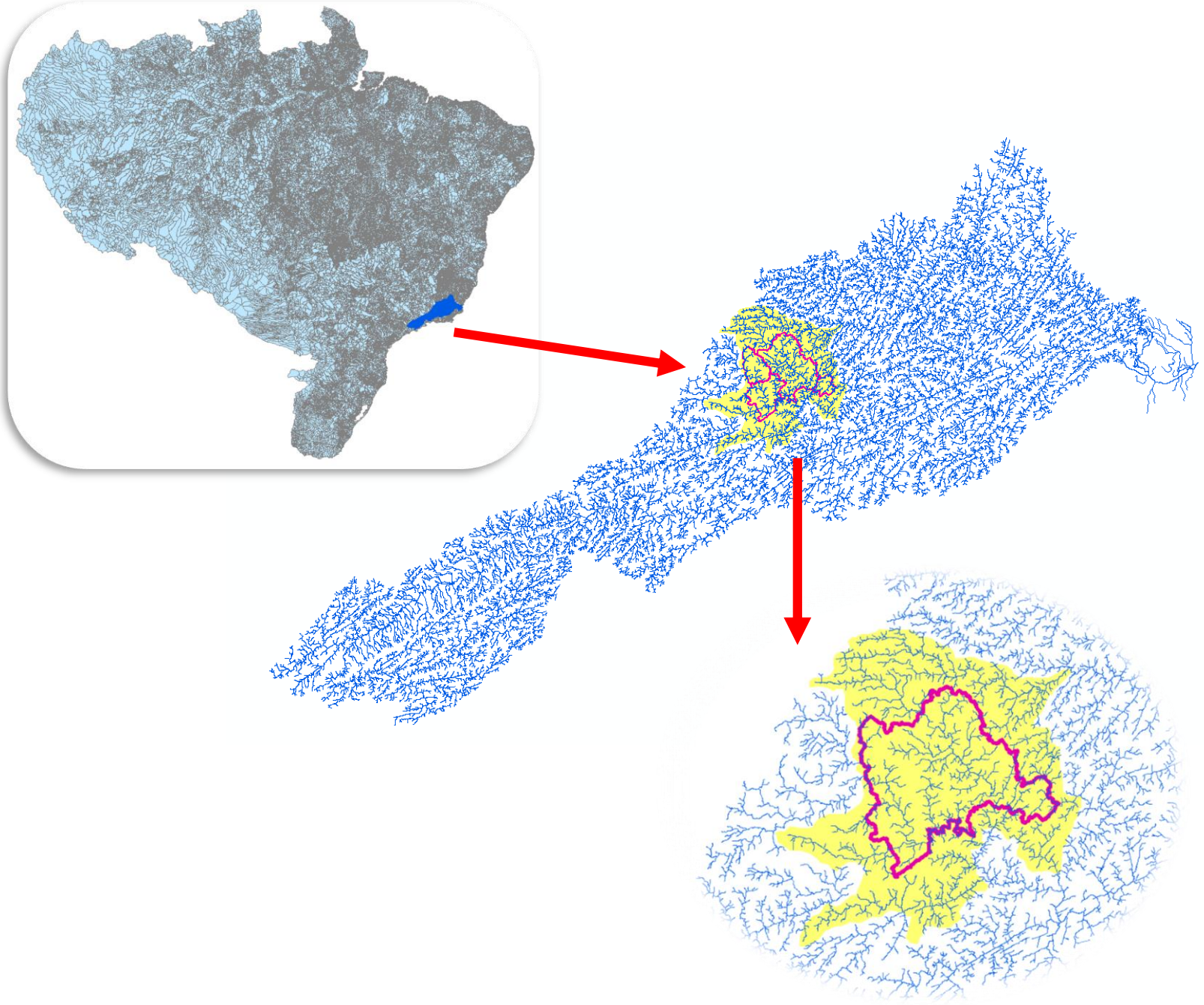
- The selection of watershed must avoid to cut the polygons in the line of the municipality, and must choose all the polygons that are inside or are touched by the boundary line (selection by location: inside and interception)



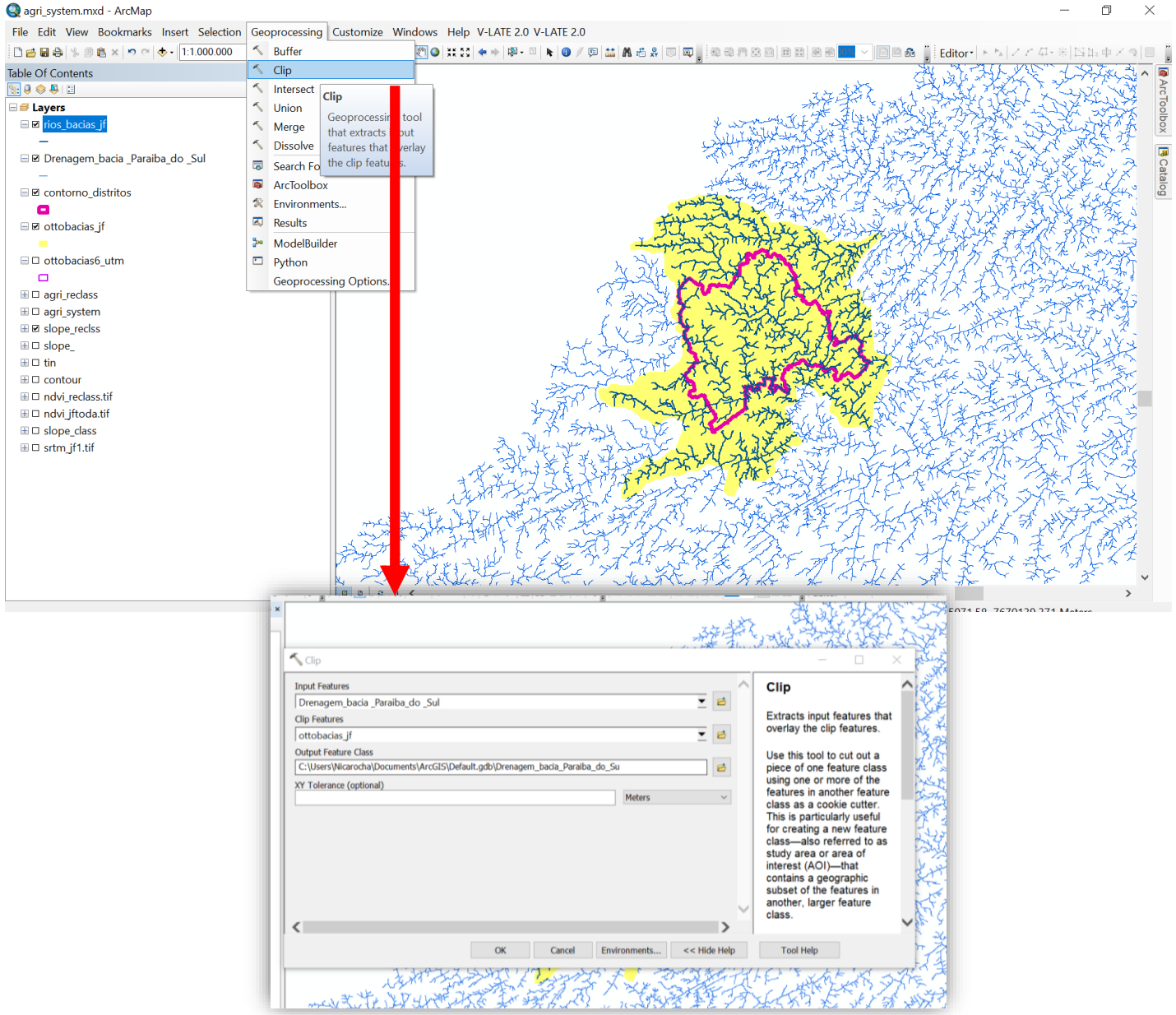


Download of rivers

- 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

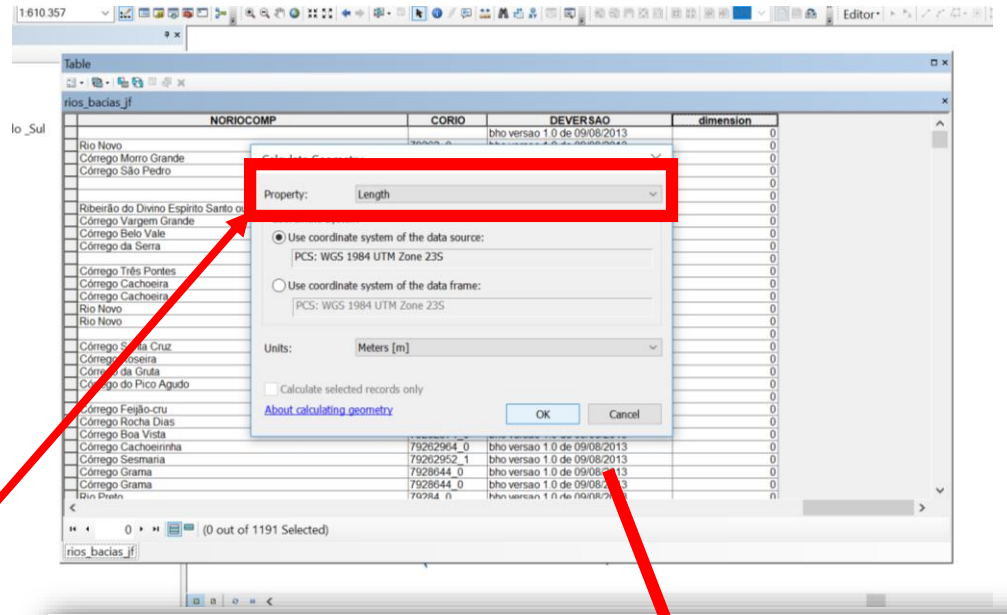


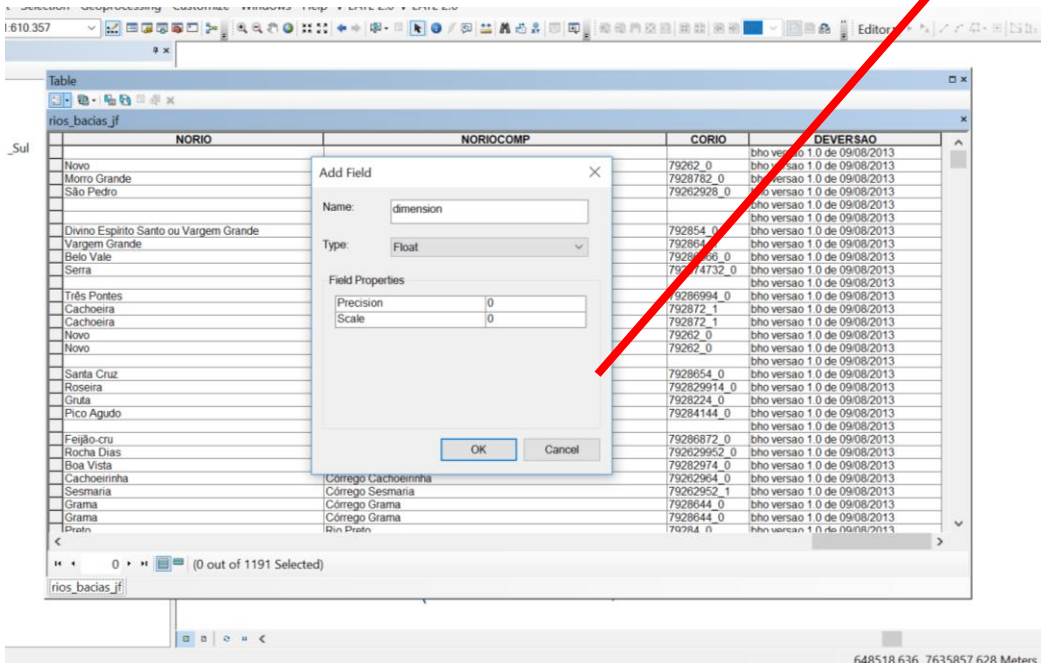
- Now, we need cut the polylines of rivers using the tool “clip”

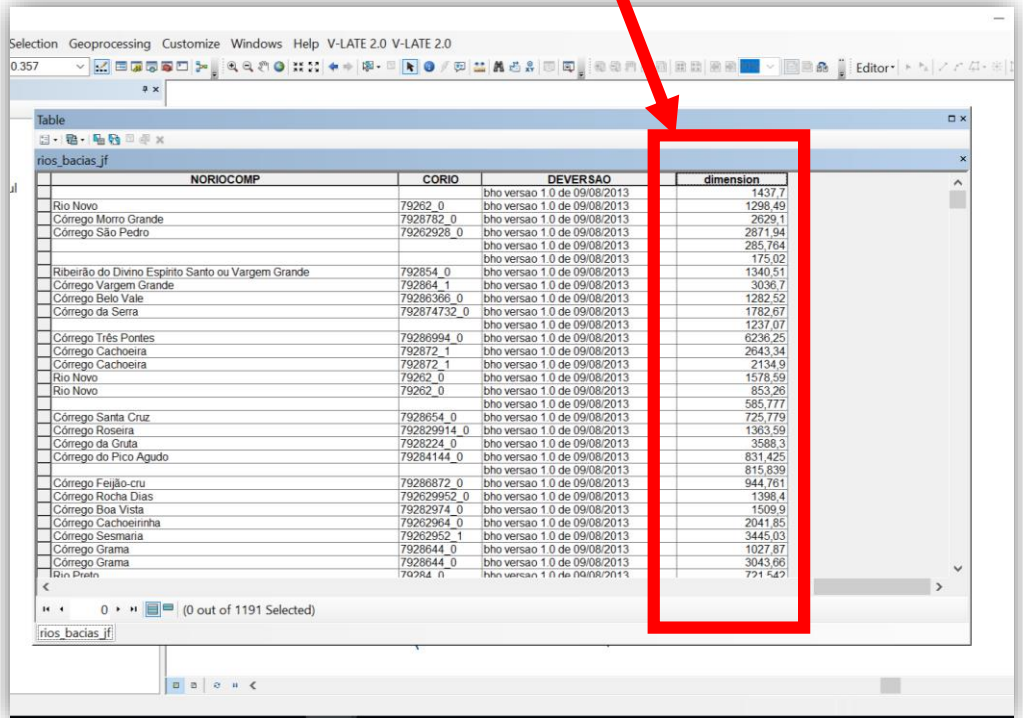


Treating the polylines of rivers

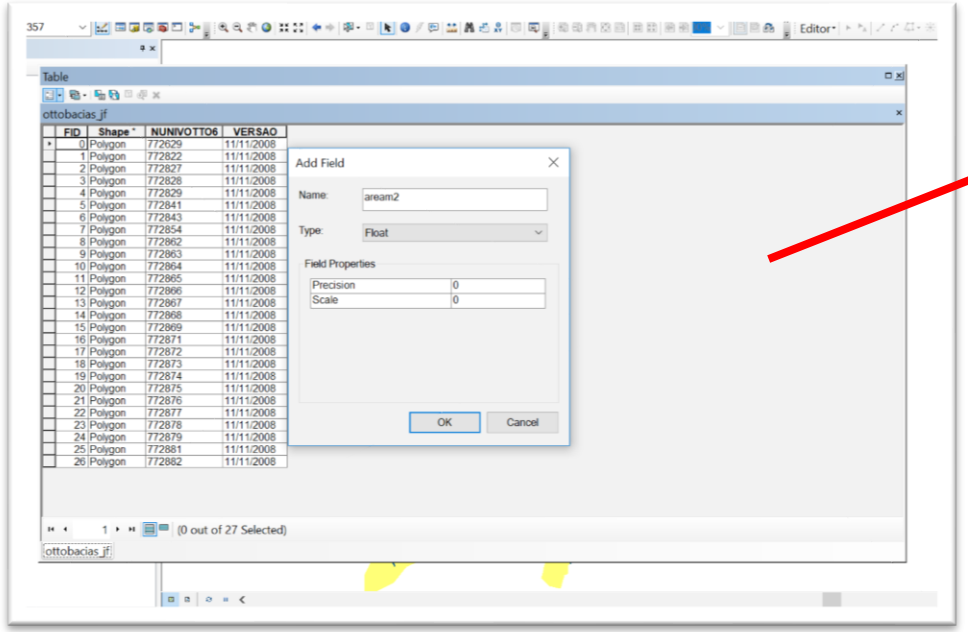
- Go to “open attribute table”
- Add the field, in this case we called “dimension” to obtain the length of each drain run – type: float
- After that, click on the new field created and select the “calculate geometry” to have the result

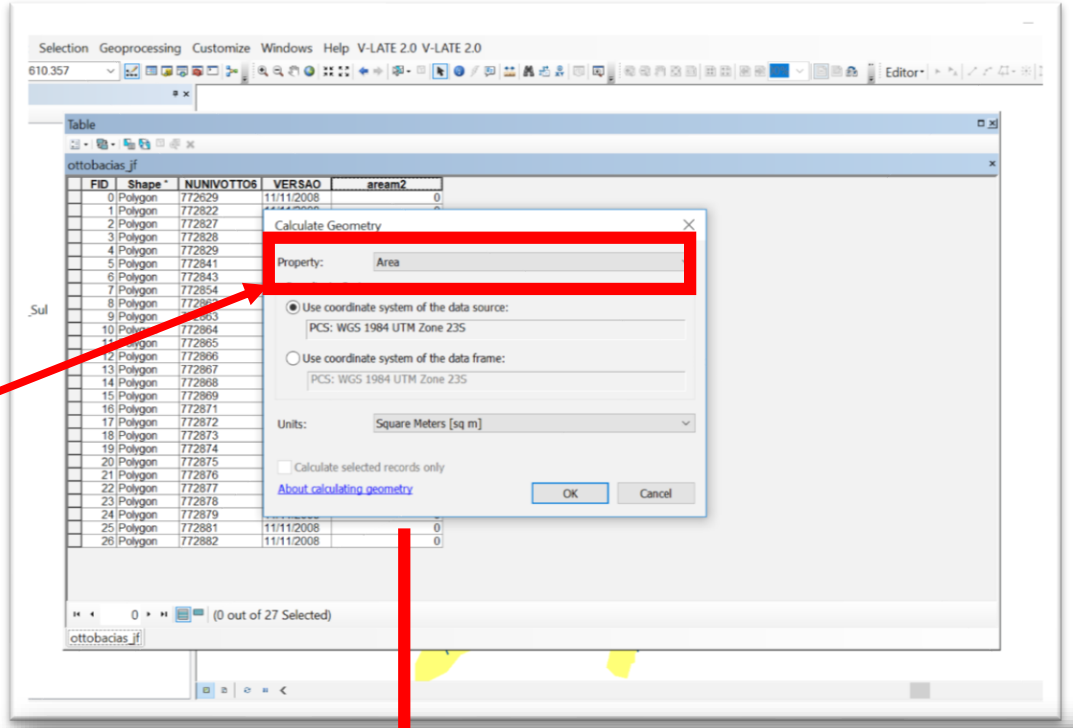


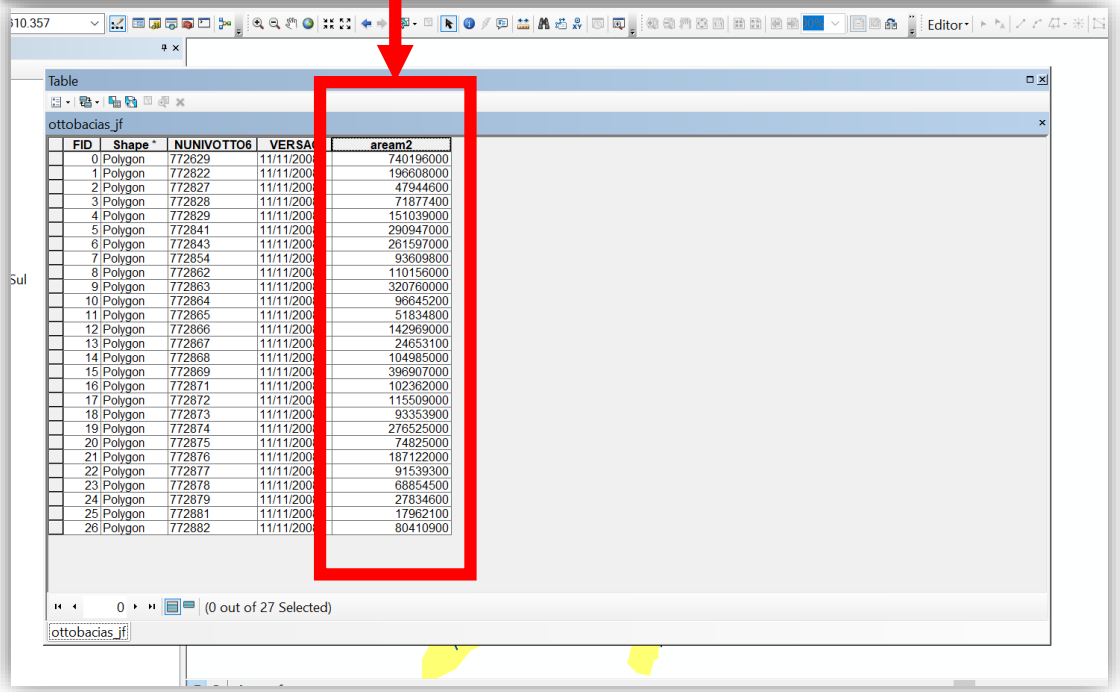




Treating the Polygons of Watershed



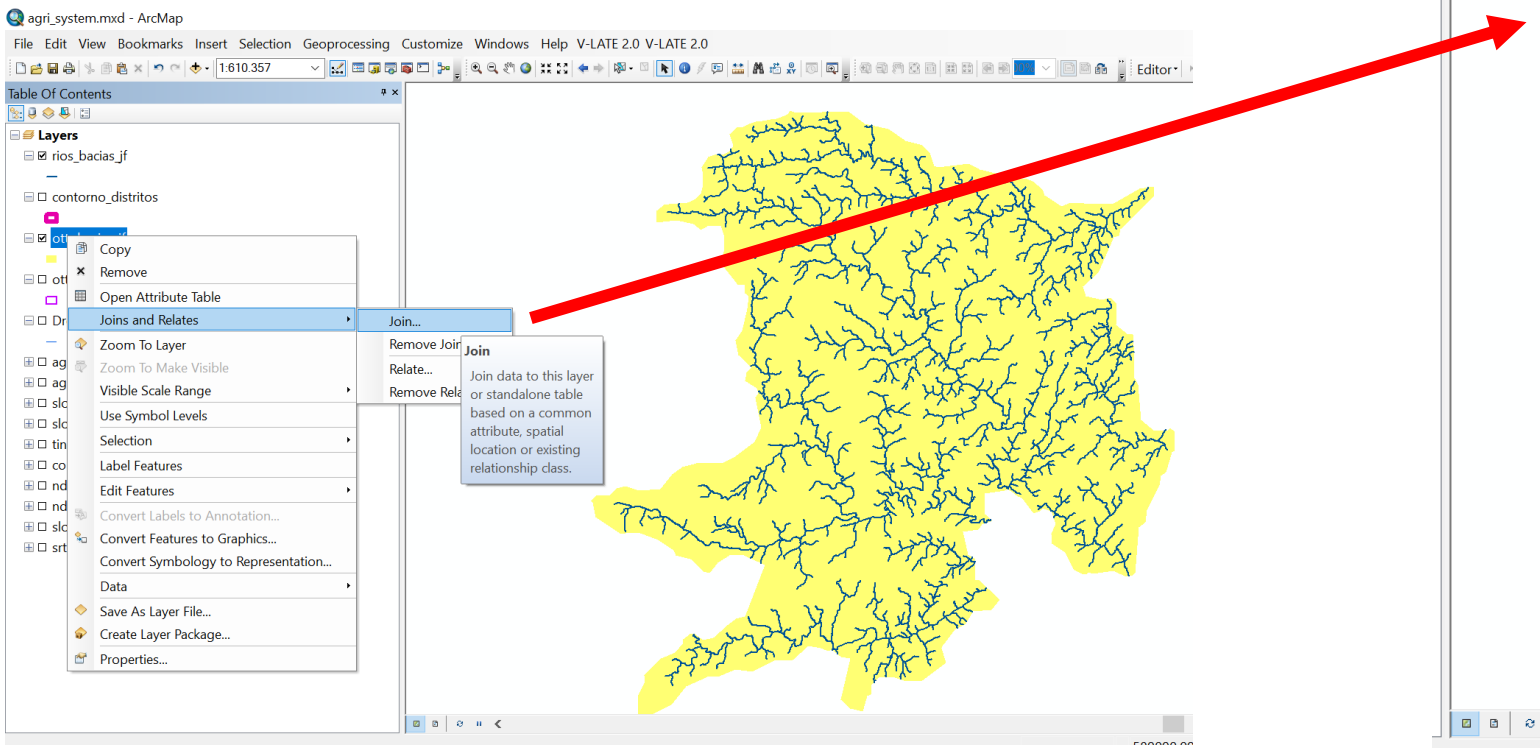


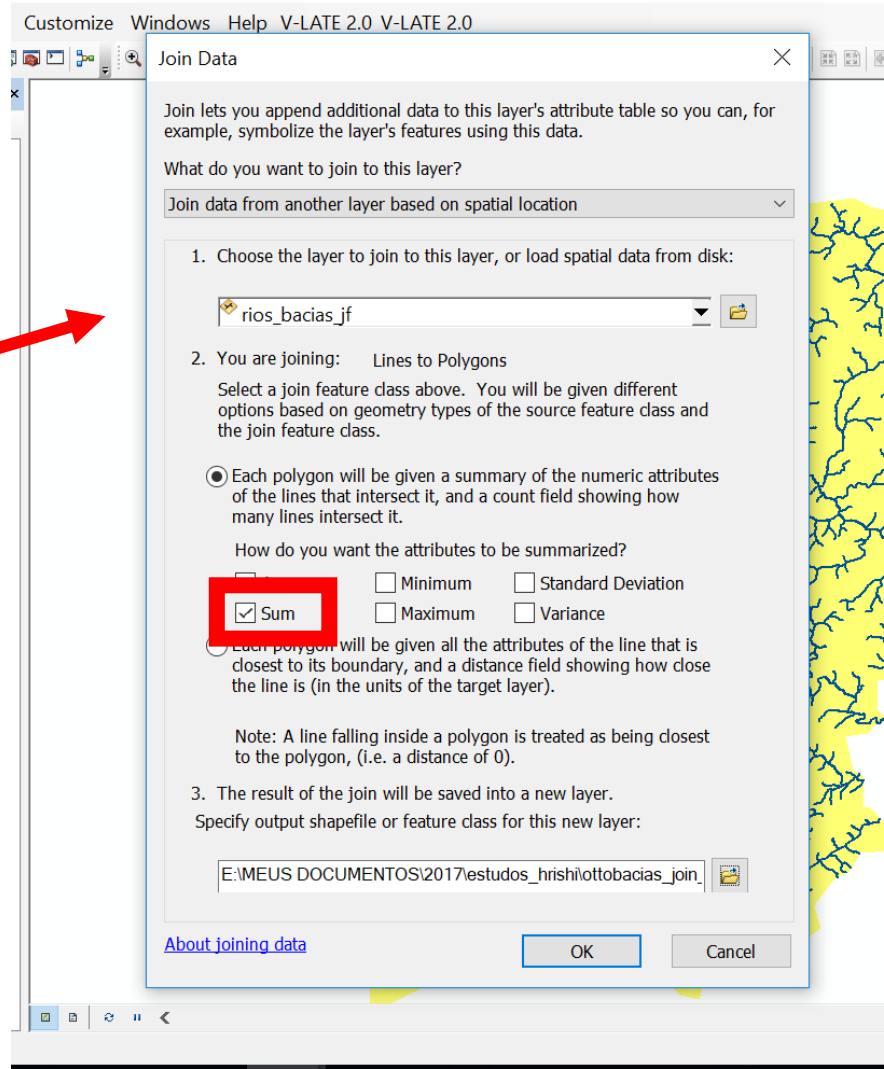


- Go to “open attribute table”
- Add the field, in this case we called “aream2” – type: float
- After that, click on the new field created and select the “calculate geometry” to have the result

Join the polylines of rivers and Polygons of Watershed

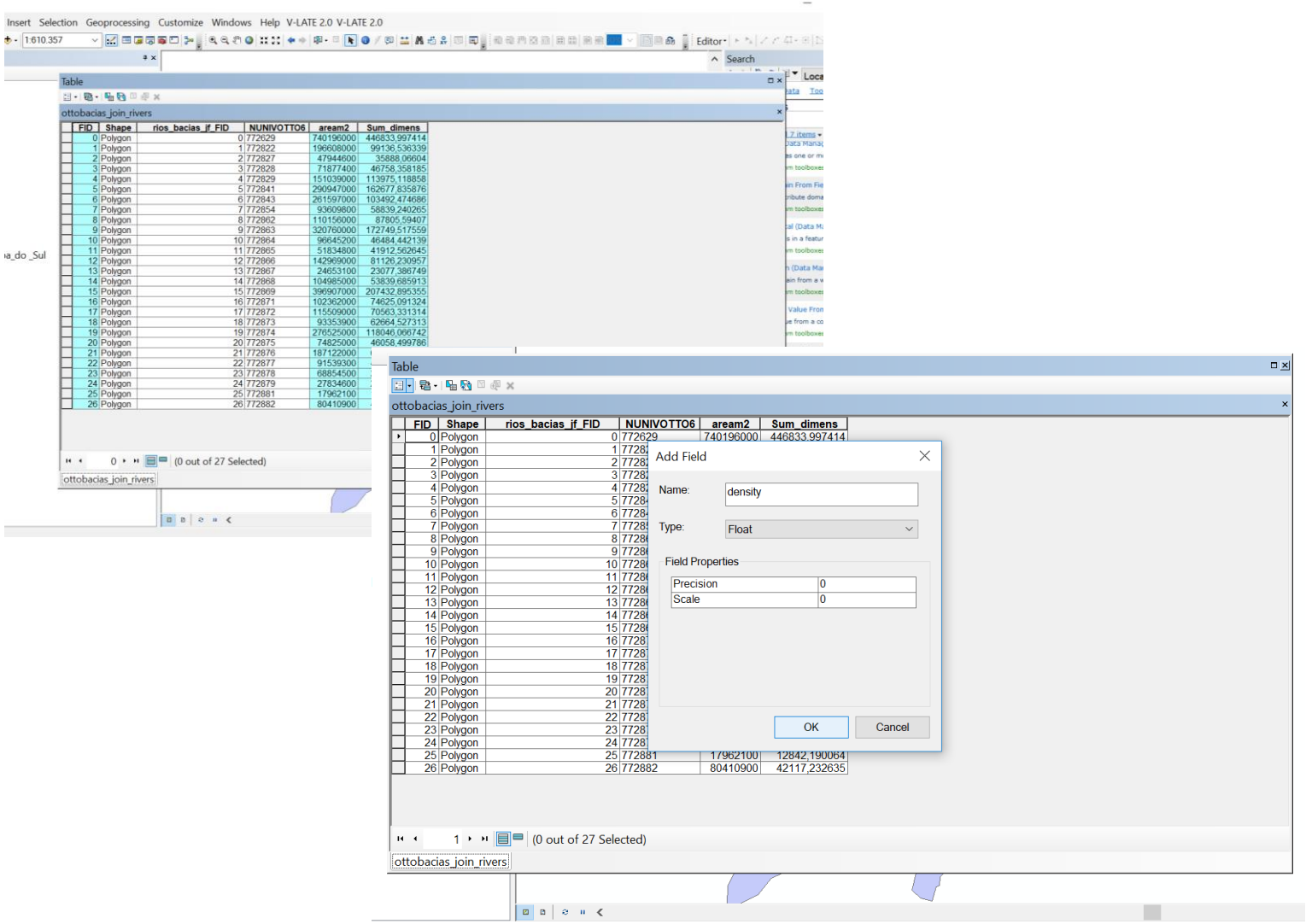
- Select “Join and relaters” – select the option “join”
- Select the option “sum”



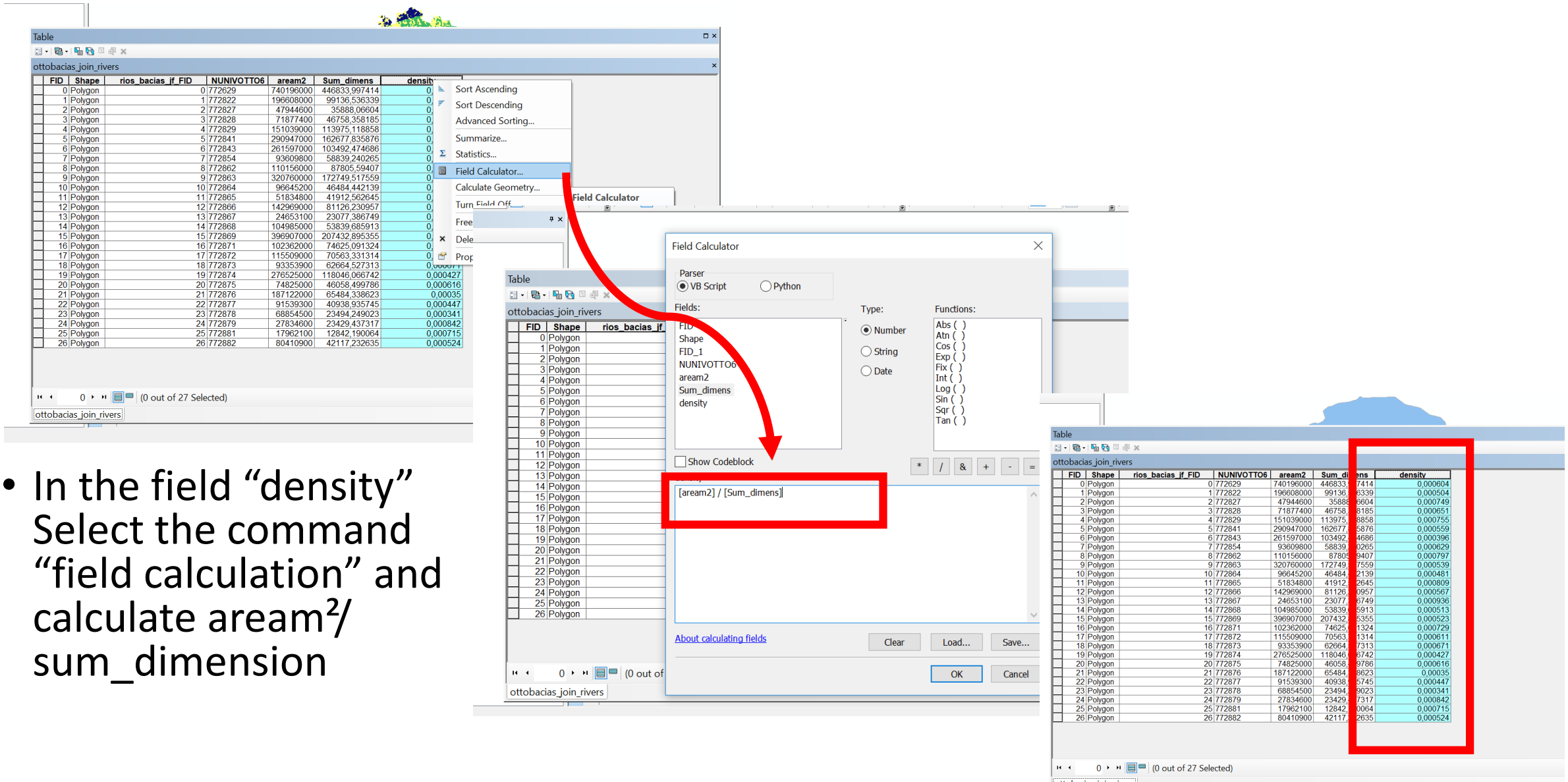


Working with the sum the datas

- After sum the datas, we have the data with area (m²) + lenght
- Now, we need creat a new field, we called “density“.



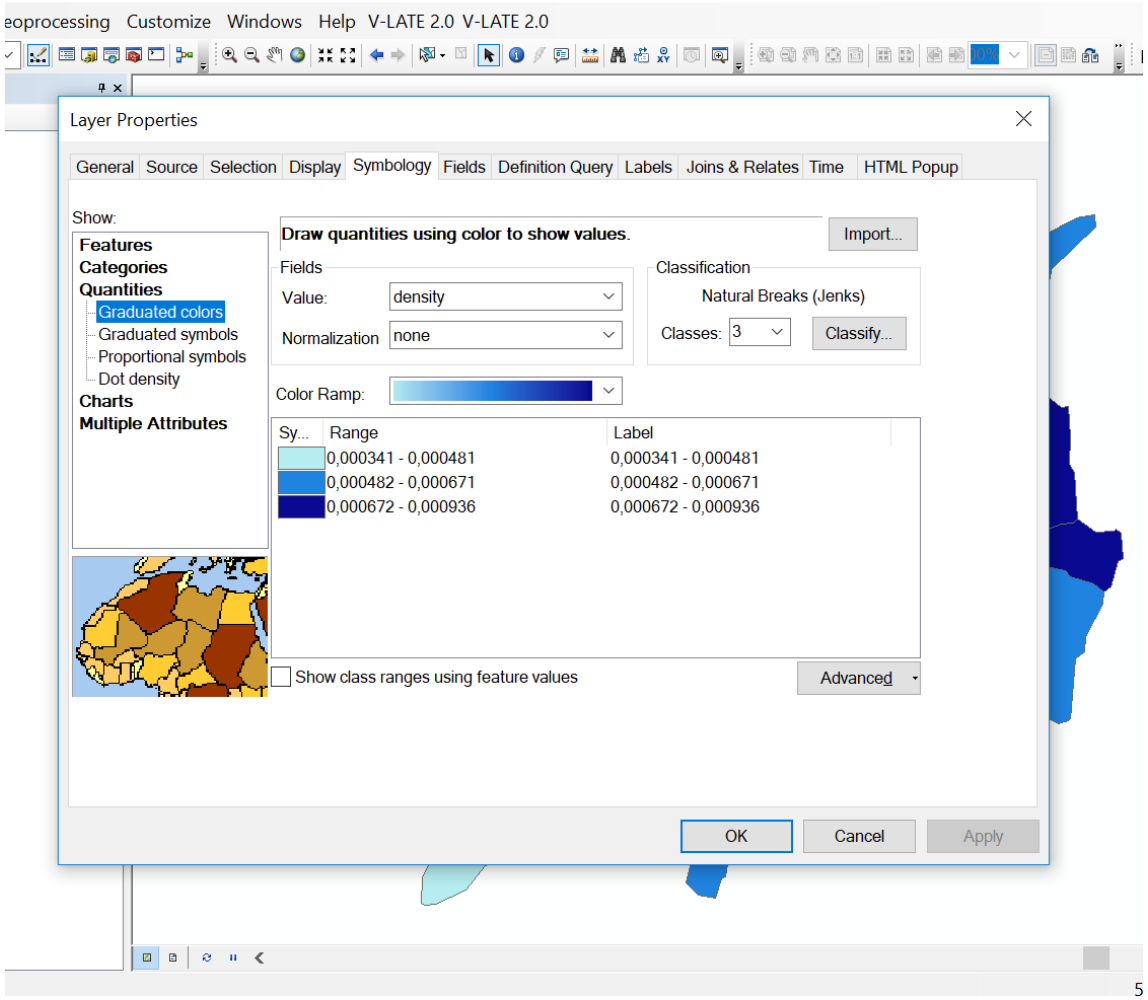
Working with the sum the datas



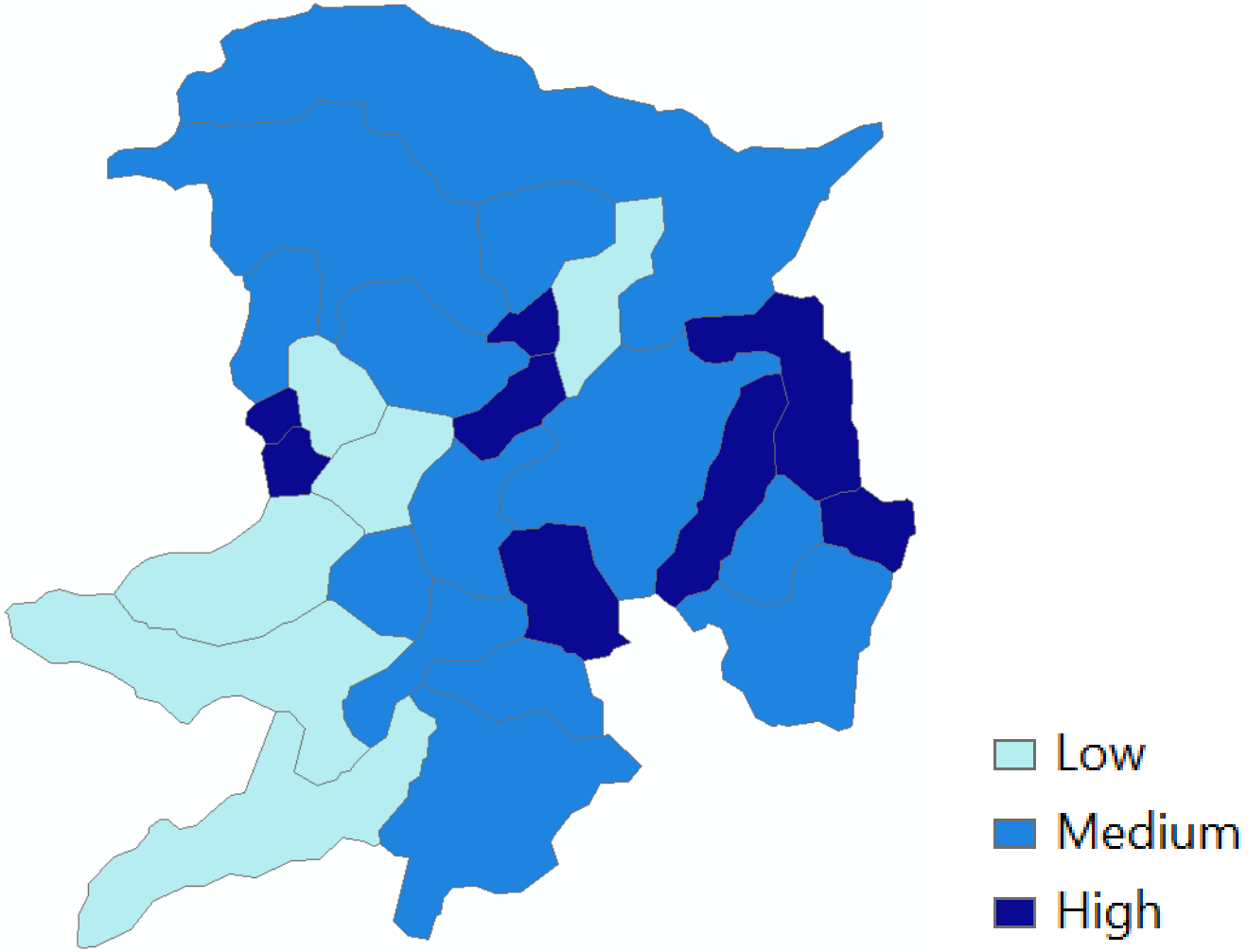
- In the field “density” Select the command “field calculation” and calculate aream²/ sum_dimension

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

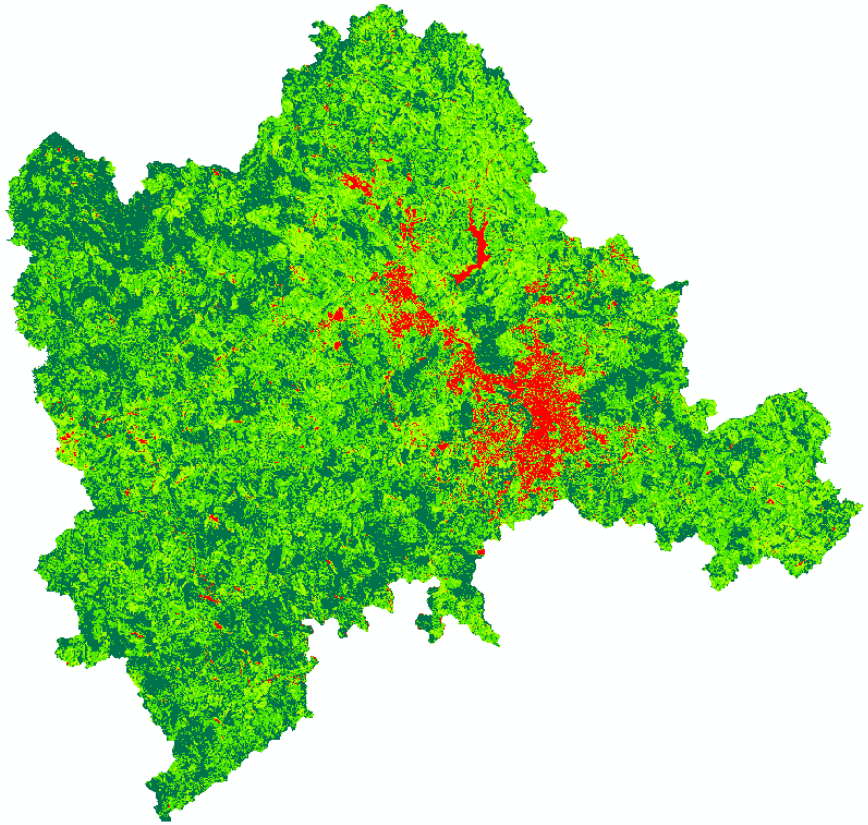


AGRICULTURE and HYDROLOGY SYSTEM MAP

Combinatorial analysis

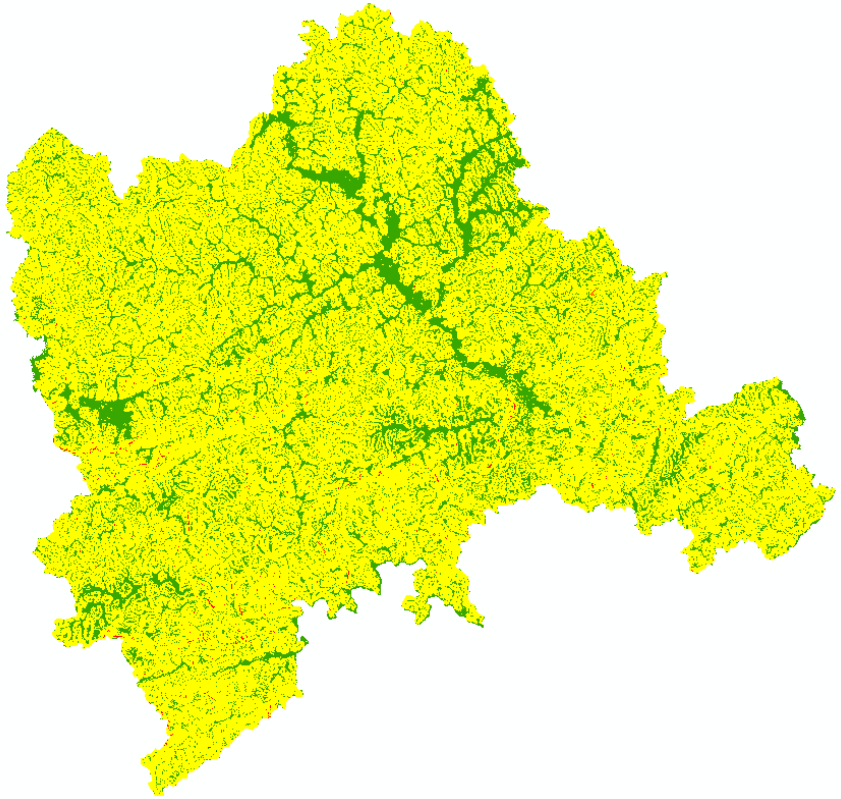
- To produce the Agriculture map we need the two maps using combinatorial analysis.
- After, add the waterway to identify the water

NDVI MAP



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

SLOPE MAP - Agriculture



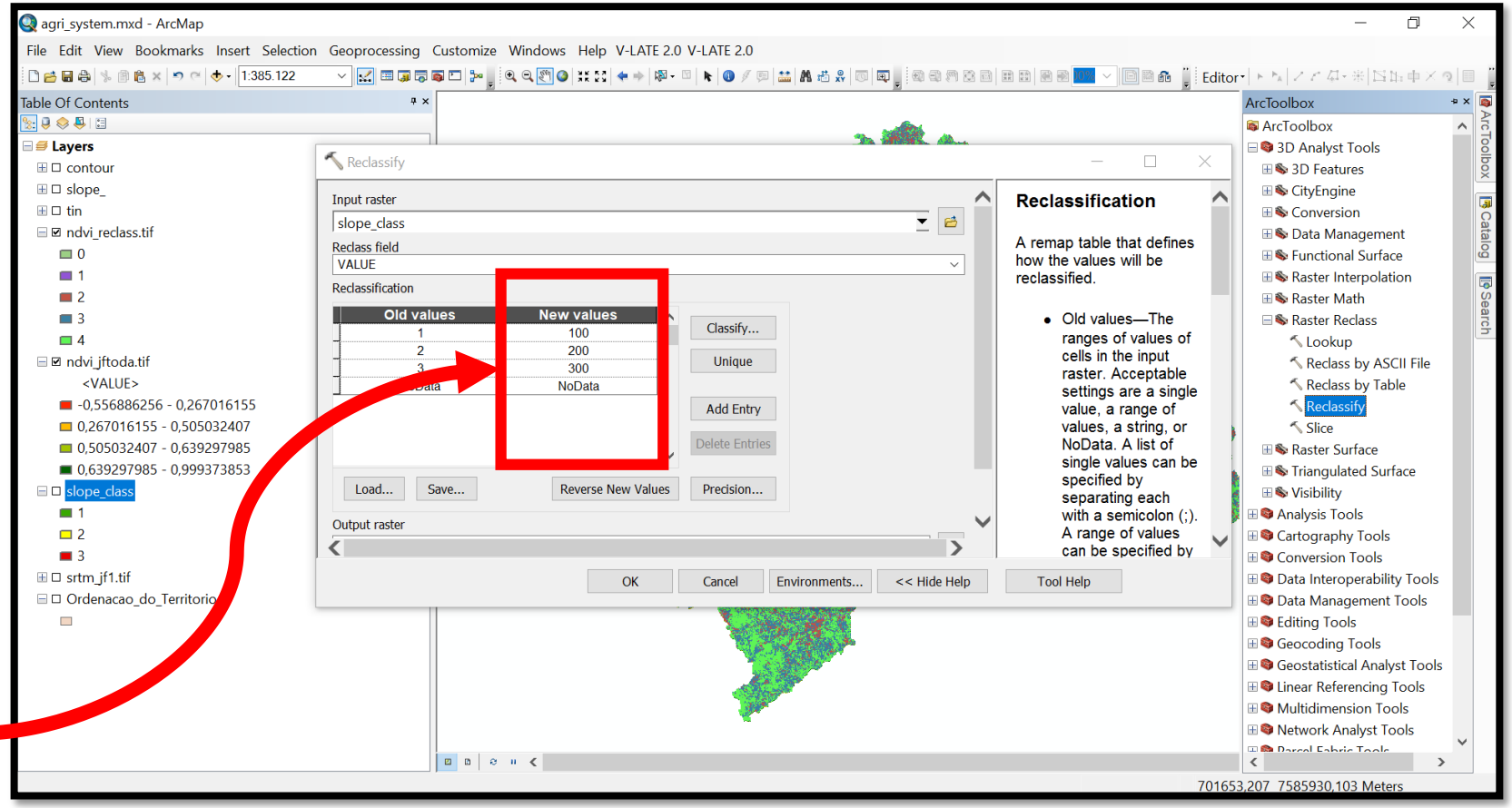
- 0,00 - 13,00 - allowed to mechanized agriculture
- 13,00 - 100,00 - family farming
- > 100,00 - Permanent protection Area

The logic about combinatorial analysis

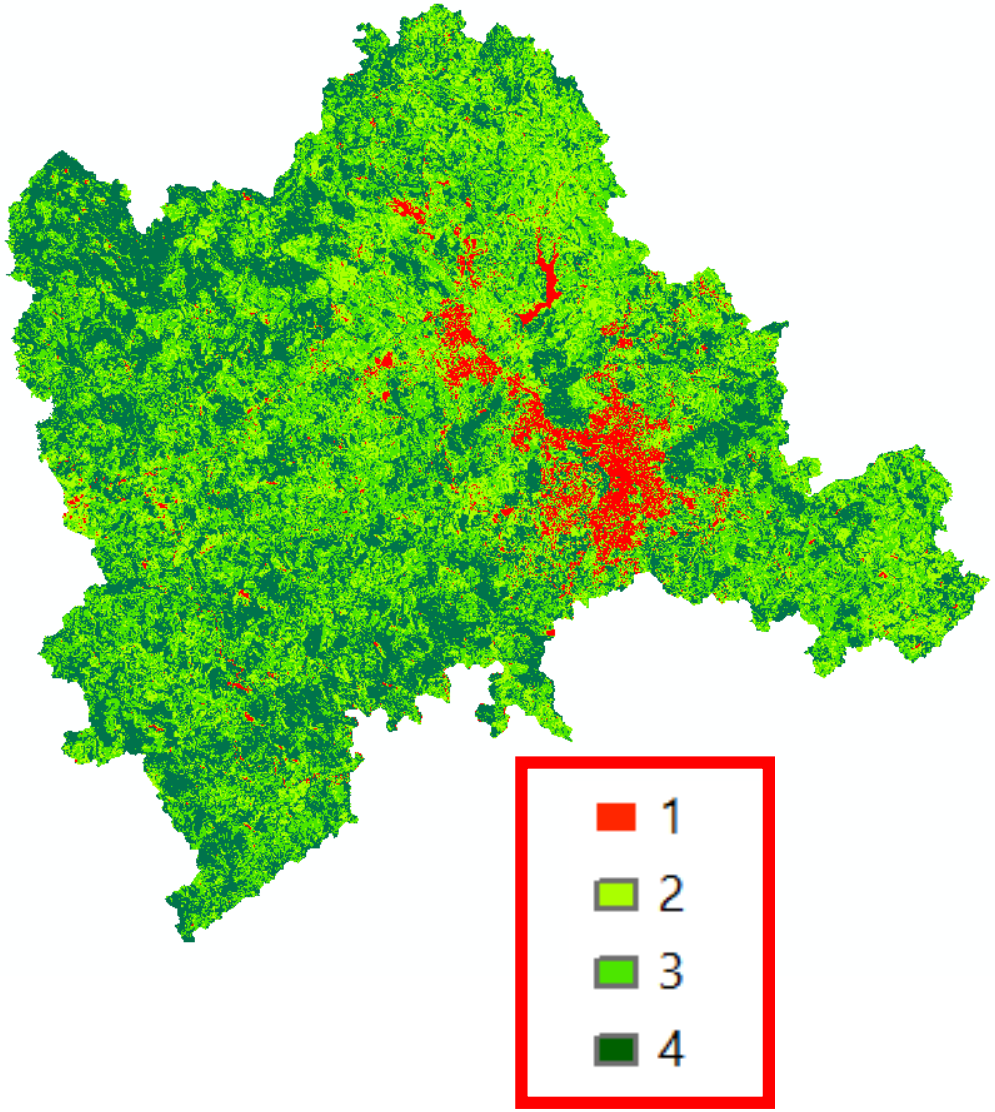
- According Groenwald *et al*. (2009), "*Combinatory Analysis is the part of Mathematics that studies and develops methods for solving problems involving counting or existence, in general, it can be said that it is the part of Mathematics that analyzes discrete structures and relations*".
- The Combinatory 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.

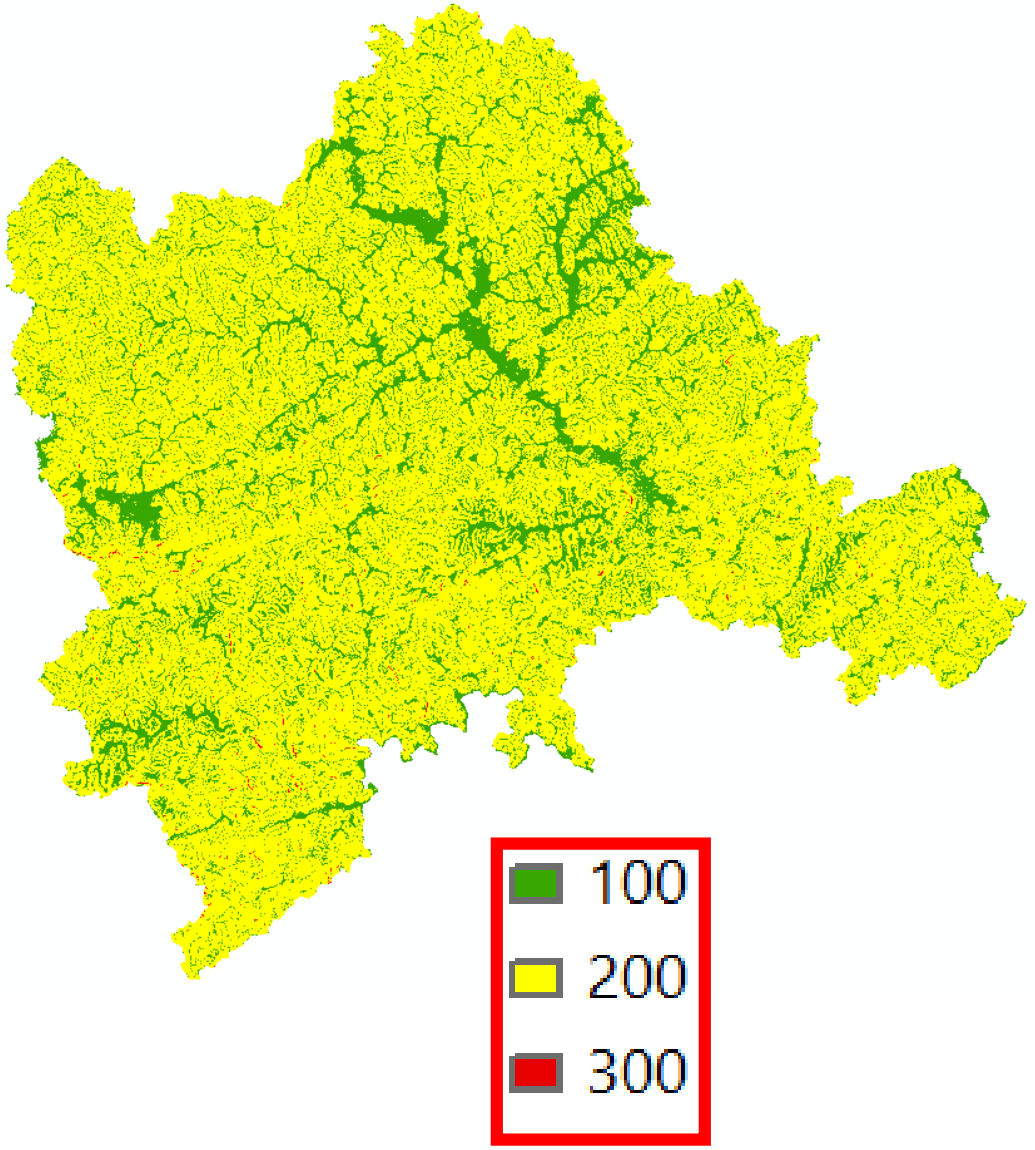
Reclassing the class

- 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



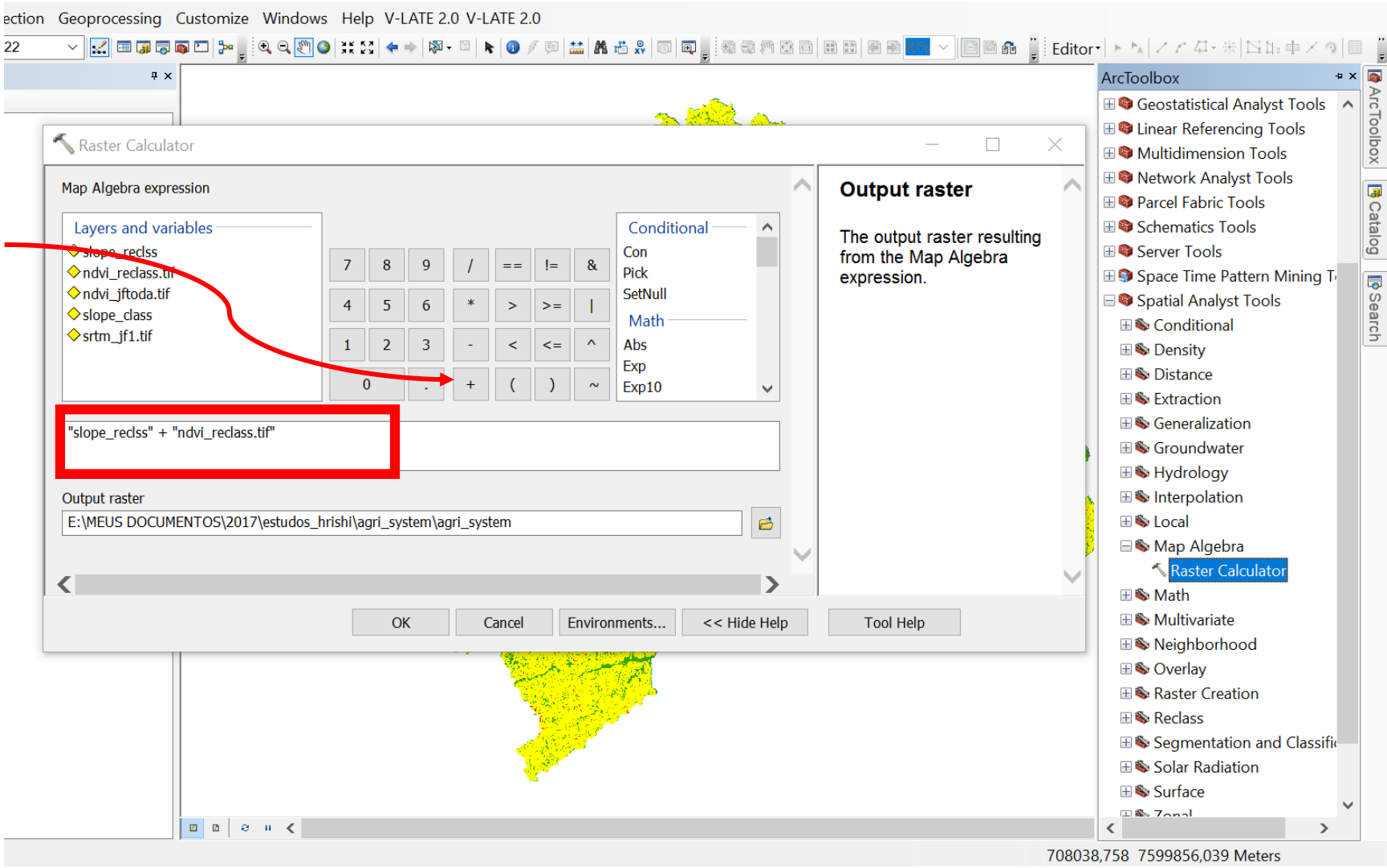


Combinatoryal analysis matrix

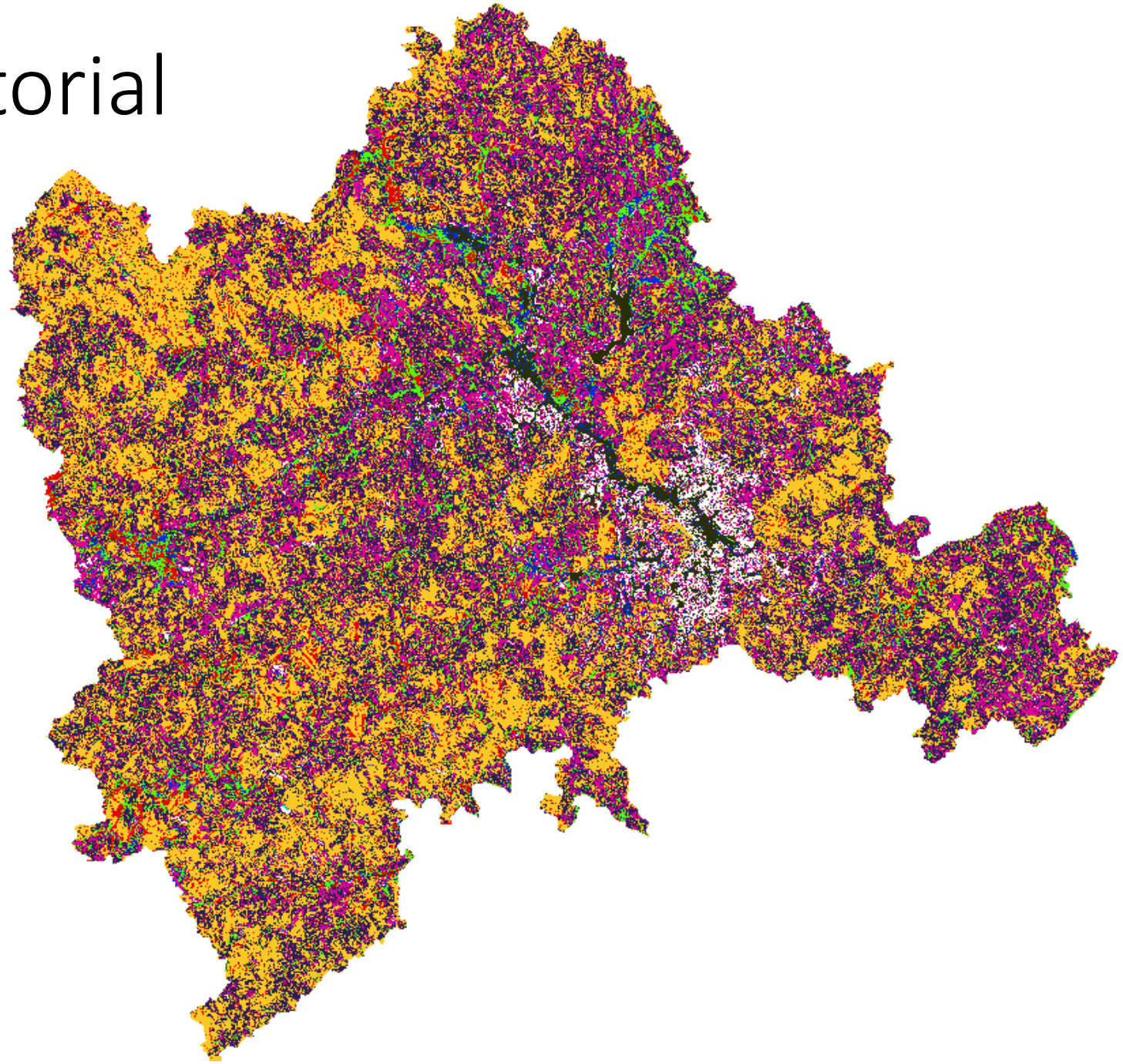
SLOPE \ LAND USE		Impervious areas/ Exposed soil/ water and shadow	Grassy	Shrubby	Robust vegetation
		1	2	3	4
0-13 %	100	101	102	103	104
13 -100%	200	201	202	203	204
100%	300	301	302	303	304

Sum the two maps (slope + land use)

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



Result of Combinatorial Analysis



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

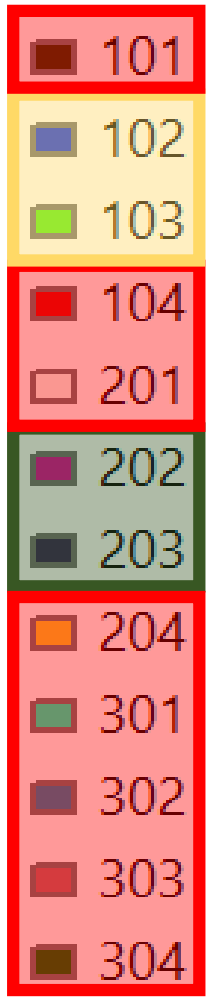
LAND / USE / SLOPE		Impervious areas/ Exposed soil/ water and shadow	Grassy	Shrubby	Robust vegetation
		1	2	3	4
0-13 %	100	101	102	103	104
13 -100%	200	201	202	203	204
100%	300	301	302	303	304

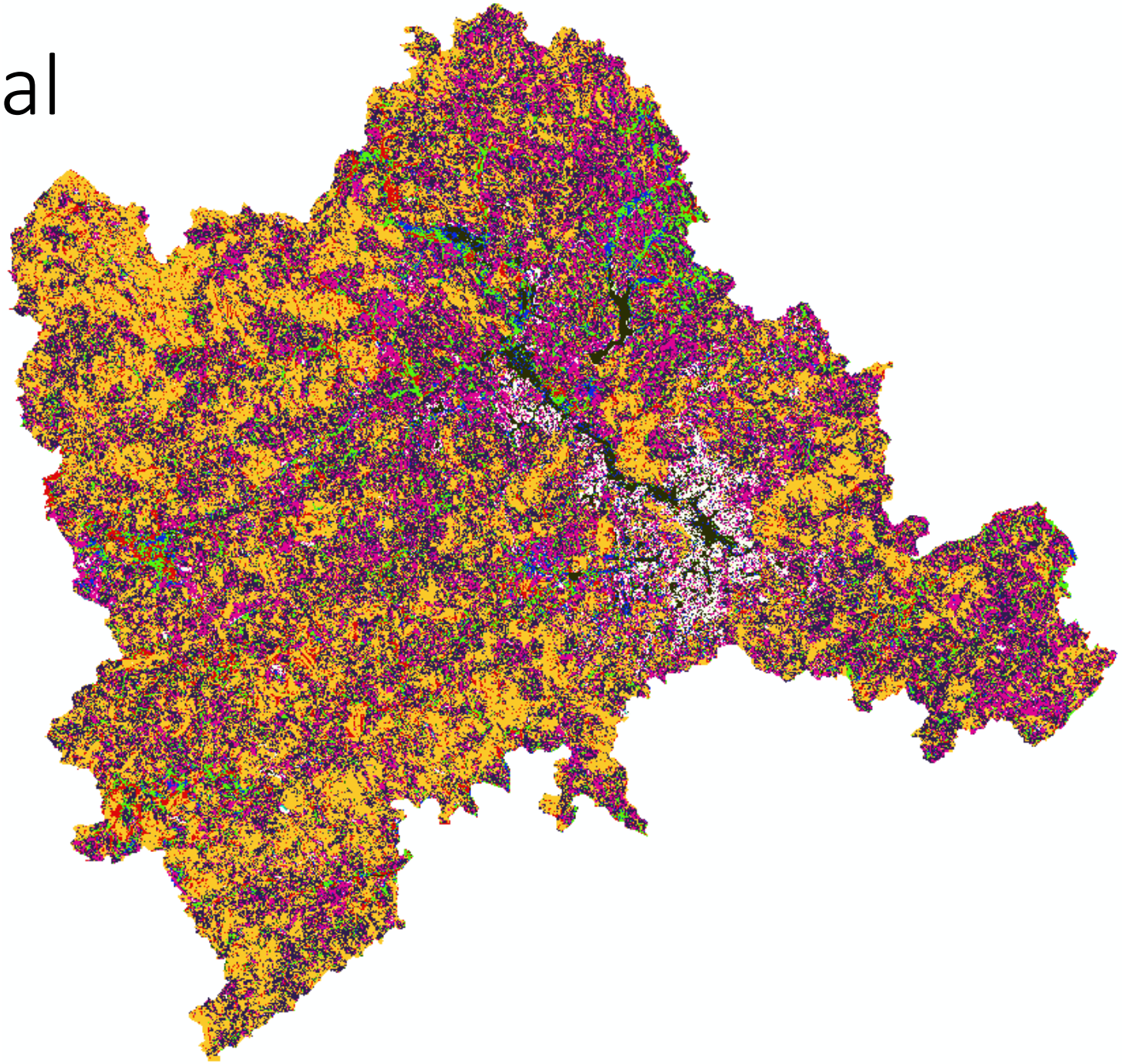
Interpretation of result of Combinatory Analysis

- 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

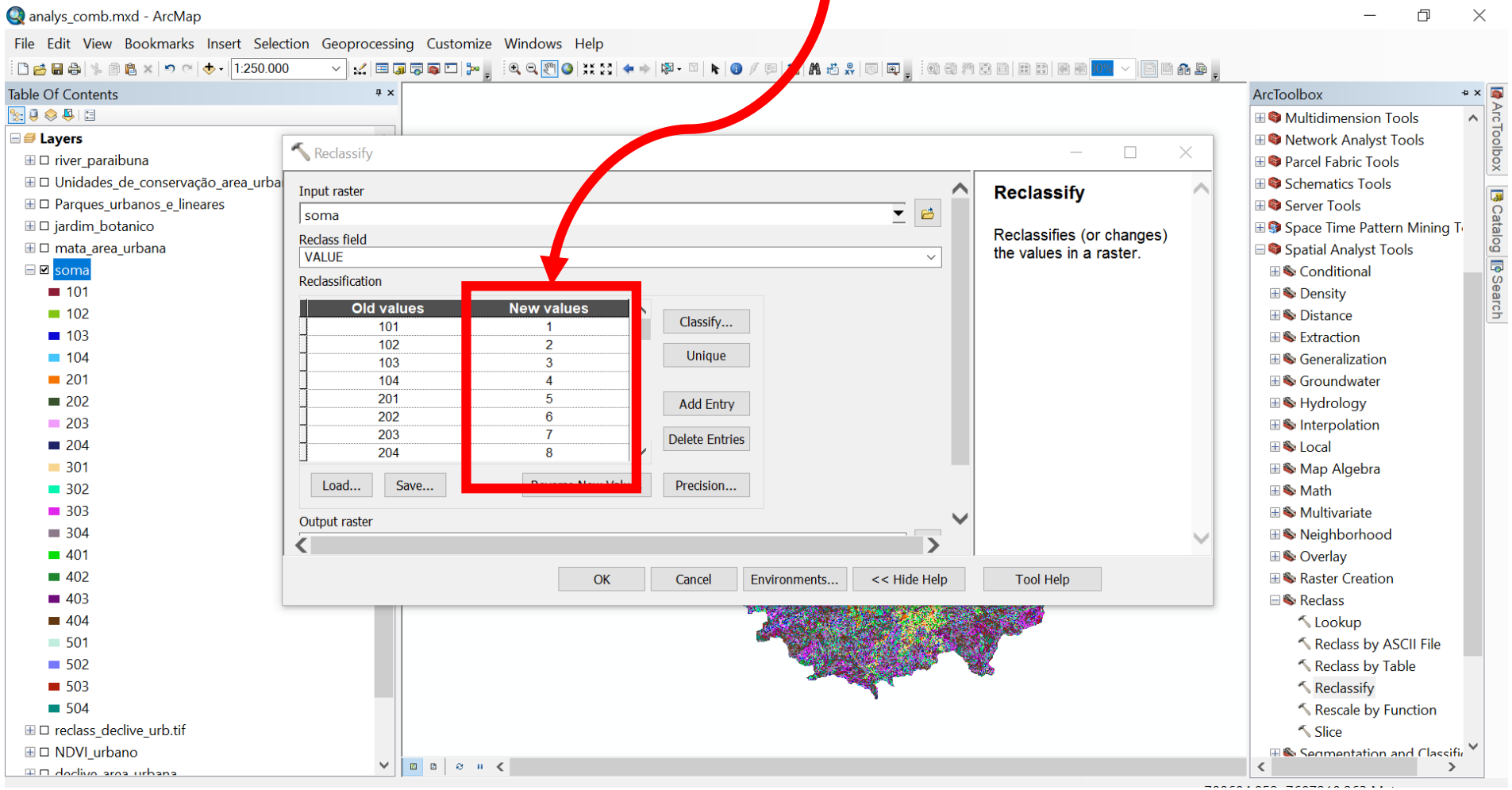
- Not suitable /inappropriate to agriculture growth: 101, 104, 201, 204, 301, 302, 303, 304.
- Capable to agriculture (specific methods to plant): 102, 103
- Suitable to agriculture growth: 202, 203



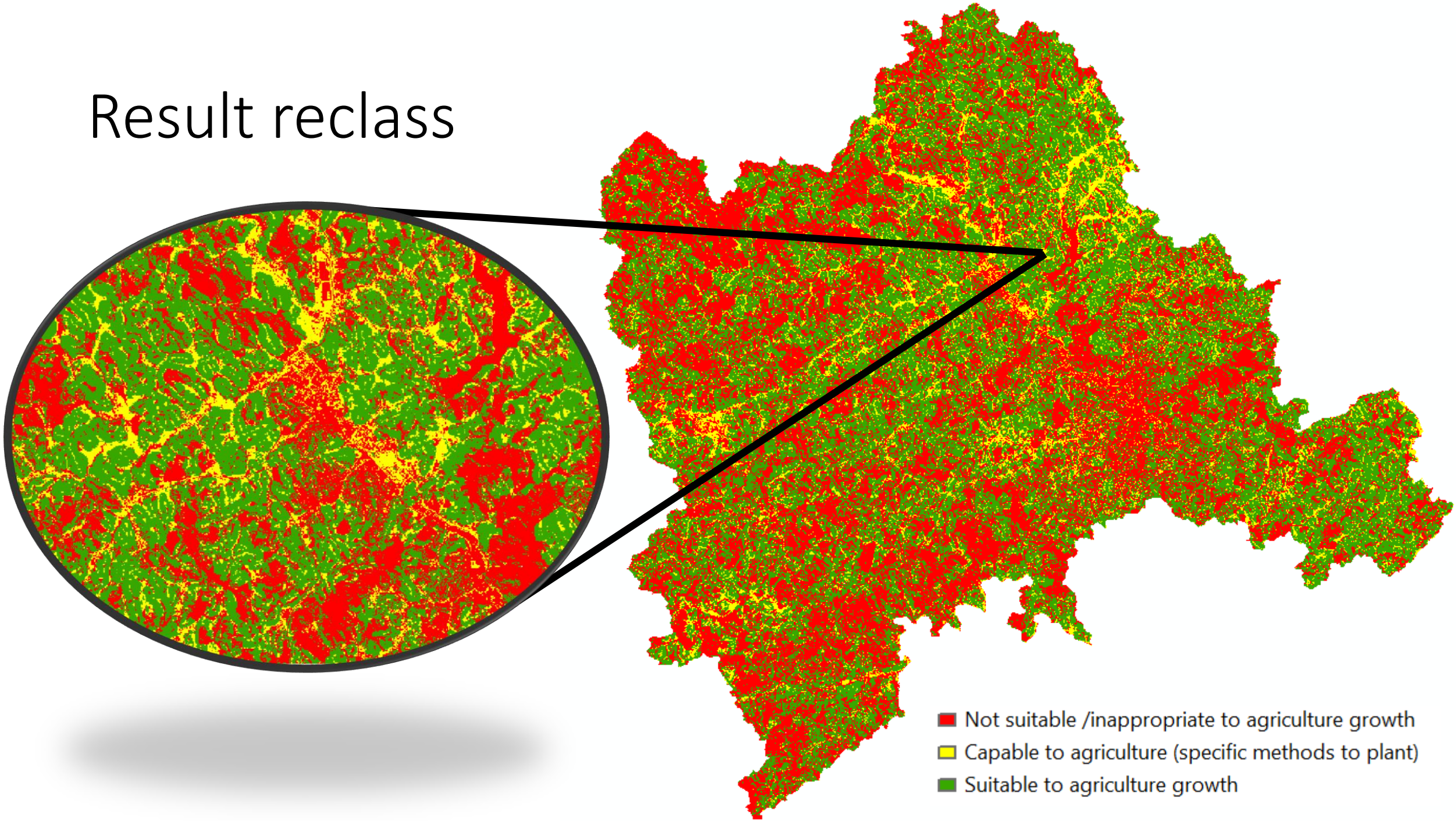


Reclassify the groups

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



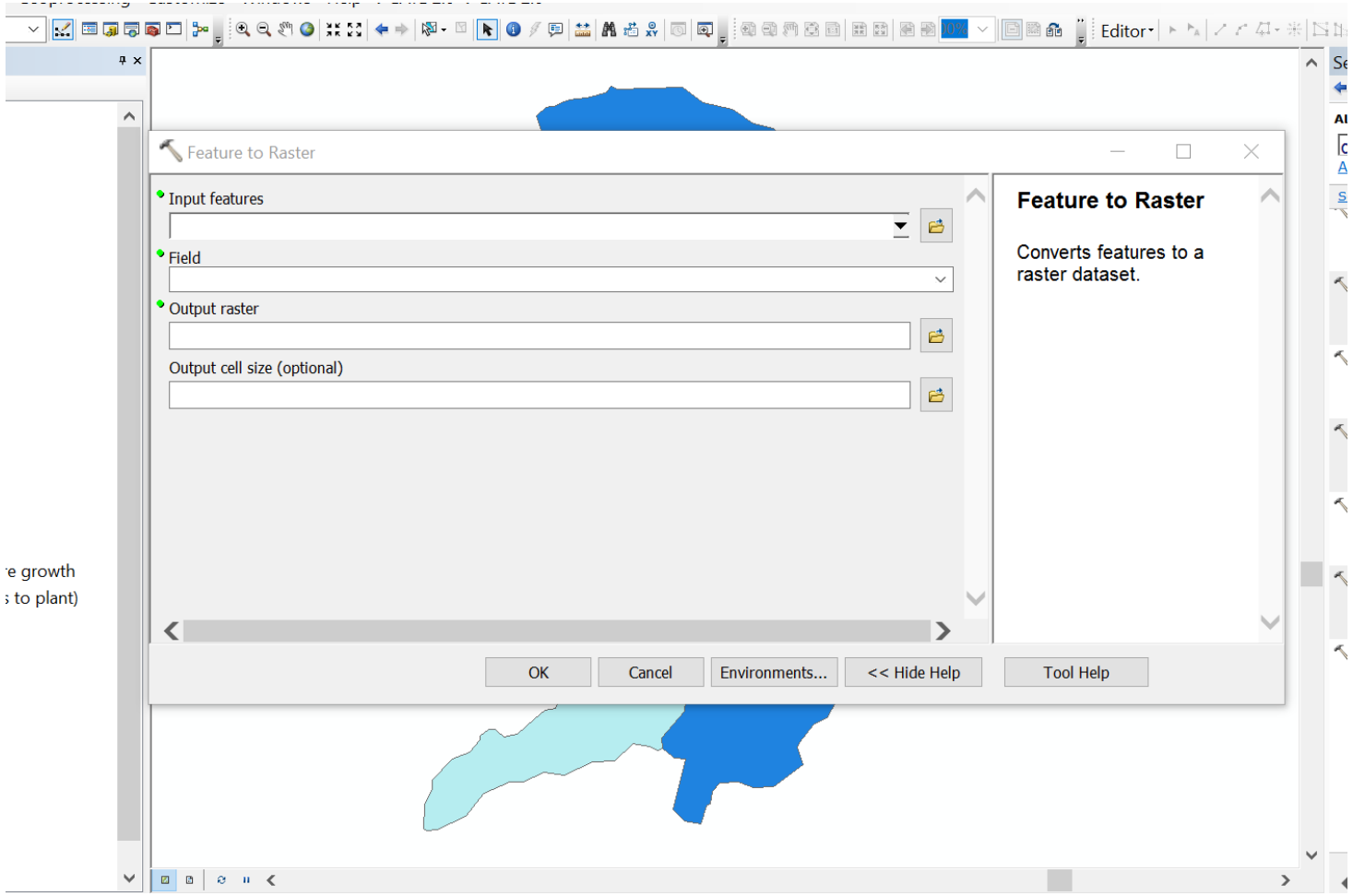
Result reclass



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”



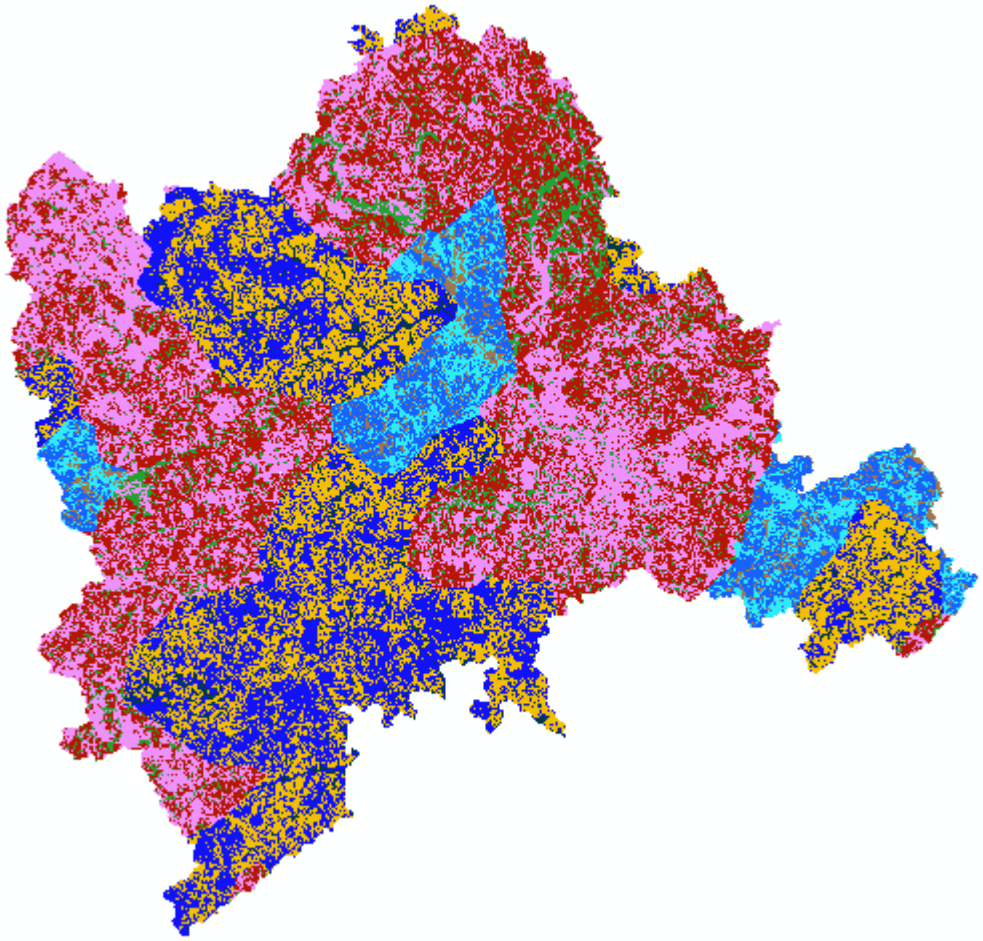
Combinatoryal analysis matrix with the variable of water

WATER / SLOPE/ LAND USE		Low	Medium	High
		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



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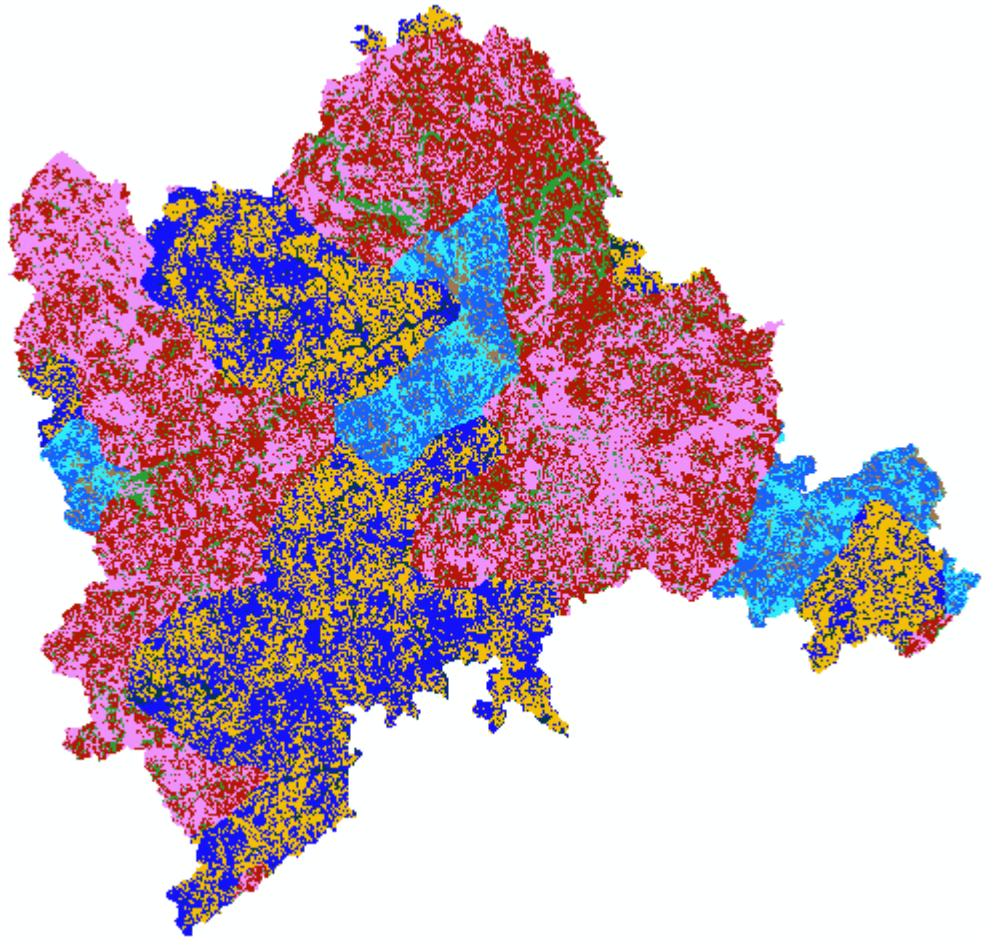
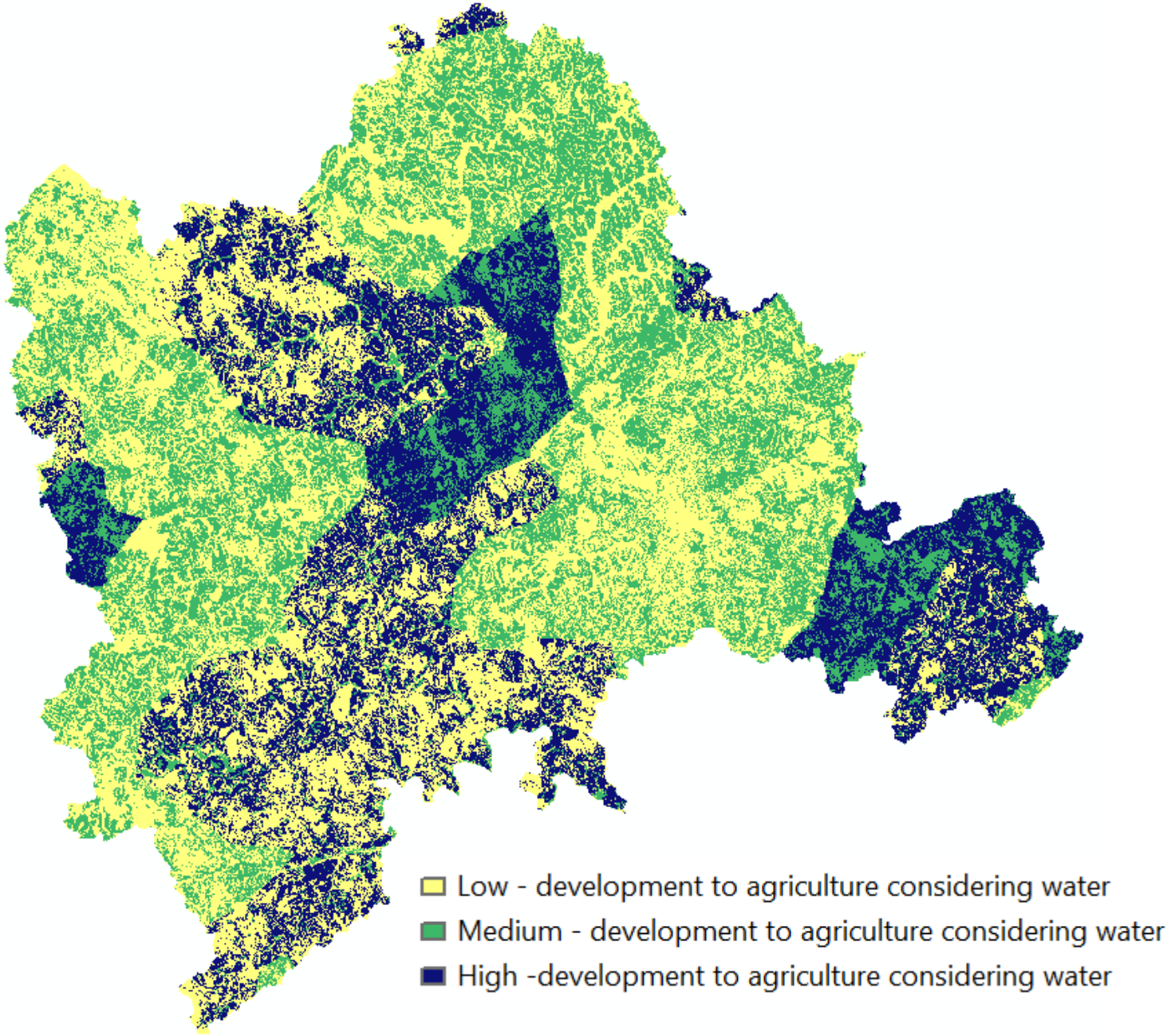


Result map with variable water

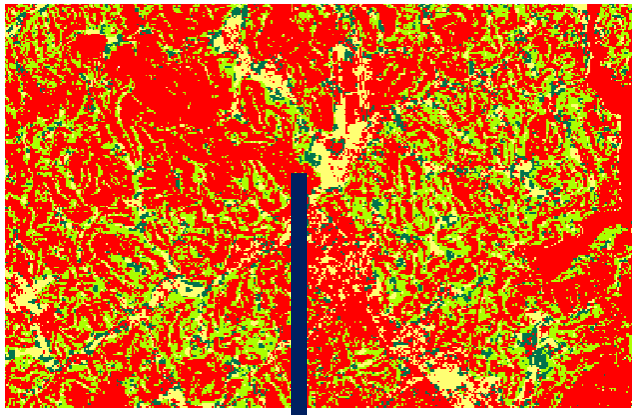


To improve the map visualization

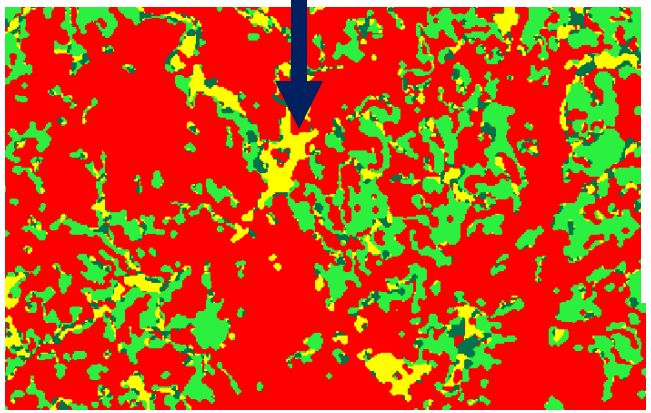
DEVELOPMENTS – to improve the map

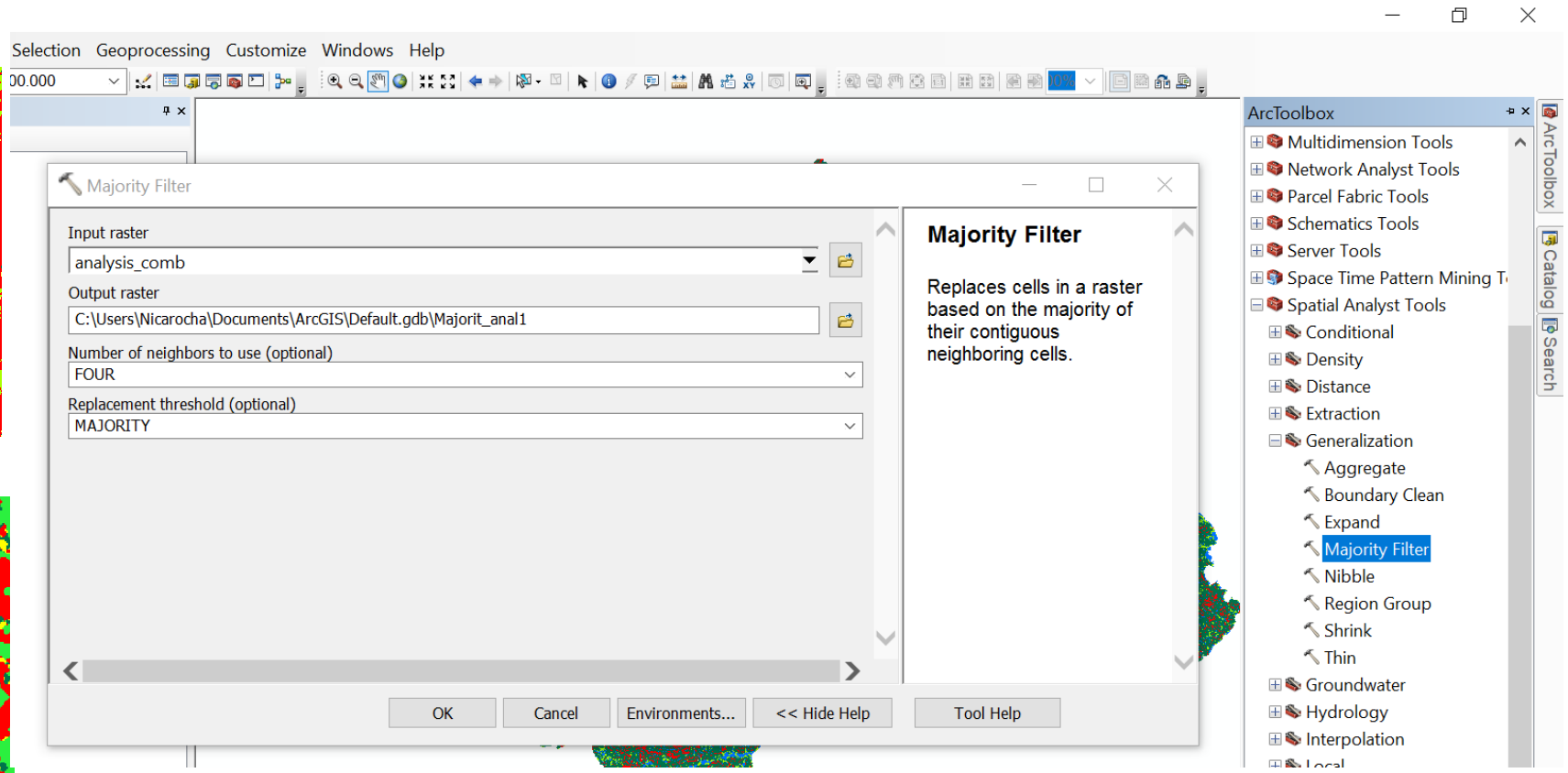
- Image processing to eliminate the “pixel effect” use the majority filter command as many times as necessary

Before



After

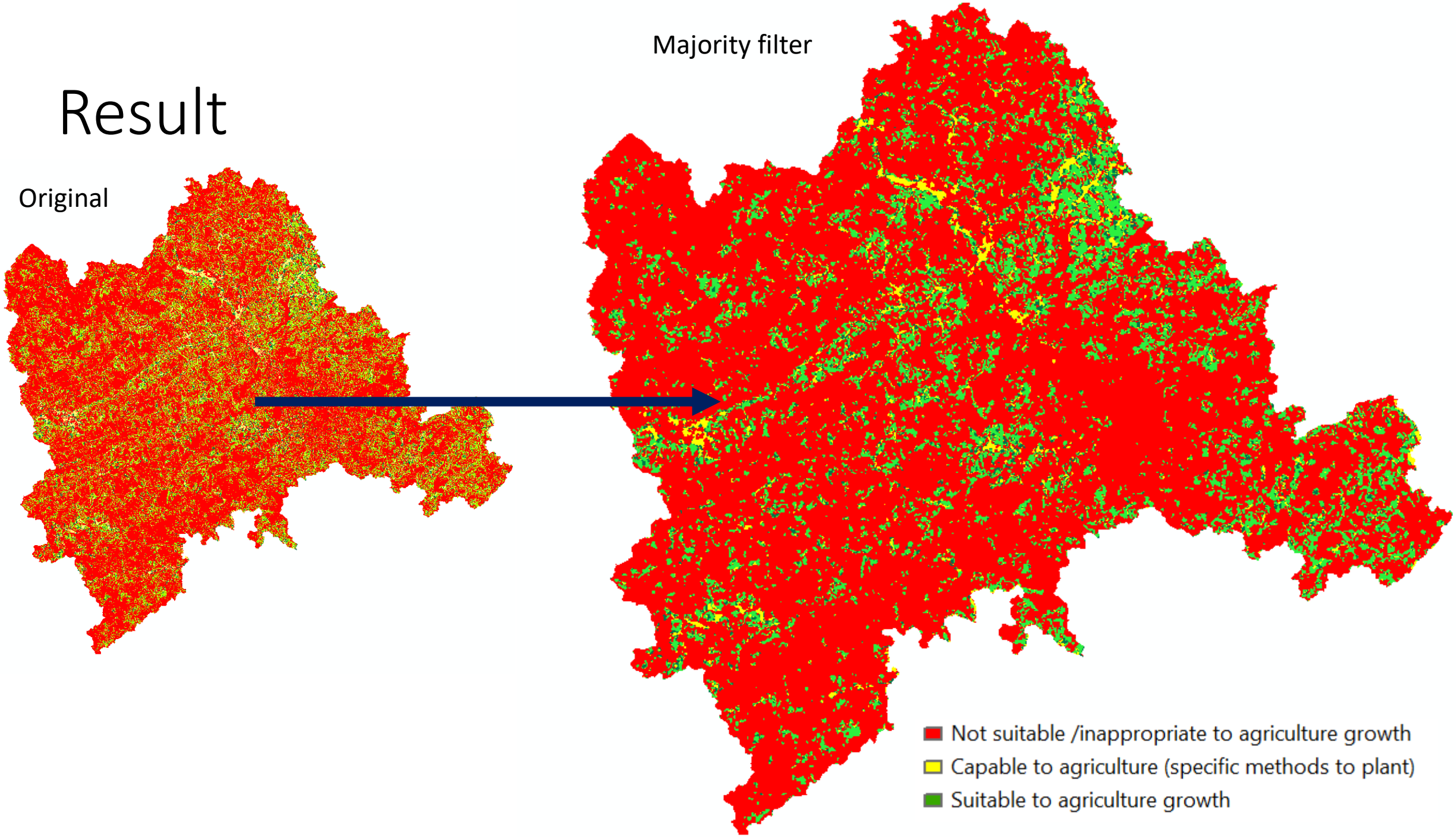




Result

Original

Majority filter



To improve the map visualization using the "majority filter"

Majority filter

Original