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BASICS OF GIS FOR IMPROVING SPATIAL PLANNING IN FORCIBLY DISPLACED SETTINGS

PART 2

TABLE OF CONTENT

1. INTRODUCTION

Planning any life support infrastructures require a good understanding of the terrain on which they will be built. Geographic Information System (GIS)[1] and Computer Aided Design (CAD)[2] coupled with Remote Sensed (RS)[3] data allow the planner to design solutions adapted to the specific realities of the terrain. This saves time and money and make possible to plan more efficient solutions, as well as to monitor their implementation. In addition, risk management and other non-classical engineering thematic, may be included the design process, thus improving the resilience of the planned infrastructure.

The goal of this document is to introduce GIS for engineers beginning with such software. It is a big asset for planners to improve their working knowledge of GIS, since this is the "Swiss knife" for preparing robust data that will be then imported into CAD for the detailed design of infrastructure. The basic GIS procedures are here presented, as well as how to synchronize GIS data and CAD.

This tutorial uses use the flood phenomenon as an example, as it is one of the main external elements constraining the settlement design, but GIS can be used for many other settlement planning, monitoring and management tasks. This document presents how to measure specific characteristics, such as the area (of a plot, block, etc.) in order to compute hydrologic parameters important for flood protection. However, it doesn't replace more in depth GIS trainings[4] available elsewhere and it relies on the "Basic notions of GIS for settlement mapping, part 1".

This document is composed of two sections. In the first part, some theoretical elements necessary for understanding the data model are presented. The second part provides a practical guidance on how to create your own data, that is drawing items on a map and adding to them attribute values.

2. THEORETICAL ELEMENTS

2.1. A database with spatial reference

GIS is a way to store information linked to a specific location. Therefore, one could see GIS as a spatially referenced database.

BEFORE going to GIS it is crucial to consider how you want to model your data.

By experience the development of a data model is a trial-and-error process. It is best done using brainstorming session. Anyway, the simple rules apply when you are developing a data model :

1. A model is a succession of tables.
2. Each entity must have a unique identifier → **key.**
3. Data must not be duplicated.
4. Attributes must provide an information to the **key**.
5. A similar column must exist in different tables to enable a relation to be made.
6. No repeating group of attributes (different attributes having the same meaning).
7. Use automatic computations wherever it is possible to avoid typing inconsistencies.

Excel is a good drafting tool for modelling data. An example of spreadsheet is provided in the folder "February 22 training" on the TSS sharepoint. The Figure 1 provides an example of a data model that may be replicated. Remember that in the shapefile format, the name of the attribute cannot be longer than 10 characters.

As a preliminary conclusion, why is it important to develop an adequate data model ?

1. A good data model will facilitate and speed your work.
2. A weak data model may not only be less efficient, but it may also prove to be unusable.
3. Time invested in data structuration is very well invested.
4. This information may be transferred to CAD during the «ingestion» of shapefiles.
5. Therefore, this information may be, if useful, brought to the last level of detail.

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1 Well-known GIS software are Arcmap (proprietary) and QGIS (open source)

2 Well-known CAD software used for mapping are AutoCAD (proprietary) and QCAD (open source)

3 Often used acquisition sources are satellite, drones, airplanes, *etc*.

4 https://docs.qgis.org/3.22/en/docs/gentle_gis_introduction/
https://gistbok.ucgis.org/bok-basic-page/welcome-gist-body-knowledge
https://volaya.github.io/gis-book/en/Cartography.html
https://www.esri.com/training/mooc/

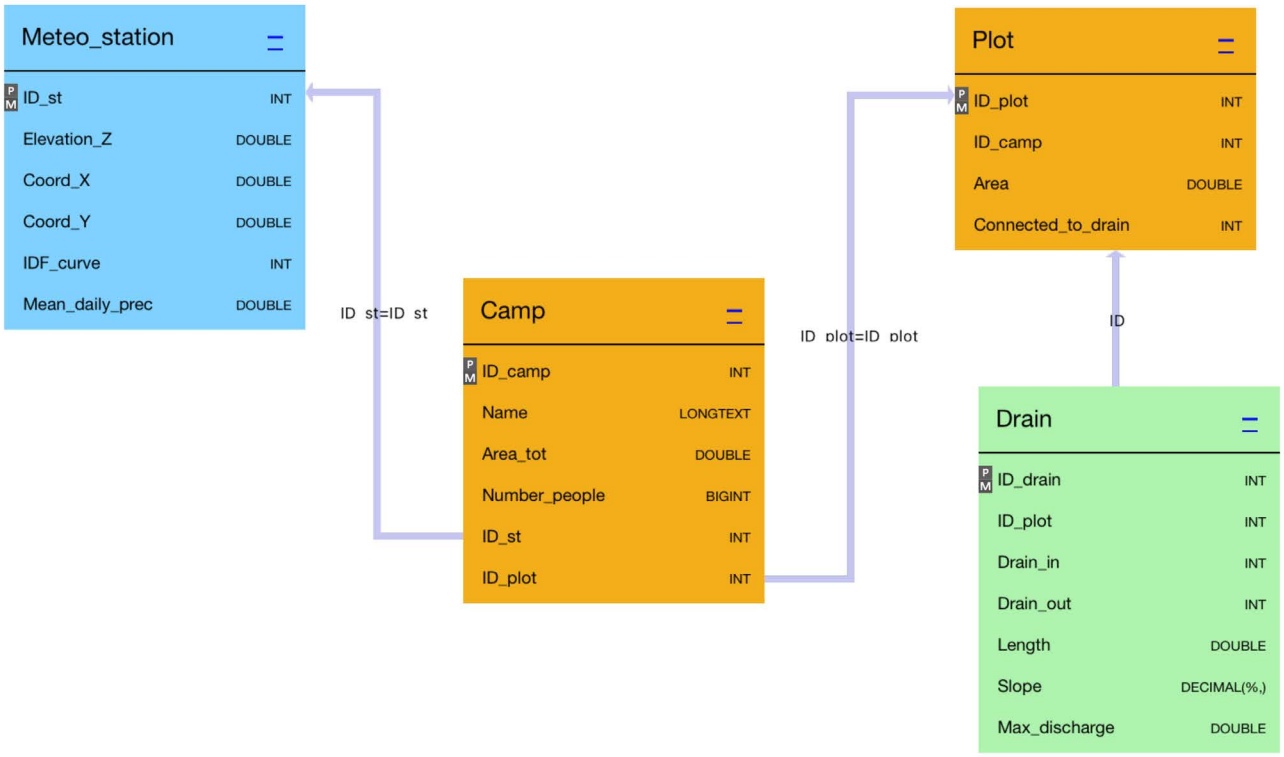

Figure 1. *Working example of a spatial database, with 4 elements (blue box represent points, green lines, orange polygons)*

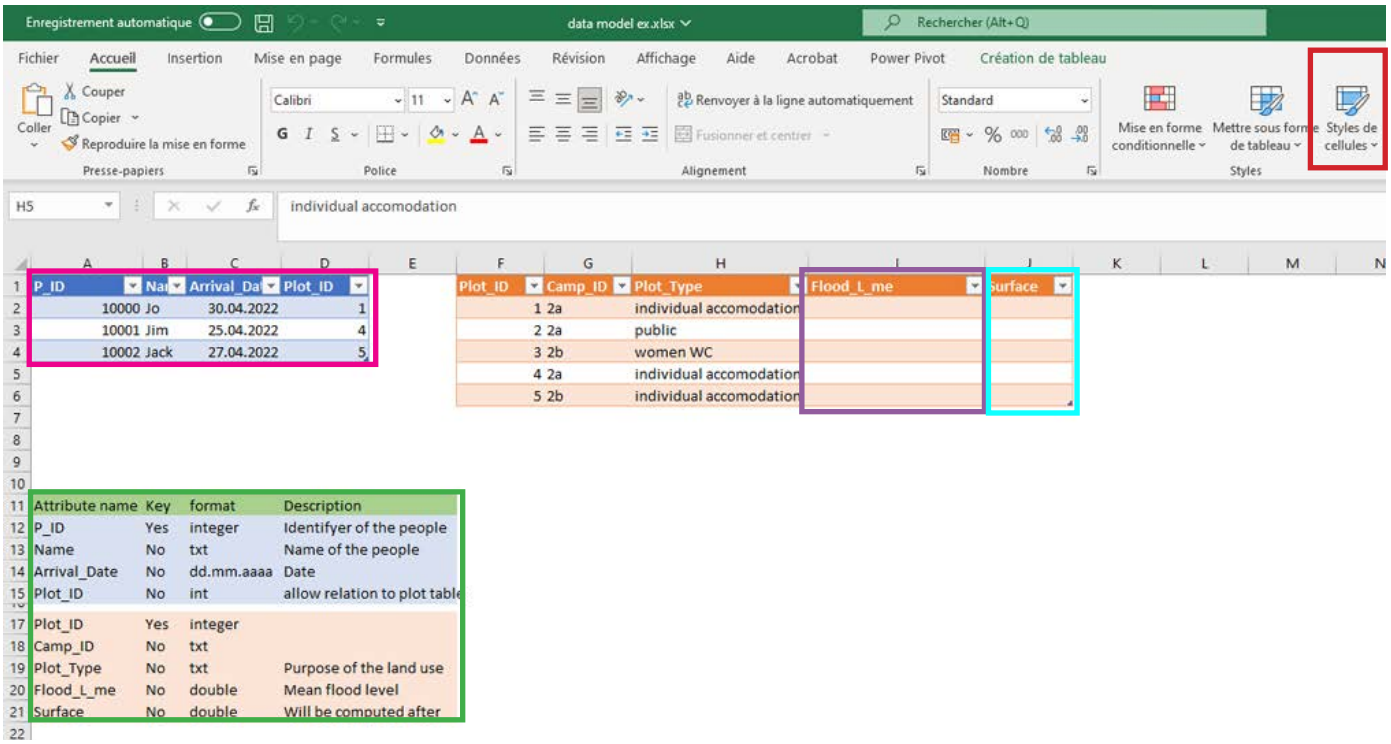

Figure 2. *Drafting your data model with a spreadsheet defining the attribute type (green box) and having manual entries (magenta box) and automatic computation (violet and cyan boxes).*

3. GIS PROCEDURES

The procedures below are prepared with the version 3.22.4 of the long term release of QGIS downloadable at : https://qgis.org/en/site/forusers/download.html#

On the image below a red box means mouse click, and a green box a right-click !

3.1. Create your own data

Once you finalize the data model and know how you will arrange your data in between points, lines, and polygons and with which attributes, you can open QGIS. Then, go to :

Layer → Create a layer → new shapefile layer (as in Figure 3).

Then you have to provide the relevant info in the new window that appear as follow (see Figure 4):

- The name (remember that it will create at least 3 files with different extension).
- The coding (preferably UTF-8).
- Consider type of geometry (*i.e.* point, line, polygon).
- Ensure a correct the Coordinate Reference System, CRS, for now WGS84 is OK (see comments on the CRS, chapter 2.4, in part 1).
- Define the attributes (Define the attributes (as prepared in the Excel spreadsheet).

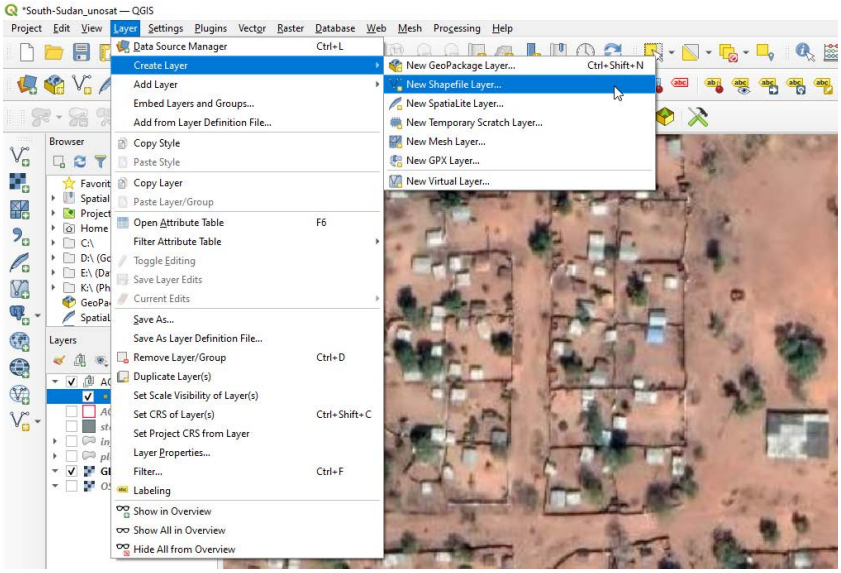

Figure 3. Creating a new shapefile layer.

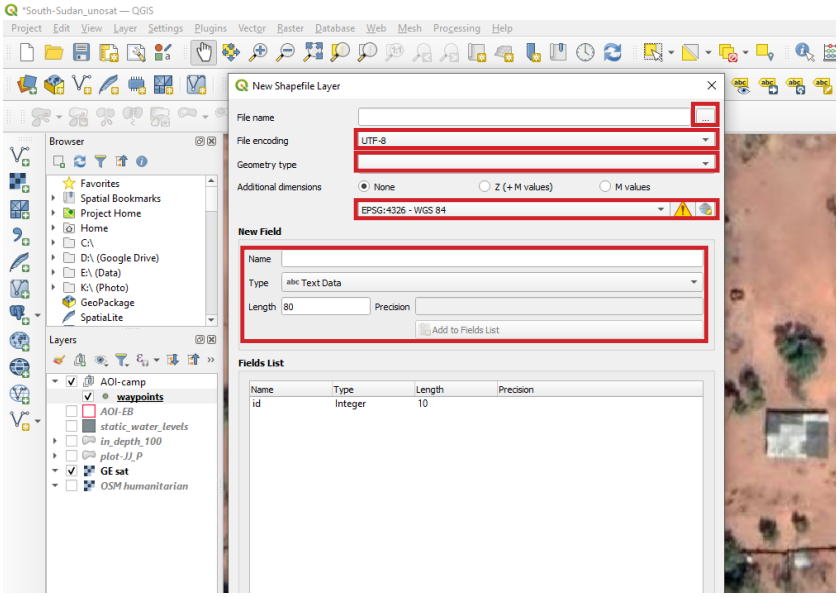

Figure 4. Integrating the attributes as defined in the data model.

3.2. Fit the ingestion of data to your data model

The digital world does only what you want it to do, not more ! If in an attribute column (especially if several people are working on it) the inputs are not set exactly on the same labelling it will prevent further research. Therefore, it is very important to be precise and organized.

You can define drop-down lists for ensuring the good labelling of data.

Right-click on the *layer → properties → attributes form*

Then select for which attributes you want to define a list and in widget type select Value Map, you should then get the same image than in Figure 5. Select the value from the excel draft (red box) and enter the value into the value column (magenta box).

Once this is done and once your layer is in edition mode (see § 3.4) the drop-down list appears when you are entering info on the given column.

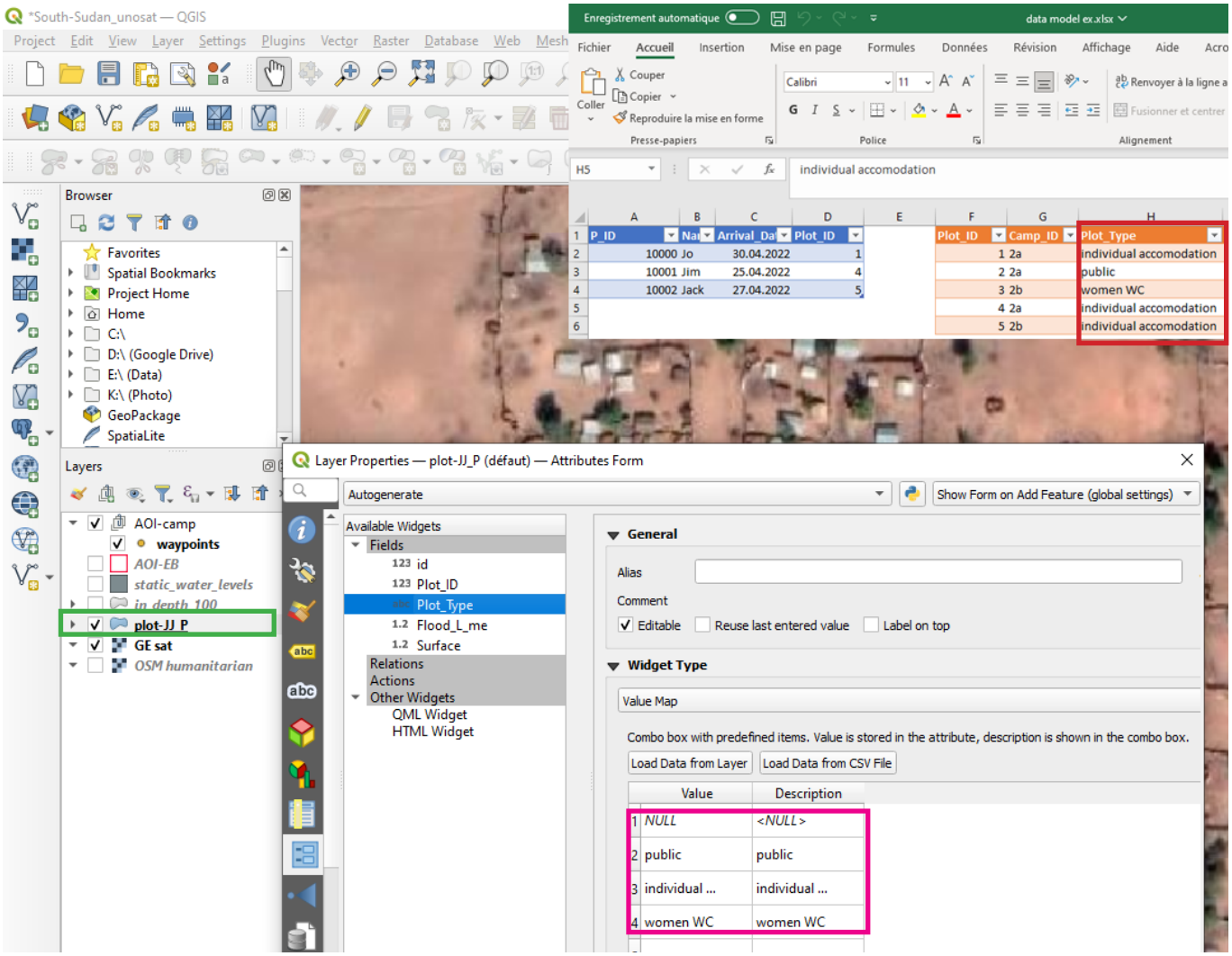

Figure 5. Defining a drop-down list for the ease of data ingestion.

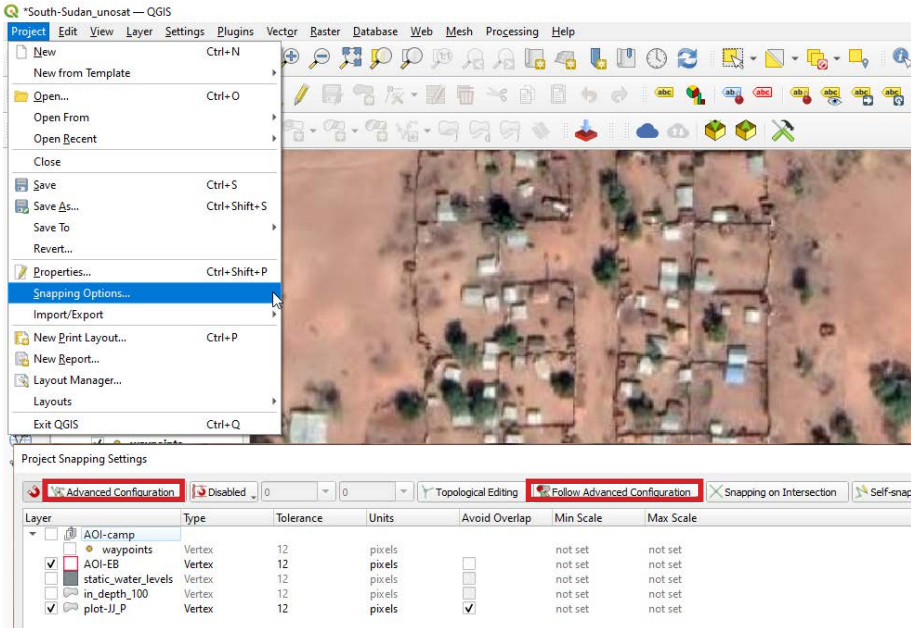

Figure 6. Defining the snapping options

3.3. Prepare your GIS for data acquisition

There are several way of achieving geometrically coherent layer. It is important, as geometric errors may prevent further computations and export. For ensuring that, you have to define the snapping options.

Click on *Project → snapping options*, then a new window appears.

In this window chose on the left red box in Figure 6 the "Advanced Configuration" and on the right red box "Follow Advanced Configuration". Then check the layers (there may be several ones) on which you want snapping and (especially for polygons) the "Avoid Overlap".

3.4. Edit your layer

Select the layer you want to edit and click edit button (yellow pen, see Figure 7). You see now that the same yellow pen appears on your layer.

Then click add a polygon (second right red square box on the Figure 7).

Then on the map panel, click on the first point (orange star on Figure 7) → click on all necessary points → click once on the last point. Then right-click to finish your polygon.

At that moment a new window appears with all the field where input may be made, manually or from a drop-down list (in this case Plot_Type on Figure 7).

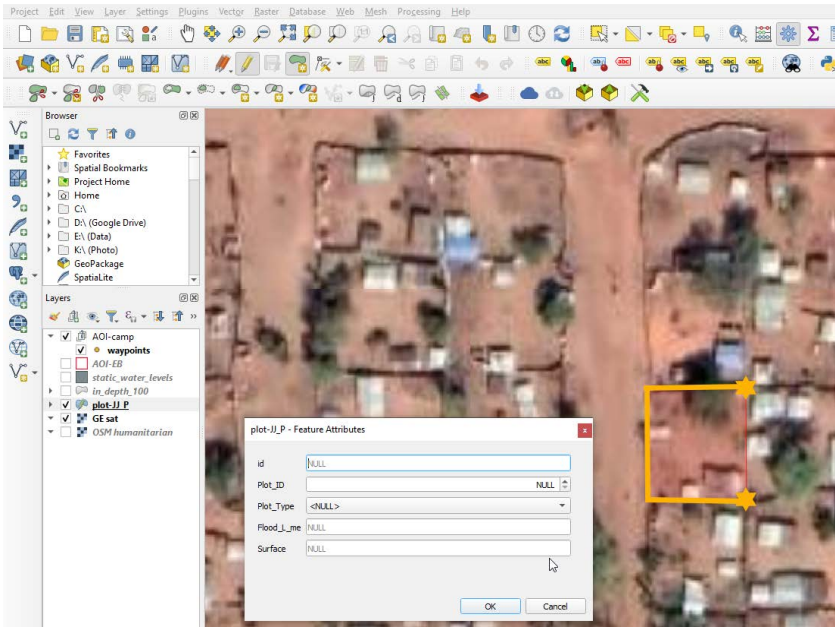

Figure 7. Adding a polygon on your own layer and insert attributes.

3.5. Computing attribute from your data

As mentioned before your geometric data are linked to a table with attributes. For looking at these attributes you can display the attribute table following the procedure below (Figure 8).

select the *layer → open attribute table*

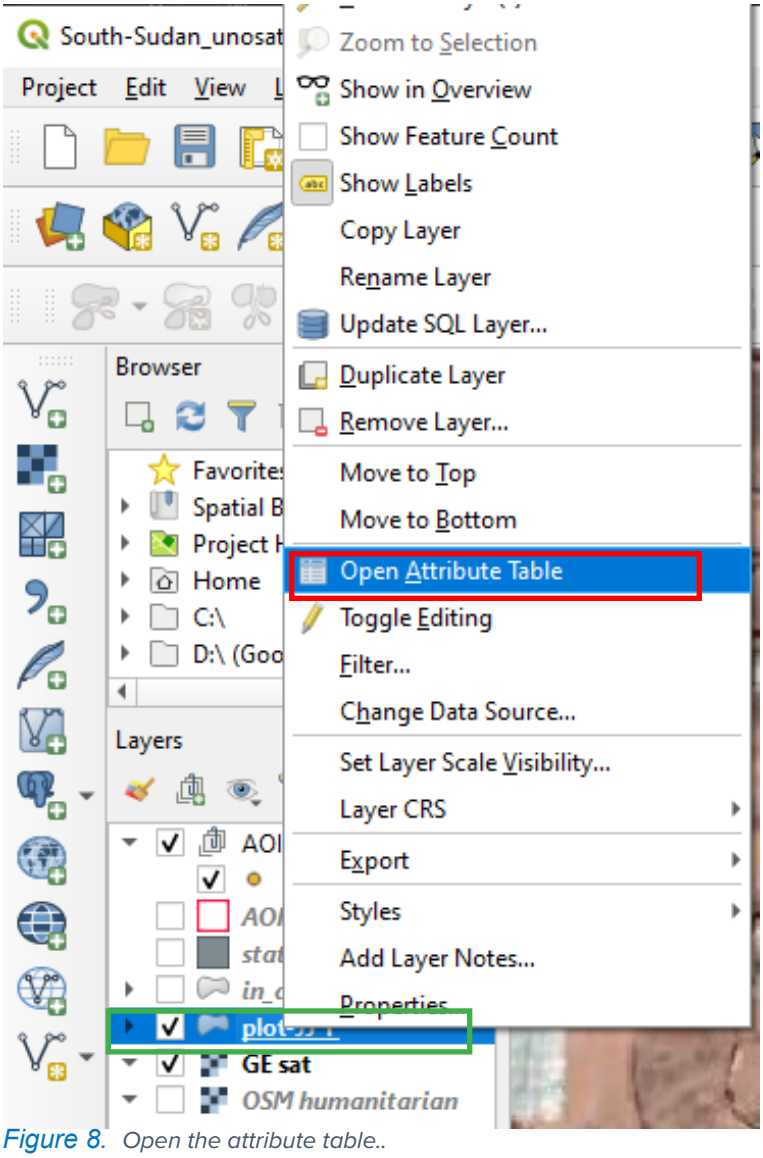

Figure 8. Open the attribute table..

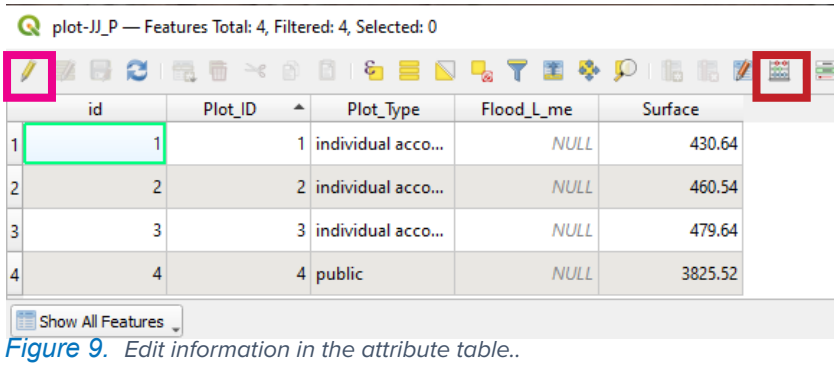

Figure 9. Edit information in the attribute table..

Then it opens the table. Remember that, , depending on the case, if you want to make the table editable you need to click on the yellow pen (magenta box on Figure 9).

For making computation on one field, click on the abacus (red box on Figure 9).

Example : inform the area of each plot

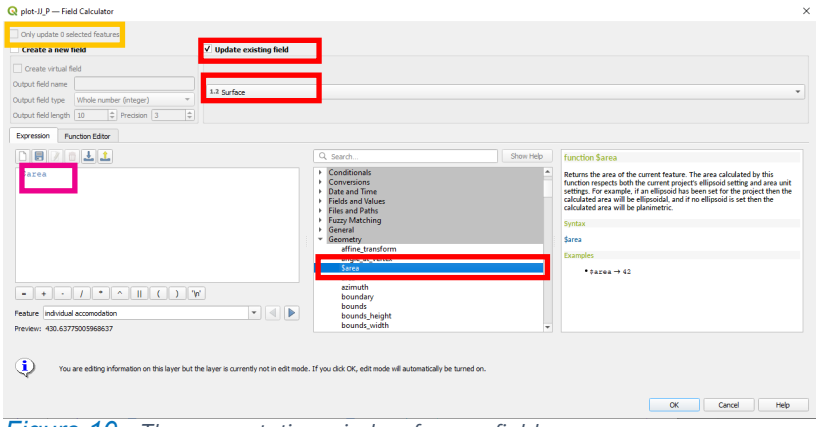

Figure 10. The computation window for one field..

Then it opens the table. Remember that, depending of the case, if you want to make the table editable you should clicking on the yellow pen top red box on Figure 10.

Then select the field you want to make a computation on, in this example we choose the attribute *surface*. Be aware that if the attribute type definition is not adequate (for example if we put the type of surface as text, it will prevent to do this computation) !

As we want to know the area in m^2 we may do a search in the geometry tab and select the function "*$area*" (bottom red box in Figure 10. Alternatively, we could type directly *$area* (*$length* will retrieve the length of a line) in the expression notepad (magenta box).

Be cautious of the checkbox under the orange box. Indeed, if you make a selection in the map panel (see § 3.8) you have the choice of updating the computation only for the selected elements or for all of them.

3.6. Arranging the display of data

For visually analysing your data and for making spatial relations you may want to change the displayed shape and colour of the items you draw on the map (points, lines or polygons). Right-click on the data (green box on Figure 11), and click on Properties: a window pops up where one has to click on *symbology*.

If you keep single symbol (magenta box on Figure 11) you can define the colour for all the features contained in a shapefile. For more control on the display, you could click on the second square in the window (orange box on Figure 11) where options are self-explanatory.

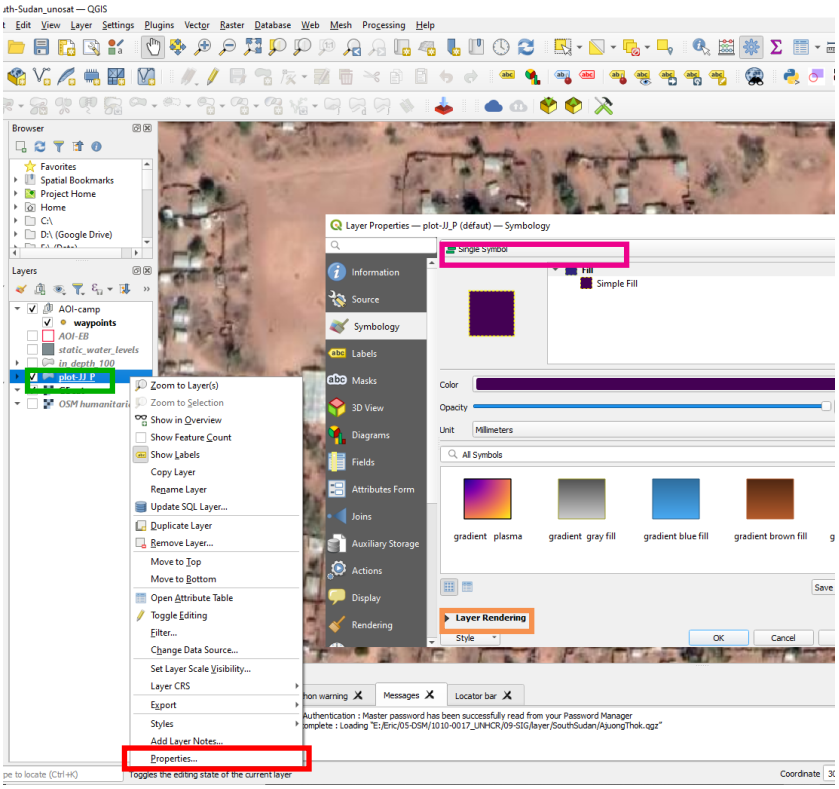

Figure 11. Selecting the colour of a polygon..

It may be useful to change the colour in function of the numerical value of an attribute. In this case, select *graduated* (top red box in Figure 12), then selecting the field, for example here the field surface we just created before (§ 3.5).

One can select different colour ramps, here we select a viridis colour. Choose the mode of *classes separation* (here we choose Natural Breaks, Jenks) and click on the classify button.

It is possible to modify the number of classes (orange box on the right of Figure 12).

For the subsequent ease of the analysis on the map, the layer can be turned transparent. Develop the Layer rendering button (bottom orange box on Figure 12) and play with the opacity ruler.

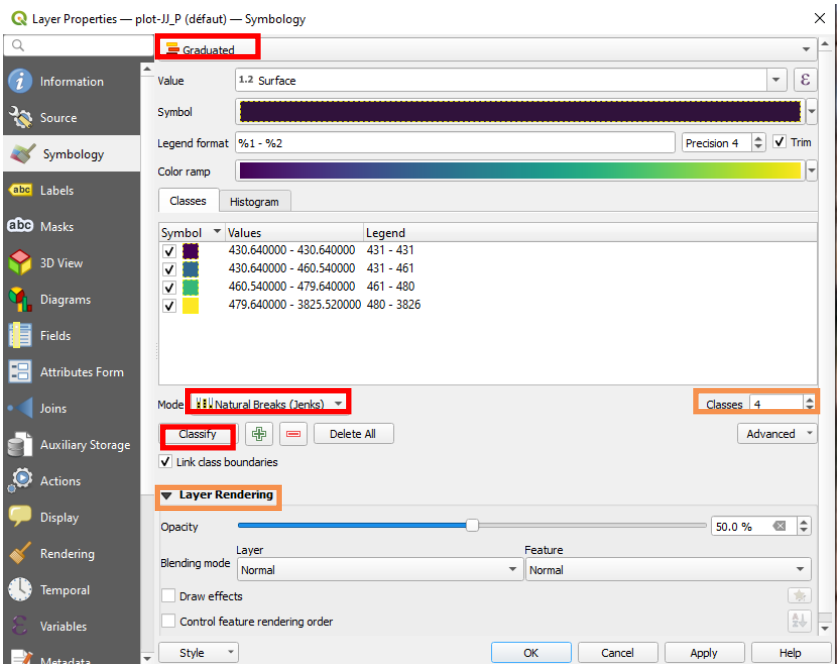

Figure 12. Making the colour varying according to the numerical value

Once you are happy with the display options, you may save your legend for being easily re-used in another project location. Having such standard will ease comparison between locations. For doing that go on *Style* → *Save style* (see Figure 13) and provide a name to the legend.

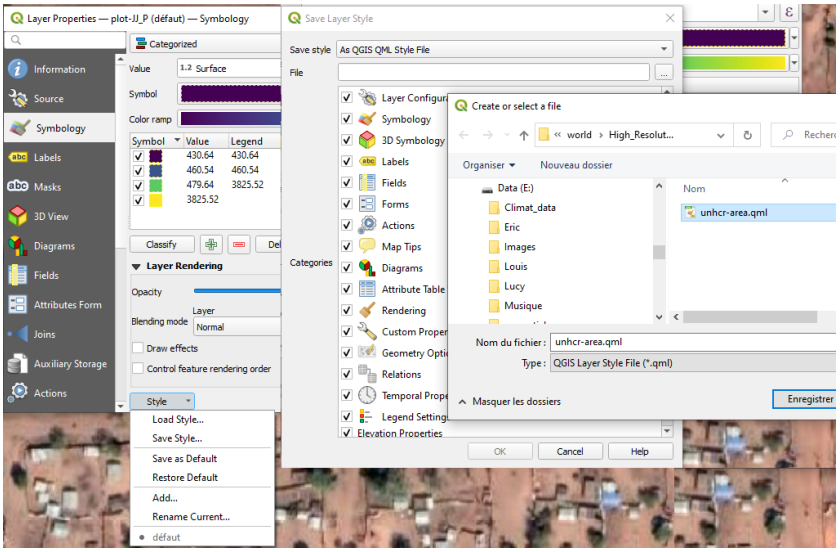

Figure 13. Saving you legend allows you to have a standard which ease the comparative tasks from one place to another.

3.7. Adding text or value on the map

It could be convenient adding values or labels to each feature you have drawn on the map. For that, right-click on your data (green box on Figure 14), click on *Properties* : a window pops up where one needs to select Single label (which column of the attribute table you want to display (it is possible to write more complex expressions, but it goes beyond this course serie).

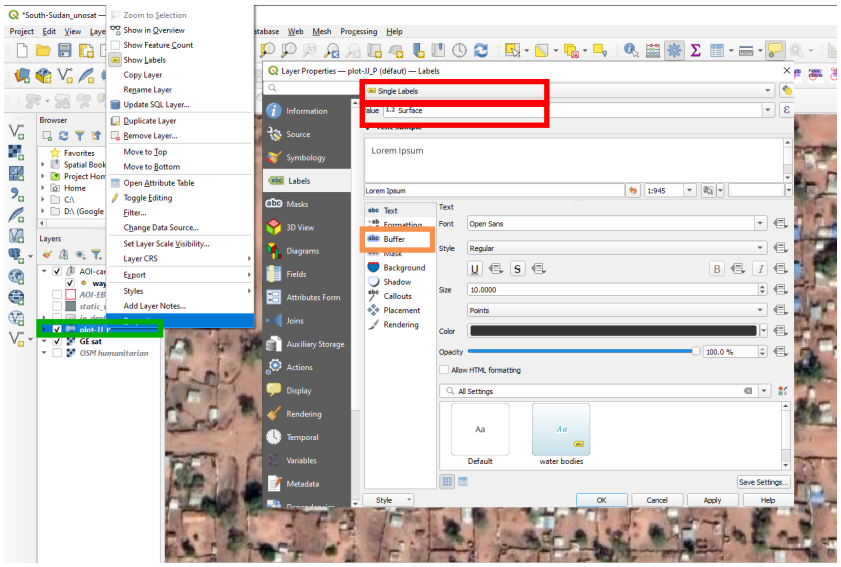

Figure 14. Adding labels to your display.

For the sake of readability, it may be useful to check the *Draw text buffer* (small orange square on Figure 14).

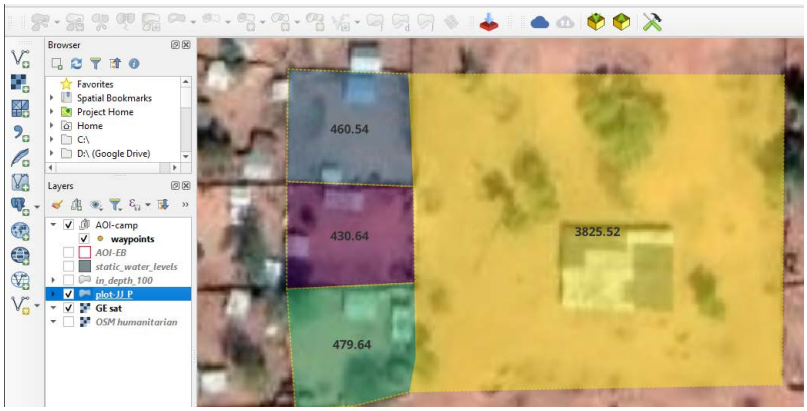

Figure 15. Final display with different colours in function of the value of plot area in m².

Then you should get something like the Figure 15, allowing to analyse the urban structure.

3.8. Selecting elements

For analysis purposes it may be also interesting to make a subset, selecting features from your whole dataset. Be aware that it is possible only on the shapefile which is selected in the layer panel on the left of your screen. The selection is possible via several methods, namely :

- Direct selection by clicking on the map, by direct click, or by defining a polygon or a freehand surface, or by a circle (red box on Figure 16)
- Direct selection by clicking on the row in the attribute table (the very left button with number (violet box on Figure 16).
- Selecting features by a mathematical expression in relation to the attributes linked to the features (button with the "*epsilon*" sign, cyan box in Figure 16).
- Selecting features by location (by geometric relationship with another layer green box in Figure 16).

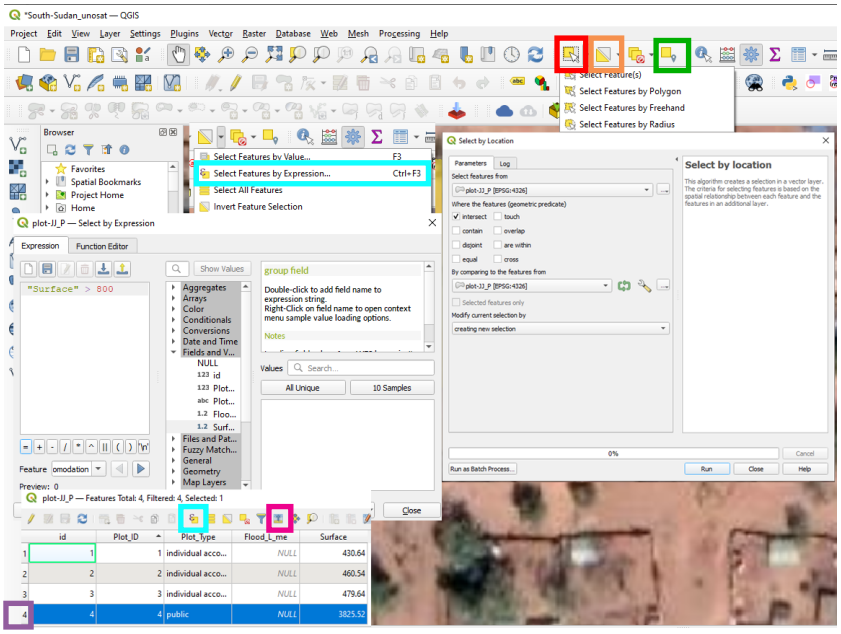

Figure 16. Several modes of selection from the top ribbon.

Note that if the attribute table is very long, it may be difficult to see your selection. A convenient tool is highlighted by the magenta square in Figure 16, which brings the selected lines to the top rows of the table.

4. AUTOCAD PROCEDURES

For importing shapefile in AutoCAD you need to use the tools dedicated to mapping that are embedded in Civil3D. You can then save it in .dxf or .dwg format and open it AutoCAD.

4.1. Prepare your project

The tools needed for importing a shapefile require to first set the CIVIL3D mode into "*Planning and Analysis*" (see Figure 17).

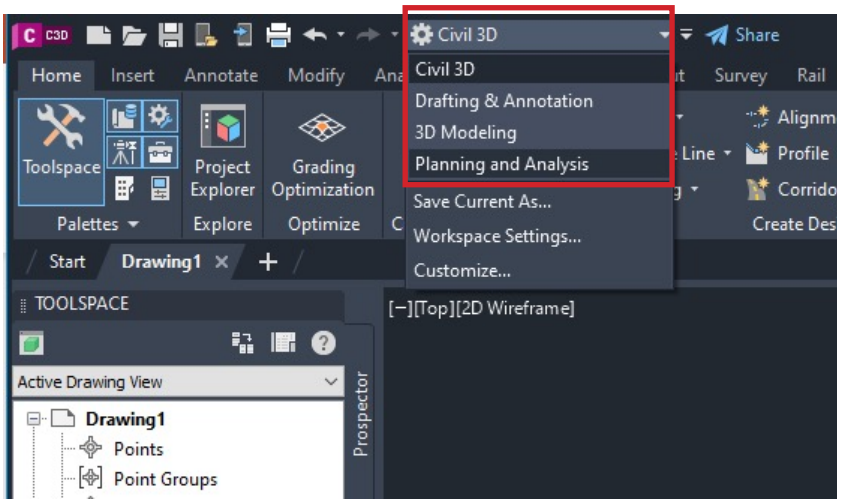

Figure 17. Preparing Civil3D for mapping task by selecting "Planning and Analysis".

Then to make the tools appearing, type in the command line the instruction : "*MAPWSPACE*" and then type "on", (Figure 18).

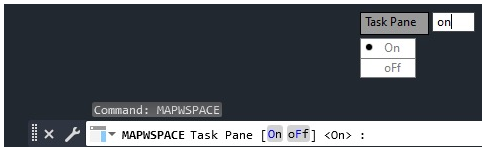

Figure 18. Command line to type for preparing the software and for choosing the display that show you the tools you need.

Then you get a left panel with several tabs (Figure 19). Click on *Map Explorer* and then right-click on the *Current Drawing*. In the window appearing click on Coordinate System.

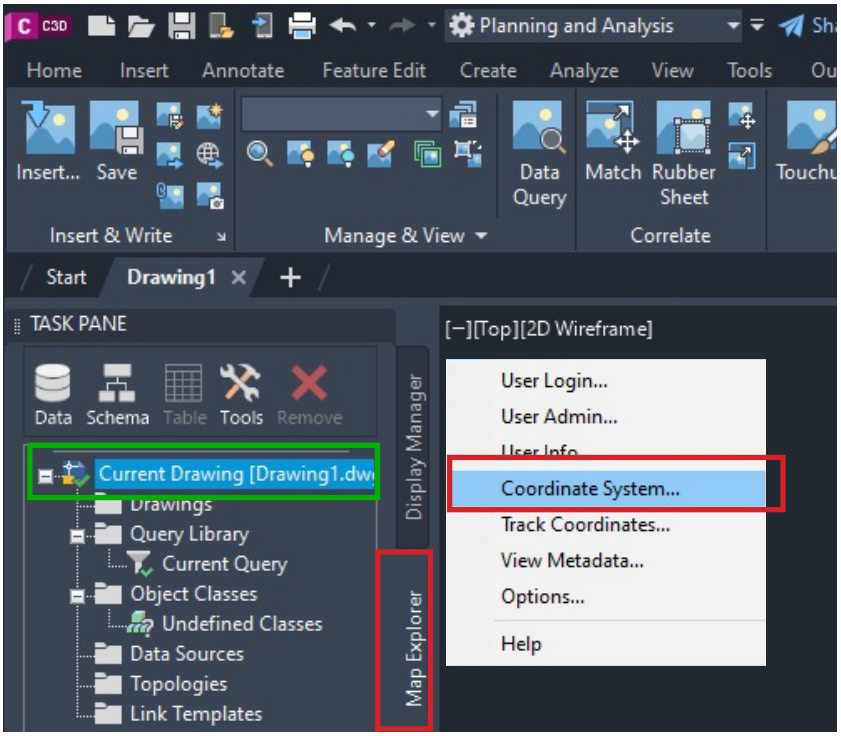

Figure 19. Define the coordinate system for your current drawing.

Select the *Coordinates Reference System* (CRS) you want. Remember that for applications linked to slope (like hydrology) it should be a projected system, indicated with a "*P*" in the definition type column (Figure 20).

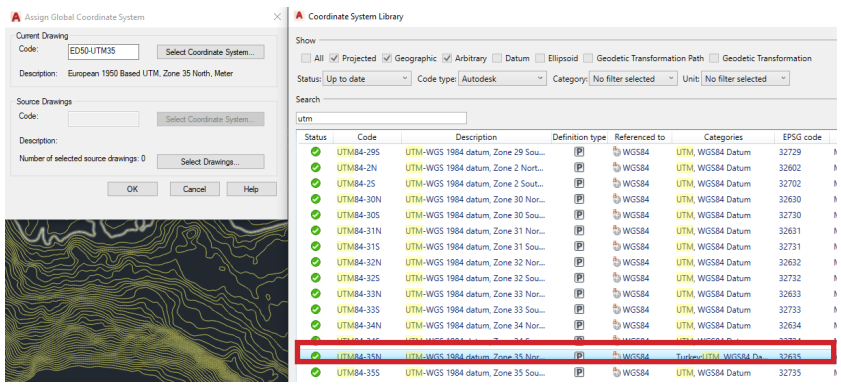

Figure 20. Selection of the coordinates reference system (in Definition type, the letter "P" means projected, therefore the possibilities to work thereafter with slopes.

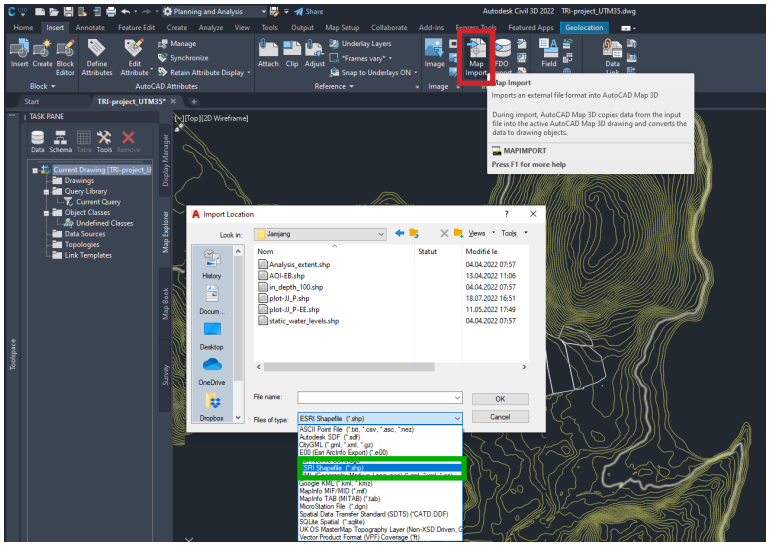

Figure 21. Importing the shapefile into Civil 3D.

4.2. Importing shapefile in AutoCAD

Once your Civil 3D is set with the appropriate *Coordinate Reference System* (CRS) you can start the importation of the shapefiles by clicking on map import or typing *MAPIMPORT* (red box on Figure 21), then selecting the appropriate file format, here “shapefile” (green box on Figure 21).

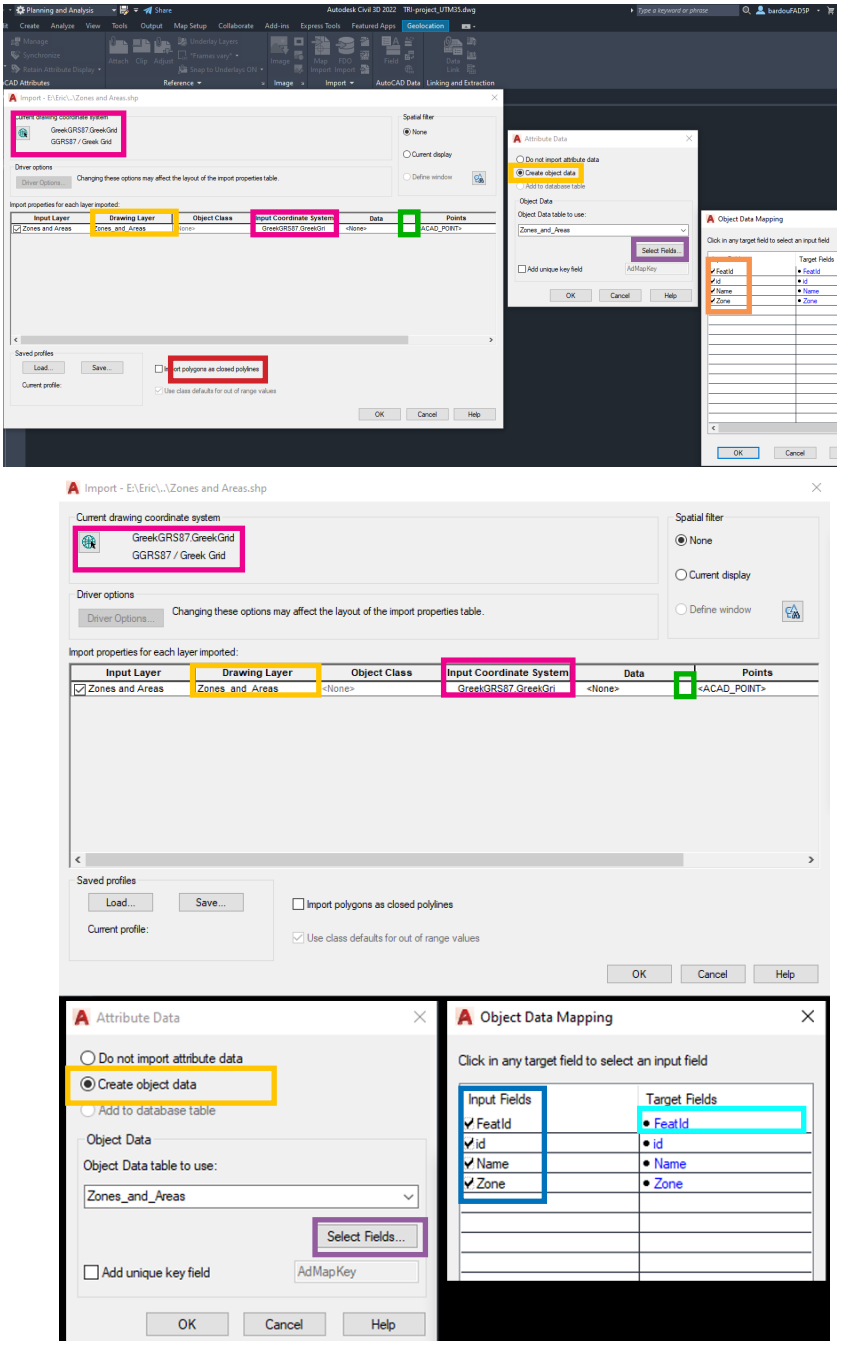

Figure 22. The different wizards used for importing shapefile with their attributes on the top as it appears in Civil 3D and on the bottom zoom on the wizards.

After having selected the appropriate file, different wizards appear (Figure 22). The first element to pay attention to is the CRS, the one you want to use in your AutoCAD project (left magenta box in Figure 22) and the one used for the shapefile (right magenta box in Figure 22). Civil 3D will reproject automatically into the CRS you want to use. Remember, it is better to use projected reference system.

According to your project, indicate into which CAD layer you want to draw the imported features (top orange box on Figure 22).

If you import polygons and you want to display them with a pattern fill don’t forget to *check the import polygon as closed polyline* (red box on Figure 22).

Then click on the right of *the white rectangle below Data* (green box on Figure 22). This is the most important step in terms of GIS → CAD convergence.

A new wizard appears (named *Attribute Data*). Here check “*Create object data*“ (orange boxes on Figure 24) and then select the fields (column from attribute table, violet box on Figure 22).

A new wizard appears, with the name of the column of the attribute table of the shapefile (that you can uncheck if you want to avoid importation, blue box on Figure 22) and you can rename the field that will appear in the CAD layer (cyan box on Figure 22).

Finally, you have to click OK on each wizard. As a check, in the command line you will see how many features/objects are imported into Civil 3D (see Figure 23). In the command line you may have to type *ZOOM* and then *EXTENT* to see the imported objects.

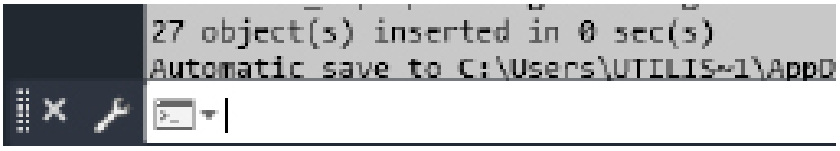

Figure 23. The indication of how much features are imported.

If you select one object and display its properties (right-click on the object after selection), you see the imported attributes. In our case, we see *ID-plot, Name and Zone* under the tab *OD: Zones and Areas* (see Figure 24).

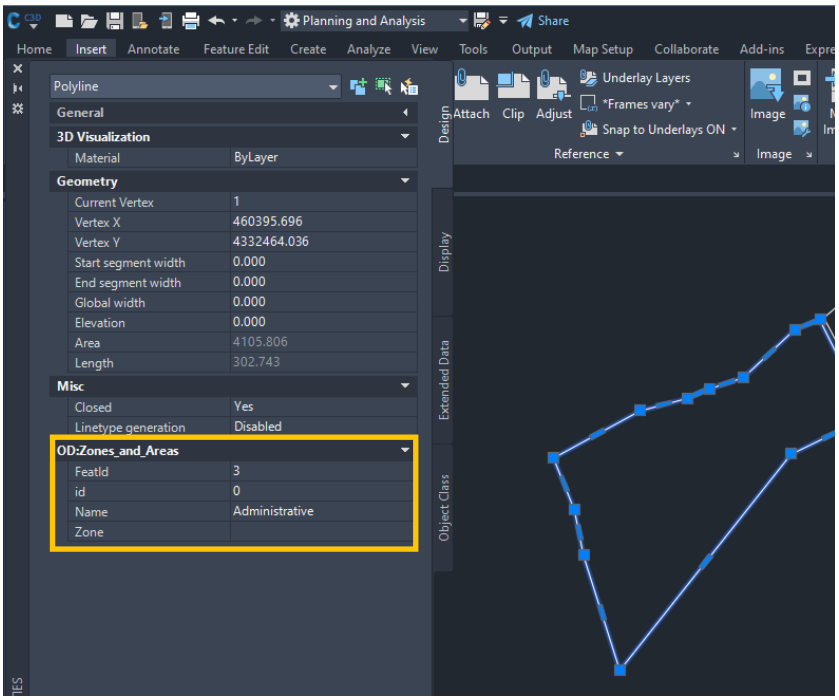

Figure 24. Displaying the properties of one object with its attributes (orange box).

You can now save your drawing under typical CAD format .dxf or .dwg (Figure 25). For shapefiles with simple 2D information, saving the file in the previous version of AutoCAD will ensure that it may be opened by your colleagues having older versions or using other software (like QCAD[5]) and will not be the cause of loss of information.

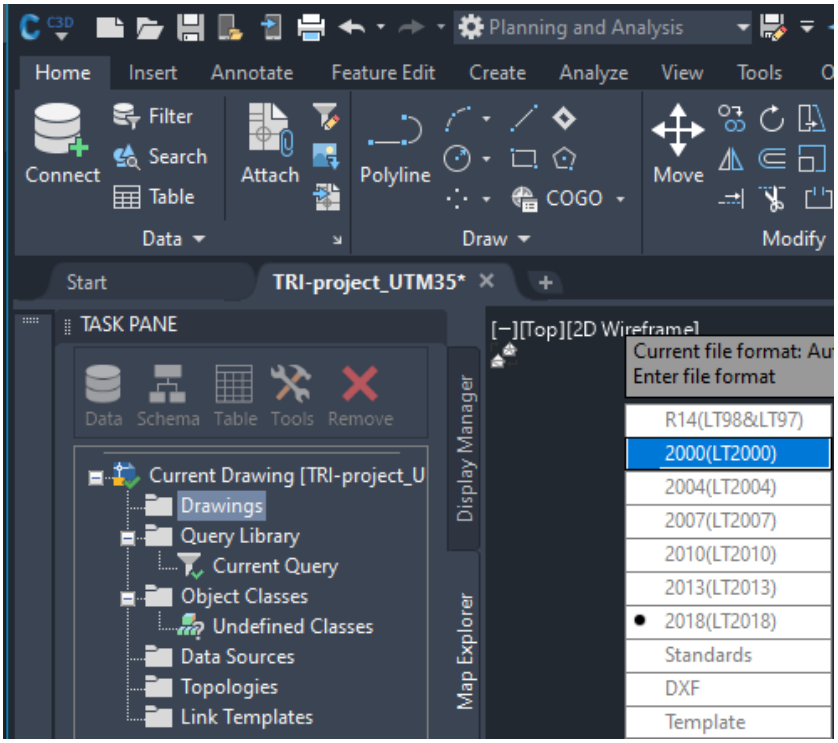

Figure 25. Saving the drawing under CAD format. Paying attention to the AutoCAD version may ensure interoperability.

5 https://qcad.org/en/