USING SPATIAL INFORMATION TO SUPPORT DECISIONS ON SAFEGUARDS AND MULTIPLE BENEFITS FOR REDD+

STEP-BY-STEP TUTORIAL V1.1:

HOW TO GEO REFERENCE A SCANNED MAP OR IMAGE WITH OPEN SOURCE USING QGIS 2.18

UN-REDD PROGRAMME

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The UN-REDD Programme is the United Nations Collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Programme was launched in September 2008 to assist developing countries prepare and implement national REDD+ strategies, and builds on the convening power and expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP).

The United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) is the specialist biodiversity assessment centre of the United Nations Environment Programme (UNEP), the world's foremost intergovernmental environmental organisation. The Centre has been in operation for over 30 years, combining scientific research with practical policy advice.

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We welcome comments on any errors or issues. Should readers wish to comment on this document, they are encouraged to get in touch via: ccb@unep-wcmc.org.

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This tutorial has been produced from materials generated for working sessions held in Tanzania with the National Forestry Resources Monitoring and Assessment of Tanzania, FAO Tanzania and Sokoine University, to aid the production of multiple benefits maps to inform REDD+ planning and safeguards policies using open source GIS software. The tutorial was then updated for training sessions in Liberia and Myanmar.

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Contents

1. Introduction

REDD+ has the potential to deliver multiple benefits beyond carbon. For example, it can promote biodiversity conservation and secure ecosystem services from forests such as water regulation, erosion control and non-timber forest products. Some of the potential benefits from REDD+, such as biodiversity conservation, can be enhanced through identifying areas where REDD+ actions might have the greatest impact using spatial analysis.

Open Source GIS software can be used to undertake spatial analysis of datasets of relevance to multiple benefits and environmental safeguards for REDD+. Open-source software is released under a license that allow software to be freely used, modified, and shared (http://opensource.org/licenses). Therefore, using open source software has great potential in building sustainable capacity and critical mass of experts with limited financial resources.

This tutorial, originally produced using as operating system Open Foris Xubuntu Live with pre-installed GIS, image processing and other open source software, has been updated using a windows environment and the open source software QGIS 2.18. These materials enable a user to georeference a scanned map or image in QGIS.

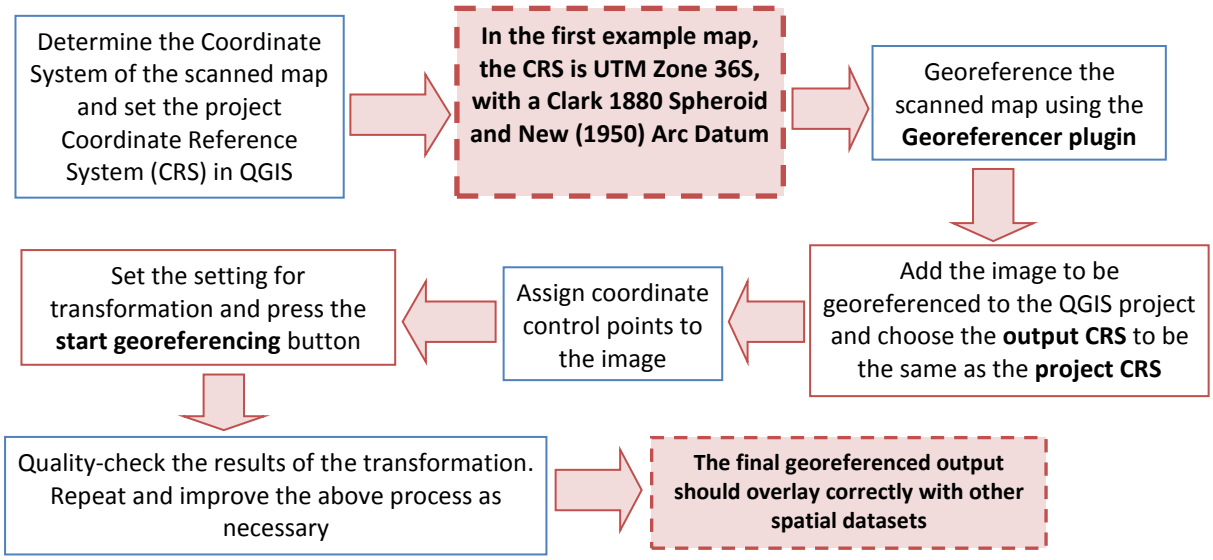
2. Georeferencing a scanned map/ image

These materials have been adapted from an online tutorial available at
http://qgis.spatialthoughts.com/2012/02/*tutorial-geo referencing-topo-sheets.html?pfstyle=wp*

2.1. Technical summary

Georeferencing is the process of assigning real world coordinates to a scanned map or image. If a paper map is scanned it does not automatically know where in the world it is located and therefore it cannot be overlaid with other spatial datasets until it is georeferenced. Sometimes other images such as satellite images or aerial photographs may also require georeferencing.
Coordinates can be assigned to known boundary coordinates of an image or the graticule/grid lines on a scanned map. A scanned map or image may also be georeferenced by matching easily identifiable features to an existing georeferenced dataset or by matching GPS coordinates taken during field surveys. Whichever method is used these sample coordinates or GCPs (Ground Control Points) are used to warp the image to fit within the chosen coordinate system. If possible use the coordinate reference system specific to the image or scanned map that is being georeferenced to minimize the distortion during warping.

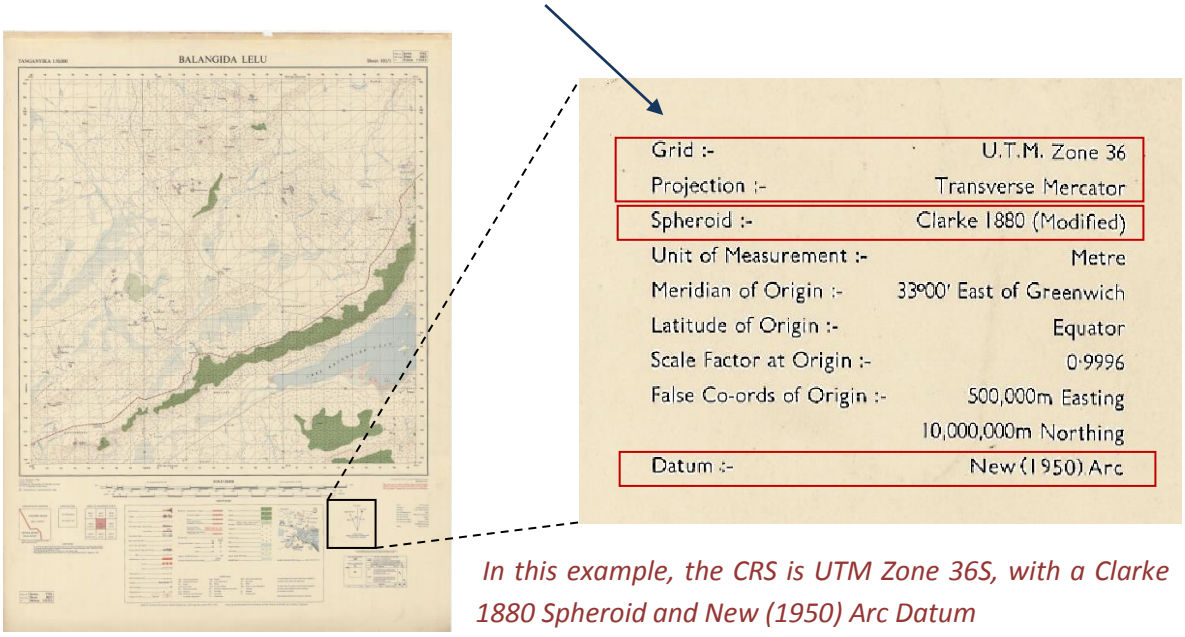
Overview of the workflow



2.2. Determine the Coordinate system (projection) of the scanned map

a. Before importing a scanned map or image into QGIS, try to identify its Coordinate Reference System (CRS). During the georeferencing process the scanned map or image will be warped (stretched) to fit the CRS of the QGIS project and it is imported to try to minimize distortion to obtain the best accuracy

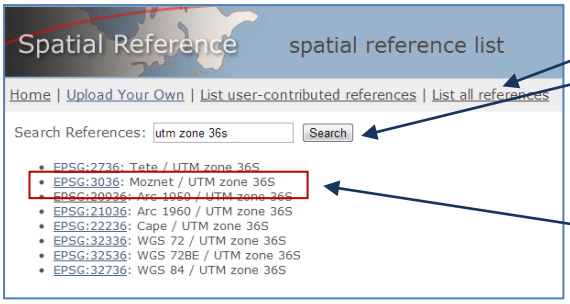
If georeferencing a scanned map the CRS information is often presented on the map itself.



In this example, the CRS is UTM Zone 36S, with a Clarke 1880 Spheroid and New (1950) Arc Datum

Unfortunately CRS information is not always present and it may be necessary to try georeferencing using a number of different coordinate systems to determine the one that produces the best fit and smallest error, i.e. run this tutorial a few time using different projections.

b. If the projection information present on the map is minimal or unclear, open a web browser and go to http://spatialreference.org/. This spatial reference website can help with verifying and searching for a particular map projection.



c. Click on **List all references**

d. In the search box type **'UTM Zone 36S'**

e. Click **Search**. The system filters the results

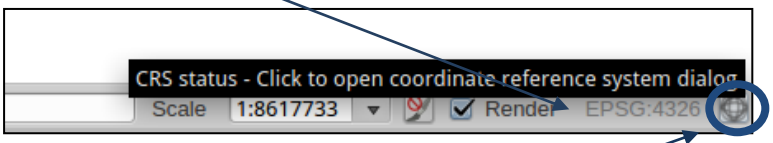
Note there is more than one CRS for this UTM Zone but only one corresponding to Arc 1950 (EPSG: 20936)

QGIS uses an international standard for defining its CRS values, where each CRS has a unique identifier (EPSG ID).

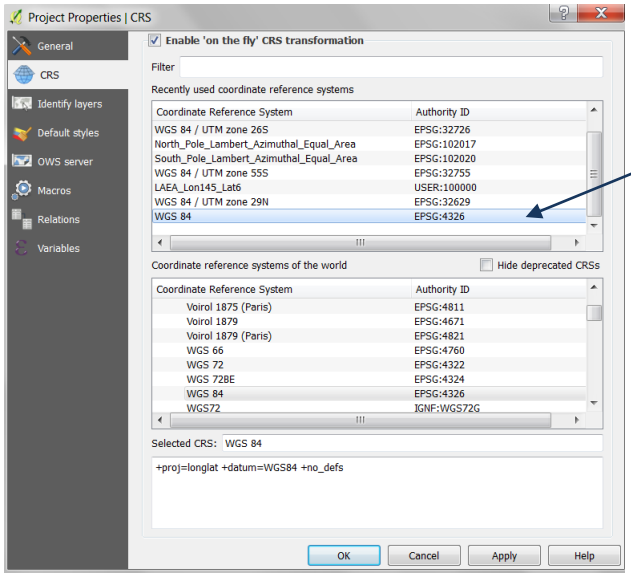
2.3. Set the Project Coordinate Reference System (CRS)

a. Open QGIS with a new project

b. Note the current CRS of the project in the bottom right hand corner of the QGIS project window. In this example QGIS opens with the default geographic coordinate system set to EPSG 4236



c. If the map you are georeferencing is not in this geographic coordinate system then click the **icon in the bottom right hand corner** of the QGIS project screen to open the project properties window. The window will open on the **Coordinate Reference System** tab.



d. Set the project CRS to match the CRS of the map to be georeferenced i.e. the CRS determined in step 2.2.a.

In this example EPSG: 4326

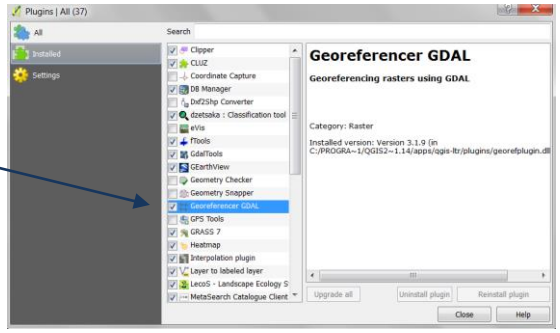
e. Save the project

It is important to note that the CRS selected here will need to be used for the control points defined in the next steps e.g. if you intend to georeference using longitude latitude in decimal degrees you will need to set the CRS here as Geographic WGS84 (EPSG:4326).

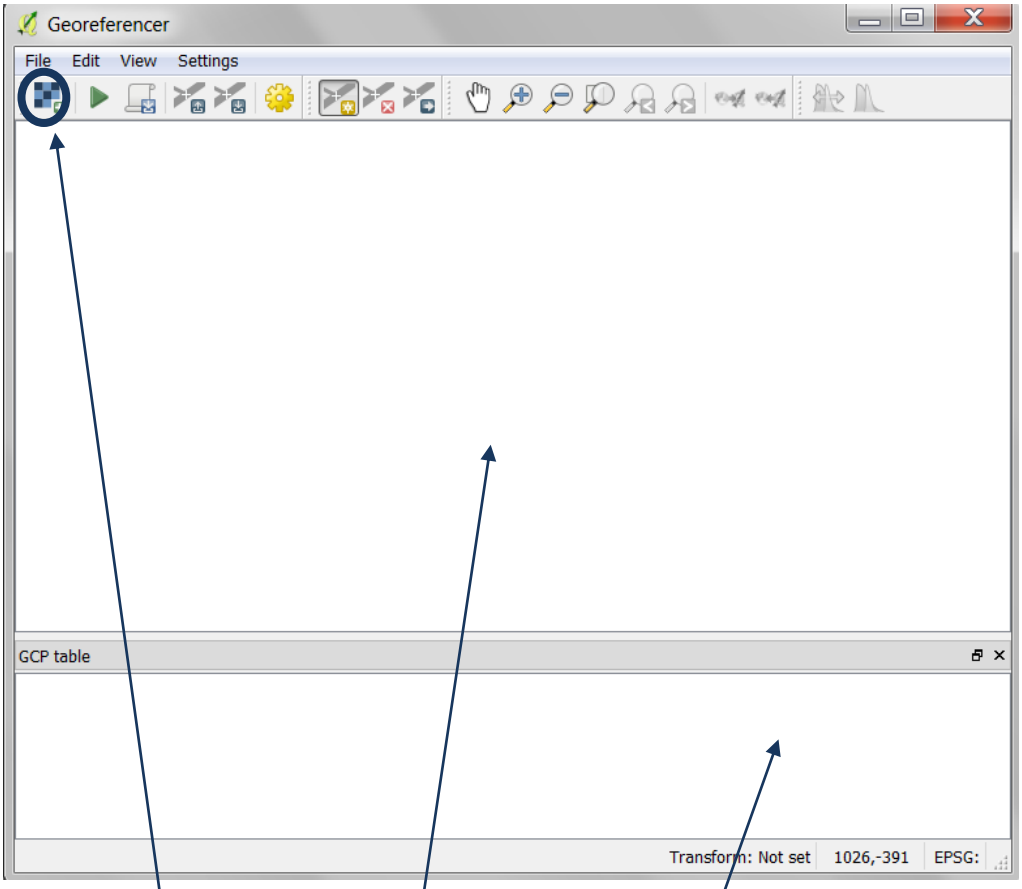
2.4. Georeference the scanned map / image with the Georeferencer

Georeferencing in QGIS is done via the Georeferencer plugin.

a. Go to Plugins -> **Plugin Manager** and tick the **GDAL Georeferencer**



b. From the main menu click **Raster>>>Georeferencer**

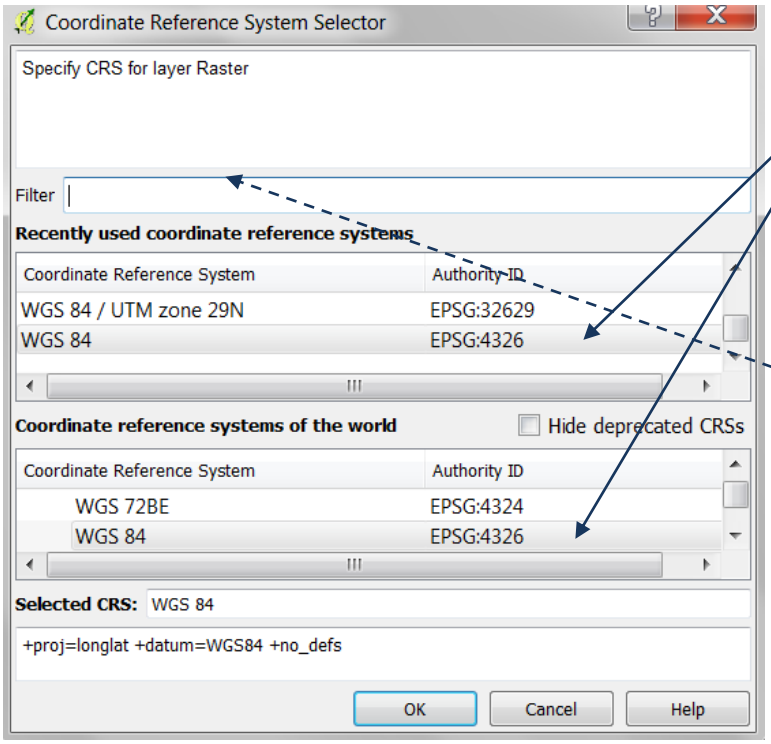


The **Georeferencer** window opens, and it is divided into two sections.
The **top** section is where the raster will be displayed
The **bottom** section is where a table showing the GCPs will appear.
If preferred, the GCP window can be dragged to separate it from the top section.

c. Click on the **Open Raster** button in the top left corner

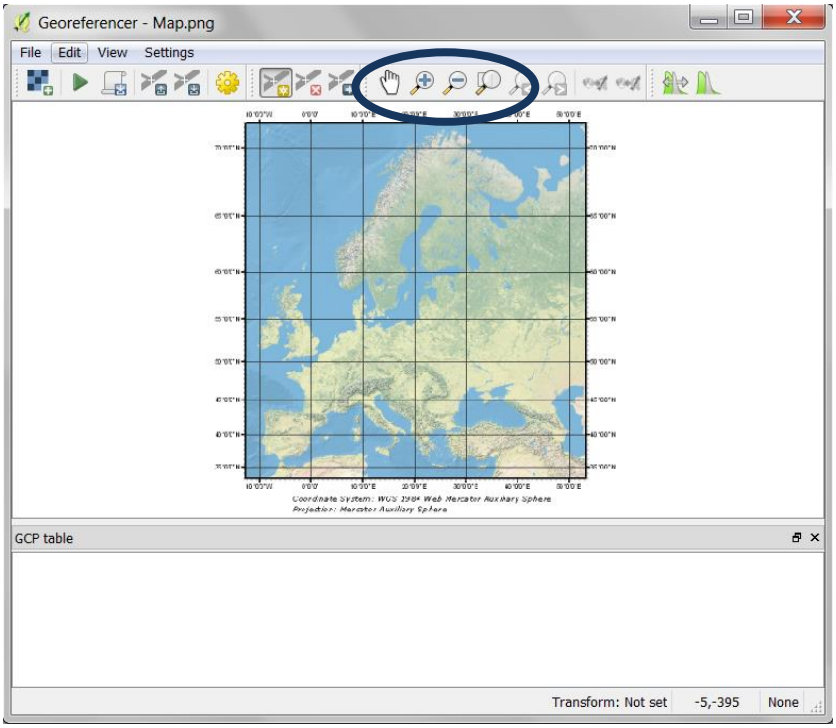
d. Browse to the folder containing the scanned map image to georeference and click **Open.**

The **Coordinate Reference System Selector** window opens. As the scanned map is not yet georeferenced it does not know what projection it is and needs to be told i.e. the projection noted on the map (step 2.2.a)



Select the raster's Coordinate Reference System (CRS) from either the recently used or the complete reference list *(i.e. In this example "EPSG 4326")*

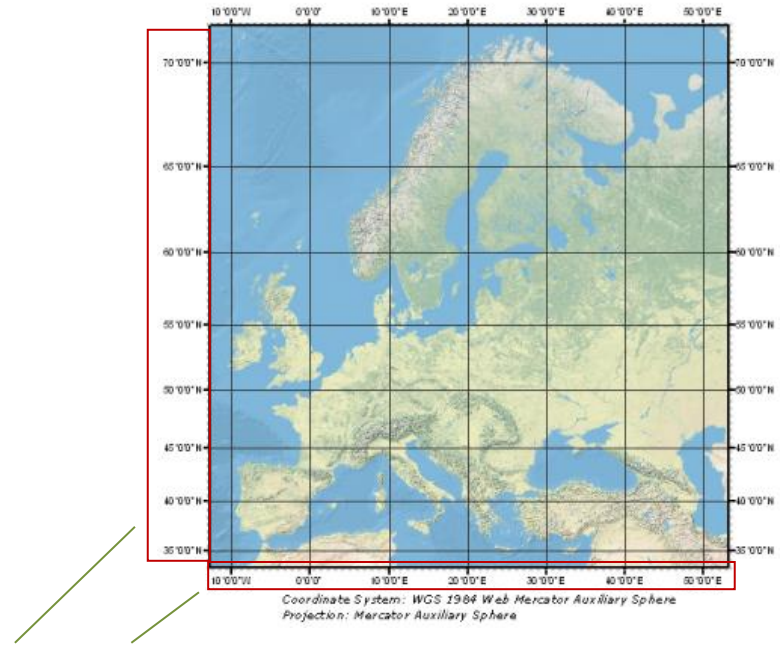
If the CRS is not visible, scroll through the records or type the name of the CRS into the "Filter" to filter the list of projections



The image is loaded on the top section. This window has its own set of zoom and pan tools. Use these zoom/pan controls to look at the map in more detail.

Control points assigned using the graticule/grid on the image

If present, a graticule/grid on the image can be used to assign control points. In this example the grids present on the map show geographic coordinates in degrees, minutes, seconds.



Coordinates in degrees, minutes, seconds format

As specified earlier the GCPs (Georeferencing control points) need to be entered in the CRS set up in the previous steps and as the map in this example stated the projection as WGS84, the coordinates need to be entered in these units.

a. In the **Georeferencer** window, click the zoom icon and zoom to the bottom left hand corner of the map

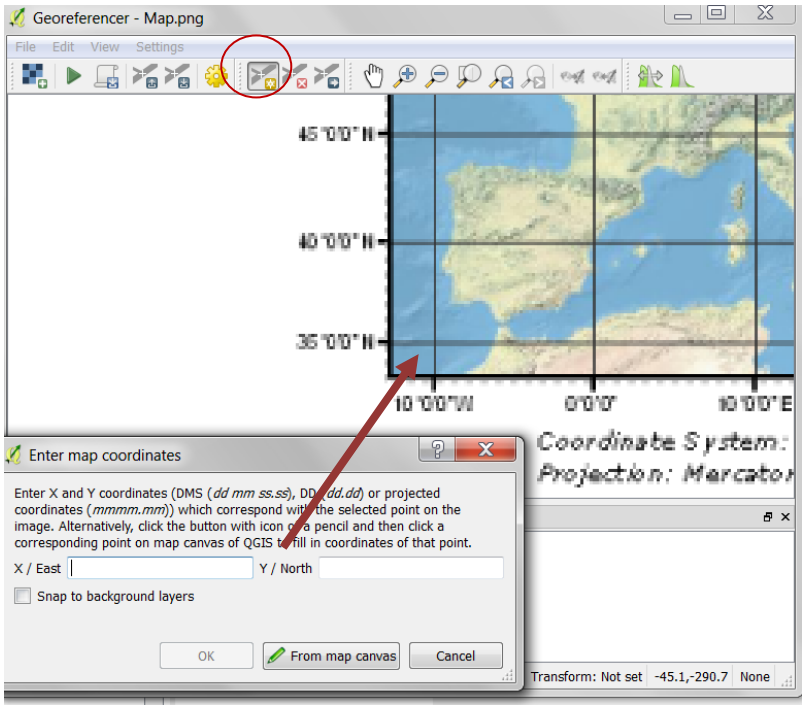
In this example see markings for 10 longitude and 35 latitude. A careful look at the map showed the coordinates have been truncated by 3 0's so the real-world coordinate at the intersection of these grid lines will be.
Remember that X= longitude and Y=latitude.

b. Click on the **Add point** button to add the first coordinates

c. Then, click at the intersection of the longitude latitude line *i.e. in this example of the 10 and 35 grid line*

d. A new pop-up window will appear, enter the X (longitude) and Y (latitude) values for that point. *In this example enter '10' in the X field, and '35' in the Y field.*

e. Click **OK**



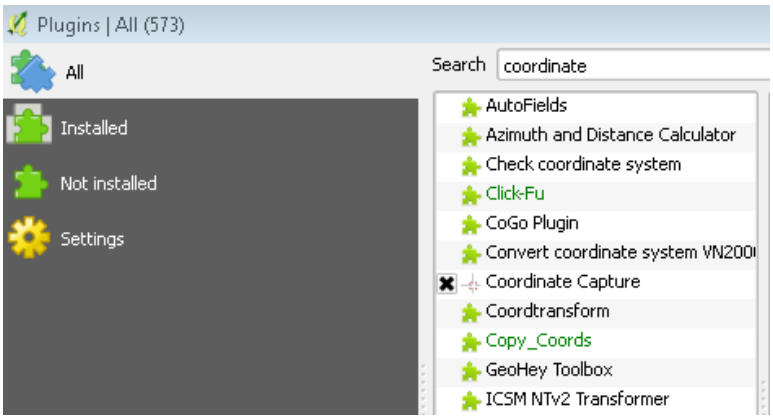
Notice a row is added to the GCP table containing details of the first GCP.

f. Similarly, take GCPs for the other three corners of the image where there are grid intersections. The more GCPs have been entered the better but the minimum is four. The georeferencing is more accurate if GCPs are spread evenly across the image.

Control points assigned using another base layer

If the scanned map or image has no grid lines, another base layer such as administrative boundaries or a topographic map with a known spatial reference can be added to the QGIS project and be used to georeference the map. This process works in a similar way to the instructions above except that, instead of using the intersection of a longitude and latitude line, georeferencing is done by choosing a recognizable location or physical feature that can also be identified and located on both the image and base layer. The coordinates of these features are obtained from the base layer and used to establish GCPs in the scanned map. This is done via the **coordinate capture plugin**.

To install this plugin go to the Plugins tab -> "Manage and install plugins" and search for the "coordinate capture" plugin. Enable the plugin by ticking the box next to it.

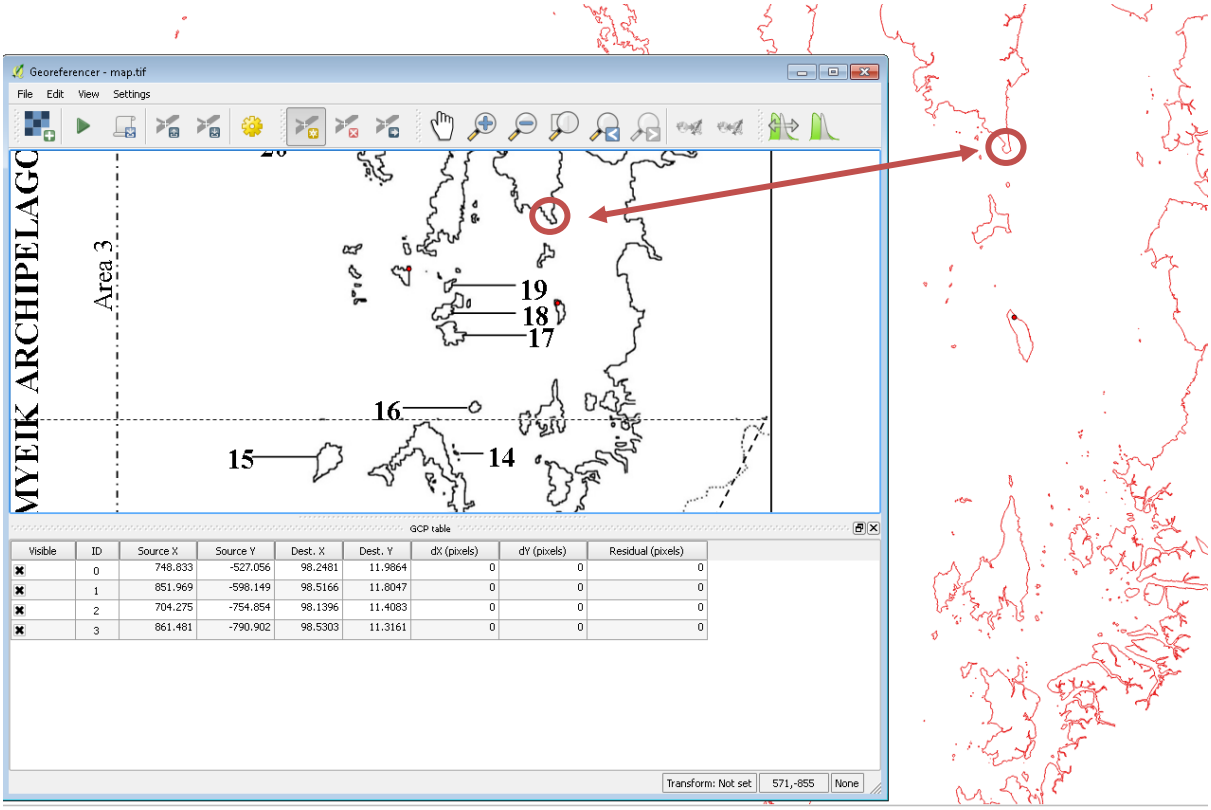


a. Open the base layer shapefile which will be used to obtain the coordinates

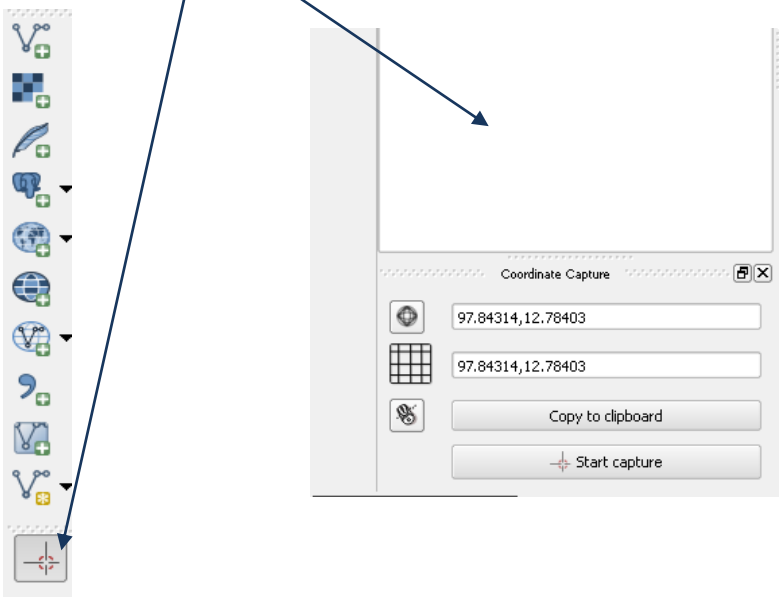
b. From the main menu click **Raster** >>> **Georeferencer**

c. Ensure that both maps (the scanned map in the Georeferencer and the base layer) are in the same coordinate system

d. Then compare the scanned map with the base layer and find distinct points that can be identified on both maps, as shown in the figure below.



a. Click the **Coordinate Capture** plugin (located in the side bar) and then click "Start capture" and click on point you identified in the base layer. The coordinates for this point will appear in the "Coordinate capture" field. Note these coordinates down.

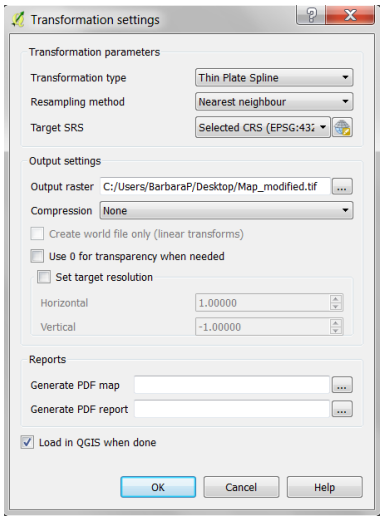


b. Find the same point on the scanned map in Georeferencer and click on "Add point". Enter the coordinates you identified for this point in the fields.

c. Repeat for at least 10 points. The more points there are, the more accurate the georeferenced map will be. The GCSs should be evenly spread across the image.

Once enough GCPs points have been added click **Settings** >>> **Transformation settings**

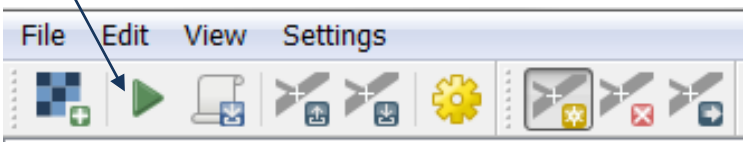
The **Transformation Settings** dialog window appears in which there is a choice for multiple parameters.



To keep things simple, set the parameters:

- Transformation type: Thin Plate Spline
- Resampling method: Nearest neighbor
- Compression: None
- Output raster: (make sure the ending says .tif)
- Target SRS (the CRS that has been used in above)
- Tick "Load in QGIS when done"

g. Click the **Start Georeferencing** button from the toolbar



Once the process is complete, you will see the georeferenced geotiff loaded in your QGIS project canvas.

The Georeferencing is now complete but it is essential to check how well QGIS has done the transformation and in case any errors were made when entering the GCPs. To check for accuracy, load in an administrative boundaries layer or a feature dataset that can be overlaid with the image and compare the positioning to see how well they match. Zoom in to look at how good the match is as errors may not be visible from a distance. Errors can be reduced by taking further GCP points.

Note: In this example the CRS of the scanned map was known and the accuracy of the transformation was good. However, if there were no details of the CRS on the paper map it may be necessary to repeat the georeferencing with different projections until a good result is achieved.