

Hydrogeology Digitizing Handbook

For Zimbabwe and Mozambique.

Kartoza Pty (Ltd.) and IGRAC

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1 IGRAC Digitizing Project for Zimbabwe and Mozambique



1 IGRAC: Georeferencing Methodology

1.1 Mozambique

1. Create a QGIS project for Mozambique and import the Mozambique Hidrogeological Map_North Region and Mozambique Hidrogeological Map_South Region tifs into the project.
2. Find the GAUL dataset, as this was the suggested reference dataset. The dataset was downloaded from [here](#).
3. The Coordinate Reference System (CRS) for the Mozambique tifs was unknown. In the "Legenda" (legend) on the Mozambique Hidrogeological Map_South Region image, it is stated "Projeccao Conica Conforme de Lambert" (Lambert Conic Conformal Projection). The Lambert Conic Conformal Projection requires two parallels, a central meridian, and a Datum. The two parallels and the central meridian were obtained from the scanned maps, and then through research the datum was discovered to be the Tete datum (discovered through this [column](#) by Clifford J. Mugnier for ASPRS.org). A custom CRS was made using that information.
4. The custom CRS using the Tete datum worked but, due to lack of information on the scanned images, was not accurate for georeferencing. A new custom CRS based on the WGS84 datum was made using the proj4 string:

```
+proj=lcc +lat_0=0 +lon_0=35.5 +lat_1=-14 +lat_2=-24  
+x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs .
```

The new CRS was made to save having to datum transformations in the future. It was then decided that georeferencing would be done using the GAUL dataset for reference points because a graticule transformation was not possible.

1.1.1 Georeferencing Mozambique Southern Region

Note:

Note: Multiple iterations were required as the georeferencing was done against a reference dataset and could not be done by simply taking the corner graticules from the tifs and projecting them into the custom CRS.

1. The first iteration of georeferencing the Southern Region of Mozambique was done using a linear transformation. The resulting image ended up being nowhere close to the reference dataset spatially and so was immediately discarded.
2. The second iteration was done using a Helmert transformation and gave a decent result but there were far too many discrepancies between the reference layer and the georeferenced image.
3. The third iteration was done using the Helmert Transform again but with all Residual pixels for the Ground Control Points (CPs) being under 10. 9 GCPS were used for the referencing. There were too many discrepancies between the reference dataset and the georeferenced image so it was disregarded as a viable image.
4. The fourth iteration was done using a Polynomial 1 Transformation (with all residual pixels less than 10) and 12 GCPs. Again, there were too many discrepancies between the reference dataset and the georeferenced image but there was minimal warping on the polygons.
5. The fifth iteration was done using a Polynomial 2 Transformation (with all residual pixels less than 10) and 17 GCPs. There were fewer discrepancies between the reference dataset and the georeferenced image than in the previous iterations but there was slight warping on the polygons.
6. The sixth iteration was done using a Polynomial 3 Transformation (with all residual pixels less than 10) and 18 GCPs. There were fewer discrepancies between the reference dataset and the georeferenced image than in the previous iterations but there was warping on the polygons.
7. The seventh iteration was done using a Thin Plate Spline transformation. All residual pixels were zero but this was likely a false result. This iteration had the best results for lining up the georeferenced image with the reference dataset. 102 GCPs were used to help correct discrepancies from previous iterations. The issue with this transformation was the significant warping of the polygons in the georeferenced image.
8. For the last iteration, it was decided that the Polynomial 1 transformation warped the internal polygons of Mozambique's Southern Region the least but more GCPs would help with the discrepancies between the reference dataset and the tif. 55 GCPs, with residual pixels lower than 10, were used for the georeferencing and ended up with the best result. There were still small discrepancies between the georeferenced image and the reference dataset but to correct the discrepancies would warp the polygons too much to be a viable image.

1.1.2 Georeferencing Mozambique Northern Region

Note:

Note: Fewer iterations were required for the Northern Region of Mozambique as it was done using knowledge gained from georeferencing the Southern Region. The first 2 iterations were also done before the final iteration of georeferencing the Zouth Region of Mozambique.

1. The first iteration was done using the Thin Plate Spline transformation where all the residual pixels were a false zero. 10 GCPs were used and resulted in good approximation that had some discrepancies between the georeferenced image and the reference dataset.
2. The second iteration also used the Thin Plate Spline transformation. All the Residual Pixels were zero. Points were added to the previous attempt's GCPs to total 201 GCPs. The Northern Region of Mozambique had many small islands and outlying points that had to be 'forced' into the correct place.
3. The last iteration of georeferencing Mozambique's Northern Region was done using a Polynomial 3 transformation with 149 GCPs. All the Residual Pixels for the GCPs were under 10. A polynomial 3 transformation was chosen as it warped the image the least but had the fewest discrepancies between the reference dataset and the georeferenced image.

1.1.3 Checking Alignment of georeferenced Mozambique Images

Note:

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1.2 Zimbabwe

1. Create a QGIS project for Zimbabwe and import the four Zimbabwe sheets into the project.
2. Attempt to find any info about Zim projection, datum, etc. through research. Finding the memoir for the sheets would be the ideal situation. The maps being from 1986 mean that their projection system was most likely based on the Arc 1950 datum (which is based on the Clarke 1880 ellipsoid).
3. Research did not yield the projection used for creating the sheets. The projection is required to make custom projected CRS for better georeferencing. The closest option found during research was a report from UNESCO from 1995 (Hydrogeological Maps A Guide and Standard Legend. Vol. 17., by Struckmeier, Wilhelm F, and Jean Margat) referencing the Zimbabwe Hydrogeological maps stating that "preferably UTM grid" was used for locations. Using this information, a custom tmerc (Transverse mercator) projection system was made using the proj string:

```
Custom CRS: +proj=tmerc +lat_0=-19 +lon_0=30 +k=1 +x_0=0 +y_0=0 +a=6378249.145 +rf=2
```

The Central Meridian (lon_0) and the Latitude of Origin (lat_0) were taken from the Zimbabwe sheets and the +a and +rf values are for the Arc 1950 datum.

1.2.4 Georeferencing Zimbabwe Sheets 1 through 4

1. First iteration of georeferencing Zimbabwe Sheet 1 was done using a Thin Plate Spline, 11 GCPS (zimbabwe_sheet1_1). Discrepancies between GAUL boundary and, GLAD LANDSAT and OSM. Needs a lot more refinement
2. Sheet 2, Thin Plate Spline, 12 GCPS (zimbabwe_sheet2_1). Discrepancies between GAUL boundary and, GLAD LANDSAT and OSM. Needs a lot more refinement
3. Sheet 3, Thin Plate Spline, 08 GCPS (zimbabwe_sheet3_1). Discrepancies between GAUL boundary and, GLAD LANDSAT and OSM. Needs a lot more refinement
4. Sheet 4, Thin Plate Spline, 11 GCPS (zimbabwe_sheet4_1). Discrepancies between GAUL boundary and, GLAD LANDSAT and OSM. Best out of the initial iterations.

1.2.5 Refining Zimbabwe Sheet 4

Thin Plate Spline, 46 GCPS (zimbabwe_sheet4_2). Discrepancies between GAUL and Map boundaries. 10.2 Thin Plate Spline, 75 GCPS (zimbabwe_sheet4_3). Discrepancies between GAUL and Map boundaries, aiming for all under 500m.

1.2.6 Refining Zimbabwe Sheet 3

11.1 Thin Plate Spline, 29 GCPS (zimbabwe_sheet3_2). Discrepancies between GAUL and Map boundaries, aiming for all under 500m.

1.2.7 Refining Zimbabwe Sheet 2

12.1 Thin Plate Spline, 53 GCPS (zimbabwe_sheet3_2). Discrepancies between GAUL and Map boundaries, aiming for all under 500m.

1.2.8 Refining Zimbabwe Sheet 1

13.1 Thin Plate Spline, 53 GCPS (zimbabwe_sheet1_2). Discrepancies between GAUL and Map boundaries, aiming for all under 500m.



<https://github.com/kartoza/IGRAC-ZimAndMozDigitizing>