Calculating catchment areas for health facilities in Chicualacuala, Mozambique

Scenario

Infrastructure such as clinics and schools in Mozambique was devastated by a prolonged period of civil war. After a period of peace, the government is embarking on a reconstruction programme, which will involve the construction of new rural clinics and health centres.

Your job is to examine the existing pattern of clinic catchments in relation to population in one area, Chicualacuala, in southeast Mozambique. You wish to identify the areas that are currently most poorly provided with health facilities, as a first step in planning the reconstruction programme.

Data

Three map layers have been provided to help you in this task:

- **Moz_facilities**: This point map layer describes health facilities throughout the study district. The **no_staff** field describes the number of medical staff at each facility.
- **Moz_villages:** This point map layer contains the locations of villages and their population (stored in the **total** field) and numbers of males and females (**masculino / feminino)**.
- **Impedance**: A cost surface, based on slopes derived from a Digital Elevation Model for the area and on roads. The cells in this raster grid describe the degree of difficulty of movement, relative to flat ground not covered by any road network. Therefore, the road network has values less than 1, steep slopes have values greater than 1, and flat ground away from the road network has a value of 1.

All of these map layers are in a Universal Transverse Mercator Zone 36S projection and data sources can be found in the 'references' section at the end of this document.

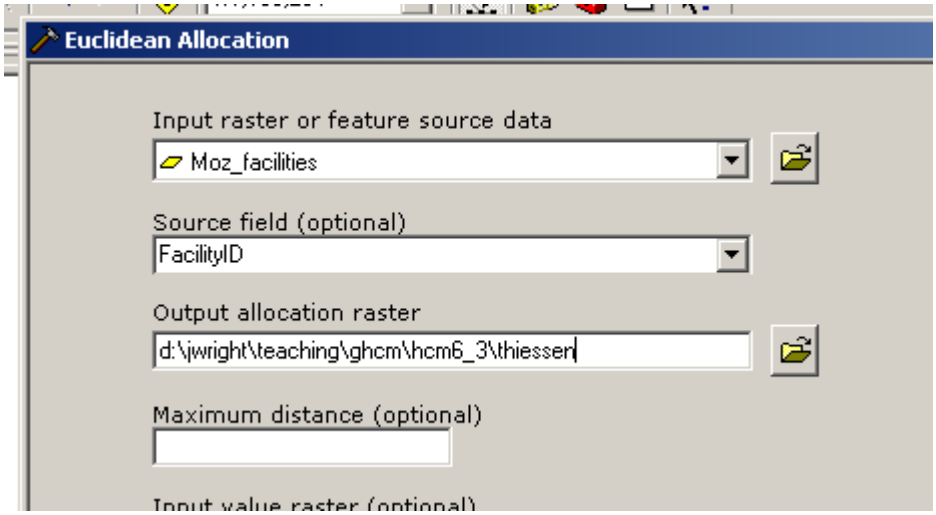
Activity:

To import the cost surface data, use the *conversion tools / to raster / float to raster* facility in the ArcToolBox to import the cost surface described above and call the cost surface **impedance**.

Calculating health facility catchment areas using straight-line distances

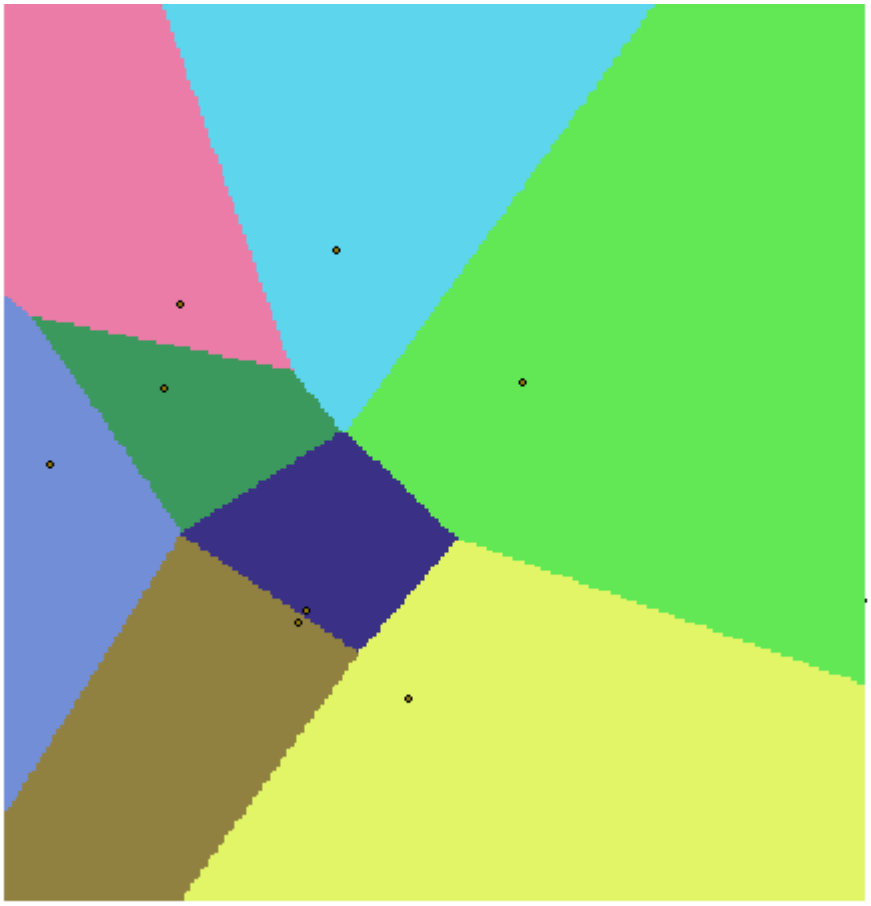
We can calculate simple catchment facilities for these health facilities as follows:

- Within the ArcToolBox, select *spatial analyst tools,* then *distance* and then *Euclidean allocation*
- Select **moz_facilities** as the *input raster or feature source data* and select **facilityID** (a unique number for each facility) as the *source field*.
- Call the *output raster* **thiessen.**



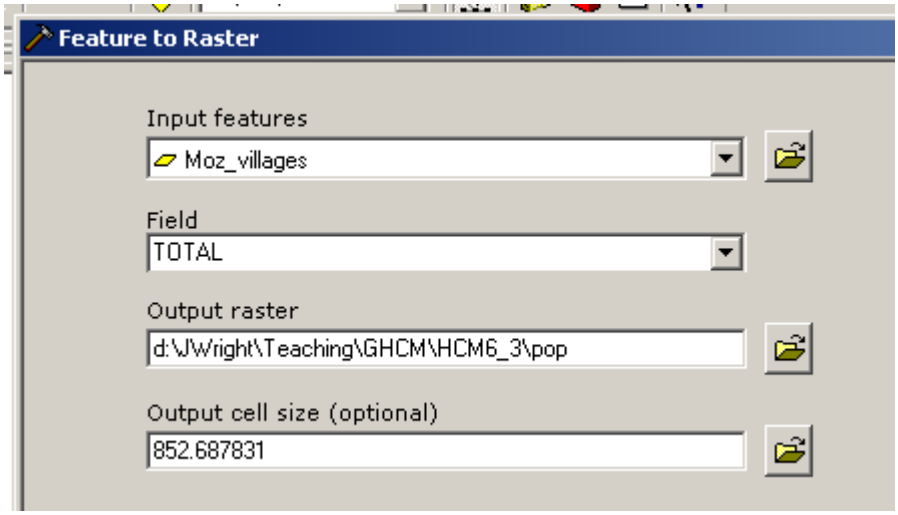
- click on the *environments* button at the bottom of this screen, then click on *general* and at the foot of this screen of options, set the *output extent* to be the *same as layer impedance*. Click on OK.

You should now have generated a set of catchment areas (Thiessen polygons) for the health facilities based on simple straight-line distances.



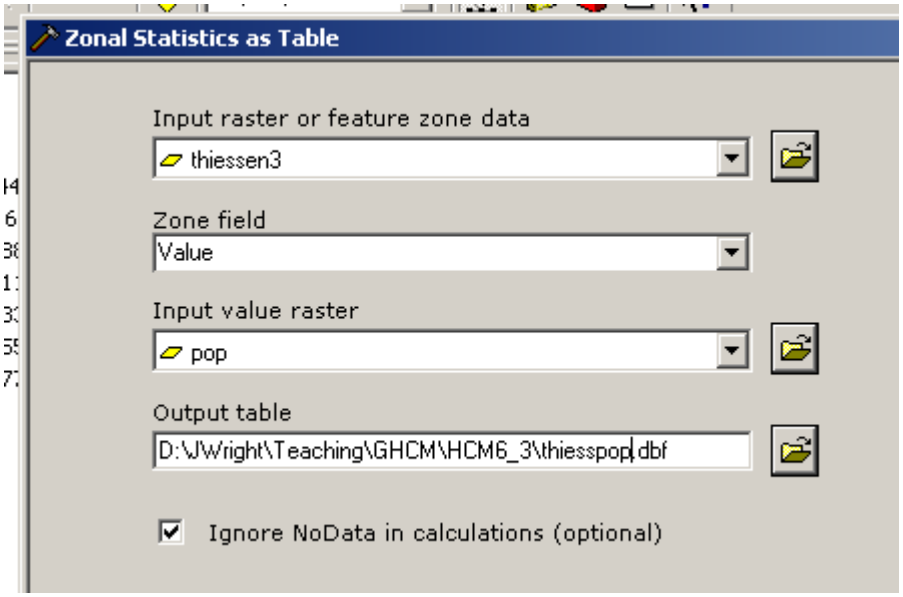
We will now try to calculate the population living within each catchment area. To do this, we will first need to create a raster version of our population data:

- Within the ArcToolBox, go to *conversion tools*, and then *to raster*, and then *feature to raster*
- Select **moz_villages** as the *input villages* and under field, select **total** (the field containing population totals for each village). Call the *output raster* **pop.**
- click on the *environments* button at the bottom of this screen, then click on *general* and at the foot of this screen of options, set the *output extent* to be the *same as layer impedance*. Click on OK.



We are now in a position to use the 'zonal statistics' capability within ArcView to summarise the population in each zone. To do this:

- Within the ArcToolBox, select *spatial analyst tools,* then *zonal* and then *zonal statistics as table*
- Select your **thiessen** raster grid as the *input raster or feature zone data* (the zones for which data will be summarised) and leave the *zone field* set to **value** (i.e. the FacilityID numbers that are now stored in this grid).
- Select **pop** as the *input value raster* and call the *output table* **thiesspop**



- To view the results, you may need to use *add data* on the *file* menu to open up the **thiesspop** file that you created.
- Right-click on this file and choose *open* and you should see a summary of the population living in each health facility catchment:

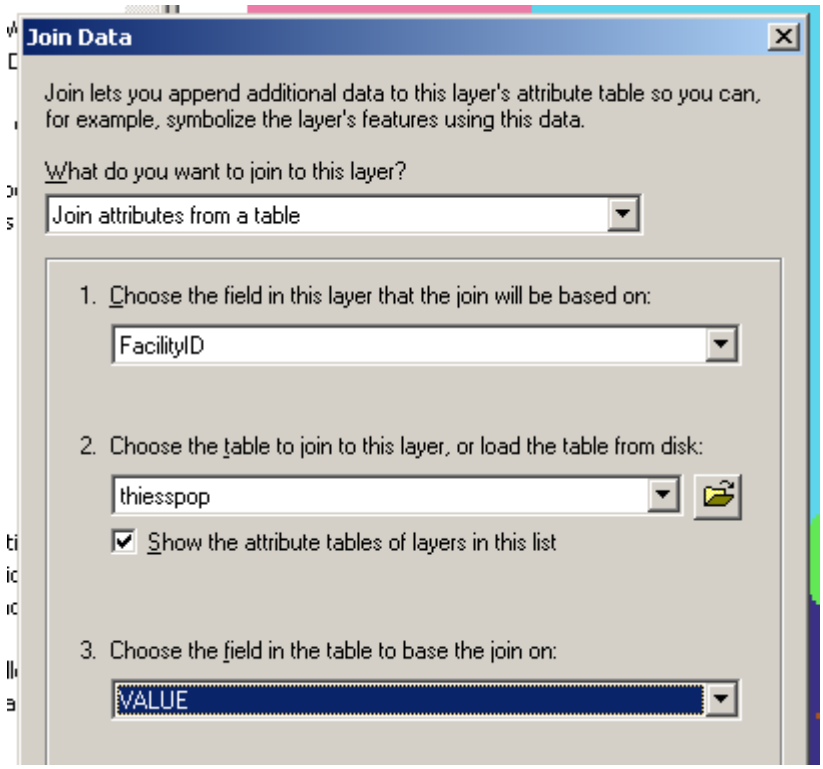
Attributes of thiesspop

OID	VALUE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM	VARI
0	1	1	810720	403	403	0	403	0	403	
1	2	39	31618100	87	2503	2416	654.564	587.849	25528	
2	3	13	10539400	194	968	774	419.846	233.937	5458	
3	4	6	4864320	106	571	465	342.5	163.652	2055	
4	5	12	9728640	242	4254	4012	955.583	1210.23	11467	
5	6	26	21078700	31	1159	1128	450.577	290.478	11715	
6	7	10	8107200	76	1476	1400	449.8	410.966	4498	
7	8	6	4864320	256	471	215	337.333	66.71	2024	

The *value* field here represents the FacilityIDs (from the catchment area Thiessen polygons). The *sum* field here represents the total population in all of the grid cells within that catchment (i.e. the sum of all the raster grid cells lying within the catchment). The other fields are not that meaningful to us, but represent summaries of the grid cell values in the **pop** grid lying in each facility catchment area (e.g. the maximum grid cell value, mean value, etc).

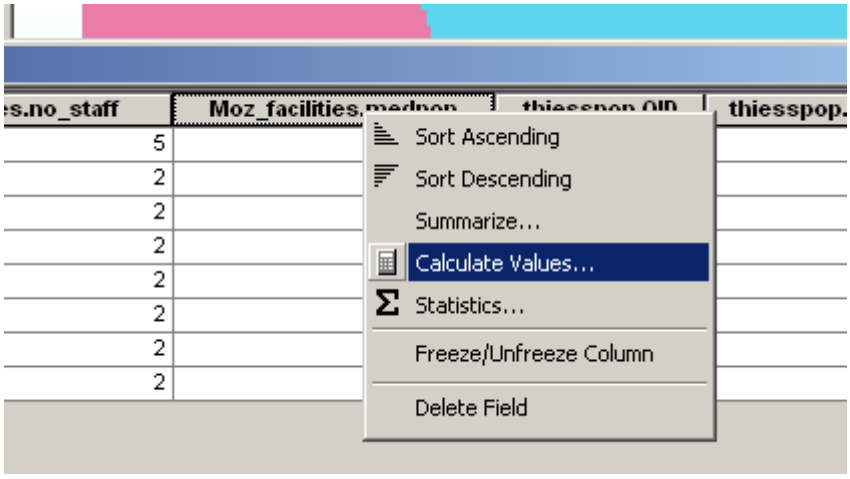
Finally, we can calculate medical staff: population ratios as follows:

- right-click on the **moz_facilities** map layer and choose *joins and relates* and then *join…*
- Make sure that *join attributes from a table* is selected, so that we can match up corresponding values of FacilityID in this attribute table with those in our **thiesspop** table.
- Under *choose the field in this layer that the join will be based on,* select **facilityID**, the field with the unique numbers for each facility. Under *choose the table to join to this layer…*, select **thiesspop**. Under *choose the field in the table to base the join on*, select **value** – the field that has the facilityID numbers copied into it.
- If you get a message about indexing, click on 'yes'.

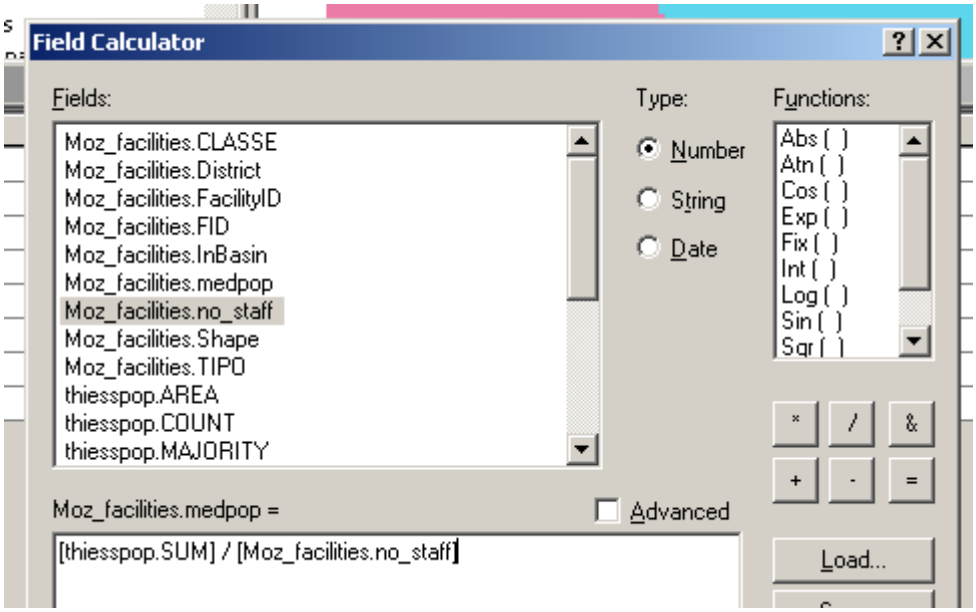


If you now right-click on **moz_facilities** again, and this time choose *open attribute table*, you should be able to see the results of your join. You should see the original attributes on the left of this table, with the information from **thiesspop** added into some right-hand columns. We can now calculate medical staff: population ratios from the combined data as follows:

- click on *options* and select *add field.* Use this to create a new field called **medpop** of type *double*. Set the precision (the number of digits that can be stored in the field) to be **10** and the scale (the number of digits that are stored after the decimal place) to be **1**.
- In the middle of your table, you should find your new field, entirely filled with zeros. Right-click on its heading and choose *calculate values.*



- click 'yes' to any message that comes up about making calculations outside of an edit session.
- In the dialogue box that appears, we will enter the formula for calculating the population per medical staff member. To do this, first click on **thiesspop.sum** (total population in each catchment) under *fields*, then click on the '/' button ('divide by'), and then finally click on **moz_facilities.no_staff**



Click on OK and you should now have calculate population: medical staff ratios for each facility.

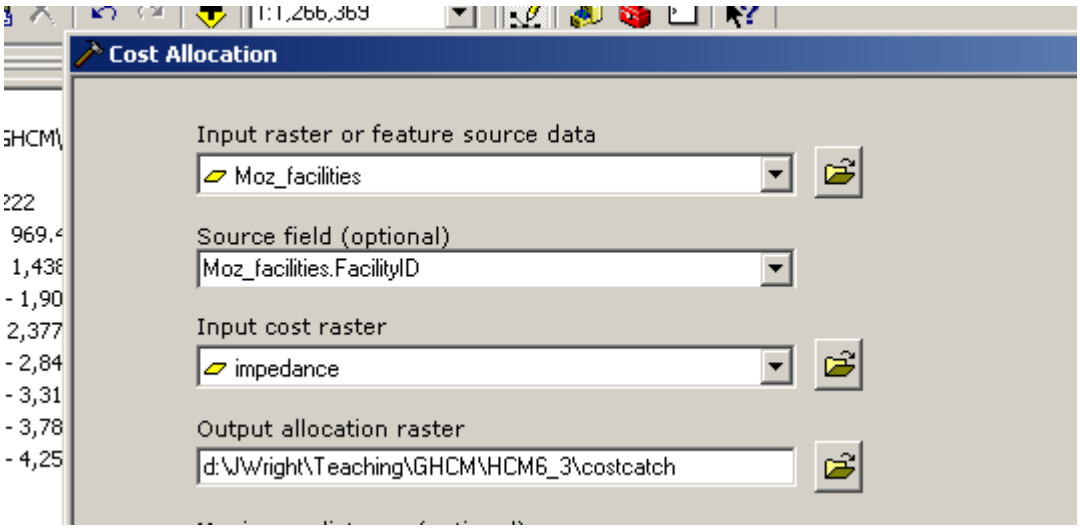
Task A:

1. Which facility has the worst level of service provision in terms of the medical staff: population ratio?
2. Which facility has the best level of service provision in terms of the medical staff: population ratio?

Calculating health facility catchment areas using a cost surface

We will now repeat this calculation, but this time, we will use a cost surface to calculate the population: medical staff ratio. To calculate catchment areas using a cost surface:

- Within the ArcToolBox, select *spatial analyst tools,* then *distance* and then *Cost allocation*
- Select **moz_facilities** as the *input raster or feature source data*
- Select **moz_facilities.facilityID** as the *source field*
- As the *input cost raster*, select your cost surface **impedance.**
- Call the *output allocation raster* **costcatch**
- Finally, click on the *environments* button at the bottom of this screen, then click on *general* and at the foot of this screen of options, set the *output extent* to be the *same as layer impedance*. Click on OK.



The calculations are more time-consuming and may take some time. When they have finished, compare the **costcatch** catchment map (which incorporates the cost surface and therefore the effects of terrain and roads) with the **thiessen** catchment area map.

Task B:

1. Using the same methodology as you used for the **thiessen** catchment areas based on straight-line distances, work out the physician: population ratio for each health facility using these new catchment areas (note that you do not have to rasterise the population data again!).
2. Which facility has the worst level of service provision in terms of the medical staff: population ratio?
3. Which facility has the best level of service provision in terms of the medical staff: population ratio?
4. What conclusions would you draw about health facility catchments and their effect on summary statistics?

Data sources:

The population and health facility data were originally taken from the Southern Africa Humanitarian Information Management Network (SAHIMS) web site at: http://www.sahims.net/ (Unfortunately, the web site and related data links have since been taken offline and have not been made available again)

The Shuttle Radar Topography Mission elevation data that form the basis for the cost surface are taken from the following site:

http://seamless.usgs.gov/

[Choose the 'view and download international data' option]