GIS SITE SELECTION FOR A RESIDENTAL DEVELOPMENT IN SWELLENDAM

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Assignment submitted in partial fulfilment of the requirements for the module Geographic Communication (GEO 363) at Stellenbosch University.

DATE OF SUBMISSION

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

DECLARATION

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ACRONYMS AND ABBREVIATIONS

GIS	Geographic information systems
GPS	Global positioning systems
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1 INTRODUCTION

Geographic Information Systems (GIS0 are very powerful tools that integrate spatial data to support informed decision making in land development. For this project, GIS played a crucial role as we applied it to perform a site selection analysis for a new residential development located in Swellendam, Western Cape. The process demonstrated how spatial analysis can guide developers in identifying locations that meet multiple geographic and infrastructure criteria simultaneously.

The study further integrated vector and raster data analysis to evaluate the suitability of farm properties for development. Vector analysis was used to assess the administrative boundaries, accessibility and the proximity to essential facilities such as roads and schools. Raster analysis on the other hand was used to evaluate topographical suitability by considering slop and aspect, which influences construction feasibility and solar exposure.

The project showed us in a practical way that GIS is a great support tool for sustainable urban planning. It showed that GIS can reduce uncertainty land use and ensure developments are both environmentally and logistically viable by using integrating multiple data sources and spatial operations.

Aim:

To identify the most suitable farm for residential development in Swellendam through multi-criteria spatial analysis using GIS.

Objectives:

1. To determine the accessibility based on proximity to major roads and schools
2. To identify farms located within the Swellendam municipal boundary
3. To evaluate terrain suitability using slope and aspect data.
4. To combine vector and raster analyses to determine the final optimal site for the residential Development.

2 METHODS

An analysis conducted in three successive exercises using QGIS. All was projected in WGS 84/UTM 33S (EPSG:32733) this was to ensure accurate distance and area calculations in meters and hectares.

2.1 Data and Software

The analysis was presented using QGIS 3.44. The retrieved data provided vector datasets including farm_33S, roads_33S, and schools_33S. Whereas the raster dataset provided a Digital Elevation Model (DEM.tif). All the output files from the analysis were saved to a dedicated residental_development folder.

2.2 Vector Analysis: Identifying Well-Located Farms

The vector analysis focused on selecting farms based on administrative, infrastructural, and size criteria

Essentially, the farms were filtered to include only those within the Swellendam town boundary using the query of "TOWN" = 'Swellendam' (Figure 2.1). The result was saved as swellendam_farms.shp.

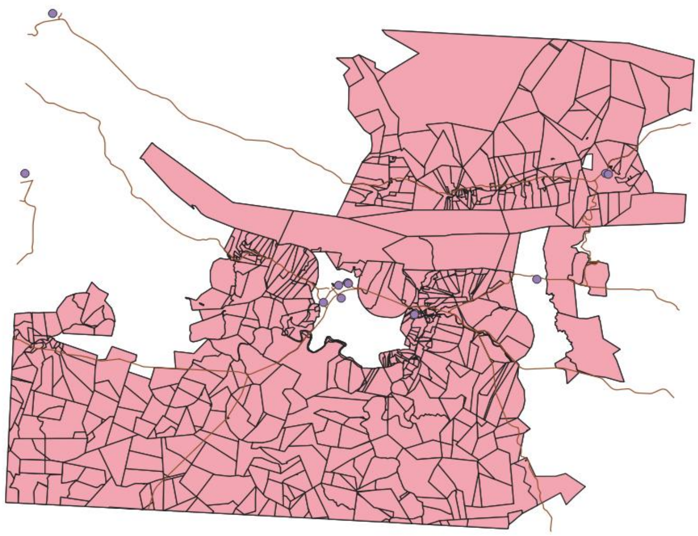

Figure 2.1: Query to select farms within Swellendam

Evidently, the roads layer was filtered to include only major routes ("TYPE" IN ('primary', 'secondary', 'tertiary', 'trunk')), it was then saved as important_roads.shp. The school’s layer was filtered for high schools ("has_high_s" = 'y'), and saved as high_schools.shp.

To define areas of good access and proximity to amenities, a 1km buffer was created around the important_roads layer, with the ‘Dissolve results’ option selected to create a unified polygon (Figure 2.2.). A 15 km buffer was then created around the high_schools layer. The Intersect tool was also used to find the overlapping area between these two buffers, creating a single zone that met both accessibility and school proximity criteria (road_school_buffers_intersect.shp).

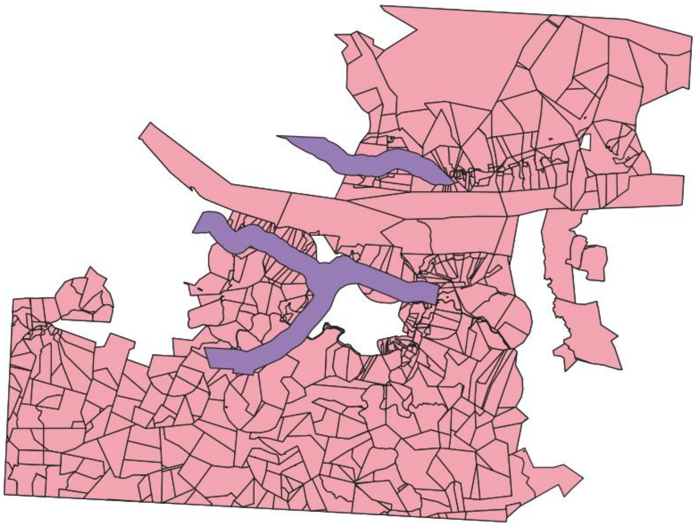

Figure 2.2: Buffer creation for important roads (1km)

The select by location tool was used to select all farms from the Swellendam_farms layer that highlighted the zone of overlap intersecting. These were saved as well_located_farms.shp. The area of these farms was then calculated in hectares using the Field Calculator with the expression $area*0.0001. Finally, a query (“AREA” >= AND “AREA” <= 200) was applied to select farms of the correct size, resulting in the final vector solution layer, solution.shp.

2.3 Raster Analysis: Identifying Suitable Terrain

The raster analysis utilised the DEM.tif to help evaluate terrain suitability based on slope and aspect.

Firstly, the slope tool was used to create a slope.tif layer, and the Aspect tool was used to create an aspect.tif layer. Additionally, the Raster Calculator was then used to create three binary (1 = suitable, 0 = not suitable) layers:

- aspect_north.tif: Identifying north-facing slopes ("aspect@1" <= 90 OR "aspect@1" >= 270) (Figure 2.3).
- slope_lte2.tif: Identifying slopes ≤2 degrees ("slope@1" <= 2).
- slope_lte5.tif: Identifying slopes ≤5 degrees ("slope@1" <= 5).

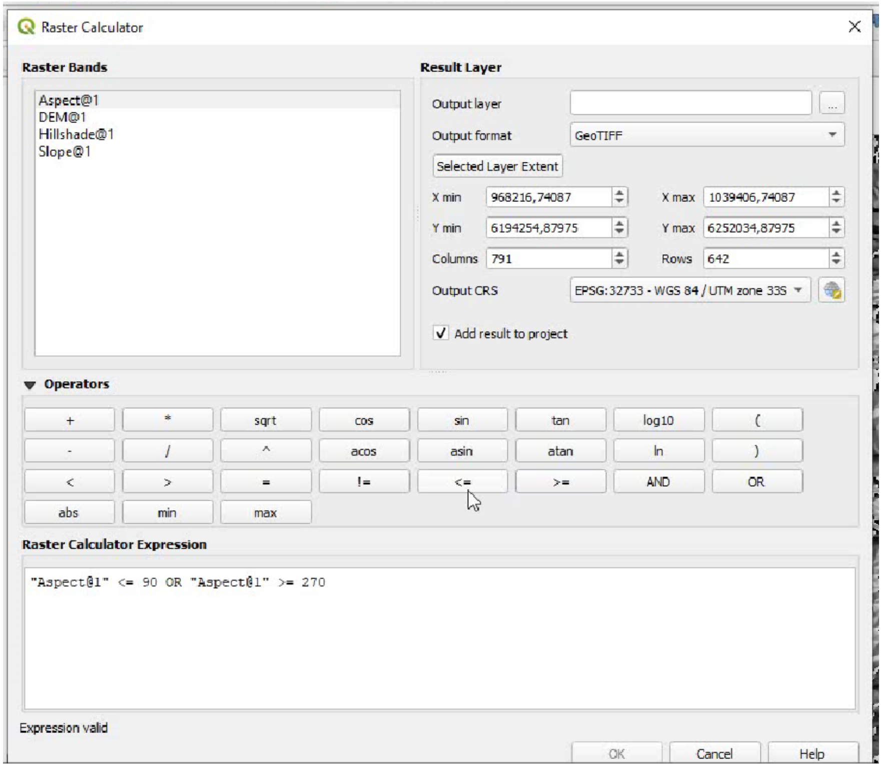

Figure 2.3: Raster Calculator expression for identifying north-facing slopes

These layers were combined using the Raster Calculator with the expression: (“aspect_north@1” = 1 AND “slope_Ite5@1” = 1) OR “slope_Ite2@1” = 1 (Figure 2,4).
This allowed us to identify all terrain that was either very flat (≤2°) or moderately flat and north-facing (≤5°) and north). The result produced, all_conditions.tif, which was also simplified using the sieve tool based on (threshold = 8) this was to remove small, unusable patches, and the null values were set to 0, this resulted in all_conditions_simple.tif.

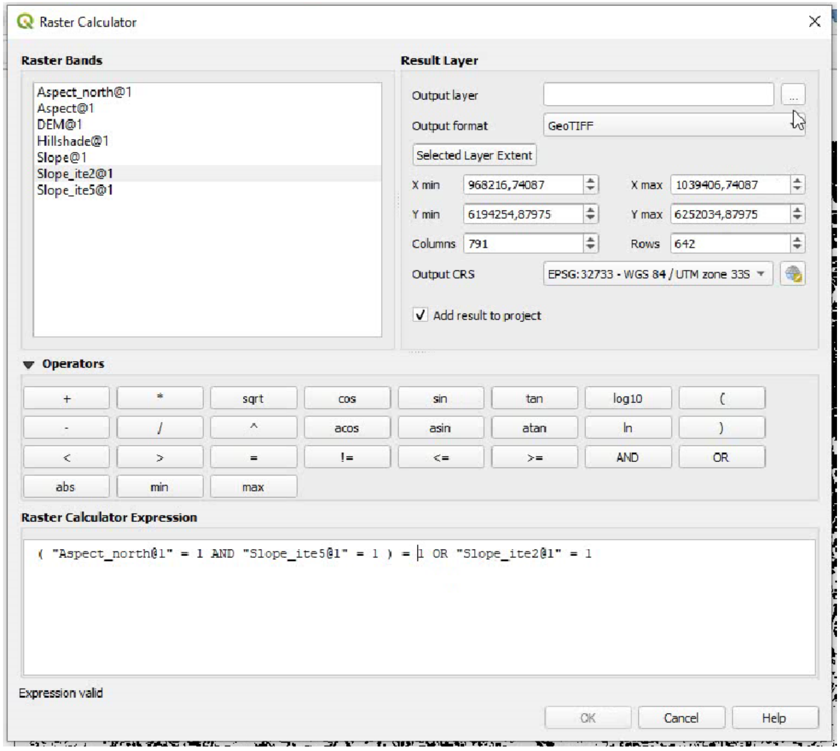

Figure 2.4: Final combined suitability expression in Raster Calculator

This final raster was then converted to a vector polygon layer using a Polygonize tool, which created all_terrain.shp. The polygons where the suitable field was equal to 1 was then exported as the final suitable terrain layer, suitable_terrain.shp.

2.4 Combining Vector and Raster Results

The final step was integrating the results of the previous analyses. So, the intersect geoprocessing tool was used with the solution.shp (suitable fams) and suitable_terrain.shp (suitable terrain) layers as inputs. This evidentily produced the final output layer, new_solution.shp, which contained only those portions of the candidate farms that lie on terrain suitable for development.

3 RESULTS

So, the mutli-step spatial analysis successfully identified a farm that meets all the specific criteria for residential development. The vector layer analysis, which entailed location, accessibility, school proximity, and size, resulted in a shortlist of farms being saved in the solution.shp. Subsequently, the raster analysis refined this selection by assessing the terrain, ultimately excluded areas that were deemed too steep or not north-facing.

The final output, the new_solution.shp layer, contains the "Optimal Farm Site Selection for Residential Development in Swellendam". Essentially, this farm is confirmed to be within the region of Swellendam, within 1km of a major road, within 15km of a high school, between 150 and 200 hectares in size, and predominantly located on the terrain side that is either flat (≤2°) or moderately sloped and north-facing (≤5°). See (Figure 3.1) which presents the final map of the selected site.

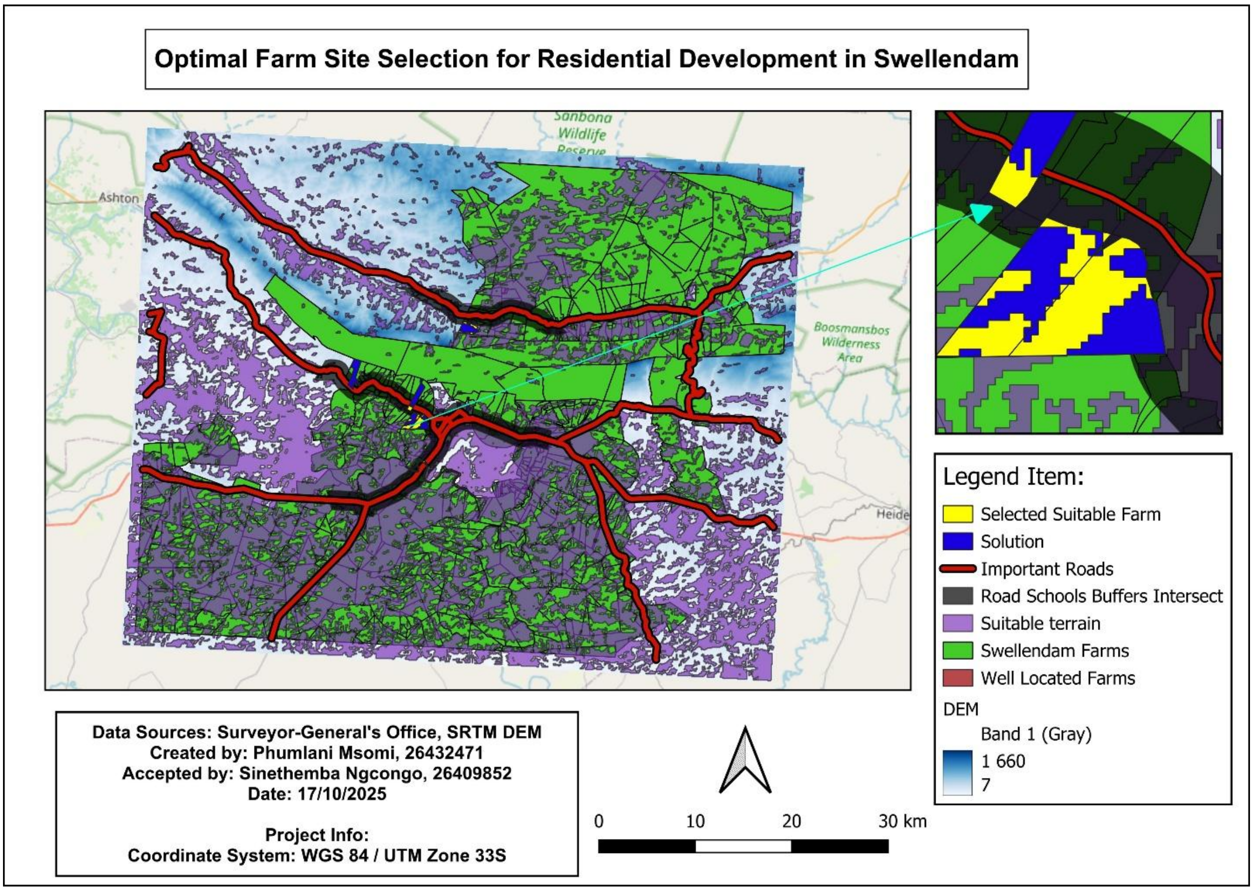

Figure 3.1: Final selected farm for residential development

4 DISCUSSION

The methodology used in this particular project effectively illustrated the power of GIS for producing a multi-criteria site selection. The development requirement was done through sequential vector exercises and raster operations, further addressed based on logical and comprehensive process. The usage of Projected Coordinate System was key as it allowed us to maintain accuracy throughout all the covered distance and area of measurements, including a common prerequisite for meaningful spatial analysis (Longley et al., 2015).

The challenge we encountered during the raster analysis phase was the initial output from the sieve tool which contained null values that unfortunately disrupted the visualisation. In order to solve this issue, we had to consult the layer metadata so that we can diagnose the issue. In addition, this highlighted the importance of understanding the data properties and tool outputs beyond the default visual results. This problem was resolved by utilising the Raster Calculator to recode the null values to zero.

A limitation I identified based on the analysis was the reliance of a single, static Digital Elevation Model (DEM). This is due to; the terrain suitability model could possibly assume that the slope and the aspect are the primary determinants for “easy construction” and resultantly staying out of the shadow. Something that would provide a more robust assessment throughout the year is factors such as soil stability, geotechnical properties and aa detailed solar radiation model. Something that could be a limitation, is the fact that the analysis only focused on the proximity to high schools and not integrating other amenities such as healthcare facilities, shopping centre hubs, and primary schools, which could actually provide a more holistic view of the location suitability for residential community.

Despite the limitations mentioned, the selected farm still presents a strong candidate based on the initial criteria. Therefore, the combination of both vector and raster analysis, ensures that the site is not only logistically sound but also environmentally appropriate for construction and comfort, especially in the Southern Hemisphere.

5 CONCLUSION

This project successfully identified an optimal farm site for residential development in Swellendam by integrating vector and raster GIS analyses. The stepwise approach began with accessibility and location criteria and ending in terrain evaluation ensured that the final site met both environmental requirements and infrastructure requirements

The outcome, which is represented by the new_solution.shp layer, fulfilled all selection criteria. This was because it lies within the Swellendam region, within 1km of major roads, within 15km1 of high school, is between 150-200 ha in area and is situated on terrain that is either flat (<2 degrees) or gently sloping and north-facing (< 5 degrees).

The projected highlighted the effectiveness of GIS in supporting evidence based on spatial decision making. Although limitations such as reliance on a single DEM and exclusion of additional amenities (shopping, healthcare etc) this approach remains robust and replicable.

Recommendations

Future studies need to integrate additional socio-economic and environmental datasets, including flood risk, soil stability and the proximity to essential services to enhance decision accuracy. The studies could use similar GIS-based frameworks that could be used for urban expansion planning or even renewable energy site selections.

REFERENCES

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You can use Endnote, Mendelay or Refworks to create a reference list automatically.

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