**Assignment 2: Geographic Information Processing**

**33 marks**

**Objectives**

In this assignment, you will be doing the following:

1. Conduct a viewshed analysis and interpret the results;

2. Perform a least cost path analysis and interpret the results.

**Background:**

You are working for the local tourism bureau to plan a new sightseeing location on top of a local mountain and identify the optimal path for a hiking trail that connects the urban area to that sightseeing location. As you create the path to town you must consider both <u>slope</u> and <u>land cover</u>. This type of analysis is known as least cost path analysis.

More details on least cost path analysis: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/creating-the-least-cost-path.htm



Figure 1: This map shows an example of a spatial model to calculate the least cost path between a stand of forest being cut and the nearest sawmill.
Source: http://wiki.gis.com/wiki/index.php/Cost_Path_Analysis

**Part I: Viewshed Analysis (15 Marks)**

The local tourism bureau is planning on a new sightseeing location on top of a local mountain and connected that location to the urban area with a hiking trail. The urban area (developed area) should be visible when a hiker is at the new sightseeing location (peak area of the mountain). There are several candidate spots for this new sightseeing location at the peak area of the mountain. To identify the best sightseeing location from these candidate spots, you need to conduct a viewshed analysis for each of these candidate spots and compare the coverage of the visible area.

Details on viewshed tool: https://pro.arcgis.com/en/pro-app/latest/tool-reference/3d-analyst/viewshed.htm

You will need to use the following data in the **File Geodatabase** at "Data\Data.gdb":
- CandidateSpot_A
- CandidateSpot_B
- CandidateSpot_C
- LandUse
  - Land cover including urban land cover (i.e. high intensity development, medium intensity development, low intensity development) and other land use types.
- DEM
  - Digital elevation model of the region.

ArcGIS Pro Tools that may be helpful:
- Viewshed
- Con
- Times
- Reclassify

Note: The Viewshed analysis output raster can only be saved in a **File Geodatabase**. Therefore, put all output rasters into the File Geodatabase at "Data\Outputs.gdb"

**Question 1: [15 Marks]**

Implement <u>viewshed analysis</u> for each of the three candidate spots and produce <u>THREE viewshed maps</u> respectively (one for each candidate spot) with all the necessary map elements that includes the elevation as the background, the candidate spot, all area viewable from the candidate spot, the urban region (developed area) viewable from the candidate spot, and proper map title and legend (<u>3 Marks for each map</u>). Please include the maps in both the PDF file (snapshots of your maps) and the ZIP file (full-size maps with better resolution) submission.

Compare these viewshed maps and <u>identify one candidate spot</u> as the best sightseeing location where visitors could overlook **the largest area of the urban region (developed area including low, medium, and high density)** (<u>2 Mark</u>). Please also justify your choice with **calculation** and **explanation** (<u>4 Marks</u>).

**Part II: Least Cost Path Analysis (18 Marks)**

With your **selected best sightseeing location** in the last step, you need to plan an appropriate route (hiking trail) between the sightseeing location and the urban area. You have to **create a model builder** to finish the following analysis.

You will need to use the following datasets in your analysis:
- CandidateSpot_X
  - Your selected best sightseeing location in the last step as the destination.
- TrailHead
  - The origin of your hiking trail connects to the best sightseeing location.
- Landcover
  - Land cover including urban land cover (i.e. high intensity development, medium intensity development, low intensity development).
- DEM
  - Digital elevation model of the region.

The main step when conducting a least cost path analysis is creating the cost raster. The final cost raster will be composed of **two equally weighted cost rasters**, one using slope and the other using land cover. A cost raster identifies the cost of traveling through each cell.

*Slope Cost Raster*
The slope cost raster will be based on Tobler's Hiking Function, which provides estimates of walking speed with the following function. You will need to firstly generate the Slopes raster (based on Elevation raster), and secondly calculate the Walking Speed raster (based on the Slopes raster), and then reclassify (using Equal Interval Classification method) the Walking Speed raster to costs between 1 (easiest) to 10 (hardest).

$$W = 6e^{-3.5|\theta + 0.05|}$$

where

> $W$ = walking velocity [km/h]
> $\vartheta$ = angle of slope (radians) = [degree of slop] * PI / 180°
> $e = 2.71828$

*Warning: in ArcGIS Pro, the ^ symbol is a Boolean operator and does not mean "to the power of" like in other programs. You will need to use the exp() function.

*Land Cover Cost Raster*
- The Reclassify tool will be used to transform the values of the Landuse layer onto a common scale from 1 (easiest) to 10 (hardest) according to the following table. Don't forget about the areas (e.g., Water) that are impassible. Normally, we will use "NODATA" as the value of the cell to represent impassible areas.

| VALUE | New values | Descriptions (for reference only) |
|-------|------------|-----------------------------------|
| 1 | 1 | Developed, High Intensity |
| 2 | 2 | Developed, Medium Intensity |
| 3 | 3 | Developed, Low Intensity |
| 4 | 5 | Agriculture |
| 5 | 6 | Grassland |
| 6 | 10 | Forest, Deciduous |
| 7 | 8 | Forest, Coniferous |
| 8 | 9 | Forest, Mixed Deciduous-Coniferous |
| 9 | 7 | Scrub/Shrub |
| 10 | NODATA | Wetland (Impassible) |
| 11 | 4 | Bare Land |
| 12 | NODATA | Water (Impassible) |

*Final Cost Raster*

The final cost raster will be composed of **two equally weighted cost rasters (50%:50%)**, one using *Slope cost raster* and the other using the reclassified *Land Cover cost raster*.

*ArcGIS Pro Tools that may be helpful*
- Slope
- Raster Calculator
- Reclassify
- Weighted Sum
- Least Cost Path (Intelligence)

Utilizing the cost raster, find **the least cost path** for the visitors to reach the **best sightseeing location**.

**Question 2: [8 Marks]** Using the model builder to complete the spatial data processing and finally generate the least cost path polyline from the trailhead to the best sightseeing location. You have to include a graphic of your Model Builder that shows the whole analysis processing in the PDF submission, and include the model you created in the ZIP file submission.

- To export a graphic, go to ModelBuilder tab > click the down-arrow on Export > Export To Graphic
- To save the model file, go to ModelBuilder tab > click the down-arrow on Save > Save As …

Please include the graphic in the PDF file and the model file in the ZIP file submission.

**Question 3: [5 Marks]** Create a three-panel map (with all necessary map elements) with each panel showing the Slope cost raster, the Land Cover cost raster (reclassified), and the final cost raster with the vector least cost path separately. Make sure the value of all cost rasters (including your combined cost raster) are between 1 and 10. Please include the map in both the PDF file (snapshots) and the ZIP file (full-size maps with better resolution) submission.

**Question 4: [5 Marks]** Complete the following table demonstrating your reclassification of slope into the correct cost values.

| Slope (Degree) | Walking Speed | Cost Value |
|---|---|---|
| 63° | | |
| 42° | | |
| 28° | | |
| 7° | | |
| 0° | | |

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Note: Please submit your answers in the following format as two files before the due date:

1. One PDF file: include all your response to all the questions (including snapshots of required maps and figures).

2. One ZIP file (name as Map&Model.zip): include all the files (full-size maps and ArcGIS models/tools) you created (do not include the original dataset we provided) while working on the assignment. Please also include a technical description (ReadMe.txt file) of all the files included in the ZIP file.