GEOG 4092/5092: Assignment 4
Raster convolution with NumPy

Due October 16 (30 points)

Scenario: You have been contracted to conduct a site suitability analysis for a wind farm in the Philippines. Based on wind resource data and a set of exclusions, you will identify potential sites for the wind farm. You will then calculate the distance from potential sites to electricity grid transmission substations.

Data: Copy the *lab4.zip* file from Canvas into your working directory. The data folder includes five raster layers: urban areas (*urban_areas.tif*), water bodies (*water_bodies.tif*), IUCN-1b protected areas (*protected_areas.tif*), slope in degrees (*slope.tif*), and mean annual wind speed in meters per second (m/s) at 80m hub height (*ws80m.tif*). All layers are in the same projected coordinate system with the same spatial resolution. There is also a text file with the coordinates for grid transmission substations.

Overview: You will create a final suitability surface of potential sites for the wind farm by combining the raster layers. To do so, you need to create Boolean arrays for the five different selection criteria based on the thresholds specified below. You will develop a framework for conducting moving window operations. The dimensions of the moving window will be **11km North-South by 9km East-West**, producing 99km^2 potential wind farm sites. Finally, you will calculate the Euclidean distance between the center of suitable sites and the closest transmission substation.

Selection Criteria:

The following five conditions for the potential sites are the basis for your suitability analysis:

1. The site **cannot contain urban areas**.
2. **Less than 2%** of land can be covered by **water bodies**.
3. **Less than 5%** of the site can be within **protected areas**.
4. An average **slope** of **less than 15 degrees** is necessary for the development plans.
5. The average **wind speed** must be **greater than 8.5m/s**.

Part I: Evaluate site suitability

1. Write a generic framework for calculating the mean value of a raster within a moving window, i.e., create a focal filter using NumPy:
    a. Create an empty output array to store the mean values.
    b. Loop over each pixel (each row and column) and calculate the mean within the moving window. The window dimensions must be **11 rows by 9 columns**. Ignore the edge effect pixels.
    c. Assign the mean value to the center pixel of the moving window in the output array.
2. Evaluate each of the selection criteria to produce five separate Boolean arrays.
3. Create a surface of suitability values by summing the five Boolean arrays. Only sites with a score of 5 will be considered; create a final Boolean suitability array indicating the location of the selected sites.
4. Convert your final numpy suitability array to a geotif raster file for visualization purposes.
5. In a final print statement, report the number of locations you found with a **score of five**.

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Part II: Calculate distance to transmission substations and implement functions

1. Using the substation coordinates, calculate the Euclidean distance from the centroid of each suitable site (i.e., with a score of 5) to the closest transmission substation. Print the shortest and longest distance to the closest transmission substation among all of the suitable sites, i.e., you will only print two distances.
   HINT: You can get the coordinates for the upper left corner of the extent using the arcpy Raster object. This is the upper left corner, not the centroid location of the upper left pixel. You need to use the locations of cell centroids for distance calculations. How can you get the centroid location for the upper left pixel? One way to get the centroid locations for the suitable sites is to calculate the centroid locations for all pixels and then subset those locations for only the suitable sites. Look at the numpy.meshgrid function.
2. Effectively implement functions for reusability and overall organization.

NOTE: You do not need to complete Part II step 1 to implement functions. Functions should be implemented wherever they are effective throughout your program flow to improve reusability and overall organization.

Take the time to learn how to work with raster data and moving window operations with NumPy. Think through the task to understand the single implementation steps. There are many different ways of conducting this analysis, so develop a solution that is the most logical and efficient.

By the start of next class in two weeks upload your script (*lastname_lab4.py*) to Canvas.

Grading: You will be evaluated on the following: your script runs without errors (3); Part I: evaluates the 5 criteria and produces the final suitability surface—steps 1-3 (12), and prints the correct number of sites and correctly exports the result (4); Part II: calculates distance to transmission stations (4), and uses functions effectively (2); and the clarity, logic and efficiency of your script (5).

Optional Challenge: Do the same analysis but with a circular window. The radius of this circle should be $\sqrt{area/pi}$ (area is 99km^2). The circular window you create will obviously be a raster representation of a circle, and thus will approximate the shape of a circle given the resolution of the raster. All cell centroids in this raster footprint must be within the radius distance from the centroid of the circle.