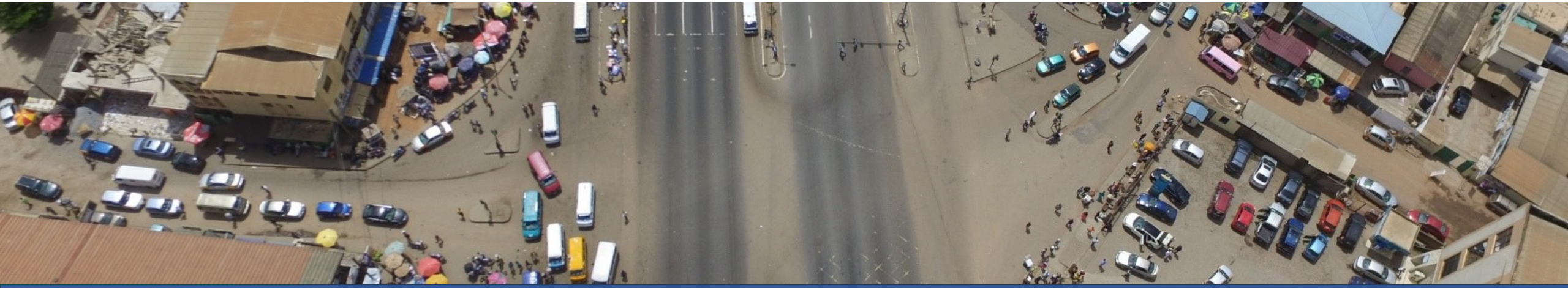
Global Engagement

UNIVERSITY OF GHANA

Geography

Civil, Environmental and Geomatic Engineering



UCL-UoG International Workshop

Day 2: Introduction to Geoprocessing of Rasters in RStudio

Team: Dr. Anwar Musah, Prof. Luiza Campos, Dr. Mumuni Abu, Dr. Stephen Law

What will we learn?

Global Engagement

UNIVERSITY OF GHANA

Geography

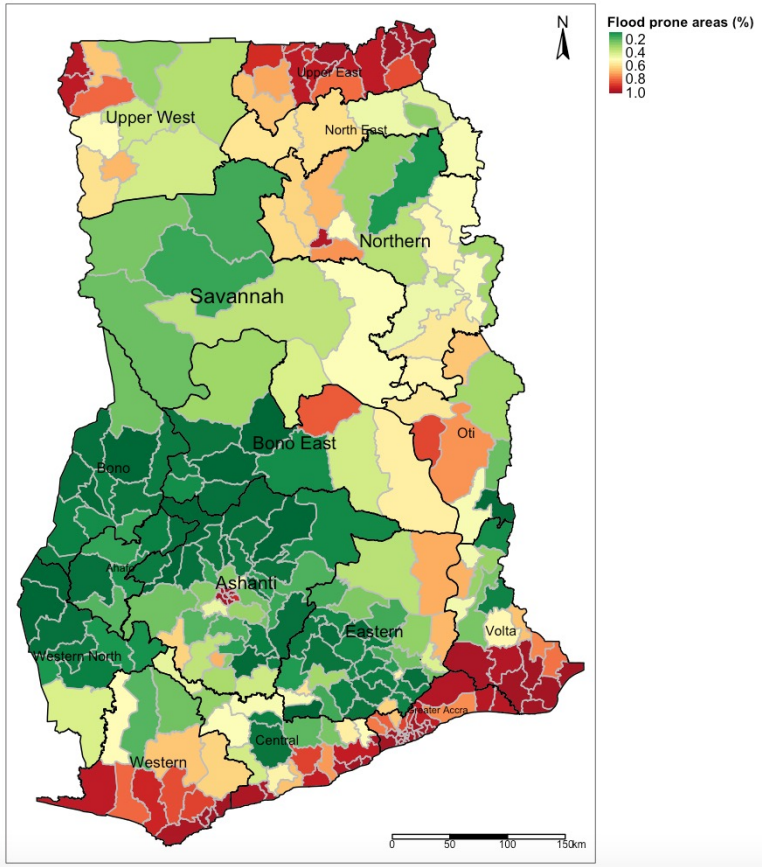
Civil, Environmental and Geomatic Engineering

What will we learn?

- To introduce you to further etiquettes of RStudio and its programming environment
- You will be introduced to the various types of spatial data – raster data
- For the day 2 practical – you will be shown how reclassify rasters based on conditions to predict risk of flooding. The focus will be on “vector data”
- You will be shown how to use the “raster” package for gridded. These sets of dataset will focus on generating an output to show flood hazards across Ghana.

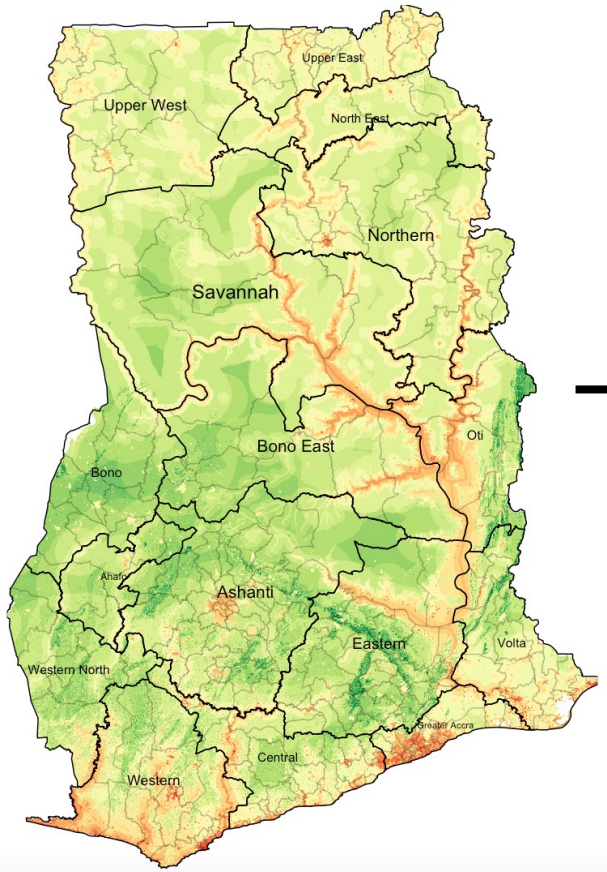
https://uclpg-msc-sgds.github.io/UCL-UoG-Workshop/

Day 1 (Vector)

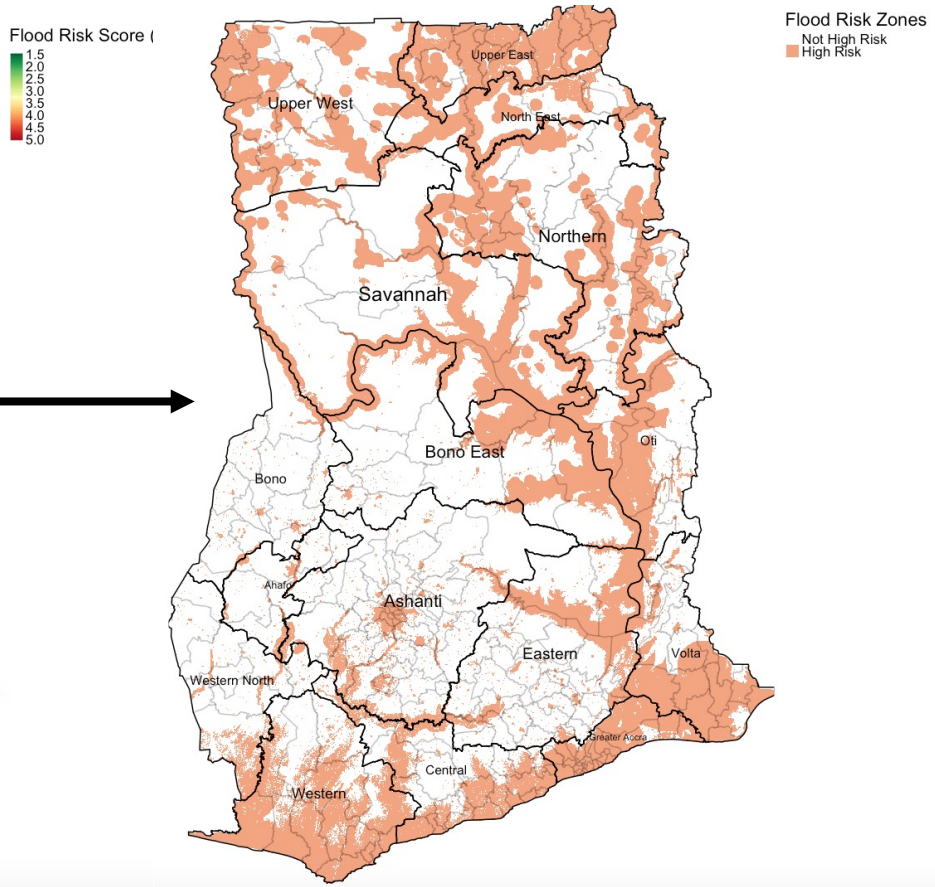


Mapping burden of surface affected by floods in districts in Ghana

Day 2 (Raster)



Compute risk score for pixels across Ghana based on a set of environmental variables with decisions



Reclassify risk scores based on a threshold (> 4, high risk and above). Zone the areas in Ghana

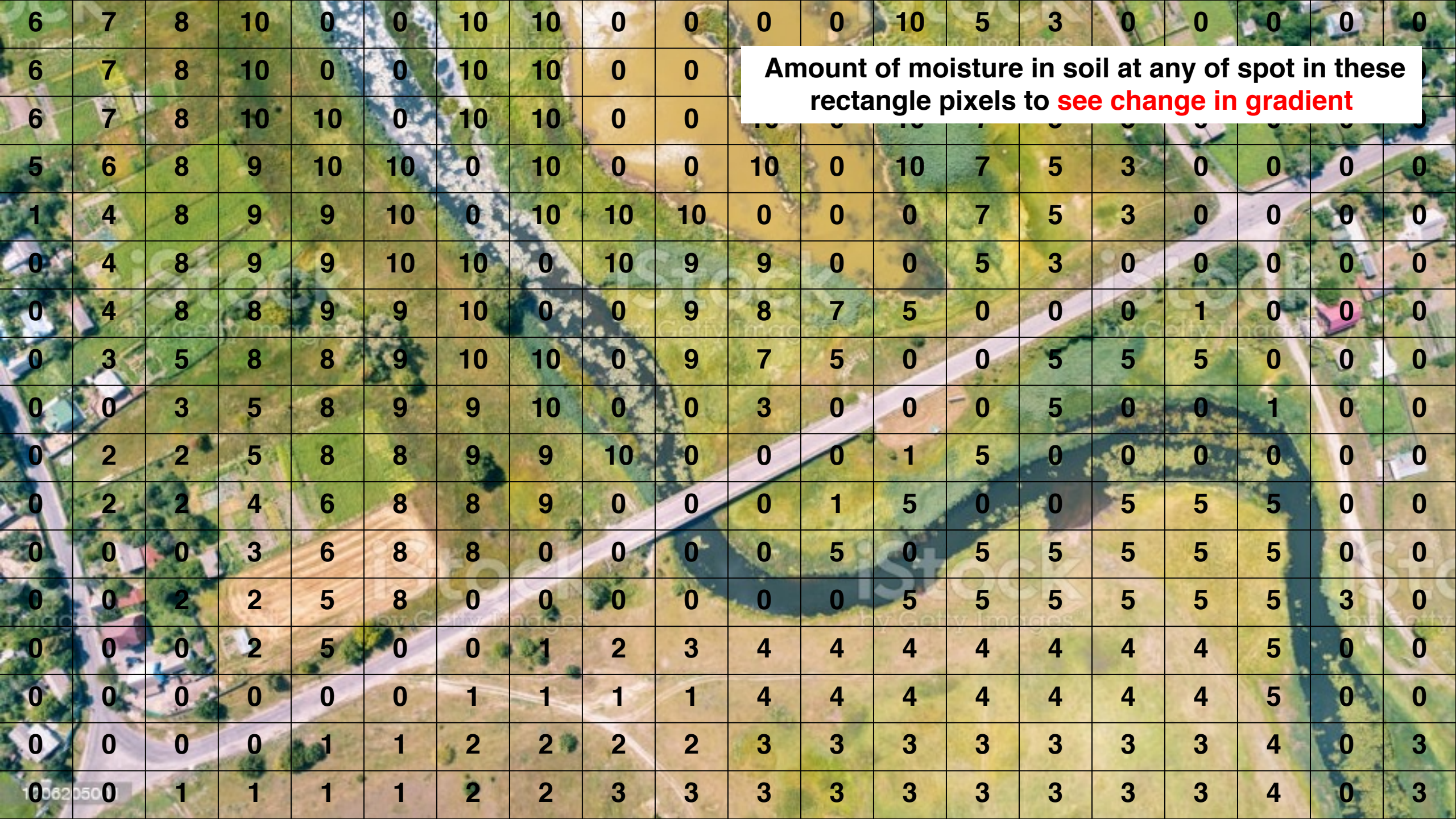
Suppose we want to map the following from this landscape:

1. Physical objects:

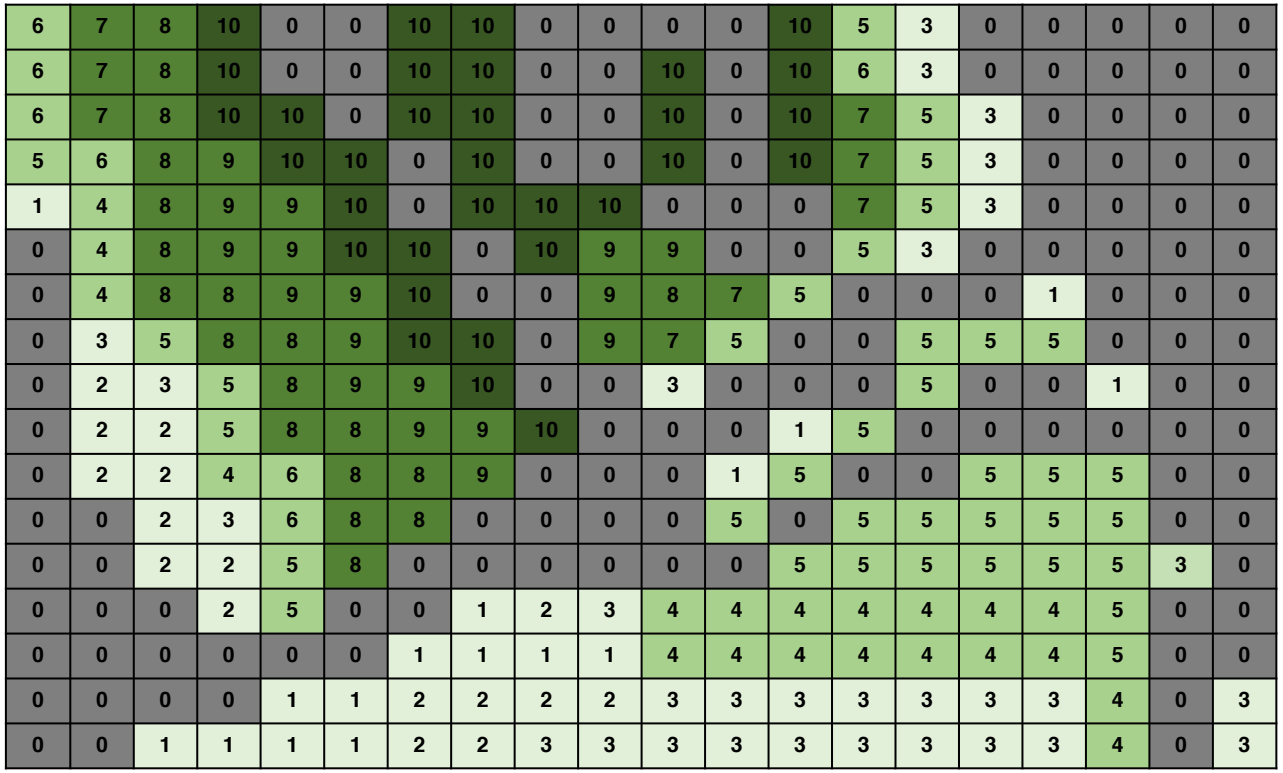
- Location of buildings
- Farm plots
- Locations of trees
- Road network
- Block areas (divided by the road)

2. Levels of soil moisture across the landscape


What about the soil moisture



6	7	8	10	0	0	10	10	0	0	0	0	10	5	3	0	0	0	0	0
6	7	8	10	0	0	10	10	0	0										
6	7	8	10	10	0	10	10	0	0										
5	6	8	9	10	10	0	10	0	0	10	0	10	7	5	3	0	0	0	0
1	4	8	9	9	10	0	10	10	10	0	0	0	7	5	3	0	0	0	0
0	4	8	9	9	10	10	0	10	9	9	0	0	5	3	0	0	0	0	0
0	4	8	8	9	9	10	0	0	9	8	7	5	0	0	0	1	0	0	0
0	3	5	8	8	9	10	10	0	9	7	5	0	0	5	5	5	0	0	0
0	0	3	5	8	9	9	10	0	0	3	0	0	0	5	0	0	1	0	0
0	2	2	5	8	8	9	9	10	0	0	0	1	5	0	0	0	0	0	0
0	2	2	4	6	8	8	9	0	0	0	1	5	0	0	5	5	5	0	0
0	0	0	3	6	8	8	0	0	0	0	5	0	5	5	5	5	5	0	0
0	0	2	2	5	8	0	0	0	0	0	0	5	5	5	5	5	5	3	0
0	0	0	2	5	0	0	1	2	3	4	4	4	4	4	4	4	5	0	0
0	0	0	0	0	0	1	1	1	1	4	4	4	4	4	4	4	5	0	0
0	0	0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	4	0	3
0	0	1	1	1	1	2	2	3	3	3	3	3	3	3	3	3	4	0	3



6	7	8	10	0	0	10	10	0	0	0	0	10	5	3	0	0	0	0	0
6	7	8	10	0	0	10	10	0	0	10	0	10	6	3	0	0	0	0	0
6	7	8	10	10	0	10	10	0	0	10	0	10	7	5	3	0	0	0	0
5	6	8	9	10	10	0	10	0	0	10	0	10	7	5	3	0	0	0	0
1	4	8	9	9	10	0	10	10	10	0	0	0	7	5	3	0	0	0	0
0	4	8	9	9	10	10	0	10	9	9	0	0	5	3	0	0	0	0	0
0	4	8	8	9	9	10	0	0	9	8	7	5	0	0	0	1	0	0	0
0	3	5	8	8	9	10	10	0	9	7	5	0	0	5	5	5	0	0	0
0	2	3	5	8	9	9	10	0	0	3	0	0	0	5	0	0	1	0	0
0	2	2	5	8	8	9	9	10	0	0	0	1	5	0	0	0	0	0	0
0	2	2	4	6	8	8	9	0	0	0	1	5	0	0	5	5	5	0	0
0	0	2	3	6	8	8	0	0	0	0	5	0	5	5	5	5	5	0	0
0	0	2	2	5	8	0	0	0	0	0	0	5	5	5	5	5	5	3	0
0	0	0	2	5	0	0	1	2	3	4	4	4	4	4	4	4	5	0	0
0	0	0	0	0	0	1	1	1	1	4	4	4	4	4	4	4	5	0	0
0	0	0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	4	0	3
0	0	1	1	1	1	2	2	3	3	3	3	3	3	3	3	3	4	0	3

Soil moisture index
10
7 to 9
4 to 6
1 to 3
0

Unlike the vector data. The above feature describes how moisture levels across the surface of the landscape – the feature is is not measured discretely but on a **continuous** surface to show gradient in changes for soil moisture across the landscape

Now, this **Non-discrete** feature is classed a **Raster Data**

What is Raster Data?

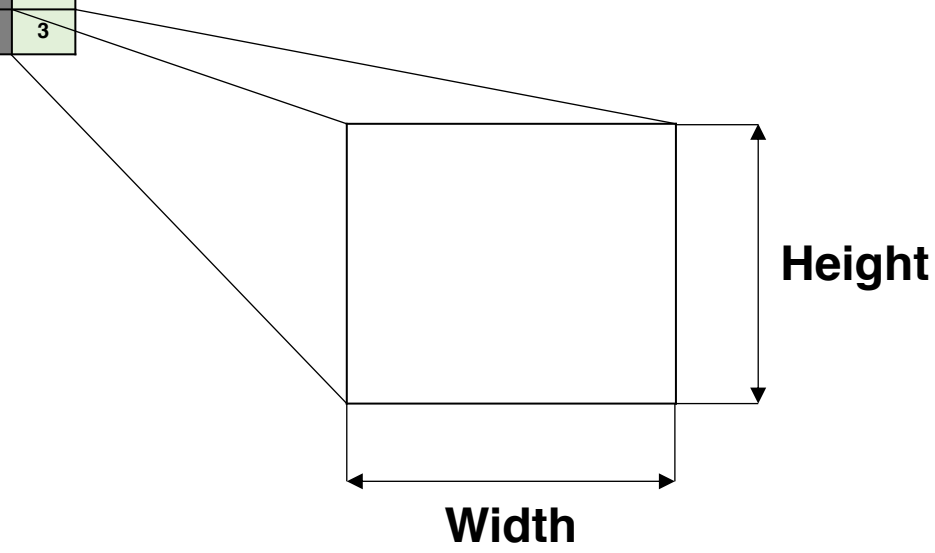
- **It is a matrix of pixels or grid-cells** that contains a numeric or text value for a feature its representing
- It is composed of **rows and columns**
- Each pixel or grid-cell has a **resolution** (or **size for height and width**)

6	7	8	10	0	0	10	10	0	0	0	0	10	5	3	0	0	0	0	0
6	7	8	10	0	0	10	10	0	0	10	0	10	6	3	0	0	0	0	0
6	7	8	10	10	0	10	10	0	0	10	0	10	7	5	3	0	0	0	0
5	6	8	9	10	10	0	10	0	0	10	0	10	7	5	3	0	0	0	0
1	4	8	9	9	10	0	10	10	10	0	0	0	7	5	3	0	0	0	0
0	4	8	9	9	10	10	0	10	9	9	0	0	5	3	0	0	0	0	0
0	4	8	8	9	9	10	0	0	9	8	7	5	0	0	0	1	0	0	0
0	3	5	8	8	9	10	10	0	9	7	5	0	0	5	5	5	0	0	0
0	2	3	5	8	9	9	10	0	0	3	0	0	0	5	0	0	1	0	0
0	2	2	5	8	8	9	9	10	0	0	0	1	5	0	0	0	0	0	0
0	2	2	4	6	8	8	9	0	0	0	1	5	0	0	5	5	5	0	0
0	0	2	3	6	8	8	0	0	0	0	5	0	5	5	5	5	5	0	0
0	0	2	2	5	8	0	0	0	0	0	0	5	5	5	5	5	5	3	0
0	0	0	2	5	0	0	1	2	3	4	4	4	4	4	4	4	5	0	0
0	0	0	0	0	0	1	1	1	1	4	4	4	4	4	4	4	5	0	0
0	0	0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	4	0	3
0	0	1	1	1	1	2	2	3	3	3	3	3	3	3	3	3	4	0	3

Soil moisture index
10
7 to 9
4 to 6
1 to 3
0

Characteristics of Raster Data and its pixels (or grid cells):

- It can take any shape (circle, square, rectangle, hexagon etc.). The usual shape you will encounter is a **square**
- Resolution (width and height: units - m, km, miles etc.)



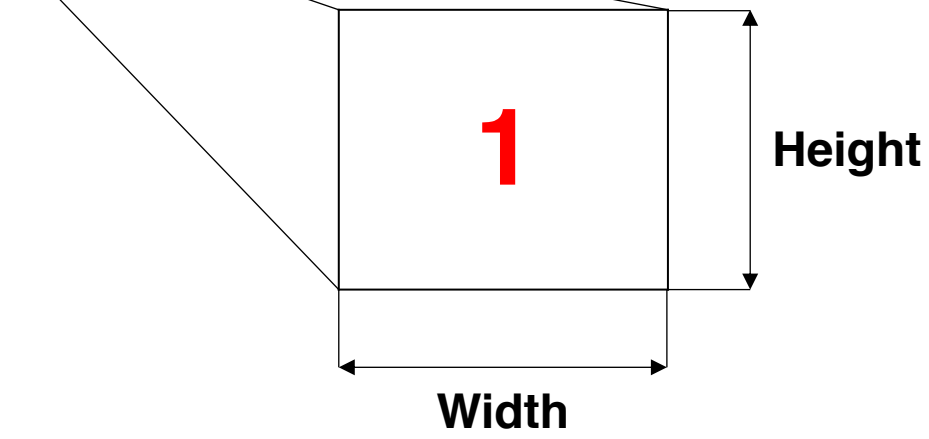
6	7	8	10	0	0	10	10	0	0	0	0	10	5	3	0	0	0	0	0
6	7	8	10	0	0	10	10	0	0	10	0	10	6	3	0	0	0	0	0
6	7	8	10	10	0	10	10	0	0	10	0	10	7	5	3	0	0	0	0
5	6	8	9	10	10	0	10	0	0	10	0	10	7	5	3	0	0	0	0
1	4	8	9	9	10	0	10	10	10	0	0	0	7	5	3	0	0	0	0
0	4	8	9	9	10	10	0	10	9	9	0	0	5	3	0	0	0	0	0
0	4	8	8	9	9	10	0	0	9	8	7	5	0	0	0	1	0	0	0
0	3	5	8	8	9	10	10	0	9	7	5	0	0	5	5	5	0	0	0
0	2	3	5	8	9	9	10	0	0	3	0	0	0	5	0	0	1	0	0
0	2	2	5	8	8	9	9	10	0	0	0	1	5	0	0	0	0	0	0
0	2	2	4	6	8	8	9	0	0	0	1	5	0	0	5	5	5	0	0
0	0	2	3	6	8	8	0	0	0	0	5	0	5	5	5	5	5	0	0
0	0	2	2	5	8	0	0	0	0	0	0	5	5	5	5	5	5	3	0
0	0	0	2	5	0	0	1	2	3	4	4	4	4	4	4	4	5	0	0
0	0	0	0	0	0	1	1	1	1	4	4	4	4	4	4	4	5	0	0
0	0	0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	4	0	3
0	0	1	1	1	1	2	2	3	3	3	3	3	3	3	3	3	4	0	3

Soil moisture index
10
7 to 9
4 to 6
1 to 3
0

Characteristics of Raster Data and its pixels (or grid cells):

- It can take any shape (circle, square, rectangle, hexagon etc.). The usual shape you will encounter is a **square**
- Resolution (width and height: units - m, km, miles etc.)
- Data types:
  - Integer: for discrete values (e.g., above raster for moisture)
  - Boolean (or Binary) 1 = “Yes” and 0 = “No” (Presence/absence)

Example with Boolean

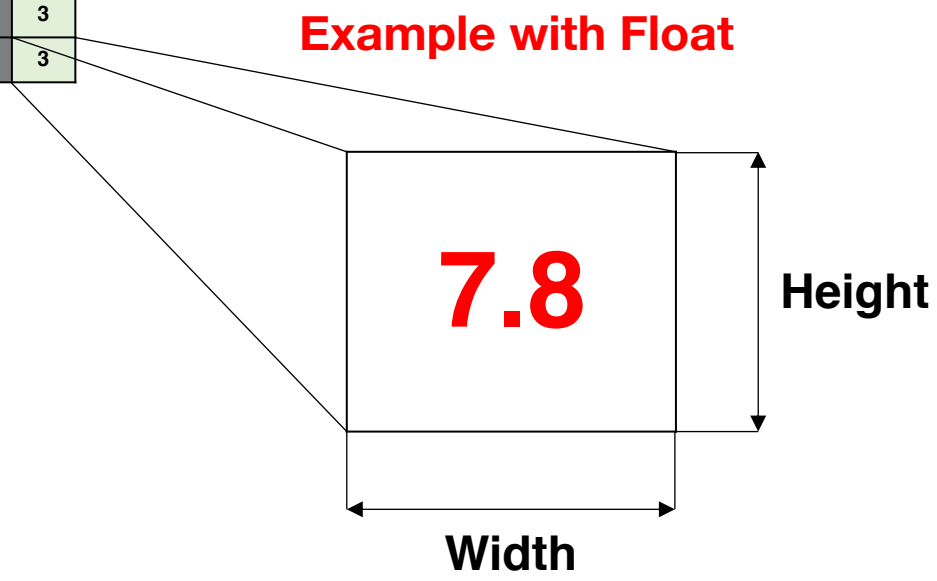


6	7	8	10	0	0	10	10	0	0	0	0	10	5	3	0	0	0	0	0
6	7	8	10	0	0	10	10	0	0	10	0	10	6	3	0	0	0	0	0
6	7	8	10	10	0	10	10	0	0	10	0	10	7	5	3	0	0	0	0
5	6	8	9	10	10	0	10	0	0	10	0	10	7	5	3	0	0	0	0
1	4	8	9	9	10	0	10	10	10	0	0	0	7	5	3	0	0	0	0
0	4	8	9	9	10	10	0	10	9	9	0	0	5	3	0	0	0	0	0
0	4	8	8	9	9	10	0	0	9	8	7	5	0	0	0	1	0	0	0
0	3	5	8	8	9	10	10	0	9	7	5	0	0	5	5	5	0	0	0
0	2	3	5	8	9	9	10	0	0	3	0	0	0	5	0	0	1	0	0
0	2	2	5	8	8	9	9	10	0	0	0	1	5	0	0	0	0	0	0
0	2	2	4	6	8	8	9	0	0	0	1	5	0	0	5	5	5	0	0
0	0	2	3	6	8	8	0	0	0	0	5	0	5	5	5	5	5	0	0
0	0	2	2	5	8	0	0	0	0	0	0	5	5	5	5	5	5	3	0
0	0	0	2	5	0	0	1	2	3	4	4	4	4	4	4	4	5	0	0
0	0	0	0	0	0	1	1	1	1	4	4	4	4	4	4	4	5	0	0
0	0	0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	4	0	3
0	0	1	1	1	1	2	2	3	3	3	3	3	3	3	3	3	4	0	3

Soil moisture index
10
7 to 9
4 to 6
1 to 3
0

Characteristics of Raster Data and its pixels (or grid cells):

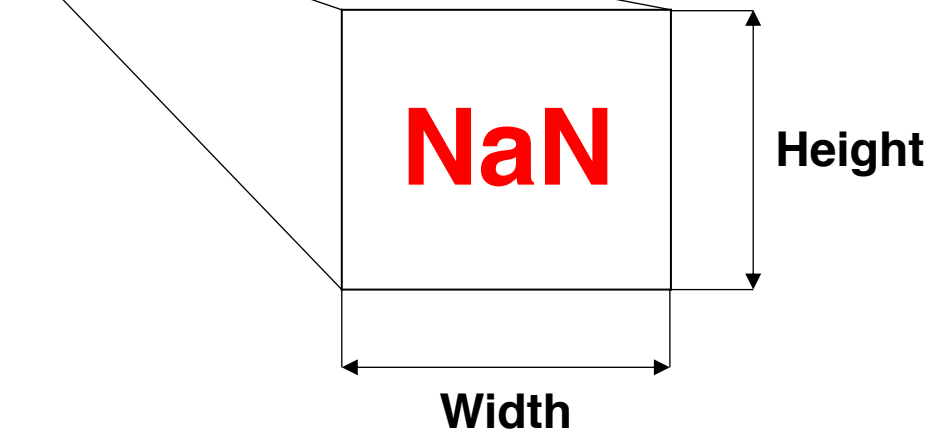
- It can take any shape (circle, square, rectangle, hexagon etc.). The usual shape you will encounter is a **square**
- Resolution (width and height: units - m, km, miles etc.)
- Data types:
  - Integer: for discrete values (e.g., above raster for moisture)
  - Boolean (or Binary) 1 = “Yes” and 0 = “No” (Presence/absence)
  - Float (or continuous data)



6	7	8	10	0	0	10	10	0	0	0	0	10	5	3	0	0	0	0	0
6	7	8	10	0	0	10	10	0	0	10	0	10	6	3	0	0	0	0	0
6	7	8	10	10	0	10	10	0	0	10	0	10	7	5	3	0	0	0	0
5	6	8	9	10	10	0	10	0	0	10	0	10	7	5	3	0	0	0	0
1	4	8	9	9	10	0	10	10	10	0	0	0	7	5	3	0	0	0	0
0	4	8	9	9	10	10	0	10	9	9	0	0	5	3	0	0	0	0	0
0	4	8	8	9	9	10	0	0	9	8	7	5	0	0	0	1	0	0	0
0	3	5	8	8	9	10	10	0	9	7	5	0	0	5	5	5	0	0	0
0	2	3	5	8	9	9	10	0	0	3	0	0	0	5	0	0	1	0	0
0	2	2	5	8	8	9	9	10	0	0	0	1	5	0	0	0	0	0	0
0	2	2	4	6	8	8	9	0	0	0	1	5	0	0	5	5	5	0	0
0	0	2	3	6	8	8	0	0	0	0	5	0	5	5	5	5	5	0	0
0	0	2	2	5	8	0	0	0	0	0	0	5	5	5	5	5	5	3	0
0	0	0	2	5	0	0	1	2	3	4	4	4	4	4	4	4	5	0	0
0	0	0	0	0	0	1	1	1	1	4	4	4	4	4	4	4	5	0	0
0	0	0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	4	0	3
0	0	1	1	1	1	2	2	3	3	3	3	3	3	3	3	3	4	0	3

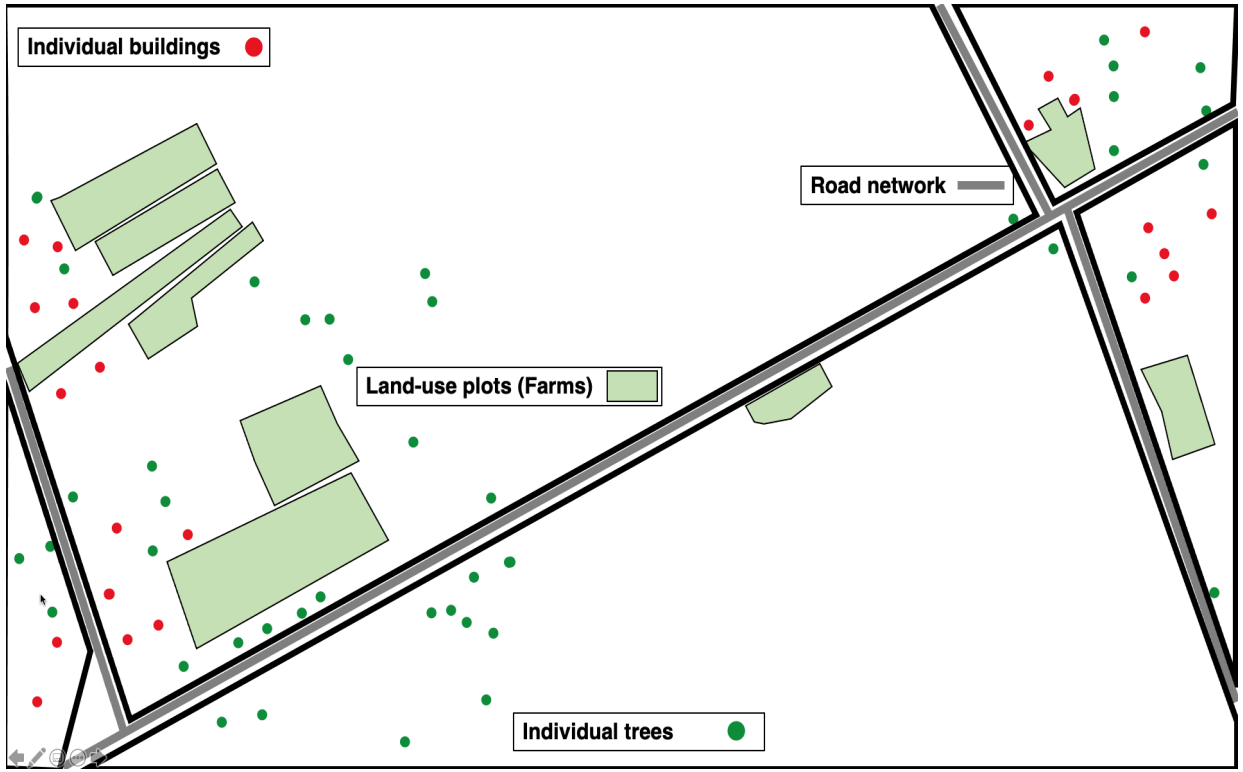
Soil moisture index
10
7 to 9
4 to 6
1 to 3
0

Example with Missing



Characteristics of Raster Data and its pixels (or grid cells):

- It can take any shape (circle, square, rectangle, hexagon etc.). The usual shape you will encounter is a **square**
- Resolution (width and height: units - m, km, miles etc.)
- Data types:
  - Integer: for discrete values (e.g., above raster for moisture)
  - Boolean (or Binary) 1 = “Yes” and 0 = “No” (Presence/absence)
  - Float (or continuous data)
  - No data, missing value in pixel: NA, NaN



Vector data

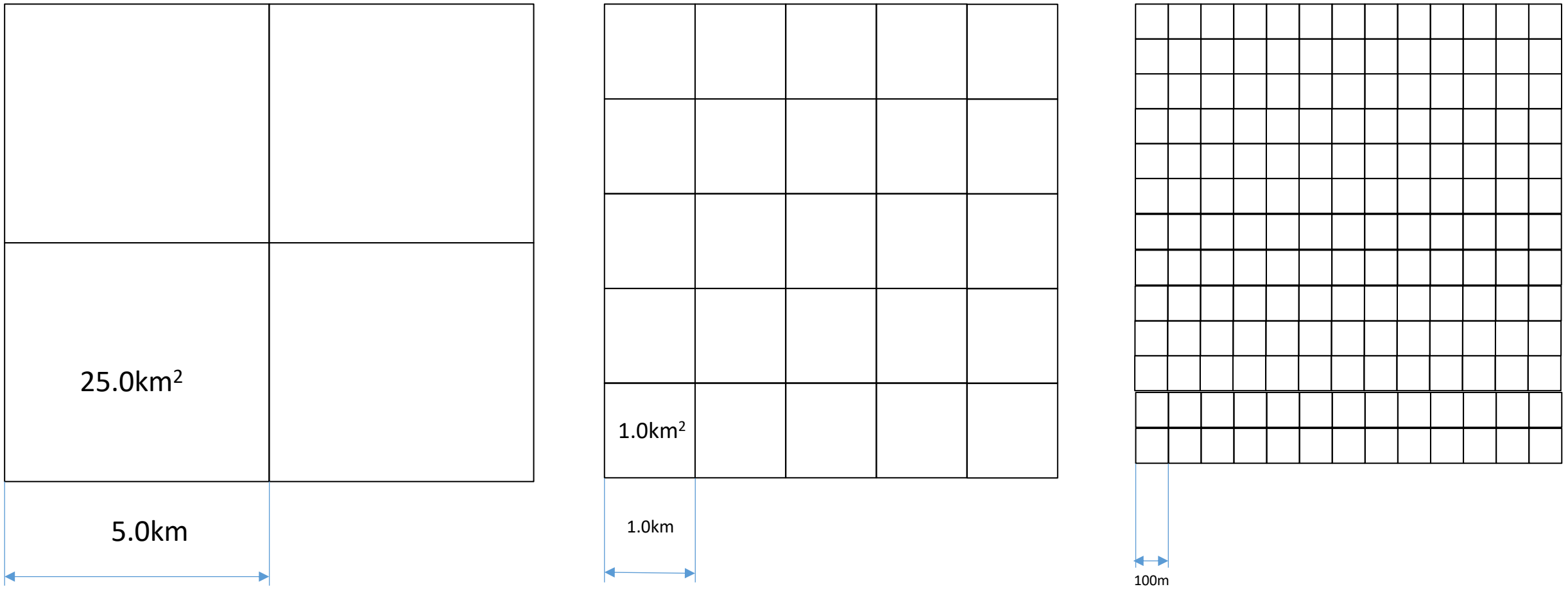
6	7	8	10	0	0	10	10	0	0	0	0	10	5	3	0	0	0	0	0
6	7	8	10	0	0	10	10	0	0	10	0	10	6	3	0	0	0	0	0
6	7	8	10	10	0	10	10	0	0	10	0	10	7	5	3	0	0	0	0
5	6	8	9	10	10	0	10	0	0	10	0	10	7	5	3	0	0	0	0
1	4	8	9	9	10	0	10	10	10	0	0	0	7	5	3	0	0	0	0
0	4	8	9	9	10	10	0	10	9	9	0	0	5	3	0	0	0	0	0
0	4	8	8	9	9	10	0	0	9	8	7	5	0	0	0	1	0	0	0
0	3	5	8	8	9	10	10	0	9	7	5	0	0	5	5	5	0	0	0
0	2	3	5	8	9	9	10	0	0	3	0	0	0	5	0	0	1	0	0
0	2	2	5	8	8	9	9	10	0	0	0	1	5	0	0	0	0	0	0
0	2	2	4	6	8	8	9	0	0	0	1	5	0	0	5	5	5	0	0
0	0	2	3	6	8	8	0	0	0	0	5	0	5	5	5	5	5	0	0
0	0	2	2	5	8	0	0	0	0	0	0	5	5	5	5	5	5	3	0
0	0	0	2	5	0	0	1	2	3	4	4	4	4	4	4	4	5	0	0
0	0	0	0	0	0	1	1	1	1	4	4	4	4	4	4	4	5	0	0
0	0	0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	4	0	3
0	0	1	1	1	1	2	2	3	3	3	3	3	3	3	3	3	4	0	3

Raster data

Raster Map:

Spatial resolution matters with raster data!

Coarse (or low) resolution ⟷ **Fine (or high) resolution**



CASE STUDY: GIS-MCDA applied to identify suitable areas for Lymphatic Filariasis (LF) transmission in Kenya.

Description: There are no available up-to-date models to explain the occurrence of Lymphatic Filariasis (LF) in Kenya and **geospatial empirical data are scarce.** The Kenyan Ministry of Health (K-MoH), through its LF control programme, is planning to launch a public health intervention by introducing mass drug administration (MDA) of albendazole (combined with ivermectin) to infected people with LF and to remove microfilaria in their bloodstream. Mapping of suspected areas for LF must be carried out, however, due to financial constraints and limited resources, the K-MoH wishes to first **identify areas that are highly suitable for LF transmission** before spending this limited resources to survey, map and apply MDAs to these areas.

African man with heavy & chronic LF microfilaria infection, resulting in a swollen leg called 'Elephantiasis'

One many vectors, i.e., the Culex mosquito, that spreads LF by injecting microfilaria (microscopic worms) into their source of food (i.e., human) before taking its bloodmeal

NOTES

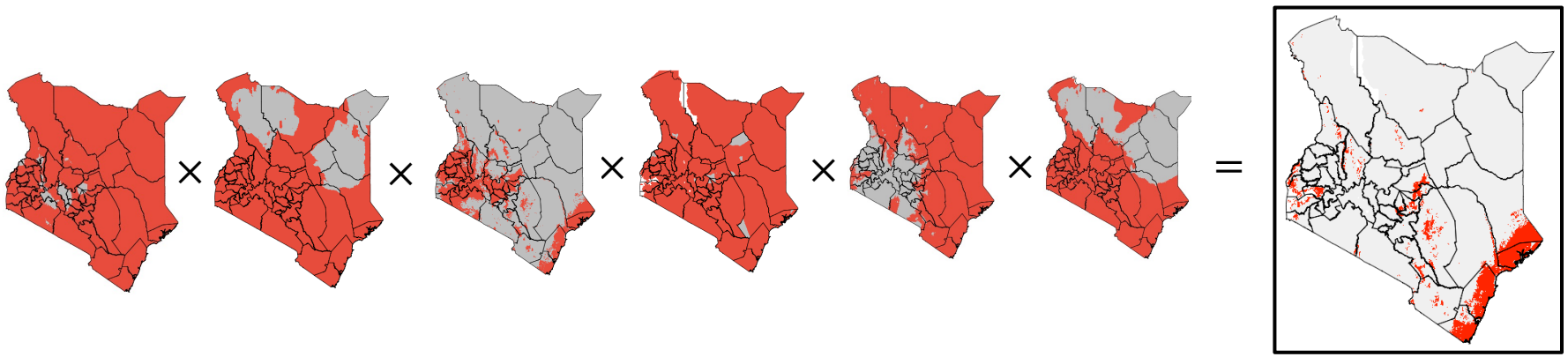
Binary (or Boolean) maps with the factor layers

NOTES

We have these data as raster – for this approach requires simply reclassification of the data into binary raster and multiplication

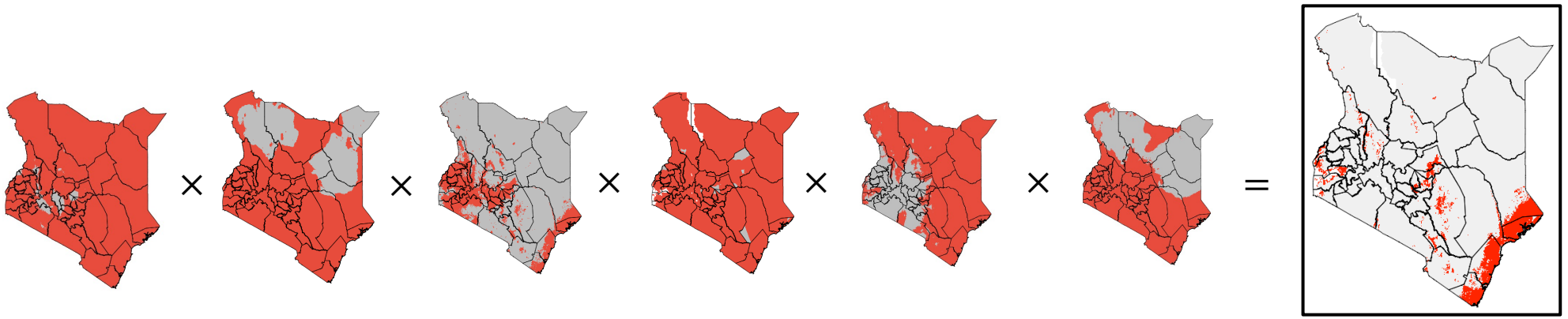
- Temperature (> 15 degree Celsius) (**F**) (↑)
- Precipitation (> 350 mm) (**F**) (↑)
- Vegetation Index (> 0.5) (**F**) (↑)
- Population Density (> 0) (**F**) (↑)
- Elevation (<1,200m above sea-level) (**F/C**) (↓)
- Aridity (> 0.2 (Semi-humid & dry environment)) (**F/C**)(↑)

e.g., if temperature > 15 then change pixel value to 1 (good condition), else change to zero (bad condition)



Binary suitability is determined simply by multiplying the six individual layers that where reclassified to 0's and 1's.

Binary: Multiplicative case



1 × 1 × 1 × 1 × 1 × 1 = 1 Suitable

1 × 0 × 1 × 0 × 1 × 1 = 0 Not Suitable

Rankings/Ratings maps with the factor layers

We have these data as raster – for this approach requires simply reclassification of the data into binary raster and summation to get scores

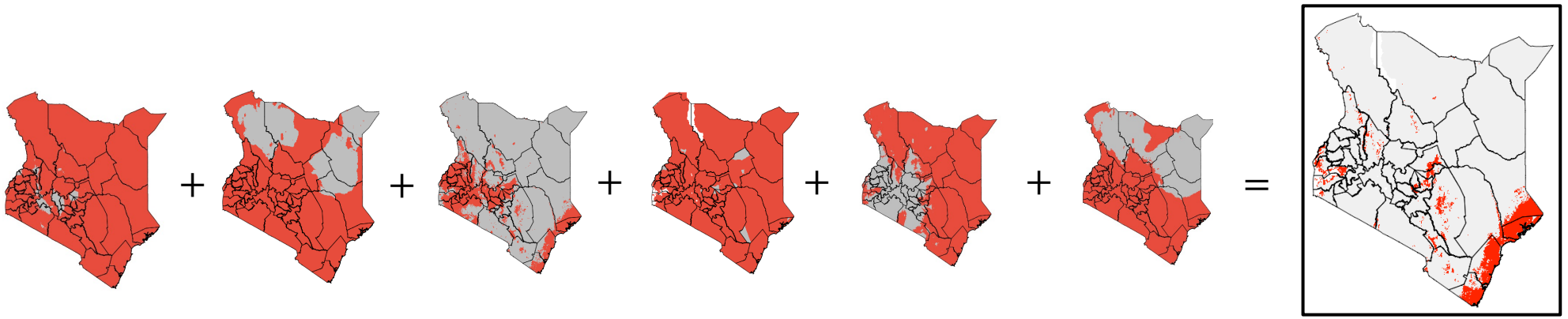
- Temperature (> 15 degree Celsius) (**F**) (⬆)
- Precipitation (> 350 mm) (**F**) (⬆)
- Vegetation Index (> 0.5) (**F**) (⬆)
- Population Density (> 0) (**F**) (⬆)
- Elevation (<1,200m above sea-level) (**F/C**) (⬇)
- Aridity (> 0.2 (Semi-humid & dry environment)) (**F/C**)(⬆)

e.g., if temperature > 15 then change pixel value to 1 (good condition), else change to zero (bad condition)

The ratings or suitability scores are determined simply by summing the values across the six individual layers that where reclassified (minimum value = 2, and maximum = 6).

NOTES

Binary: Additive case



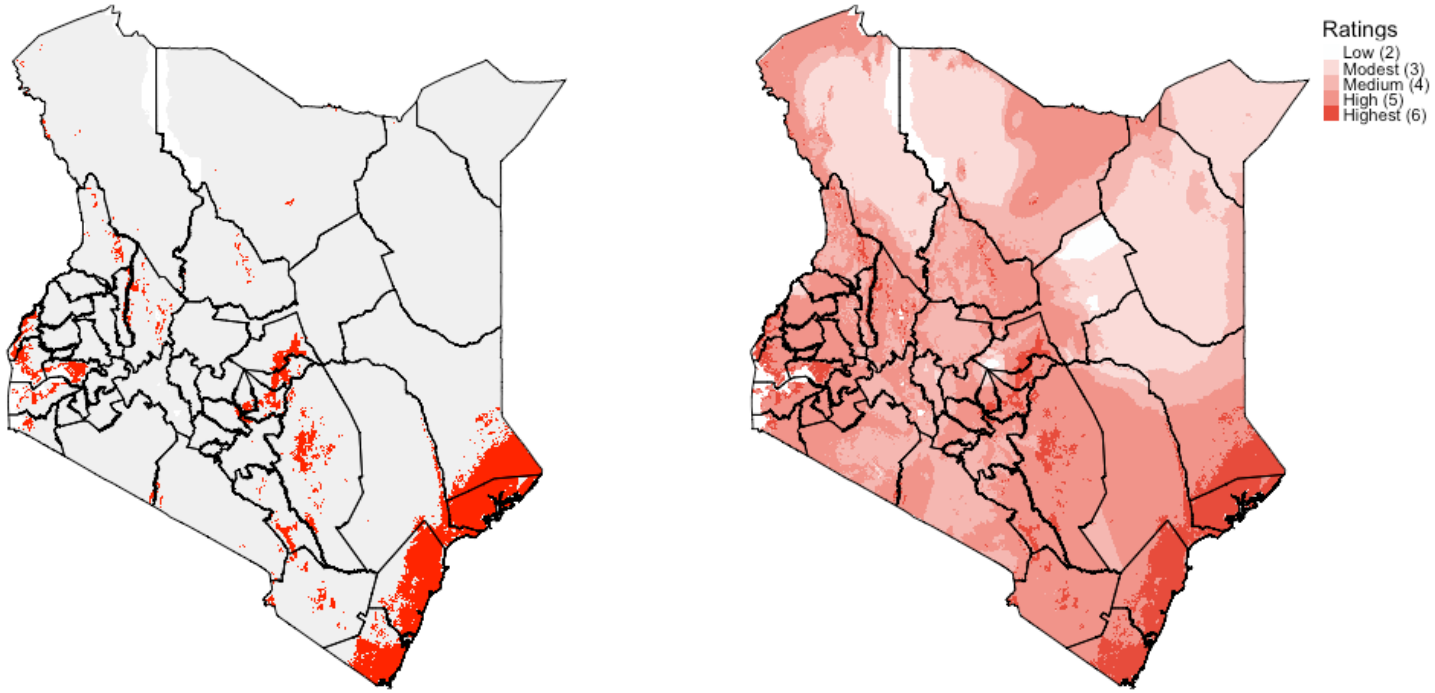
1 + 1 + 1 + 1 + 1 + 1 = 6

Highest score

1 + 0 + 1 + 0 + 1 + 1 = 4

Medium score

Boolean versus Ratings map:



- Both approaches are accessible and are very great for rapid and descriptive analysis for the potential areas for LF suitability
- However, the maps with ratings/score provides more details with regards to the intensity of LF suitability
- Both maps have major issues:
  - Does not take in to account the fact that certain variables have more importance (or dominance) in terms of influence over other variables. For instance: LF (highest importance – precipitation >> population density >> vegetation – least importance)

NOTES

NOTE 1: We can do this by applying weights to each variable in order to show level of importance for the MCDA process. This approach is referred to as Saaty's Analytical Hierarchy Process (AHP)

Let’s begin the walkthrough

Go to this website:
https://uclpg-msc-sgds.github.io/UCL-UoG-Workshop/