LESSON 2: INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS (GIS) AND THEIR APPLICATIONS

Objectives:

- Understand what Geographical Information System (GIS) is.
- Explain GIS Application in Science and Humanities

A. What is GIS?

As we understand from our previous lesson, cartography is the art and science of makings maps. In recent decades, map design has been impacted by the digital word.

> The art of making maps has changed considerably in recent years due to rapidly evolving computer technology. Geographic Information Systems (or GIS) allow digital representations of objects on a map to be connected with a database that describes that object. This ability to directly link data to objects on a map has revolutionized cartography. Geologic maps, because of their complexity, particularly benefit from being produced in a GIS format" (New Mexico Bureau of Geology & Mineral Resources, n.d.).

Geographical information System known as GIS is defined by Environmental system Research Institute (ESRI) as "a spatial system that creates, manages, analyzes, and maps all types of data" (n.d.). However, we can add to this definition by stating that GIS is computerized aid software that allows spatial features databases (Data source) to be processed and analyze throw map making.

Class Activity

- When we talk about the development of GIS, it is necessary to mention ESRI. Read the history of ESRI (https://www.esri.com/en-us/what-is-gis/history-of-gis)
- What year did GIS begin?
- What event allowed GIS to be created?
- What branch of science first began using GIS?
- Provide the year and name of the first commercial GIS software

B. Uses of GIS in Science and Humanities

Although GIS began in Environmental Science, it can currently be found used in multiple disciplines such as:

- Earth Science
- Social Sciences
- Urban planning
- Engineering
- Risk Management
- Criminology
- Recreation and Leisure Studies
- Health Sciences
- Real State
- Geographic and Atmospheric Sciences
- Digital Humanities

A practical use: Forestry

Using GIS environmentalist can inventory and identify the forest population and changes over the years and in some cases predict future changes in population. (https://www.msa-ps.com/gis-tree-inventory/).

A practical use: Wildlife, Pest Control, Migration

Tracking live motion, census animals and insects is essential for scientist to identify their Behavior (https://www.esri.com/~/media/Files/Pdfs/library/bestpractices/wildlife-conservation.pdf).

A practical use: Weather

GIS is widely use by people with regards weather forecast and warnings. A good example is the GIS mapping providing for the US National Weather Service (https://www.weather.gov).

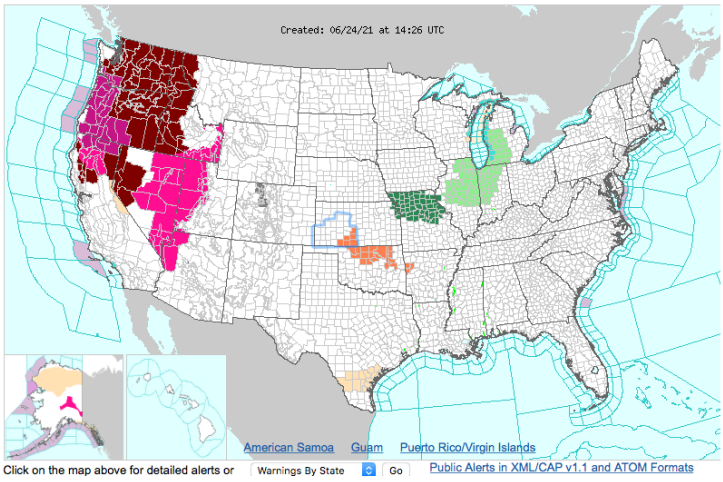

Figure 1 National Weather Service Interactive Map

https://www.weather.gov

Mathematics and Geometry

Math calculations and geometry are essential for GIS to work. Each time a new map is created, complex algorithms involving math and geometry take place to project Earth's 3D form in a 2D representation (map projections, grids, longitude, and latitude).[1]

Additionally, measuring tools of distance, area, statistic, interpolation, extrapolation, etc. require a combination of math functions that are loaded or needed to be recreated in the program.

Programing

GIS allow users to create and modify software for additional analysis tools using programing languages such as Java or Python. In fact, the statistical programing language R is used in GIS solutions.

Class Activity

- Visit the Earthquake USGS geoportal and find the last 3 earthquakes in US. Identify the time, location, depth, and magnitude (https://www.usgs.gov/products/data-and-tools/real-time-data/earthquake)

[1] https://pubs.usgs.gov/pp/1395/report.pdf

- Visit the National Weather Service and identify if there is any warning for today (https://www.weather.gov)
- Read ESRI publication GIS and Science (https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/bestpractices/gis-and-science.pdf) and briefly describe your favorite project listed in the article and why?
- How can you apply GIS in your career or classes?

C. How GIS works

Let's think about a database (an organized collection of information) where each record can be georeferenced (link to a map location). In other words, GIS allows databases with locations to be placed on a map as a layer. The special interactions between databases (layers) allow unlimited ways of data analysis that conventional databases would not be able to do.

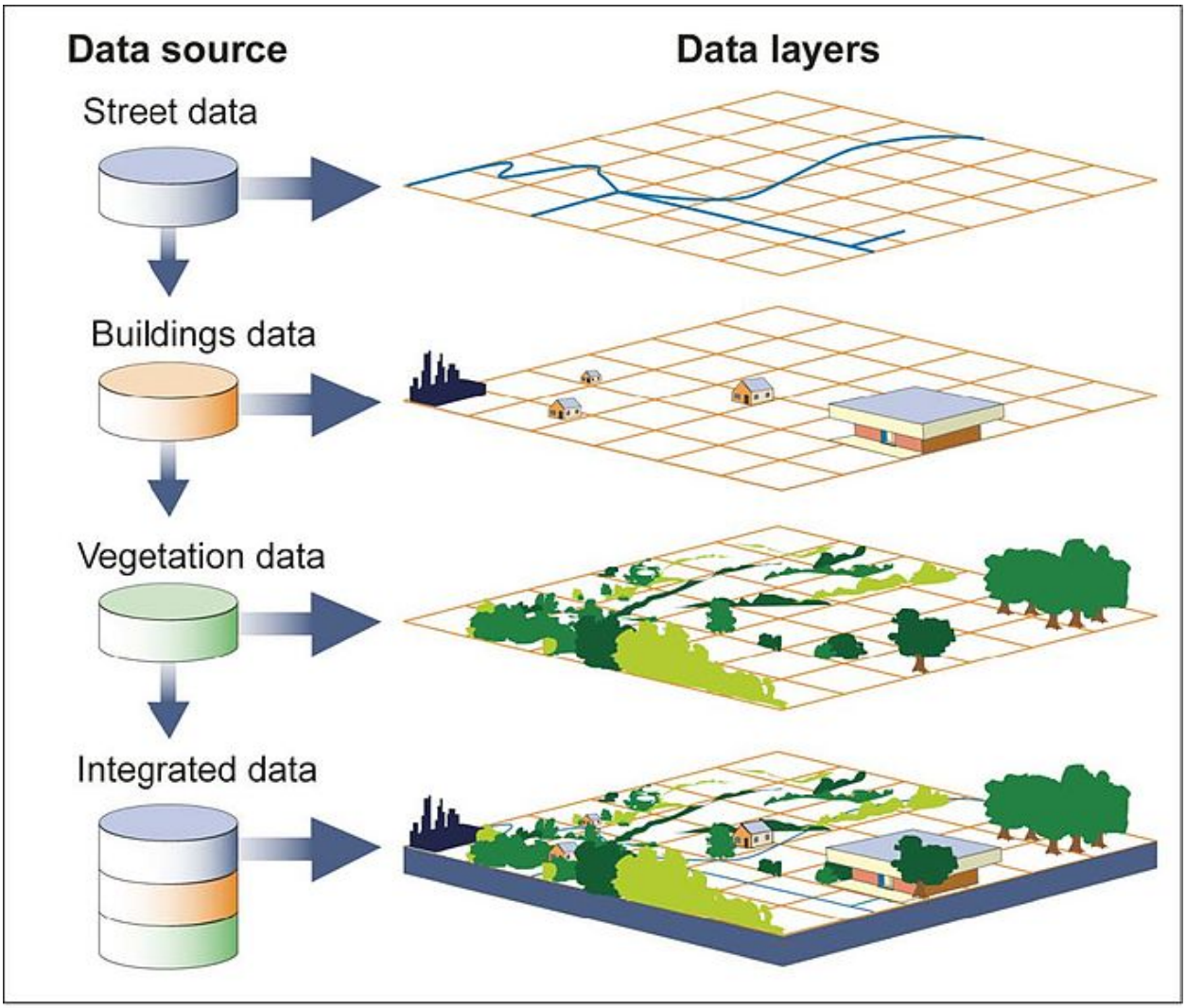

Figure 2 Visual Representation

https://commons.wikimedia.org/wiki/File:Visual_Representation_of_Themes_in_a_GIS.jpg

DATABASE WITH GEOREFERENCE

	Longitud	Latitud	Name	Cell
1	-84.395554	33.746924	John Wick	478-222-222
2	-84.396576	33.751660	Mark Thomson	478-222-224
3	-84.389392	33.753893	Clark Kent	478-222-223
4	-84.386485	33.751094	Bruce Wane	478-222-221
5	-84.384548	33.747785	Barry Alen	478-222-222
6	-84.385651	33.744932	Robert Colson	478-222-229
7	-84.396415	33.751256	Peter Parker	478-222-224
8	-84.396038	33.751982	Johny Colt	478-222-222
9	-84.396603	33.752171	Mario Disel	478-222-222

Figure 3 Example of how a Database with georeferenced is mapped with a OSM (Open Street Map) basemap

Besides displaying information, GIS allows to analyze these datasets in different ways. For example, if we needed to study all the people from dataset that are 500 feet or less from the Peter Parker location (Figure 4), this could be accomplish by GIS proximity analysis tools which would identify that Mark Thomson, Johnny Colt and Mario Disel are the closest to him.

To better understand how GIS works, it is important to identify the data types used in general. The first one is Vector Data (for discreate values) which are represented by points, lines or polygons stored with pairs of x and y coordinates. This data type is used for roads, network, buildings, states, trees, people etc.

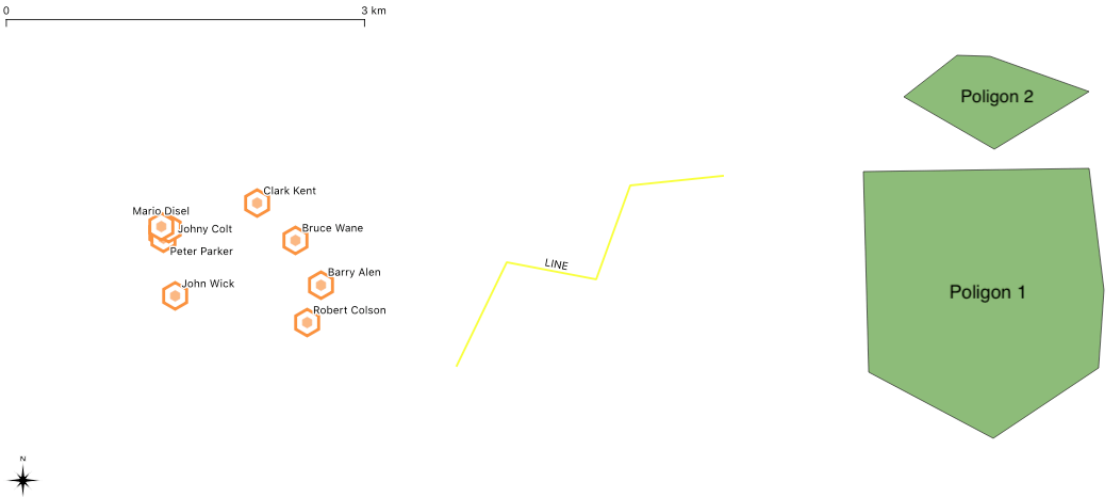

Figure 4 Vector Data (Point, Line, Polygon)

Meanwhile, Raster Data (Continuous values) store values in grids (Figure 5). This can be observed in images with elevation value where each grid or square holds a value.

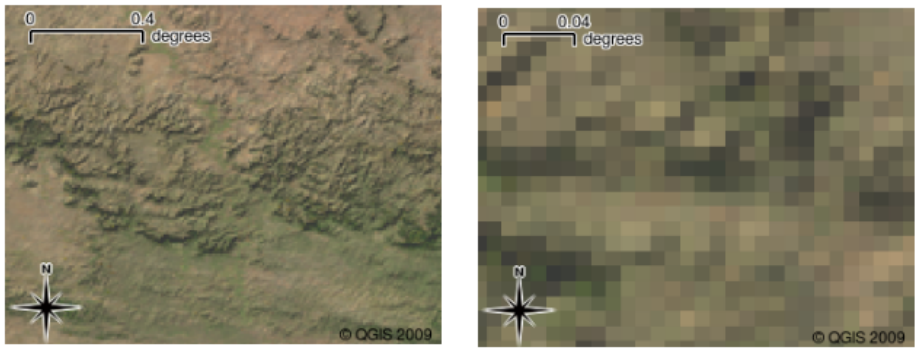

Figure 5 ESRI -Satellite Images- Introducing GIS – SOURCE QGIS
https://docs.qgis.org/2.2/en/docs/gentle_gis_introduction/introducing_gis.html#gis-data

After Class

Using a pen and a paper, create one or two small databases (5 records), then create a simple map linked with the database (Table). Finally, state a problem then analyze your data based on proximity of the records like we did in figure 4 to solve.

For instance, you can:

- analyze how many of your friends or family live near a gas station- you would need two databases: 1 friends' location and 2 gas station location then analyze how many of your friends live closer to 1 mile of the gas station.
- identify a friend or family with a pet that lives the closest to you. Create database of your friends or family and create an attribute for pet. After you display the database information in a map analyze which friend lives the closest to you

D. Applications

Write a short paragraph (250 word at least) describing how would you use GIS in your current major.

E. Cartography and STEM

Read:
GIS and Science (pages 1-38) https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/bestpractices/gis-and-science.pdf

Map Projections (pages 1-13) https://pubs.usgs.gov/pp/1395/report.pdf

References

New Mexico Bureau of Geology & Mineral Resources. (n.d.). *Cartography and GIS*. Retrieved July 23, 2021, from https://geoinfo.nmt.edu/publications/maps/gis/home.html

Environmental system Research Institute. (n.d.). *What is GIS? | Geographic Information System Mapping Technology.* Retrieved July 27, 2021, from https://www.esri.com/en-us/what-is-gis/overview