INTRODUCTION TO REMOTE SENSING AND GIS CONCEPTS: BIODIVERSITY MAPPING

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A Geographic Information System is a computerized system that helps in maintaining data about geographic space. It is defined as an information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data or geospatial data, in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities, and other administrative records.

The key components of GIS are a computer system, geospatial data and users. A computer system for GIS consists of hardware, software and procedures designed to support the data capture, processing, analysis, modeling and display of geospatial data. The sources of geospatial data are digitized maps, aerial photographs, satellite images, statistical tables and other related documents.

Geospatial data are classified into graphic data (or called geometric data) and attributes (or called thematic data). Graphic data has three elements;

- point (or called node),
- line (or called arc) and
- area (or called polygon) in either vector or raster form which represent a geometry of topology, size, shape, position and orientation.

The roles of the user are to select pertinent information, to set necessary standards, to design cost-efficient updating schemes, to analyze GIS outputs for relevant purpose and plan the implementation.

GIS in an integrated multidisciplinary science consisting of different traditional disciplines like Geography, Statistics, Cartography, Operations Research, Remote Sensing, Computer Science, Photogrammetry, Mathematics, Surveying, Civil Engineering, Urban Planning etc.

There are three important stages of working with geographic data:

- **Data preparation and entry:** The early stage in which data about the study phenomenon is collected and prepared to be entered into the system.
- **Data analysis:** The middle stage in which collected data is carefully reviewed, and, for instance, attempts are made to discover patterns.
- **Data presentation**: The final stage in which the results of earlier analysis are presented in an appropriate way.

GIS holds spatial information in independent layers. It integrates layers by registering them to a common locational reference. Thematic layers can all be made visible at the same time or selectively. It is possible to overlay these layers and get homogenous land units and other types of information allows collating data from several layers for any location (Fig.1).

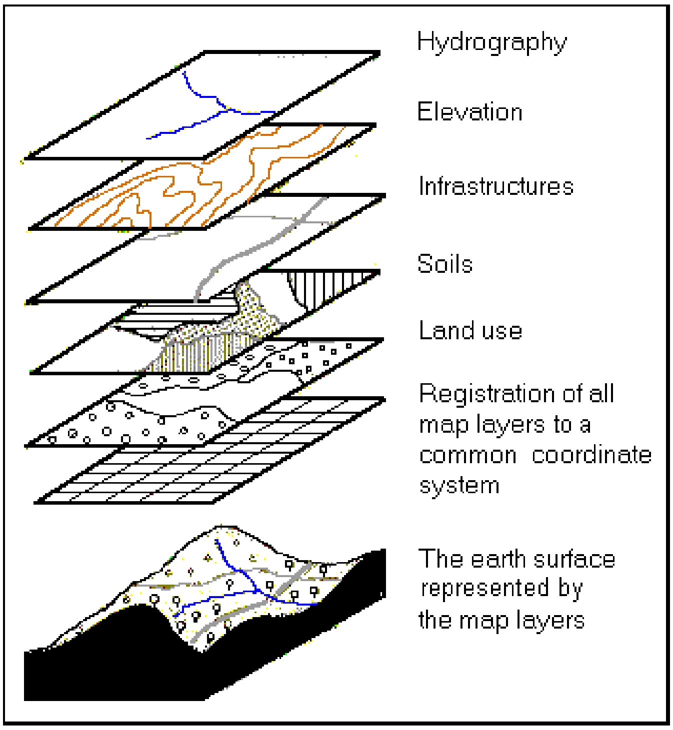


Fig.1 Overlaying of different layers in GIS

Computer Representation of Geographical Information

Point Representation

Points are defined as single coordinate pairs (x, y) when we work in 2D or coordinate triplets (x, y, z) when we work in 3D. Points are used to represent objects that are best described without shape and size, single-locality features. For a tourist city map, parks will not usually be considered as point features, but perhaps museums will be, and certainly public phone booths could be represented as point features.

Line Representation

Line data are used to represent one-dimensional objects such as roads, railroads, canals, rivers and power lines. The two end nodes and zero or more internal nodes define a line. A node or vertex is like a point (as discussed above) but it only serves to define the line; it has no special meaning to the application other than that.

The vertices of a line help to shape it, and to obtain a better approximation of the actual feature. The straight parts of a line between two consecutive vertices or end nodes are called line segments.

Area Representation

This means that each area feature is represented by some arc/node structure that determines a polygon as the area's boundary. A polygon representation for an area object is yet another example of a finite approximation of a phenomenon that inherently may have a curvilinear boundary. The above three types can be represented in vector or raster data model (Fig. 2 & 3).

Vector model uses discrete points, lines and/or areas corresponding to discrete objects with name or code number of attributes

Raster model uses regularly spaced grid cells in specific sequence. An element of the grid cell is called a pixel (picture cell). The conventional sequence is row by row from the left to the right and then line by line from the top to bottom. Every location is given in two dimensional image coordinates; pixel number and line number, which contains a single value of attributes.

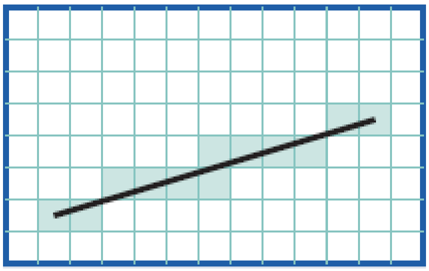
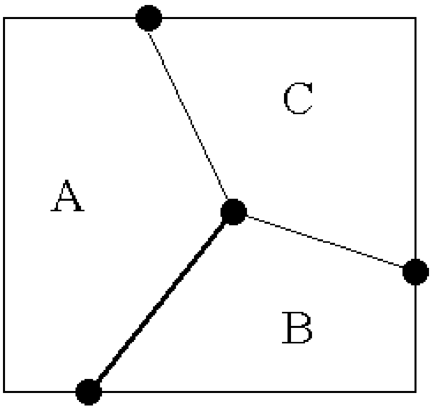


Fig. 2. An actual straight line (in black) and its representation (light gray cells) in a raster.



A	A	A	A	A	C	C	C	C	C
A	A	A	A	A	C	C	C	C	C
A	A	A	A	A	A	C	C	C	C
A	A	A	A	A	A	C	C	C	C
A	A	A	A	A	B	B	C	C	C
A	A	A	A	B	B	B	B	B	C
A	A	A	B	B	B	B	B	B	B
A	A	B	B	B	B	B	B	B	B

Fig. 3 Vector (left) and Raster (right) data model.

Remote Sensing

Remote Sensing is defined as the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation.

A device to detect the electro-magnetic radiation reflected or emitted from an object is called a "remote sensor" or "sensor". Cameras or scanners are examples of remote sensors. A vehicle to carry the sensor is called a "platform". Aircraft or satellites are used as platforms (Fig. 4).

The characteristics of an object can be determined, using reflected or emitted electro-magnetic radiation, from the object. That is, "each object has a unique and different characteristics of reflection or emission if the type of deject or the environmental condition is different.

Spaceborne Remote Sensing is carried out using sensors that are mounted on satellites. The working of spaceborne remote sensing depends on the following orbit characteristics:

1. **altitude:** is the distance (in km) from the satellite to the mean surface level of the Earth. 600–800 km (polar orbit) or at 36,000 km (geo-stationary orbit) distance from the Earth. The

higher the altitude the greater is the life of the satellite. Polar orbit satellites are pulled down by the gravity of earth and have shorter life than their geostationary counterparts. The distance also influences to a large extent which area is viewed and at which detail.

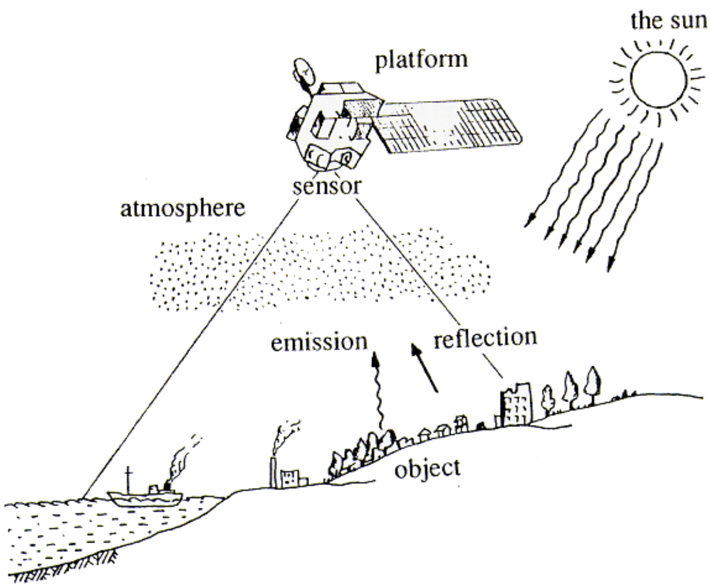


Fig.4 Data collection by Remote Sensing

2. **inclination angle:** is the angle (in degrees) between the orbit and the equator. The inclination angle of the orbit determines, together with field of view of the sensor, which latitudes can be observed. If the inclination is 60^0 then the satellite flies over the Earth between the latitudes 60^0 South and 60^0 North; it cannot observe parts of the Earth at latitudes above 60^0.

3. **period:** is the time (in minutes) required to complete one full orbit. A polar satellite orbits at 800 km altitude and has a period of 90 minutes. A ground speed of 28,000 km/hour is almost 8 km/s. The speed of the platform has implications for the type of images that can be acquired (time for 'exposure').

4. **repeat cycle:** is the time (in days) between two successive identical orbits. The revisit time, the time between two subsequent images of the same area, is determined by the repeat cycle together with the pointing capability of the sensor. Pointing capability refers to the possibility of the sensor-platform to 'look' sideways. E.g. Pushbroom scanners, such as those mounted on SPOT, IRS and IKONOS .

The image data received from the satellite has the following characteristics:

1. **Image size:** the number of rows and columns in a scene.
2. **Number of bands:** the number of wavelengths band stored. e.g. 1 (B/W photograph), 4 (multispectral image), or 256 (imaging spectroscopy data)

3. **Quantization:** the data format used to store the energy measurements. Typically for measurement one (8 bits) byte is used, representing 0-255. Using sensor specific calibration parameters, DN-values can be converted into measured energy (Watt)
4. **Ground pixel size:** the area coverage of a pixel on the ground. its a rounded figure (e.g. 20m or 30m etc)

Map Projections

A transformation is required when the three-dimensional surface of earth is to be represented on a flat map sheet. This mathematical transformation is commonly referred to as a map projection. Representing the earth's surface in two dimensions causes distortion in the shape, area, distance, or direction of the data. A map projection uses mathematical formulas to relate spherical coordinates on the globe to flat, planar coordinates. A projection could maintain the area of a feature but alter its shape or vice versa. The common projections implement cylindrical, conical or planar projections (Fig. 5 & 6).

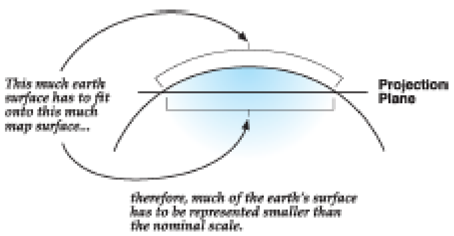


Fig. 5 Anomaly in earth's surface projection in 2-D

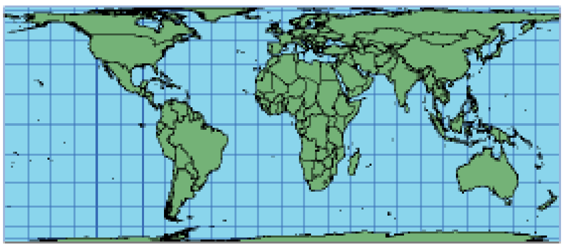


Fig. 6 Behrmann Equal Area Cylindrical Projection –used for world maps.

Biodiversity mapping

Mapping Biodiversity is one of the important applications of Remote Sensing and GIS (Fig. 7). Recent advances in spatial and spectral resolutions of sensors now available to ecologists word over are making the direct remote sensing of certain aspects of biodiversity increasingly feasible. For example, distinguishing species assemblages or even identifying species of individual trees. In cases, where direct detection of individual species assemblage is not possible, even with resolutions as high as 1m (IKONOS) or 68 cm (Quick Bird) or panchromatic hyper-spectral imagery, indirect approaches offer valuable information about diversity patterns through remote sensing of environmental parameters. Such approaches derive meaningful environmental parameters from biophysical characteristics that are revealed by remote sensing.

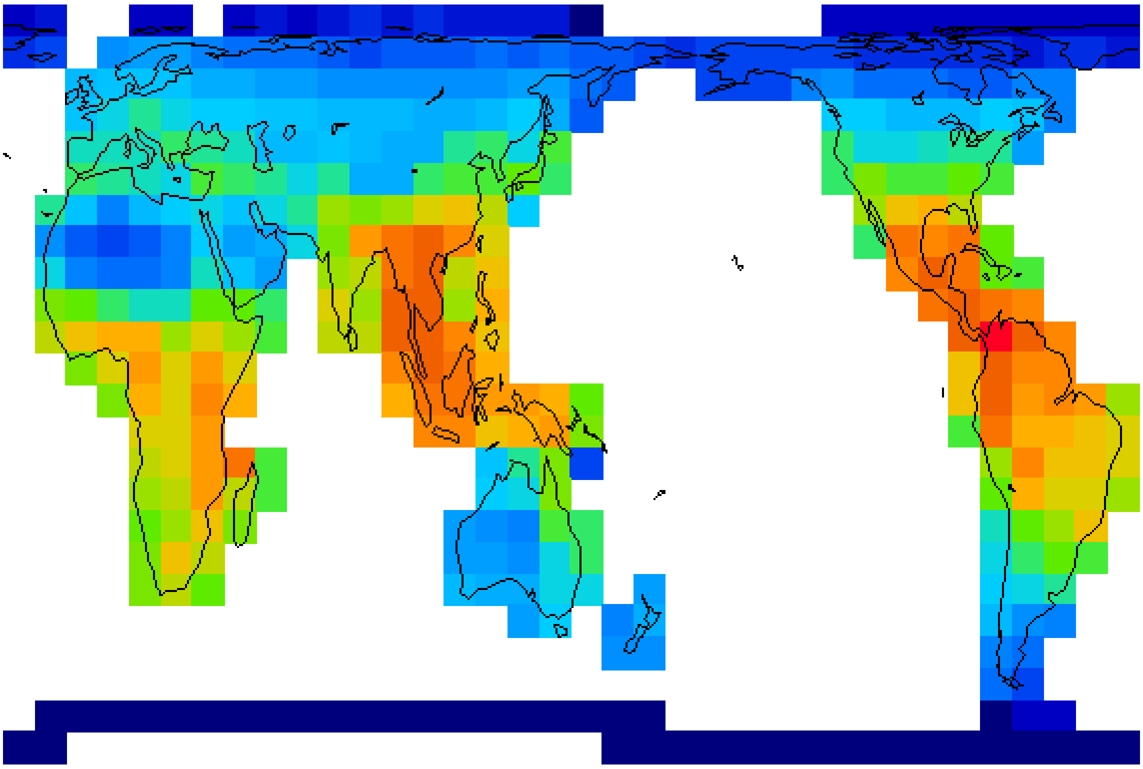


Fig. 7 A map showing the distribution of some of the most highly valued terrestrial biodiversity world-wide (mammals, reptiles, amphibians and seed plants), using family-level data for equal-area grid cells with red for high biodiversity and blue for low biodiversity.

<u>Suggested Readings and links:</u>

- Berry, J.K. 1993. "Beyond Mapping: Concepts, Algorithms and Issues in GIS". Fort Collins, CO: GIS World Books.
- Burrough, P.A. and McDonnell, R.A., 1998. Principles of geographical information systems. Oxford University Press, Oxford, 327 pp. [2]
- www.gis.com
- www.gisdevelopment.net
- www.esri.com