Topic- Basic concept or Definition of GIS and GIS data input systems.

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Paper-- REMOTE SENSING SYSTEM,GIS and GPS

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Geographical Information Systems: Concepts

INTRODUCTION

Geography is the study of Earth's features and patterns of their variations in spatial location and time. Many questions of agricultural production are geographic in nature as the production depends on the environment and prevailing socio economic conditions, both of which vary spatially and in time.. Examples are questions related to natural resources management, precision agriculture, agroecological classification for land use planning, regional trends and patterns in technology adaptation, agricultural productivity and income, non-pont source pollution from agricultural lands, etc. Answering these questions requires access to large volumes of multidimensional geographical (spatial) information of weather, soils, topography, water resources, socio economic status, etc. Further, answers to even apparently simple questions require that the data from several sources be integrated in a consistent form. Geographical Information Systems or GIS enable representation and integration of such spatial information.

GIS is a generic term implying the use of computers to create and display digital maps. The attribute data which describe the various features presented in maps may relate to physical, chemical, biological, environmental, social, economic or other earth surface properties. GIS allows mapping, modelling, querying, analyzing and displaying large quantities of such diverse data, all held together within a single database. Its power and appeal stem from its ability to integrate quantities of information about the environment and the wide repertoire of tools it provides to explore the diverse data. The history of development of GIS parallels the history of developments in digital computers and database management systems on one hand and those in cartography and automation of map production on the other. The development of GIS has also relied upon innovations made in several other disciplines – geography, photogrammetry, remote sensing, civil engineering, statistics, etc.

A GIS produces maps and reads maps. Its major advantage is that it permits identifying spatial relationships between specific different map features. It can create maps in different scales, projections and colours. But it is not just a map making tool. It is primarily an analytical tool that provides new ways of looking at, linking and analyzing data by projecting tabular data into maps and integrating data from different, diverse sources. This it does by allowing creation of a set of maps, each with a different theme (soils, rainfall, temperature, relief, water sources,etc.).

DEFINITION OF GIS

A GIS is basically a computerized information system like any other database, but with an important difference: *all information in GIS must be linked to a geographic (spatial) reference* (latitude/longitude, or other spatial coordinates).

GIS = G + IS= Geographic reference + information system

There are many different definitions of GIS, as different users stress different aspects of its use. For example:

(i) ESRI defined GIS as an organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display geographically referencedinformation.

(ii) ESRI also provided a simpler definition of GIS as a computer system capable of holding and using data describing places on the earth's surface).

(iii) Duecker defined GIS as a special case of information systems where the database consists of observations on spatially distributed features, activities or events, which are definable in space as points, lines or areas. A GIS manipulates data aboutthesepoints,linesorareastoretrievedataforadhocqueriesandanalyses.

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The United States Geological Survey (USGS) defined provided *A GIS as a computer hardware and software system designed to collect, manage, analyze and display geographically (spatially) referenced data*. This definition is a fairly comprehensive and is suitable for agricultural applications of GIS

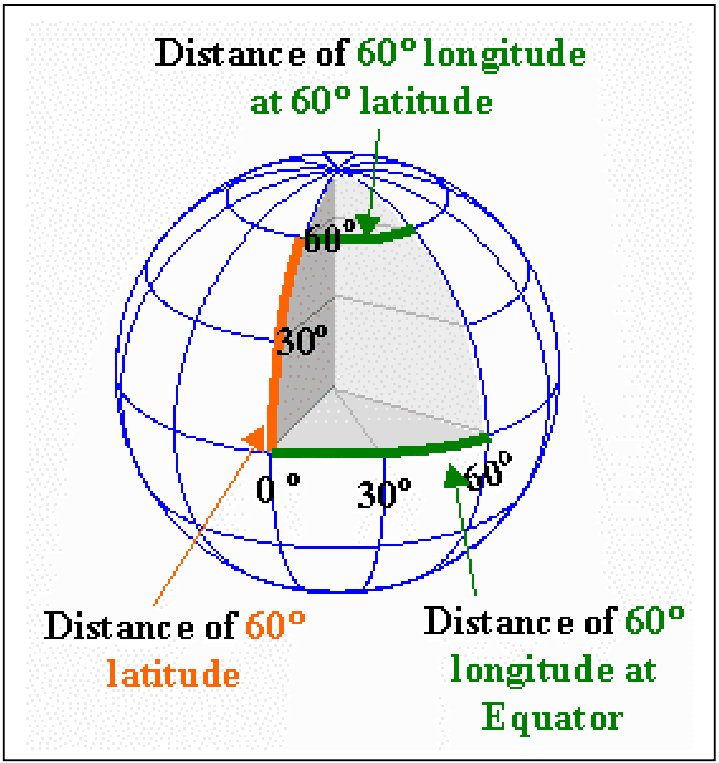
GEOGRAPHIC REFERENCING CONCEPTS

A GIS is to be created from available maps of different thematic layers (soils, land use, temperature, etc). The maps are in two-dimensions whereas the earth's surface is a 3-dimensional ellipsoid. Every map has a projection andscale.

To understand how maps are created by projecting the 3-d earth's surface into a 2-d plane of an analogue map, we need to understand the georeferencing concepts. Georefencing involves 2 stages: specifying the 3-dimensional coordinate system that is used for locating points on the earth's surface that is, the Geographic Coordinate System (GCS) and the Projected Coordinate System that is used for projecting into two dimensions for creating analogue maps.

Geographic Coordinate System

The traditional way of representing locations on the surface of the earth is in the 3-dimensional coordinate system is by its latitude and longitude.



Source: ESRI

Note that the distance between two points on the 3-d earth's surface varies with latitude. The 3-d system therefore does not provide a consistent measure of distances and areas at all latitudes.

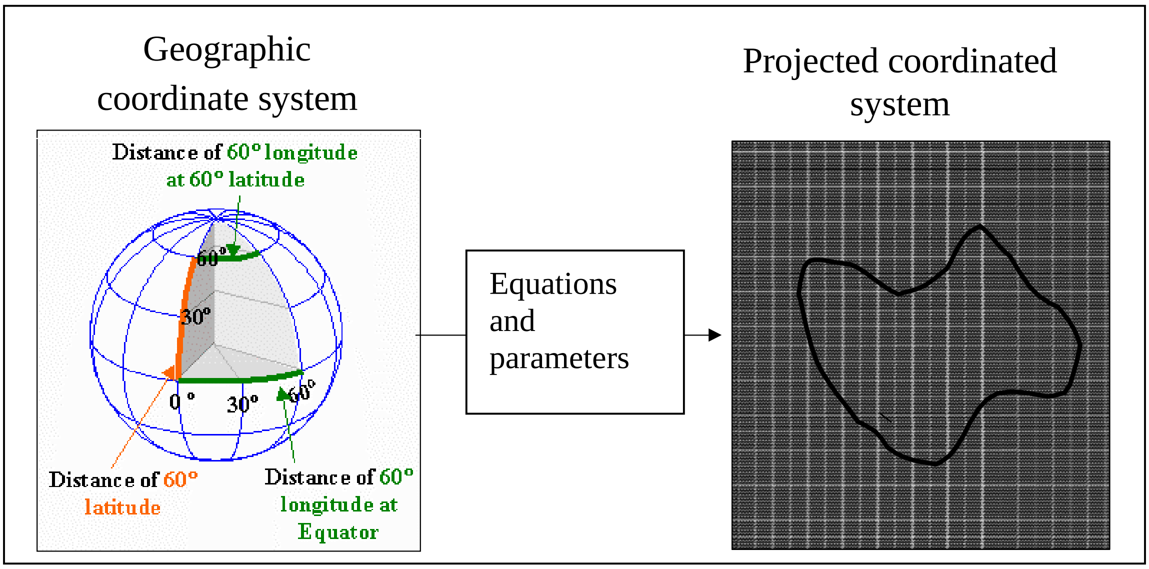
The true surface of the Earth is not the smooth ellipsoid shown in the figure but is quiet uneven and rugged. The GCS which is the surface used for specifying the latitude and longitude of a point on the earth's surface is also an approximation and a 3-d model of the earth. Several standard models of the ellipsoid are available to define the GCS (WGS 84, Everest ellipsoid) etc. The different models vary in their critical parameters (semi major or equatorial axis and semi minor or polar axis of the ellipsoid and the point of origin). The ellipsoid model that is used to calculate latitude and longitude is called the datum. Changing the datum, therefore, changes the values of the latitude and longitude.

Specifying the Geographic Coordinate System therefore requires specifying the Datum. The datum is a fixed 3-d ellipsoid that is approximately the size and shape of the surface of the earth, based on which the geographic coordinates (latitude and longitude) of a point on the Earth's surface are calculated. In fact describing a place by its lat/long is not complete without specifying its datum. In India the Everest Ellipsoid is used as the Datum for the Survey of India maps.

The ideal solution to would be a spheroidal model of the Earth that has both the correct equatorial and polar radii, and is centered at the actual center of the Earth. One would then have a spheroid, that when used as a datum, would accurately map the entire Earth. All lat/longs on all maps would agree. That spheroid, derived from satellite measurements of the Earth, is GRS80, and the WGS84. datum matches this spheroid.

Projected Coordinate System

The development of GIS starts with an available map on paper (an analogue map). This map therefore represents a projection of a 3-d GCS in 2-dimensional form.



Adopted from ESRI

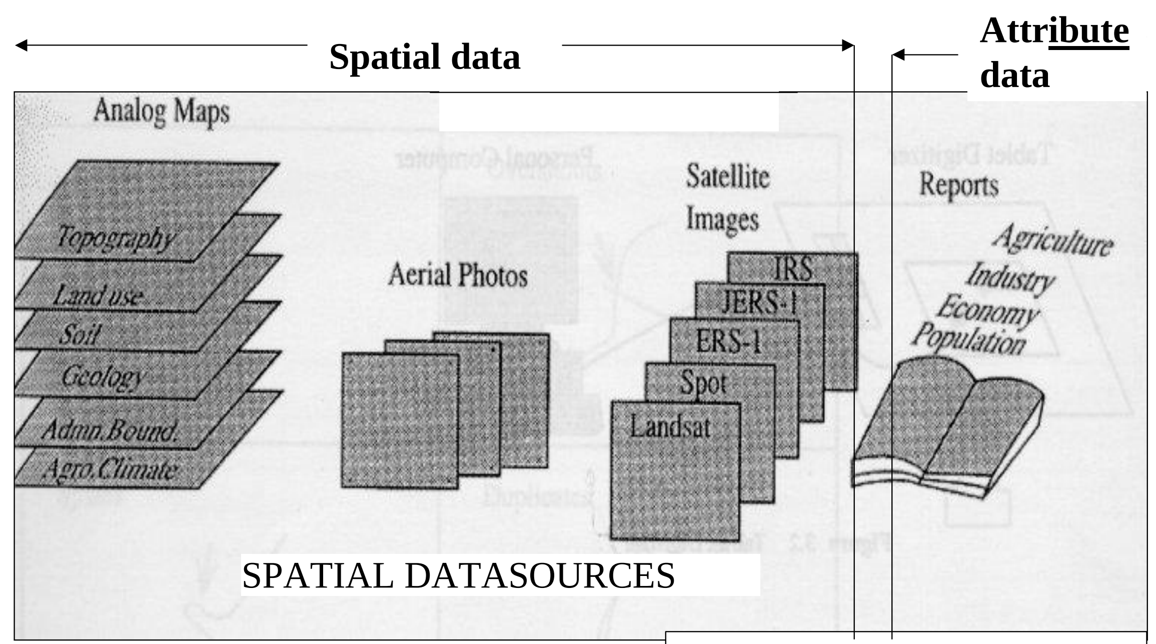
Projection is a mathematical transformation used to project the real 3-dimensional spherical surface of the earth in 2-dimensions on a plane sheet of paper. The projection causes distortions in one or more spatial properties (area, shape, distance, or direction).

GIS DATA INPUT SYSTEMS-- The distinction from other Information Systems is that for a GIS the data inputs are of two types:

(i) Spatial data (latitude/longitude for georeferencing,the features on a map, eg soil units, administrative districts),and

(ii) Attribute data (descriptive data about the features, eg soil properties, population of districts, etc.)

Components of Geographic data



Source: (Murai and Murai, 1999))

Spatial data sources for creating a GIS are analogue maps (soil map, land use map, administrative districts, map, agroecological zone map, etc.) or aerial photographs and satellite imageries. Data input is the process of encoding analogue data in the form of maps, imageries or photographs into computer readable digitized form and writing data into the GIS database.

GIS Data Input

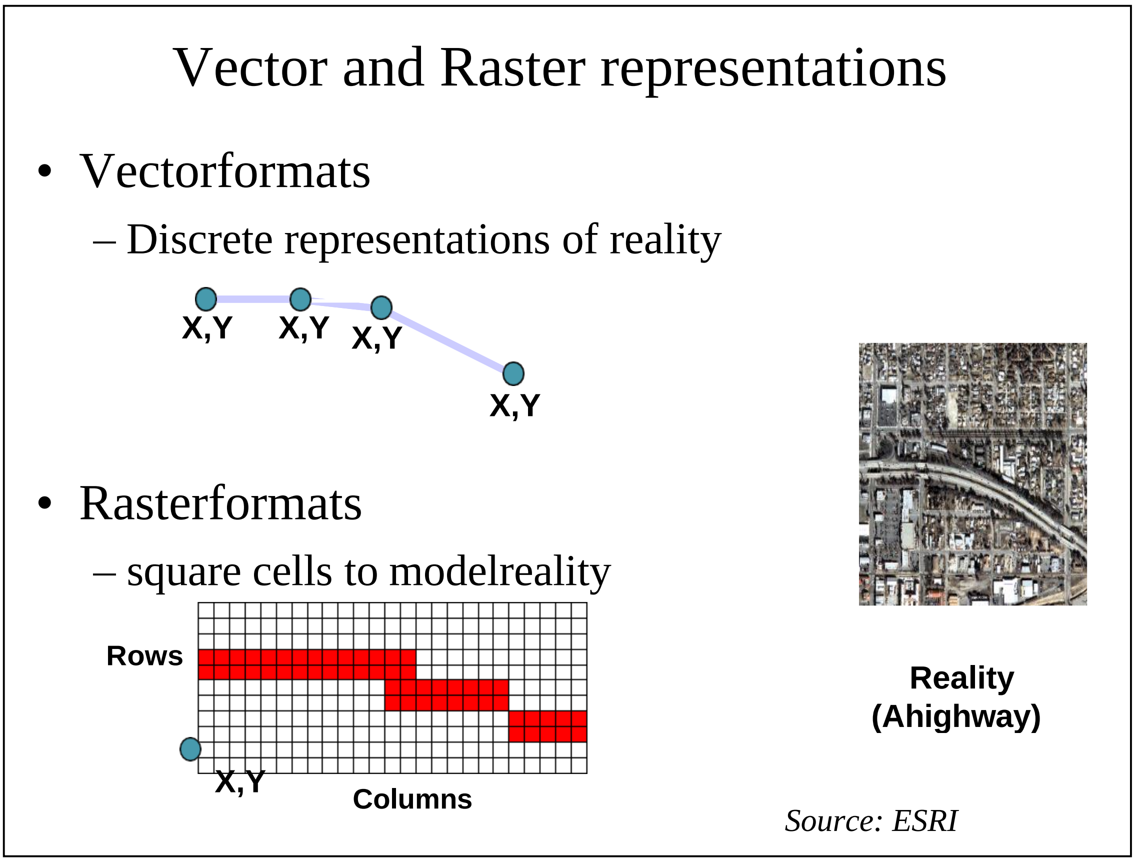
Spatial Data capture (representing locations in a database) can be in two basic formats:

(i) Vector format

(ii) Raster format

I) Vector format----

In the Vector format reality is represented as points lines and areas and in the raster format reality is represented as grid of cells/pixels. The Vector format is based on dicrete objects view of reality (analogue maps) and the raster format is based on continuous fields view of reality (photographs, imageries, etc. In principle, any real world situation can be represented in digital form in both raster and vector formats. The choice is up to the user. Each format has its advantages and disadvantages



Vector data capture

This is generally used for capturing data fro analogue maps. It is based on th observation that any map consists of 3 basic kinds of features –

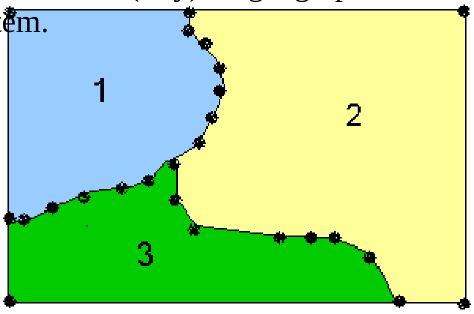
(i) point features,
(ii) line features and
(iii) polygon or area features.

I) Point----- Points do not have length, width or area. They are described completely by their coordinates and are used to represent discrete locational information on the map to identify locations of features such as, cities, towns, well locations, rain gauge stations, soil sampling points, etc.

II) Line------ A line consists of a set of ordered points. It has length, but no width or area. Therefore it is used to represent features such as roads, streams or canals which have too narrow a width to be displayed on the map at its specifiedscale.

III) Polygon----- A polygon or area is formed when a set of ordered lines form closed figure whose boundary is represented by the lines. Polygons are used to represent area features such as land parcels, lakes, districts, agroecological zones, etc. A polygon usually encloses an area that may be considered homogeneous with respect to some attribute. For example, in a soil map, each polygon will represent an area with a homogeneous soiltype.

A vector based system displays graphical data as points, lines or curves, or areas with attributes. Cartesian coordinates (x, y) or geographical coordinates (latitude, longitude) define points in a vector system.



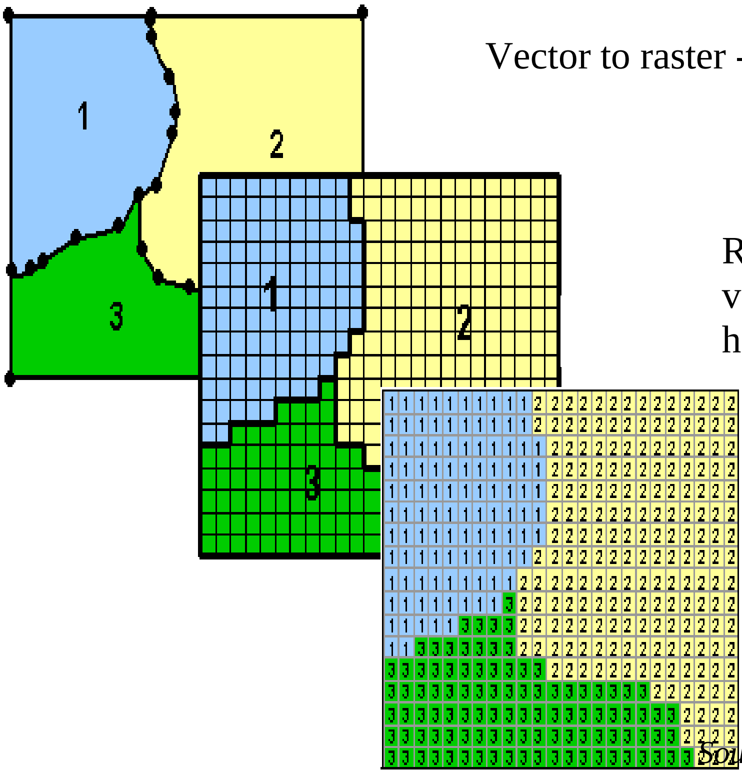
II)Raster data capture

A raster based GIS locates and stores map data by using a matrix of grid cells or pixels. Each cell or pixel is represented either at its corner or centroid by a unique reference coordinate (cell address). Each cell also has discrete attribute data assigned to it.

The raster data resolution is dependent on the pixel or grid cell size. Data can be conveniently captured from remote sensing imageries, areal photographs, and other such imageries of the earth's surface in a raster data format. In this format, the various features are identified by superposing the imageries over a fine rectangular grid of the earth's surface which they represent. Raster data capture does not build topography, that is derive spatial relationships between the identified features. But it facilitates simple scalar operations on the spatial data which a vector format does not permit. Raster data requires to be converted to vector format before topology can be built and spatial operations can be carried out. The raster format also requires more storage space on the computer than the vectorformat.

Most standard GIS software have the facility to transform maps from raster formats and vice versa.

Most GIS software permit Raster-Vector format conversions:



Vector to raster -easy

Raster to vector - hard

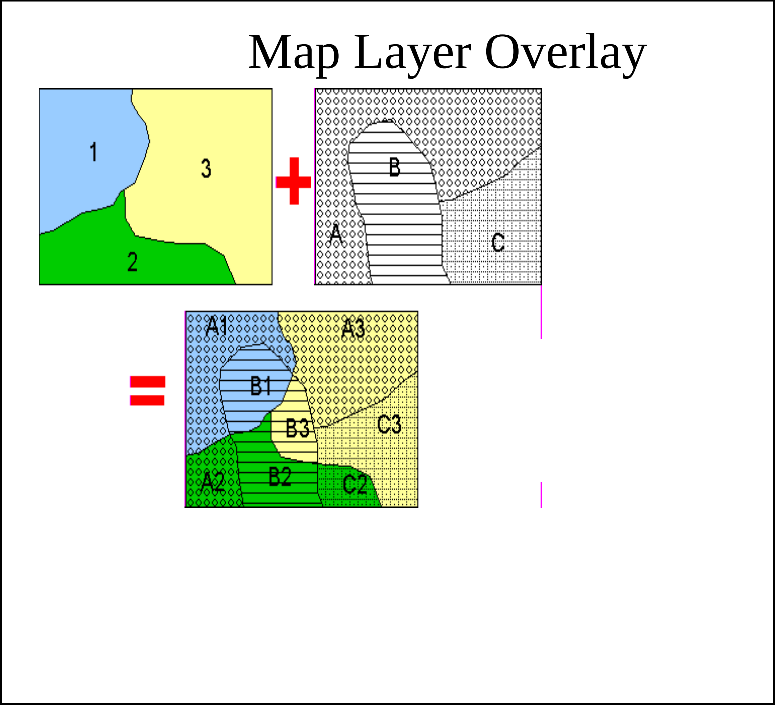
Source: FAO

Attribute data

Attribute data are descriptive data of point, line and area features. For points, this may be the name of the location, its elevation, etc. For lines attribute data could be the name of a road, or canal and other descriptions associated with them. For polygons, the attribute data may relate to name of a district and its population, area, area under specific crops in the district, etc.

Attribute data about points/lines/areas features can be entered into different database files. The files can be linked to the default spatial database generated after digitizing by creating an identification key in each data file which is also common to the spatial database generated by the GIS after digitization.

Maps representing several layers of spatial and thematic or attribute information (soil map, rainfall map, agroecozone map, district map, States map, etc.) can be digitized in this fashion independently.



STEPS IN BUILDING A GIS

The way in which a GIS is built will depend on the way information will be used in the decision-making process. Building a GIS proceeds through at least 4stages:

(i) Defining the objectives
(ii) Building the spatial and attribute data bases
(iii) Database management for geographicanalysis
(iv) Presenting results in the form of maps,etc.

The definition of objectives or the problem to be solved using GIS is critical to the choice of spatial and attribute databases. Once the problem is defined and the relevant map layers and attribute data are identified, building databases involves:

(i) database design
(ii) entering spatial data
(iii) creatingtopology
(iv) entering attribute data

Designing the database requires identifying:

(i) study area boundaries
(ii) coordinatesystem
(iii) data layers
(iv) features in each layer
(v) attributes for each feature type
(vi) coding and organizing attributes

Conclusion--

A GIS is a computer based tool for geographical analysis of information. It is not simply a digitized map, nor does it hold maps. It holds a database of spatial data and attribute or descriptive information about features on a map which can be used to create desired maps. *The crucial concept of GIS is the separation of spatial or geographic reference information and attribute or descriptive information of map features for data entry and database development, and their linkage during analysis*. Central to both spatial and attribute information is the database management concept. The separation of the two types of information facilitates entering the spatial information (map) into computers in a digitized form and establishing connectivity (topology) between different stored map features (points, lines and polygons). The feature attribute data is entered independently taking care to introduce an identification variable which is in common with the identification variable for each feature that is common with the spatial database. For geographic analysis, the spatial and attribute data are linked through this unique identifier variable common to the two types of data bases.

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