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1. Introduction

Cartography is the art and science of map making. It is a field of science, which is related to the creation, and study of maps. It has long tradition going back at least 4 thousand years back tied to geography to most of its history. Since, cartography is related to map making, we first need to understand what is map?

The map may be defined as the representation of the earth's pattern as a whole or part of it or havens on a plane surface with conventional signs drawn to a scale and projection so that each and every point on it corresponds to the actual terrestrial or celestial position.

2. A Brief History of Cartography

The credit for laying the foundation of cartography goes to the ancient Greek scholars whose achievements in this field were not excelled until the 16th century. The recognition of the earth as a spheroid with its poles, equator, tropics, the division of earth into climatic zones, the development of the system of graticules, formulation of the first projection and the calculation of the circumference of the earth are all achievements of the Greek scholars like Aristotle, Eratosthenes and Ptolemy. The Greek cartography culminated in the work of Ptolemy. His pioneering work 'Geographia' contained a world map and 26 other detailed maps. Ptolemy's maps, however, crude and rough should be appreciated considering the limitations of travelling in those days.

Unlike Greeks, the Romans did little in the development of the art of cartography. They adopted old maps of the early mapmakers, which suited for military and administrative purposes. The Arab scholars followed the Greek tradition, made some improvement in the Greek maps, and showed at least the Islamic World correctly.

The recovery of the Ptolemy's 'Geographia', the age of discoveries, and invention of printing play a vital role in the rediscovery of cartography. Map publishing becomes a very lucrative business in the 16th century. Mercator, who liberated cartography from the influence of Ptolemy, draws a map projection in 1569, which reformed the world map to a considerable extent.

With the perfection of triangulation survey and measurement of longitude by chronometer, the reformation in cartography was introduced by the French in the beginning of the 18th century. In the latter half of the 18th century when England became the foremost maritime power in the Europe, a cartographic center was developed in London. It was during this period that military operations necessitated the preparation of detailed and accurate topographical maps. In the following two centuries, great advancements were made in the art of map making. The development of lithography, wax engraving and photo engraving in combination with color printing gave much stimulus to map drawing. Rich and colorful symbols were used in place of black and white technique of the older maps. New types of National Atlases, giving all the available information about the nation were produced in France, USA and Russia. The French Colonial Atlas and the American Atlas of Agriculture own their origin to the perfection of new techniques.

We all know that hills, valleys, mountain ranges and deep-sea trenches in the oceans make a complete earth. The earth's topographical features range from about 9 km above the earth surface to about 12 km below the sea level. The representation of three-dimensional earth on a two dimensional plane paper is a difficult task.

If we want to represent the whole earth or any part of it through digital cartography or through GIS software, we need to represent it with respect to its true shape, size, are and position. For that the concept of geodetic datum, coordinate system and map projection and map scale and selection of conventional signs need to be understood.

3. Geodetic Datum

Datum is any set of numeric or geometric constants from which other quantities such as coordinate system can be defined. A geodetic datum is any numerical or geometrical quantity or set of such quantities that serves as a reference or base for other quantities. Geodetic datum defines the size and shape of the earth and the origin of the coordinate systems used to map the earth.

In cartography, we use the many geodetic datum. Referencing geodetic coordinates to the wrong datum can result in position errors of hundreds of meters. Different nations use different datum as the basis for coordinate systems. These datum used to identify positions in GIS, navigation systems and computer cartography.

World Geodetic System 1984: The Department of Defiance of USA has developed a number of geocentric reference systems to which other geodetic network may be referred. The continued availability of increasingly precise satellite information has resulted in the development of various geodetic datum systems as in 1960, 1966, 1972 and the current WGS 1984.

The World Geodetic System 1984 (WGS 1984) is a conventional terrestrial system. It was designed as a geocentric geodetic datum for mapping and navigation and accurate GPS positioning. The local datum could be mathematically connected to WGS 1984. Coordinates derived by the Global Navigation Satellite System (GNSS) will be earth centered because GNSS satellite operates with an earth centered reference model (WGS 1984). GNSS coordinates cannot be compared with coordinates based on local geodetic datum except in those areas where coordinates have been readjusted to earth-centered datum. While mapping the earth or a part of it the difference between the coordinates of a point referenced to a local geodetic datum and the coordinates of the same point referenced to the earth centered WGS 1984 datum has to be taken into account.

4. Coordinates System

In order to describe position on a spherical earth we use latitude, longitude coordinate system. The latitude of a point on earth's surface is the angle between the equatorial plane and the straight line that passes through that point and through the center of the earth. Lines joining points of the same latitude are called parallels, as they are parallel to the equator and to each other. The North Pole is + 90° N latitude and the South Pole is - 90° S latitude. The 0° parallel of latitude is designated as the equator. The equator divides the globe into northern and southern hemisphere.

Geographical Coordinates

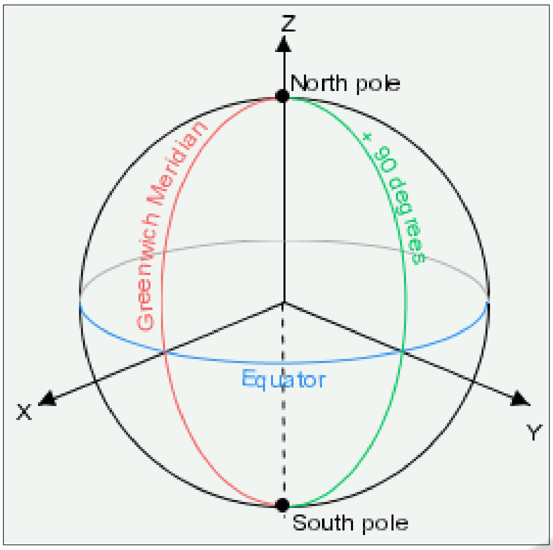

Fig. 1

Longitudes are the lines measured east and west of the prime meridian. The meridian of the British Royal Observatory in Greenwich, southeast London is the international prime meridian. The value of longitude ranges from -180° to +180° when we travel from west to east. The combination of these two components specifies the position of any location on the surface of Earth, without consideration of altitude or depth. The grid formed by lines of latitude and longitude is known as a graticule.

In cartography when we try to convert three-dimensional (3 D) earth on a plane paper, we use Projected Coordinates System (PCS). It has constant area, length and angles across the plane paper unlike a geographical coordinate system. The projected coordinate system consists of map projection and set of parameters that modify the projection for a specific location.

5. Map Projection

Map projection is a systematic drawing of parallels of latitude and meridians of longitude on a plane surface for the whole earth or a part of it on a certain scale so that any point on the earth surface may correspond to that on the map. In other words, we can say map projection is the preparation of the graticule on a flat surface. We all know that the globe is the true representation of the earth. However, the need of map projection arises from the fact:

a) The globe is useless for the reference of a small country.

b) It is not possible to make a globe on a very large scale.

c) It is very difficult to carry globe for the field references.

It is therefore, not only desirable but also necessary to construct the maps on a plane surface. Map projections vary according to the size and location of different areas on the earth surface. Hundreds of map projections are used in cartography but we will discuss few of them in brief. In this module, we will also discuss those projections in detail, which are useful for modern digital cartography.

Broadly speaking based on developable surface major projections can be classified as:

5.1. Zenithal Projections

Zenithal projections are obtained by throwing the shadow of lines of latitudes and longitudes on a plane surface. The position of light is very important the distances between various lines of latitudes and longitudes will be determined by the relative positions of the point to be projected and the source of light.

Cylindrical, Conical and Zenithal Projections (Respectively)

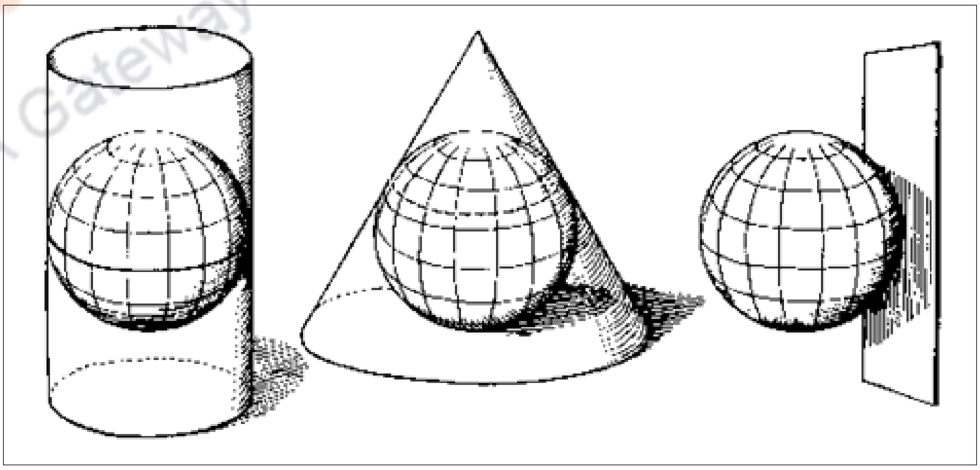

Fig. 2

It is called **Gnomonic** when the source of the light is at the centre. It is called **Stereographic** when the light is at any point on the surface of the globe, diametrically opposite the point of contact of the tangent plane. This projection is called **Orthographic** when the light is at infinity so that the rays of the light are parallel.

The plane can be tangent to a globe at several positions. When the plane surface is tangent at the poles, it is called Polar Zenithal. When the plane surface is tangent at equator, it is called Equatorial Zenithal. When the plane surface is tangent at any other point on the globe, it is called Oblique Zenithal.

This projection is good for polar area also for those areas, which are having small latitudinal and longitudinal dimensions

5.2. Conical Projection

To obtain a conical projection it is supposed that a cone is placed over a globe. This cone will touch it along a circle. Where the cone touches the circle known as standard parallel because that is, the only parallel which is true to scale. This projection is known as the **Conical Projection with One Standard Parallel**. In this projection, the area is correct in a narrow strip along both the sides of the standard parallel.

If two standard parallels are selected an area with a large north south extant can be more correctly represented. In this sense, the Conical Projection with Two Standard Parallel is an improvement upon the simple conical projection. This projection is good for the representation of the mid latitudes.

Gnomonic, Stereographic and Orthographic Projections (Respectively)

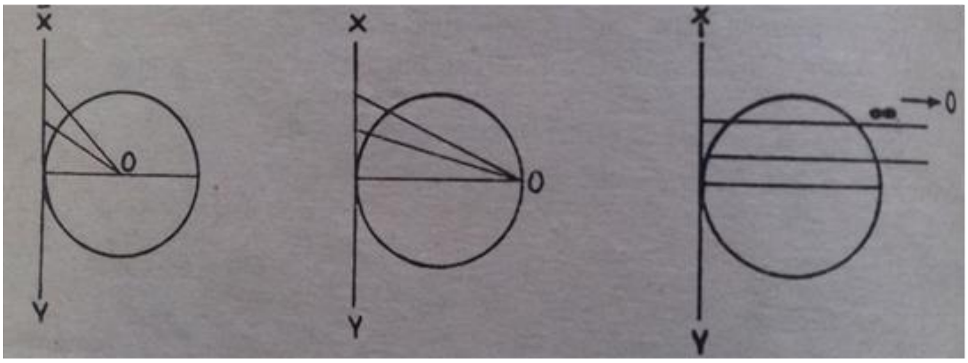

Fig. 3

5.3. Cylindrical Projections

Here we suppose that the globe has been enclosed by a cylinder and the light is placed at the cylinder. As the cylinder enclosed the globe round the equator, the scale is correct along the equator. Other parallels are also projected on the surface of the cylinder and are equal in length to that of equator. Hence, there is increasing exaggeration away from the equator.

The famous Mercator's projection, which he developed in 1512, was based on the concept of cylinder and therefore the area away from the equator exaggerated. The popularity of this projection was due to the fact that it was orthomorphic (true shape) and was true to the direction. This projection was used for navigational purposes.

5.4. Universal Transverse Mercator's Projection (UTM)

This is the projection, which we use in GIS, GPS and modern digital computer cartography. This is the modified version of the equatorial Mercator's projection.

World Map drawn on Mercator's Projection

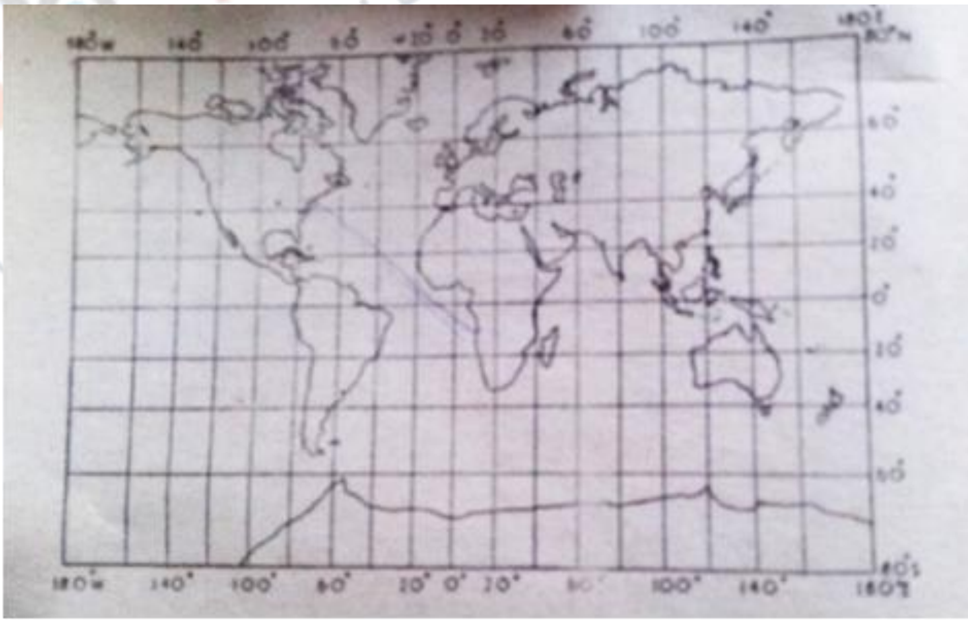

Fig. 4

Lambert, J.H. (1722) modified the Mercator's projection by changing the aspect of the projection to transverse with a view to minimize the distortion in a narrow strip running from pole to pole. This is known as Transverse Mercator's Projection.

Transverse Mercator Projection

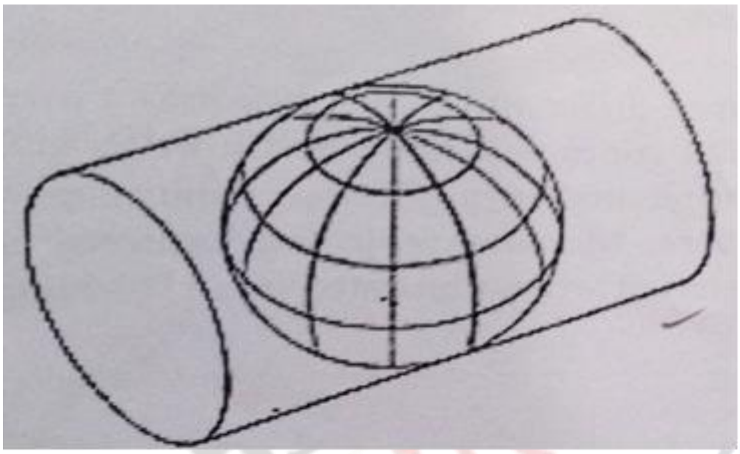

Fig. 5

In order to minimize the distortion that occurs in transverse Mercator's projection further modifications were made. This modified transverse projection is known as Universal Transverse Mercator's Projection.

Process to get Universal Transverse Mercator Projection

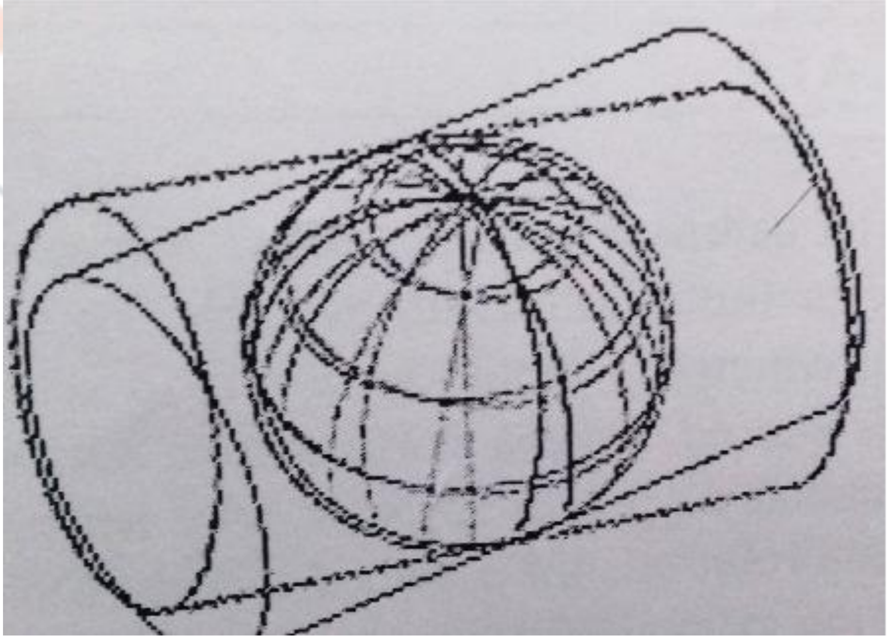

Fig. 6

The modified projection loses the properties of straight meridians and parallels of the standard Mercator projection. In this projection, the scale is true along the central meridian or along two straight lines equidistant from the parallel to the central meridian. It is repeatedly applied by using multiple cylinders that touch the globe at 6° interval. The cylinder is made to intersect the globe at two standard meridians that are 180 km east and west of the central meridian.

UTM Zones with Central and Bounding Meridians (Table 1)

Zone No	Central Meridian	Bounding Meridians	Zone No	Central Meridian	Bounding Meridians	Zone No	Central Meridian	Bounding Meridians
1	177°w	180-174°w	21	57°w	60-54°w	41	63°e	60-66°e
2	171°w	174-168°w	22	51°w	54-48°w	42	69°e	66-72°e
3	165°w	168-162°w	23	45°w	48-42°w	43	75°e	72-78°e
4	159°w	162-156°w	24	39°w	42-36°w	44	81°e	78-84°e
5	153°w	156-150°w	25	33°w	36-30°w	45	87°e	84-90°e
6	147°w	150-144°w	26	27°w	30-24°w	46	93°e	90-96°e
7	141°w	144-138°w	27	21°w	24-18°w	47	99°e	96-102°e
8	135°w	138-132°w	28	15°w	18-12°w	48	105°e	102-108°e
9	129°w	132-126°w	29	09°w	12-06°w	49	111°e	108-114°e
10	123°w	126-120°w	30	03°w	06-00°w	50	117°e	114-120°e
11	117°w	120-114°w	31	03°e	00-06°e	51	123°e	120-126°e
12	111°w	114-108°w	32	09°e	06-12°e	52	129°e	126-32°e
13	105°w	108-102°w	33	15°e	12-18°e	53	135°e	132-38°e
14	99°w	102-96°w	34	21°e	18-24°e	54	141°e	138-144°e
15	93°w	96-90°w	35	27°e	24-30°e	55	147°e	144-150°e
16	87°w	90--84°w	36	33°e	30-36°e	56	153°e	150-156°e
17	81°w	84-78°w	37	39°e	36-42°e	57	159°e	156-162°e
18	75°w	78-72°w	38	45°e	42-48°e	58	165°e	162-168°e
19	69°w	72-66°w	39	51°e	48-54°e	59	171°e	168-174°e
20	63°w	66-60°w	40	57°e	54-60°e	60	177°e	174-180°e

The UTM defines two-dimensional horizontal positions consisting of 60 zones of 6° of longitudes in width and 8° of latitudes in length. Each zone extending 3° east and 3° west of a central meridian, extending between 80° south to 84° north latitude. An additional half degree on each side is provided for overlap into the adjacent zone. The first zone starts at 180° w to 174° w with 177° was central meridian. The final 60th zone extends in between 174°e to 180e longitude.

Shape and Size of UTM Zones

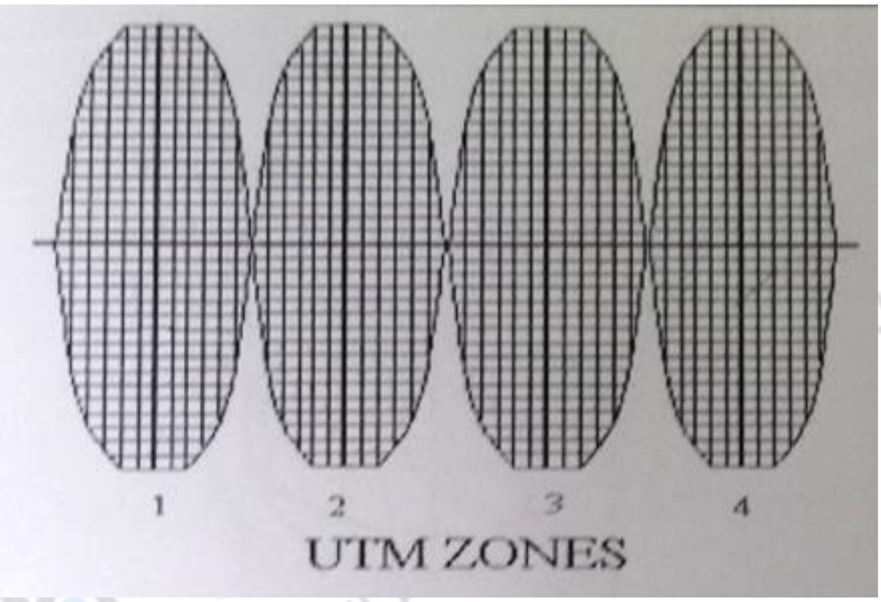

Fig. 7

The central meridian is a great circle and is the only line represented by a straight line in the map projection. Each UTM zone divided into vertical bands of 8 latitudes. These bands are identified by letters, south to north; starting with 80° south with letter C and ending with letter X. Letter I and O are omitted whereas letter A, B, Y, Z are reserved for Universal Polar Stereographic Coordinate System. Each UTM zone is in fact a different projection using a different coordinate system.

Map Scale: We all know that map is the representation of earth in parts or as a whole. To be called a map it should be on scale so that each and every point on map corresponds on the ground. Scale is the relationship between a certain distance on map and the same distance on the ground. If I say that, the Representative Fraction (RF) is 1:100,000 it means 1 centimeter on map is equal to 100,000 centimeter (1 kilometer) on ground.

Scale Factor: Scale factor is the ratio of any two corresponding lengths in two similar geometric figures i.e. one is the map of the part of the earth on the paper and another same part of the earth. If RF is 1:2000 then the scale factor will be 0.0005.

Conventional Signs: Conventional signs should be selected in such a way that they provide maximum information in minimum space. Color scheme should fallow the geometry of the map. For instance evergreen forest should be presented by the dark green and the tone of the green should be lighter for coniferous and again for deciduous forests. If we want to show the height the tone of the color, say red should increase with increasing height. The darkest red should be used for the area having maximum height.

6. Geographical Information System (GIS)

Geographical information system is software designed to capture, store, manipulate, analyze and present the spatial data. In general, the term describes any information system that integrates stores, edit, analyzes, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries, analyze spatial information, edit data in maps, and present the results of all these operations. GIS is a customized and reliable tool that can answer the complex questions and can support in decision-making. It is a problem-solving tool and can provide instantaneous answer to the complex questions.

GIS uses computer technology to integrate, manipulate and display a wide range of information to create the picture of an area's geography, environment and socio-economic characteristics. It is a customized and reliable tool that can be problem-solving, support in decision-making and can provide almost instantaneous answers to complex questions.

GIS store data on the basis of geographical features and their characteristics. The features are typically classified as points, lines, or areas or as raster images. On a city map, data about discreet objects like location of hospital or police station could be stored as points, road data could be stored as lines, and boundaries could be stored as areas, while aerial photos or scanned maps could be stored as raster images.

GIS Layers along with Vector and Raster Data Layers

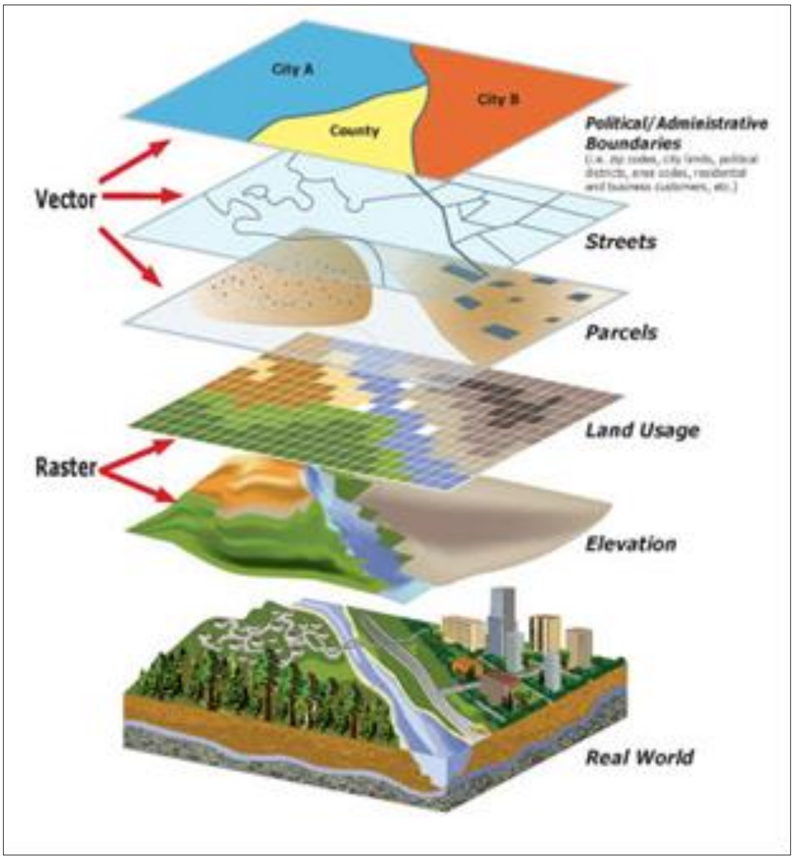

Fig. 8

Vector data is a physical quantity that requires both magnitude and direction for its description. The vector data module is an object based approach to the representation of the real world features and is best use to represent discrete objects

The GIS data can be classified as spatial data which has physical dimension and geographical location on the earth and available in the form of maps and attribute data called as non-spatial data. Spatial data are where the things are and attribute data are what the things are. Attributes are descriptive information about specified spatial objectives.

6.1. GIS Layers

The basic organization principle of GIS is the data layers. Rather than storing all the spatial information at one place, as on a topographic map, group of similar features are combined in one of a number of data layers. In addition, GIS allows creating new data layers based on existing ones. For instance, a new data layer could show watersheds derived from digital elevation data.

6.2. Mapping through GIS

GIS can be used as tool in both problem solving and decision making processes, as well as for visualization of data in a spatial environment. Geospatial data can be analyzed to determine various features. Few of them discussed below:

- **The location of features and relationships to other features**: We can map the spatial location of real-world features and visualize the spatial relationships among them. Below we see a map of agricultural districts (in green) layered over soil types. We can see visual patterns in the data by determining what soil types are best suited for agricultural districts.

Mapping of Soil Type and Agriculture

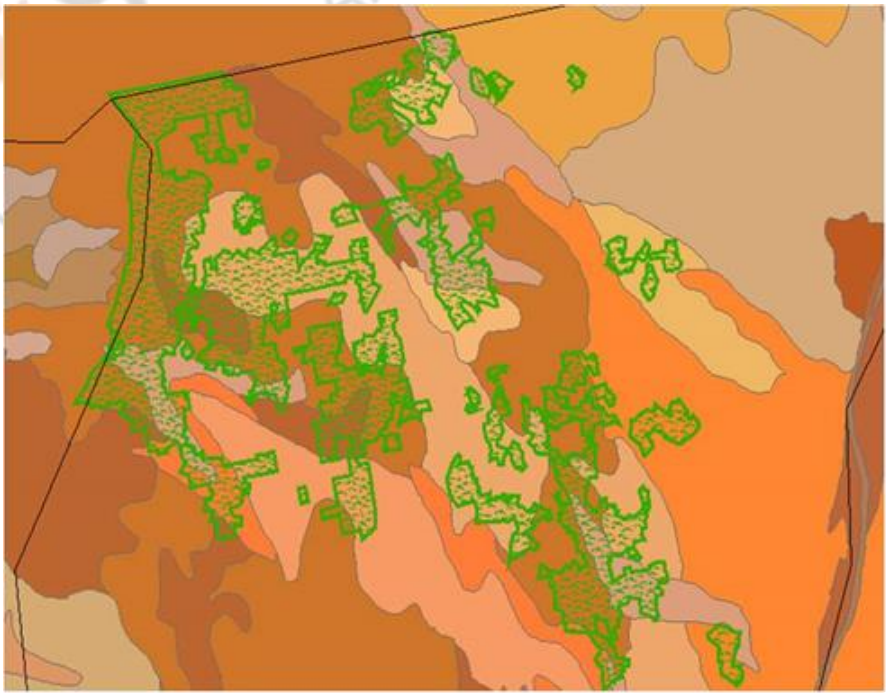

Fig. 9

- **Mapping quantities:** People map quantities, such as where the most and least are, to find places that meet their criteria or to see the relationships between places. Below is a map of cemetery locations in Wisconsin. The map shows the cemetery locations as dots (dot density) and each region is color coded to show where the most and least are (lighter blue means fewer cemeteries).

Distribution of Cemeteries

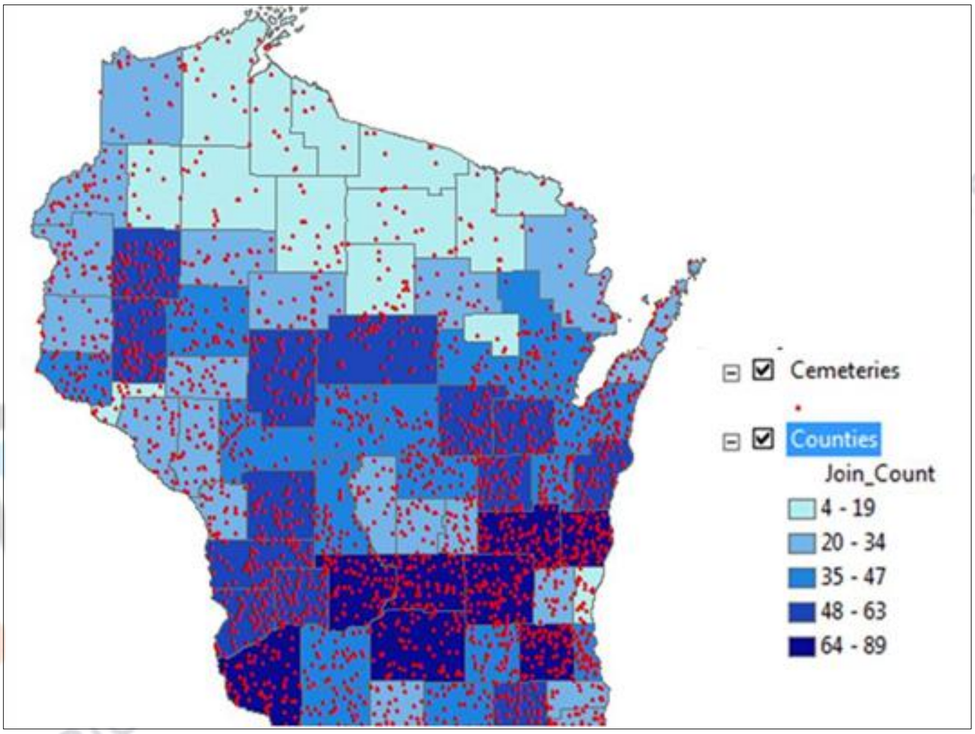

Fig. 10

- **Mapping change:** We can map the change in a specific geographic area to anticipate future conditions, decide on a course of action, or to evaluate the results of an action or policy. In the image given below, we see land use maps showing changes in residential development from 1951 to 1999. The dark green shows forest, while bright yellow shows residential development. Applications like this can help inform community planning processes and policies.

Temporal Analysis of Land Use Change

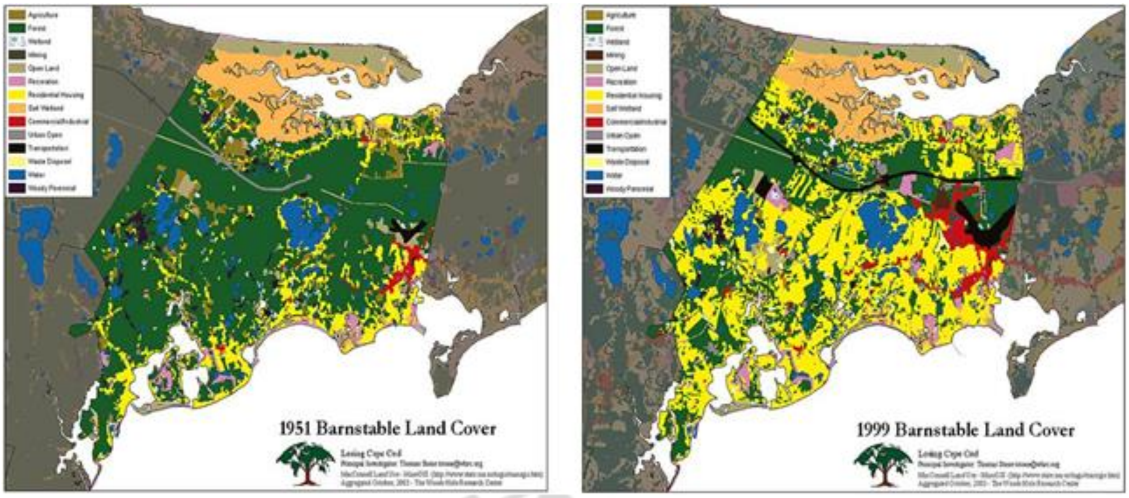

Fig. 11

- **Buffer and Proximity Analysis**: is used to constrain space around individual land features. It generally used for defining all the spaces within a certain distance of a type of feature or sub set of features that are selected according to an attribute valve. Buffer distances must be set by the user.

Buffer around Point, Line and Polygon

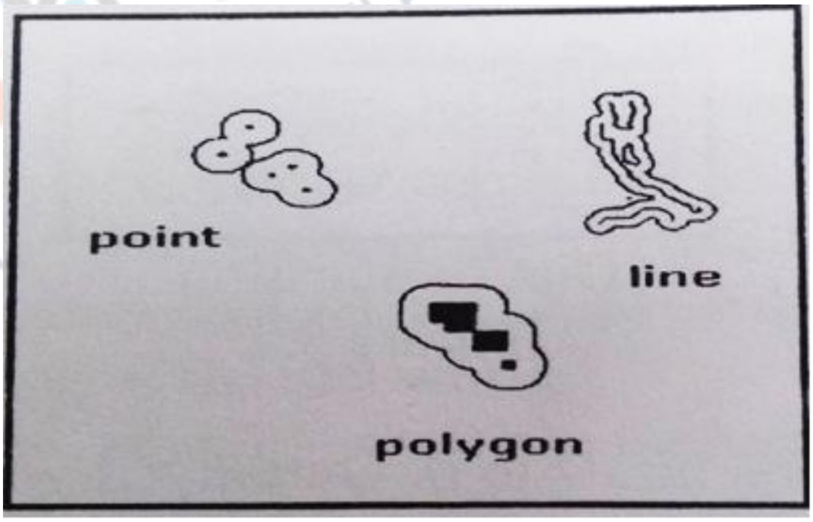

Fig. 12

Buffer acquires the shape from the features around which it has drawn. Sometimes it happens that buffer is drawn inside the polygon boundary. If we are interested in finding the hospital within 500 meters of a road, we need to draw a polygon around the road and see which hospital fall within this zone. Then generate a query to find out the name of the hospital. Another way is find out the distance of each hospital from the referenced feature i.e. the road and see, which is less than 500 meter from it. The first option is termed as buffer analysis while the second one is known as the proximity analysis.

- **Overlay Analysis:** Overlay analysis integrate spatial data with attribute data by combining information from one GIS layer with another GIS layer. Results of the overlay analysis lay on the spatial accuracy of the GIS layers. Overlay analysis is useful in accuracy assessment, change detection, multivariate classification etc.

6.3. Mapping through Digital Cartography

The introduction of the airplane photography in the beginning of the 20th century introduced a new phase in the topographical surveying. This method is quicker, cheaper and especially useful for mapping comparatively unknown and unexplored regions. USA in 1972 and 1974 collected various images through satellite LANDSTAT -1. These images have been processed by computerized cartographic tools to produce the world map into 7 parts (W.P.S. 1-7). To make these maps easily understandable meaningful systems of shading and color scheme have been employed. Consequently full analysis of topographical and landform maps has been done in a scientific way.

The cartography is now getting advanced and modernized throughout the world. New technologies are being introduced that have made map-making more accurate, precise and authentic. Geographical distances between places, depth of oceans, elevation of hills, forest reserves, mineral resource, soil quality, vegetation cover and lot more things can be done with much more accuracy and lesser time through digital cartography.

Modern cartography involves the knowledge of the subject like astronomy, surveying, mathematics, drawing etc. Maps may vary from one another depending upon the purpose and the requirements. Maps depicting vegetation cover and animal population will differ from those depicting climate, cultural regions, languages etc. Similarly, political maps are different from the physical maps in terms of drawing and layout.

The advantages offered by computer cartography are numerous and find useful application in a number of areas like mining, earthquake zone detection, cultivation, irrigation, road constriction, town planning and under water explorations. Through digital cartography software, we develop maps and images. The cartographic software keeps into account various mathematical formula, principles of applied and physical sciences, geographical features like elevations and time zones. The specialized software also makes use of fundamentals of astronomy and relevant role of measurement for determining and displaying the shape, size and other topographical features. Software firms like Microsoft and Sun have developed digital cartographic software like MapArt, Map point etc. for digital map making. Digital cartography can be easily understood with few examples given below.

6.4. The Global Digital Divide

The map given below is prepared with the help of computer cartography. This map is showing the availability of computers per 100 people in different countries of the world. The darkest color shows the highest computer density. As we approach towards the lighter color the ratio between availability of computer and people is start decreasing.

Availability of Computers per 100 People

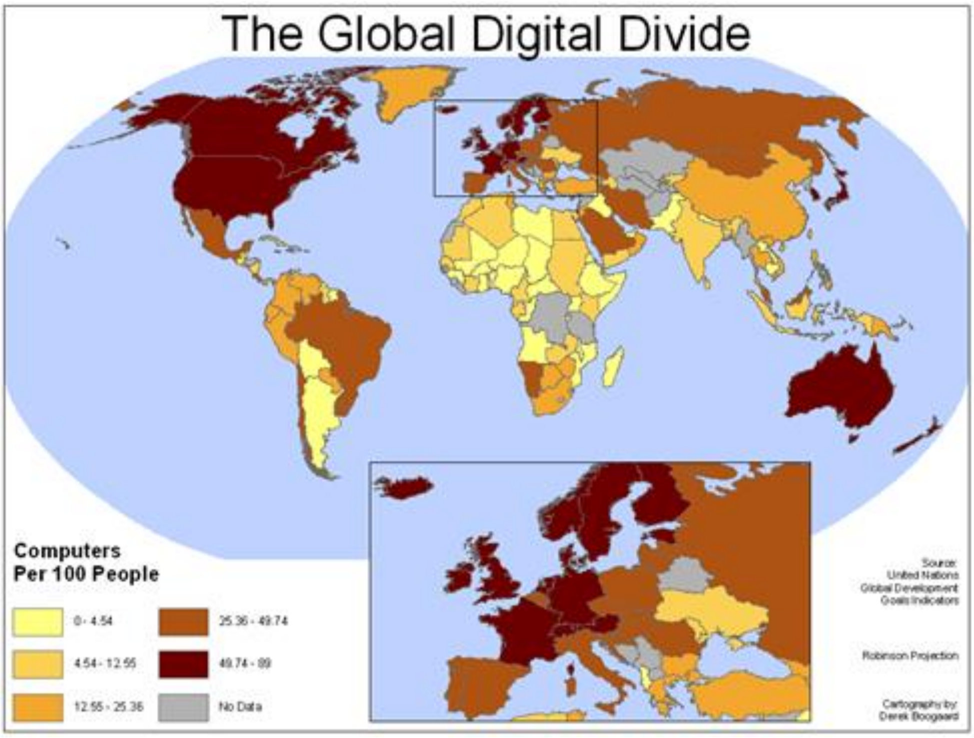

Fig. 13

- **Seismic Zoning:** The map given below shows the seismic zoning of Kyrgyzstan. The zones where the earthquake's magnitude was less than 5 on Reactor scale are shown with green color but the zones where it is more than 9 on Reactor scale are marked by red. Rests of the zones lies in between these two extremes. The distribution of cities having a population more than 10000 also shown with the help of blue dots. The relationship between the earthquake zones and cities can be easily identified through this map.

Location of Urban areas along with Seismic Zones

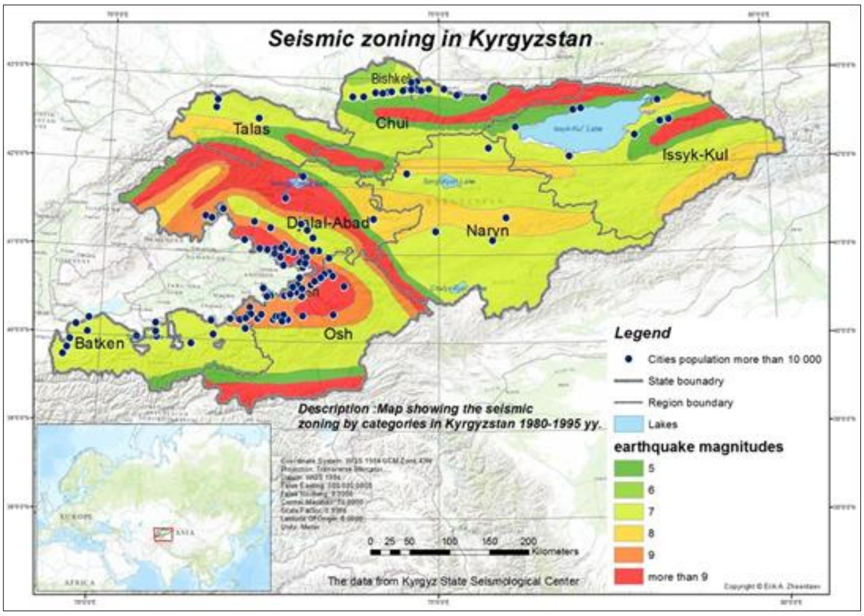

Fig. 14

- **Population Density:** It can be easily identified with the help of the map given below which states of India are more densely populated. This map is also prepared with the help of computer-aided cartography.

Distribution of Population

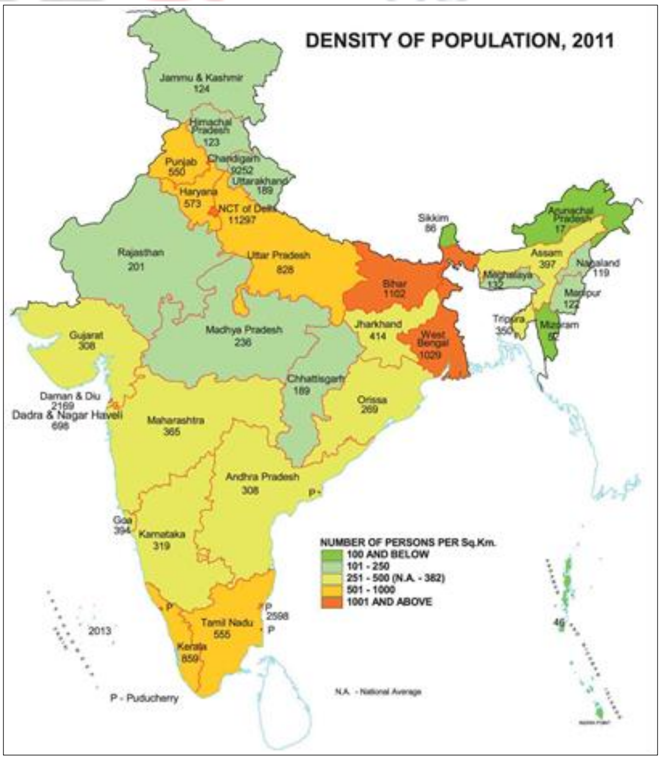

Fig. 15

7. Summary

Cartography is the art and science of map making. The credit for laying the foundation of cartography goes to the ancient Greek scholars. The Greek cartography culminated in the work of Ptolemy. His pioneering work 'Geographia' contained a world map and 26 other detailed maps. The recovery of the Ptolemy's 'Geographia', the age of discoveries, and invention of printing play a vital role in the rediscovery of cartography. Map publishing becomes a very lucrative business in the 16th century. Mercator, who liberated cartography from the influence of Ptolemy, draws a map projection in 1569, which reformed the world map to a considerable extent.

If we want to represent the whole earth or any part of it through digital cartography or through GIS software, we need to represent it with respect to its true shape, size, are and position. For that the concept of geodetic datum, coordinate system and map projection and map scale and selection of conventional signs need to be understood. A geodetic datum is any numerical or geometrical quantity or set of such quantities that serves as a reference or base for other quantities. Geodetic datum defines the size and shape of the earth and the origin of the coordinate systems used to map the earth.

In order to describe position on a spherical earth we use latitude, longitude coordinate system. The latitude of a point on earth's surface is the angle between the equatorial plane and the straight line that passes through that point and through the center of the earth. The grid to latitude and longitude is known as the geographic coordinates.

Several map projections including Zenithal, Conical and Cylindrical have been discussed. With the help of Mercator's projection, which was based on cylindrical projection, we developed Transverse Mercator and Universal Transverse Mercator Projection by dividing the globe into 60 zones. It is clear through the discussion single projection cannot produce a world map true to all dimensions. By dividing the world into 60 zones, we are able to minimize the error.

Few examples of the application of computer cartography and GIS have been presented and it became clear that digital cartography and GIS are complementary to each other. Computer cartography is simple medium to represent the information through maps while GIS is a diversified tool to integrate process and analyze the special data. The complex problems like 3 D mapping can be done with the help of GIS. Cartography may need to diversify but GIS will arguably complement and not replace it.

Frequently Asked Questions-

Q1. What do you mean by computer cartography? Explain the advantages it offers?

Ans: Computer cartography is the use of computer hardware and software like Map Art and map point to map the earth or a part of it. Thousands of phenomenon like distribution, density, earthquake zone etc. can be mapped through this technique. The advantages offered by computer cartography are numerous and find useful application in a number of areas like mining, earthquake zone detection, cultivation, irrigation, road constriction, town planning and under water explorations. Through digital cartography software, we develop maps and images. The cartographic software keeps into account various mathematical formula, principles of applied and physical sciences, geographical features like elevations and time zones.

Q2. What do you mean by Geographic Information System?

Ans: Geographical information system is software designed to capture, store, manipulate, analyze and present the spatial data. In general, the term describes any information system that integrates stores, edit, analyzes, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries, analyze spatial information, edit data in maps, and present the results of all these operations. GIS is a customized and reliable tool that can answer the complex questions and can support in decision-making. It is a problem-solving tool and can provide instantaneous answer to the complex questions.

Q3. What do you mean by Geodetic datum? Elaborate World Geodetic Datum 1984 (WGS 1984)?

Ans: A geodetic datum is any numerical or geometrical quantity or set of such quantities that serves as a reference or base for other quantities. Geodetic datum defines the size and shape of the earth and the origin of the coordinate systems used to map the earth. The World Geodetic System 1984 (WGS 1984) is a conventional terrestrial system. It was designed as a geocentric geodetic datum for mapping and navigation and accurate GPS positioning.

Q4. Explain the Universal Transverse Mercator's Projection?

Ans: Map projection is a systematic drawing of parallels of latitude and meridians of longitude on a plane surface for the whole earth or a part of it on a certain scale so that any point on the earth surface may correspond to that on the map. The UTM defines two-dimensional horizontal positions consisting of 60 zones of 6° of longitudes in width and 8° of latitudes in length. Each zone extending 3° east and 3° west of a central meridian, extending between 80° south to 84° north latitude. An additional half degree on each side is provided for overlap into the adjacent zone. The first zone starts at 180° w to 174° w with 177° was central meridian. The final 60th zone extends in between 174°e to 180e longitude.

Q5. How can we measure the temporal changes through GIS mapping?

Ans: We can map the change in a specific geographic area to anticipate future conditions, decide on a course of action, or to evaluate the results of an action or policy. In the image given below, we see land use maps showing changes in residential development from 1951 to 1999. The dark green shows forest, while bright yellow shows residential development. Applications like this can help inform community planning processes and policies.

Multiple Choice Questions-

1. Name the scholar who wrote the famous book 'Geographia' in which he draw a world map based on latitudes and longitudes

a) Aristotle
b) Eratosthenes
c) Ptolemy
d) Homer

2. Mercator's map was based on

a) Conical Projection
b) Cylindrical Projection
c) Zenithal or Azimuthal Projection
d) Neither of the above

3. Universal Transverse Mercator Projection divide the world into

a) 60 zones
b) 58 zones
c) 45 zones
d) 75 zones

4. If the bounding meridian of a zone are 150 to 144°w longitudes. What will be the central meridian

a) 147°W
b) 147°E
c) 145°W
d) 145°E

5. Name the computer cartographic software

a) ArcGIS
b) ILWIS
c) GeoMedia
d) MapArt

Suggested Readings:

1. Wells, D .E., N. Beck, D. Delikaraoglou, A. Kleusberg, EJ. Krakiwsky, G. Lachapelle, R.B. Langley, M. Nakiboglu, K.P. Schwarz, J.M. Tranquilla and P. Vanic'ek (1987). Guide to GPS Positioning. Canadian GPS Associates, Fredericton, N.B., Canada.
2. Arnoff, S. (1989) Geographic Information System: A Management Perspective, WDL Publications. ISBN: 0921804911, 978-0921804918.
3. Kaplan, Elliott D., & Hegarty, Christopher J. (Eds.) (2005). Understanding GPS: Principles and Applications, 2nd Edn., Artech House Publishers. Norwood, USA. ISBN: 1580538940, 978-1580538947.
4. Carstensen Jr, L. W. (1998). GPS and GIS: enhanced accuracy in map matching through effective filtering of autonomous GPS points. *Cartography and Geographic Information Systems*, 25(1), 51-62.
5. DeMers, Michael N. (2008). Fundamentals of Geographic Information System, 4th Edn. John Wiley & Sons. ISBN: 0470129069, 978-0470129067.