GIS-504/DGIS-504/CGIS-504

M.A. /M.Sc. Geoinformatics/ DGIS/ CGIS

CARTOGRAPHY

DEPARTMENT OF REMOTE SENSING AND GIS
SCHOOL OF EARTH AND ENVIRONMENT SCIENCE
UTTARAKHAND OPEN UNIVERSITY
HALDWANI (NAINITAL)

M.A. /M.Sc. Geo-informatics/ DGIS/CGIS

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CARTOGRAPHY

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CARTOGRAPHY

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Title:	Cartography
ISBN No.:	978-93-90845-57-6
Copyright:	Uttarakhand Open University
Edition:	First (2021), Second (2022)

Published By: Uttarakhand Open University, Haldwani, Nainital-263139
Printed By:

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UNIT 1: HISTORY AND DEFINITION OF MAPS

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1.1 OBJECTIVES

After reading this unit you will be able to:

- Know about history of maps
- Understand the definition of maps

1.2 INTRODUCTION

Histories of maps are very ancient. From starting humans begin to understand about their surroundings. To gain the knowledge of places where human travelling was not possible, human tried to make unclear sketch of that places. At the beginning in the era of Greeks and Romans, maps were used to show known and unknown area/parts of the earth surface. Eratosthenes, Hipparchus & Ptolemy were provided scientific base maps in this era. Today earth's different forms, its types, its symptoms & distribution are shown and explained by maps in small & large scale. Such maps are more complex and more technical than simple. In the field of remote sensing and GIS the role of cartography is very important. Without cartography we can't imagine remote sensing and GIS. In this unit we will talk about the History and definition of maps. How was map formed?

1.3 HISTORY AND DEFINITION OF MAPS

From the earliest civilizations onwards people have been drawing the world around them on stones, clay tablets, papyrus, and more. The earliest positive evidence of graphical representation of Earth parts was shown century before the Christian era, when Babylonians drew maps on the clay tables, of which the oldest specimens found so far that have been dated about 2300 bce. It may be assumed that map making goes back much further and it may begin among non-literate peoples. It's logical to assume that, very early man made efforts to communicate with each other regarding their environment by searching locations, routes & hazards on the ground and later on bark and skins.

Personal experience and familiarity with local features is the base of earliest maps. Doubtless routes were shown by earliest maps to neighboring tribes, where other necessities & water might be found and the location of enemies and other dangers. Stimulation of such efforts done by Nomadic life by recording ways to cross mountains and deserts, the relative locations of summer and winter pastures, & dependable springs, wells, and other information's.

Cave walls markings that are associated with primitive man's paintings have been identified by some archaeologist as attempt to show the game trials of the animals depicted, though there is no general agreement on this. Similarly, hunting trails could be possibly represented by network of lines scratched on certain bone tablets, but definitely there is no conclusive evidence that the tablets are indeed maps.

Many non-literate people are skilled in depicting essential features of their localities and travels. During exploration of Dr. Charles Wilkes's of the South Sea's in the 1840's, a friendly islander drew a good sketch of the whole Tuamotu Archipelago on the deck of the captain's bridge. Pawnee Indians in North America are reputed to have used star charts painted on elk skin to guide them on night marches across the plains. Cortes a map of the whole Mexican Gulf area painted on cloth was taken from Montezuma, while Pedro de Gambia reported that the Incas used sketch maps and cut some in stone to show relief features. Many specimens of early Eskimo sketch maps on skin, wood, and bone have been found.

1. Early Maps

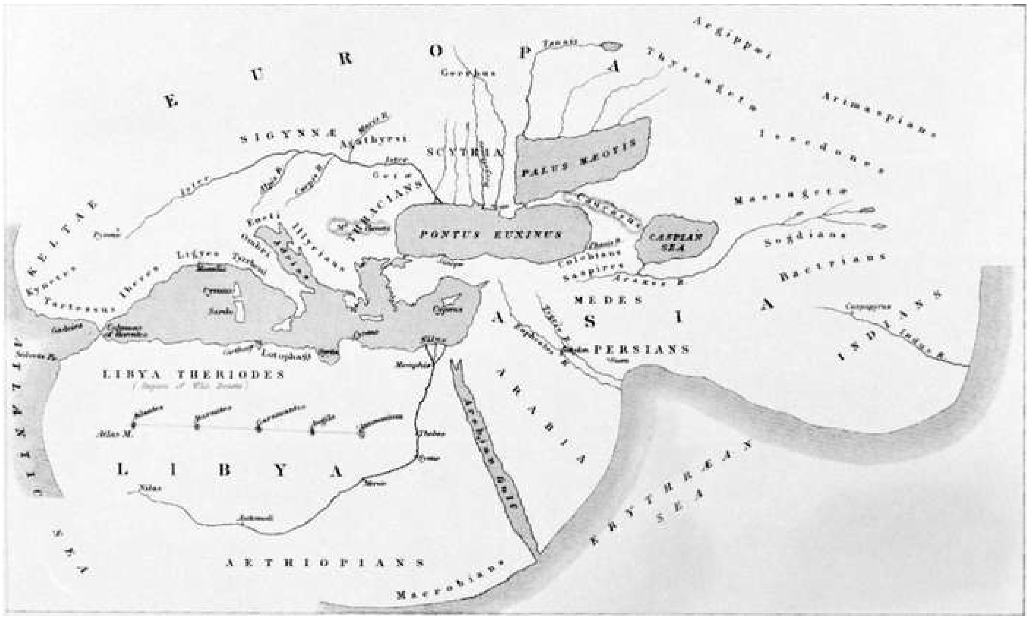
From about 2300 B.C. the oldest known maps are preserved on Babylonian clay tablets. In ancient Greece cartography was considerably advanced. Greece philosophers were well known of the concept of a spherical earth by the time of Aristotle (ca.350 B.C.) and since, have been accepted by all geographers. Map 1.1 is the world map of Babylonia. Clay material is used in making it. Its height is 12.2 cm. (4.8 in) and width is 8.2 cm. (3.2 in). The writing form of this map is Cuneiform. It was created in 6th century BC.

Map 1.1: Babylonian Map of the World

Source: https://en.wikipedia.org/wiki/Babylonian_Map_of_the_World

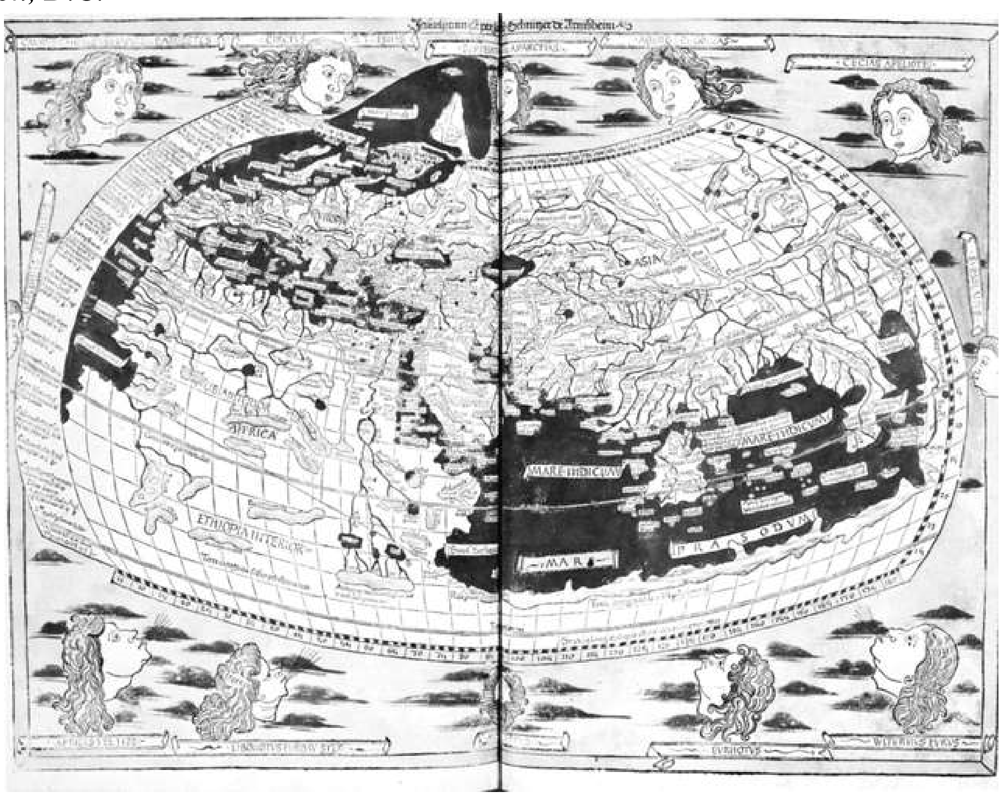
Roman and Greek cartographer reached a culmination with Claudius Ptolemaeus (Ptolemy, aboutA.D. 85-165). His “world map” depicted old world from about 60°N to 30°S latitudes. Map 1.2 is the world map. This map was created by Herodotus. It is one of the earliest maps. Map 1.3 is also a world map and created by Ptolemy. This is also an example of earliest maps. Both maps can be considered as scientific maps.

Map 1.2: Herodotus' map of the world. *Library of Congress, Washington, D.C.*



Source: Google

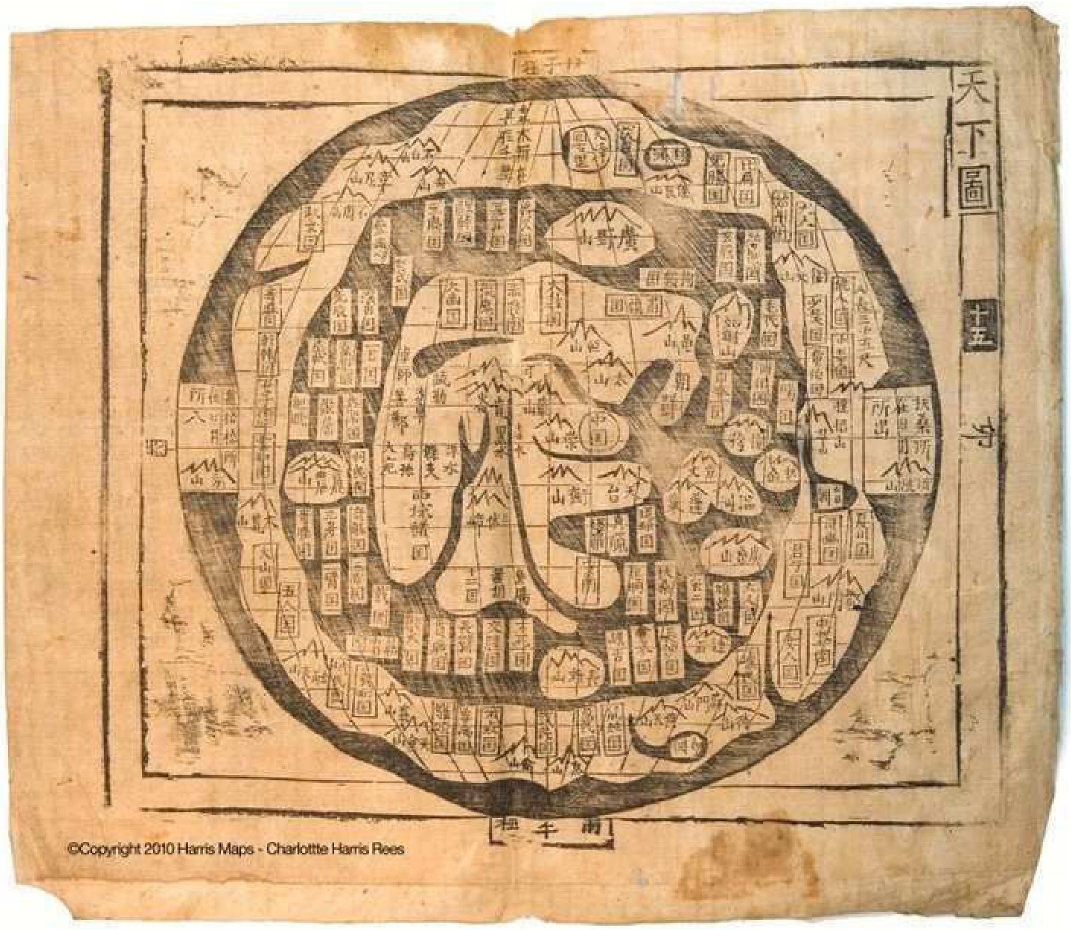
Map 1.3: world map Ptolemy's map of the world, as printed at Ulm, 1482.*Library of Congress, Washington, D.C.*



Source: Google

Map 1.4 is like one of the ancient Chinese maps from the collection of Dr. Henson Harris Jr.'s collection, published in his book in 1973. The second drawing is the interpretation of the first map.

Map 1.4: Dr. Henson Harris Jr.'s collection, published in his book in 1973



Source: https://www.asiaticfathers.com/map.htm

2. Medieval Maps

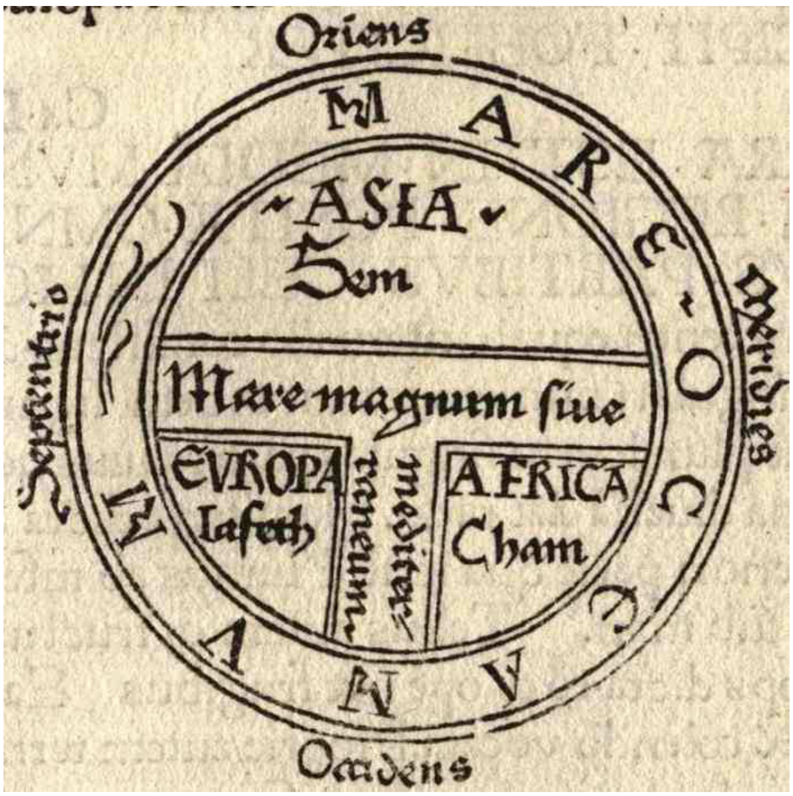
The Europe Renaissance marked the period coming out of the dark ages as literature, music, art society flourished with new knowledge. In this period advances in the art of map making were made which have influenced modern geography and cartography as we know them today.

Few different types of medieval European maps are there that have provided us with clues as how early cartographers saw and mapped with world around them. With increase in technology allowed explorers to discover parts of the world previously unknown to them, the boundaries of mapmaking were pushed farther and farther into the horizon. Additionally the increasing interactions between cultures of the world allowed for a pooling of resources and the knowledge to put together more complete maps of the Earth.

European maps were dominated by religious views during the medieval period. T-O maps were common in this time. In this map format, Jerusalem was depicted at the center and east was printed towards the map top.

In three zones T-O maps depict the world, the only known landmasses of the time. The map is oriented with east at the top of the map and a circle surrounding the known landforms of Asia, Africa and Europe forming a 'T' shape. The water in between each section represents the Red & Black sea and the Don River and the Sea of Azov. Scholars of these maps have come to understand that medieval scholars likely knew the earth was spherical, contradicting the common myth that Columbus was the first navigator to prove the Earth was round.

Map 1.5 T-O Maps



Source: https://www.geographyrealm.com/types-medieval-european-maps/

3. Renaissance Maps

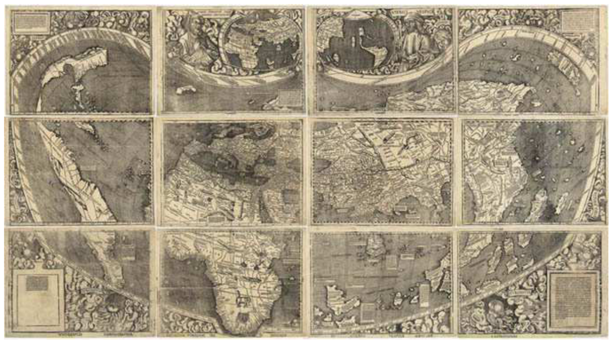
Maps were more widely available beginning in the 15th century by invention of printers. Maps were first printed using carved wooden blocks. The most important map maker among that period was Sebastian Munster in Basel (now Switzerland). In 1540, his geographia published became the new global standard for maps of the world.

Printing with engraved copper plates appeared in 16th century and continued to be in the standard until the development of photographic techniques. During the exploration age in15th and 16th centuries, map makers responded with navigation charts, which depicted coast lines, rivers, harbors, islands, and features of sailing interests. Compass lines and other navigation aids was included, new map projections were devised, and globes were constructed. Such maps and globes were held in great economic values, military, and diplomatic purposes, were often treated as national or commercial secrets classified or proprietary maps.

4. Modern Maps

In 1507 the first true was credited to Martin Waldseemuller. This map utilized an expanded Ptolemaic projection and was the first map to use the name America for the New World.

Map 1.6: Waldseemuller Map, 1507



Source: https://www.loc.gov/rr/geogmap/waldexh.html

Map: 1.7

Source: https://commons.wikimedia.org/wiki/File:Waldseem%C3%BCller_world_map_1508.jpg

Maps became accurate increasingly and factual during 17th, 18th, and 19thcenturies with the scientific methods applications. Nonetheless, much of the world was poorly known until the widespread use of aerial photography following World War 1. On combination of ground observations and Remote sensing Modern cartography is based. In 1970-80s period GIS emerged. Geographic information system represents a major shift in the cartography paradigm. In traditional cartography, the map was both database & display of geographic information. Database, analysis, and display are physically and conceptually separate aspects of handling geographic data for GIS.

This map utilized an expanded Ptolemaic projection and was the first map to use the name America for the New World.

DEFINITION

A map is a symbolic depiction which denotes relationships between elements of some space such as objects, regions and themes. Most world maps are drawn to a scale to express a ratio between two or more units of measurements. The word ‘map’ originated from the Latin world ‘mappa’ which meant a napkin or paper. Why so? Because these were the usual materials the earliest maps of the world were drawn on.

Some definitions of map are given below:

1-According to Finch and Trewartha: Maps are the graphic representations of the surface of the earth.

2-According to Dudley Stamp-"Map is a representation of the earth surface or a part of it, its physical and political features, etc. or of the heavens, delineated on a flat surface of paper. each object on the map corresponds to a geographical position according to a definite scale or projection.

3-According to Peter Greenaway “A Maps tells you where you’ve been, where you are, and where you’re going- in a sense its three tenses in one”.

4-According to Raisz, E. “ A map is a selective, symbolized and generalized picture of some spatial distribution of large area usually the earth surface as seen from much above at a much reduced scale”.

5-According to Singh, R.L & Dutt.P.K. “A map is a representation of the earth or a portion of it drawn to scale on a flat surface”.

6-According to Singh, R.N.& Singh, L.R. “A map may be defined as a small scale conventional representation of the earth or part thereof”.

7-According to J.Van Ripper “Maps are two dimensional representations of selected features of the earth surface and at reduced scale”.

8-According to R. Ogilvie Buchanan **“** A map is the scaled representation on a flat surface of the earth’s surface, or a section of it, showing certain selected features- physical, political, historical or economic”.

9-According to R.P. Misra and A. Ramesh “A map is a symbolic drawing to scale of the visible as well as conceived locational and distributional patterns of the whole or part of the earth, the sky, or any other heavenly body”.

The above definitions reveal the following characteristics of the map:

1. Map is a graphic representation of the earth or part of it.
2. It shows the physical and cultural features.
3. It is a flat piece of paper.
4. It is drawn on a definite scale.
5. It has its extension on a graticule of lines known as latitudes and longitudes.
6. The identification of objects is made either by symbols or lettering.
7. It shows selected features.
8. It is a two-dimensional representation of the earth.

1.4 SUMMARY

Maps are the tools of GIS specialist. Remote Sensing and GIS cannot be studied without maps. Though a number of disciplines are involved in the study of earth, but Remote Sensing and GIS is the only discipline which is involved in the mapping of the earth or any part of it. These are more efficient than books. Maps are records of various facts of the earth. These maps make direct appeal to the mind and bring before us the unknown and unseen areas in their original form.

1.5 GLOSSARY

1. Civilizations- The culture characteristic of a particular time or place.
2- Clay tablets- Clay tablets were a medium used for writing.
3- Christian era- The period beginning with the year of Christ's birth.
4- Map- Map is a graphic representation of the earth or part of it.
5- Graphic representation- Graphical representation refers to the use of charts and graphs to visually display, analyze, clarify, and interpret numerical data, functions, and other qualitative structures.

1.6 ANSWER TO CHECK YOUR PROGRESS

1- What do you understand by maps?
2- What are early maps?
3- What are medieval maps?
4- What are renaissance maps?
5-What are modern maps?

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1.8 TERMINAL QUESTIONS

1- Write a note on history of maps?
2- Define maps with definitions of different experts?

UNIT 2: CLASSIFICATION OF MAPS

2.1 OBJECTIVES
2.2 INTRODUCTION
2.3 CLASSIFICATION OF MAPS
2.4 SUMMARY
2.5 GLOSSARY
2.6 ANSWER TO CHECK YOUR PROGRESS
2.7 REFERENCES
2.8 TERMINAL QUESTIONS

2.1 OBJECTIVES

After reading this unit you will be able to:

- Know about different types of maps.
- Understand the uses of different types of maps.

2.2 INTRODUCTION

Three dimensional models of the earth (also called globe) best represent the spherical earth. Much detail of surface features is not shown by them. Henceforth, maps are much useful tool than globes. A map is a 2-D diagrammatic representation of the whole or part of the earth. It is a picture of physical and cultural features on a flat surface at a given scale. They have unique advantage of showing objects or patterns that may be intangible or invisible. For instance, production crop's distribution on the surface cannot be easily marked on the ground, but on the map, its identification is easy. It may help us the crop production pattern in vast area.

There are numerous ways by which the mapping of earth can be done:

a) By freehand sketches and diagrams;
b) By actual survey with the help of survey instruments;
c) By photographs-ground and aerial both;
d) By manmade satellites.

The use of computers has developed the digital mapping through Geographic Information System and Global positioning system. The amount of information given on the map depends on: *Scale, *Projection, *Conventional signs and symbols, *Cartographer skills, *Map making methods; and *Requirement of the user.

2.3 CLASSIFICATION OF MAPS

There are different types of maps. There is uniqueness in designing, construction, contenting & hence a self type of each map. There are two types maps classified broadly: Scale and purpose or content. Further on two other bases these are also classified: topographic features and nature of construction.

I. Classification Based on Scale

There are two broad categories of maps:

(i) Large Scale maps,
(ii) Small scale maps

(i) Large Scale Maps: These maps represent small area of the earth surface on a large size of paper with greater details. Such types of maps are:

1-Cadastral maps,
2-Town plan maps,
3-Topographical maps.

(a) **Cadastral Maps:** From French word cadastre the term cadastral is derived. It means a register of territorial property. To register the ownership of landed property the cadastral maps are drawn. It shows the demarcation of the boundaries of fields, buildings. To realize land revenue and property taxes these are especially prepared by government.

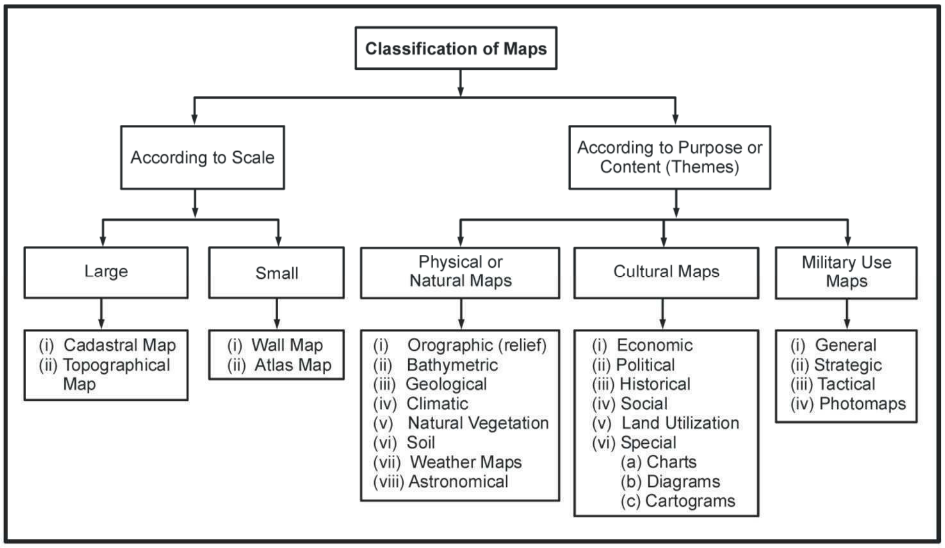


Fig. 2.1 Types of Maps

Village maps are the large scale maps showing the field boundaries, footpath, water bodies, public places, residential houses and so on. These maps are drawn on a very large scale, varying from 20 cm to a km to 40 cm to a km, so as to fill up in all possible details. To this category Rural Land use maps also belong. Also in this category city maps may be included. Different details like water-line, individual houses, sewer line, public buildings, roads, play grounds, parks etc. are showed by these maps. House layout plan is also included in it. This map is of very large scale. To this category town plan maps also belong. On a scale of 1:20000, Survey of India publishes city and town guide maps.

(b) **Topographical Maps:** On fair large scale these maps are prepared. On precise survey these are based that is conducted by survey of India, Dehradun. General surface feature are shown by them in detail comprising both natural & cultural landscape. 'A topographical map is on a sufficiently large scale to enable the individual features shown on the map to be identified on the ground by their shape and position' is according to Survey of India.

These maps are not having the boundaries of individual plots or buildings. Principle topographic forms like relief and drainage, swamps and forests, villages and towns, means of communication like roads and railways, spot and relative heights, contours are rather depicted from these.

On the scale of 1:25:000, 1:50:000 and 1:250:000 in India, these maps are mainly prepared. It is to be noted that the nature of details increase, with the increase in the largeness of the scale. For

example, a map of 1:25:000 scale shows much more details than the map of a scale of 1:250:000. With the help of convection signs various details are shown on these maps. For the study of geography of an area these maps are very important. So, some scholars have defined them as tools of geographers. For the study of an area at micro level these maps are very important.
According to their scale these maps are numbered; suppose if the number of a map is 53K, it means that the scale of map is 1:250,000, when the number of topographical map is 53K/15, it is understood that the map is on the scale of 1:50,000. The number of map with 53K/15/4 denotes the scale of 1:250,00. Such topographical maps are not still in much use.

(ii) **Small Scale Maps:** Large areas on a small sheet of paper are represented by these maps. They have few details. Wall maps and Atlas are the best examples of small scale maps. The maps included in any book, magazines, newspaper are also small scale maps. They give only a general picture of the area represented.

(a) Wall maps: Though wall maps have large scale than Atlas or book maps, but their scale is comparatively smaller one. These are drawn boldly so that they can be seen from a distance. They are used in cater and classrooms to the needs of the large audience. They are called wall maps because they are hanged on the flat surface walls. In real sense these are geographical maps. Large areas like world as a whole, continents, hemispheres, countries, states, districts & tehsils are shown by them. With certain purposes these maps are drawn like to show the types of soils, climatic conditions and distribution of minerals, types of vegetation and social, cultural, means of transport, population, economic and political patterns. These maps are of different size. On nature of objects it depends to be shown therein. Our Survey of India prepares these wall maps on a scale of 1:15,000,000 to 1:250,000.

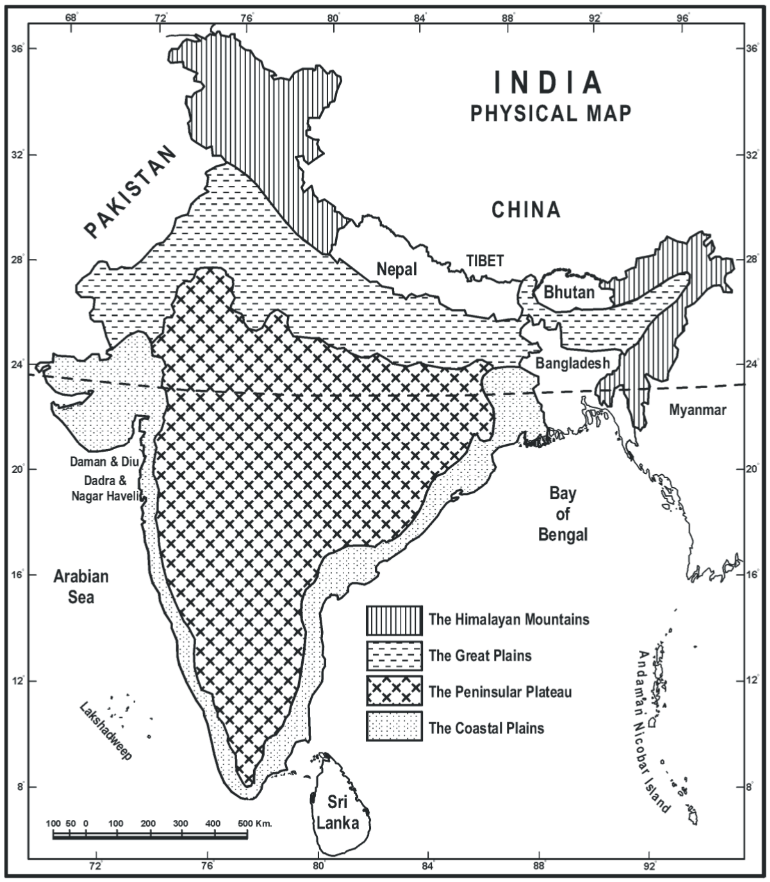
(b) Atlas Maps: Book of maps is ‘Atlas’. On very small scale these are drawn and give a highly generalized picture of natural and cultural aspects, such as physical climate, drainage, soils, agricultural crops, industries and so on. These are mainly prepared on 1:20,000,000 scales or less than that. In our country, National Thematic Mapping Organization (NATMO) is a well known important organization. For various purposes it publish all kinds of maps, depicting different parts of the country and its product is known as National Atlas of India. Other important Atlas is Oxford Atlas, Reader’s digest Atlas, School Atlas, District Atlas, State Atlas, Census Atlas, and so on. These maps are also called as chorographical maps.

II Classification Based on Purpose

Mainly these are thematic maps prepared on small scales. Thematic maps are data maps of a unique topic or for a specific purpose. Specific features of the area concerned

are highlighted by them. Into two main divisions they are broadly classified. They are:
(a) Physical Maps,
(b) Cultural Maps

Map: 2.1Physical Map of India



Source: Practical book of GE103, Uttarakhand Open University

(a) **Physical or Natural Maps:** Map 2.1 shows physical features of map. Physical maps are the maps which depict various aspects of the natural environment. They highlight various physical aspects like relief, climate, natural vegetation, soils. These may be categorized as follows:

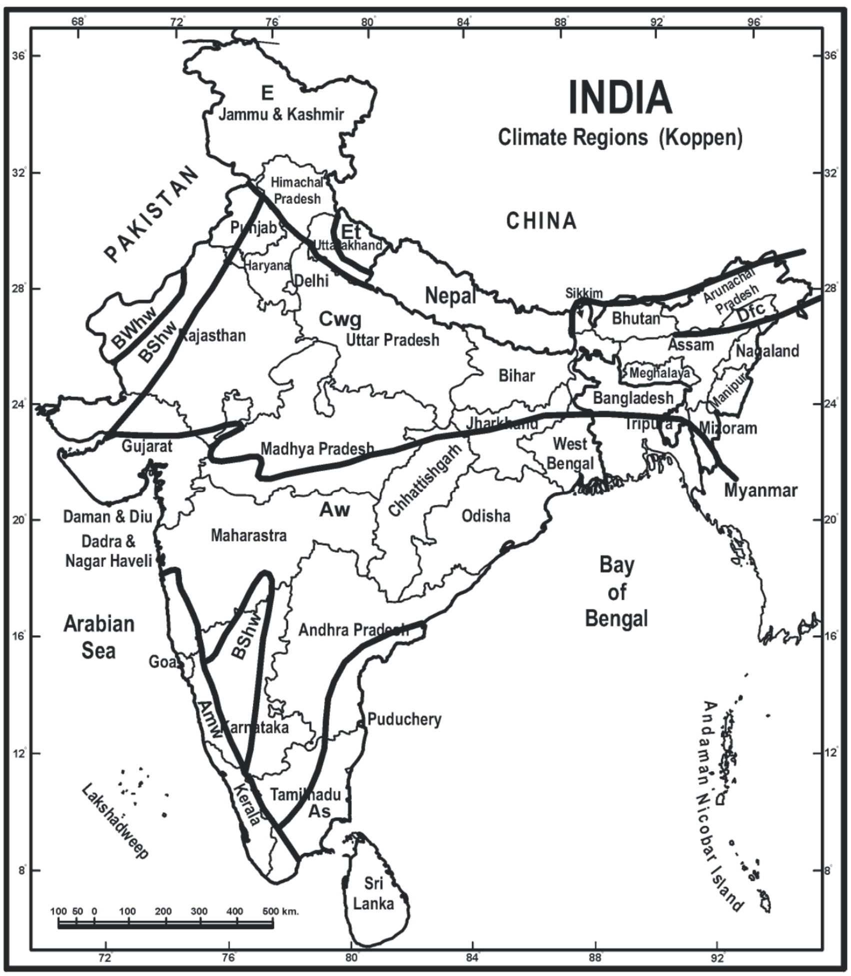
(i) **Orographic or Relief Maps:** Surface features like mountains, plains, plateaus, rivers etc, are represented by these maps. The maps showing the average slope of the area, relative relief also are of such type.

(ii) **Bathymetric Maps:** To depict the depth of the oceans and seas such maps are used. With the help of different tone of colours these depths are mainly shown.

(iii) **Geological Maps:** Distribution and type of rocks are shown by these maps. They also represent the pattern of occurrence and deposition of rocks.

(iv) **Climatic Maps:** Climatic maps are maps that show climatic condition of an area. Amount of rainfall is shown by them. Variations in temperature according to seasons, climatic regions, air pressure, direction and flow of winds for a long period of time are also shown by them.

Map: 2.2 Climate Map of India



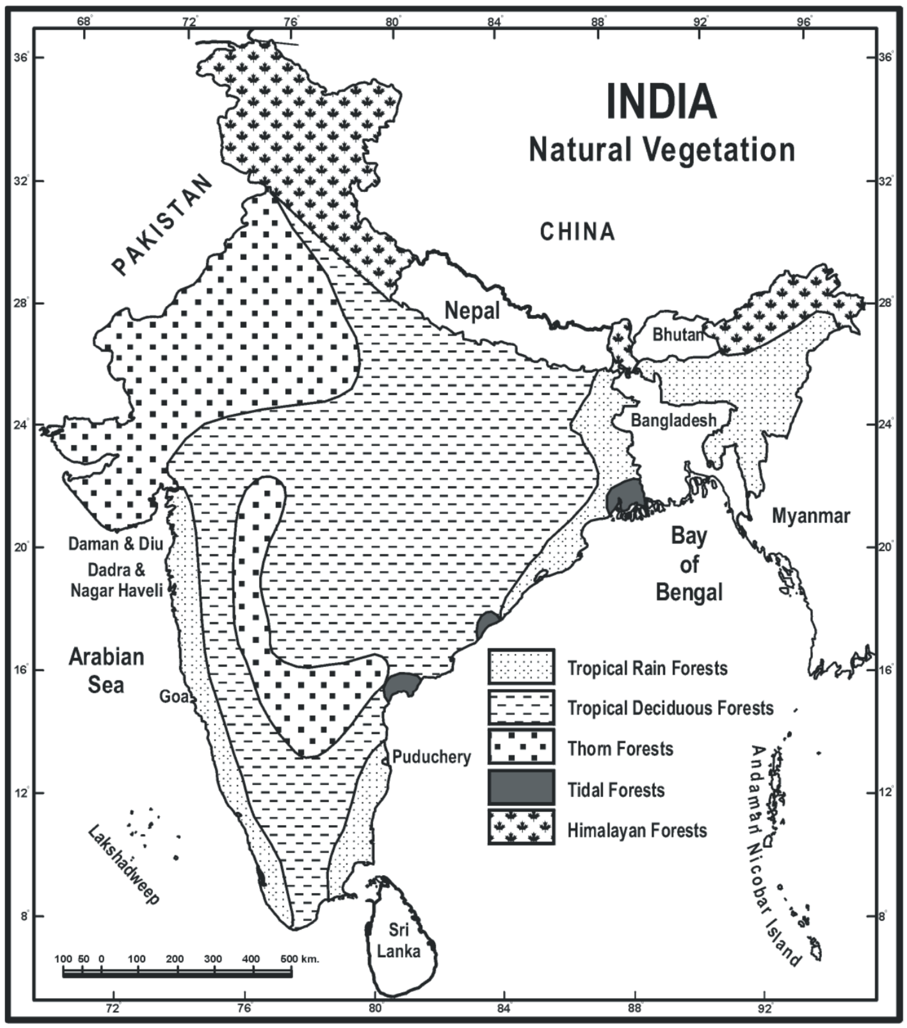
Source: Practical book of GE103, Uttarakhand Open University

(v) **Weather Maps:** Weather conditions of a particular time and day is shown by them. They show velocity and direction of winds, weather conditions, isobars, sea conditions and amount of rainfall, if it is so. Weather forecast is also depicted by them.

(vi) **Soil Maps:** Types of distribution of soil in any area is shown by these maps.

(vii) **Natural Vegetation Maps:** Natural Vegetation Maps are use to depict the types of vegetation, distribution of forests, in an area.

Map: 2.3 Natural vegetation Map of India



Source: Practical book of GE103, Uttarakhand Open University

(viii) **Astronomical Maps:** Position of stars and planets of the sky are shown by them.

(b) Cultural Maps: Man- made features and human aspects are shown by these maps. Into the following groups these are categorized. They are:

(i) **Economic Maps:** Mineral distribution, distribution of agricultural crops, types of land use, types of industries, communication and means of transport, sea ports etc, are shown by these maps. These maps also depict stage of economic development, economic regions, and potential regions and so on.

(ii) **Political Maps:** Boundaries between two countries and states are shown by political maps. Extension of continents is shown by these maps. The boundaries of districts, block, tehsils are also shown on these maps. These are also used to show the capitals and administrative boundaries.

Map: 2.4 Political Map of India

Source: Practical book of GE103, Uttarakhand Open University

(iii) **Historical Maps:** This map shows the past events, the places of historic importance, the dynasty of emperors and rulers of various times.

(iv) **Socio-cultural Maps:** This map depicts caste structure, language, religious faith, ethnic groups, migration of races and tribes.

(v) **Population Maps:** Population maps are very important as they acquaint with the socio-cultural and economic development of the area concerned. They show population distribution and density of population, literacy level, sex-ratio, age-structure, percentage and distribution of rural and urban population, working population and its occupational structure.

(vi) **Military Maps:** Maps used or prepared by defence services are called as Military Maps. These are of different types:

(a) General maps on a scale of 1:1000,000 or more depict only the broad topographical features. These are used by the defence services for general planning purpose.

(b) Maps prepared as the scales ranging from 1:1000,000 to 1:500,000 are often classified as strategic maps. These maps are used for planning concentrated military action.

(c) Maps with a scale of 1:500,000 or less are called tactical maps. They serve as guides to small units like battalions and patrol units prior to and during movements anywhere near the front line.

(d) Photo map is an Aerial Photograph with strategic and tactical data superimposed on it.

All maps have some common elements like Location, graticule of lines of latitudes and longitudes, direction, scale, distribution of various features and phenomena with the help of various symbols, shades and conventional signs.

2.4 SUMMARY

Map is two dimensional and it is true representation of three dimensional earth. Physical and cultural features of the earth or any other area's picture are map. To represent the features of the earth there are also other ways. Sketches, diagrams, photographs, are also used to depict certain features of the earth.

Maps have lot of information. Map is a graphical representation of the earth. It shows certain physical and cultural features. It is a bird's eye view. Each feature is the true representation of the object of the earth.

On the basis of scales and purposes maps are classified. Maps are of two categories. On the basis of scale, large scale maps show small area on a large size of paper with much detail, whereas small scale maps show large area on a small size of paper with selected details. Topographical maps are large scale maps, mainly published by Survey of India. Wall maps and Atlas maps are main categories of small scale maps.

Thematic maps are the maps prepared with certain purposes. Physical and cultural are the two broad categories of these. Physical maps highlight various physical aspects like relief, climate, soils, natural vegetation and geology. Manmade features are shown by cultural maps. Economic, political, historical and socio-cultural, population and military map are such maps. The variety and types of maps on the basis of purpose is quite unlimited.

2.5 GLOSSARY

1-Cadastral- Refers to a map that shows the boundaries and ownership of land within specified area.

2- Topographic- Topographic is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines.

3- Political Map- A political map is a map that shows the political boundaries of that particular area.

4- Physical Map- A map of the locations of identifiable landmarks on chromosomes.

5- Thematic Map- A map that displays the spatial distribution of an attribute that relates to a single topic, theme, or subject of discourse.

2.6 ANSWER TO CHECK YOUR PROGRESS

1-What are maps?
2-What is a Cadastral Map?
3-What is a Topographic Map?
4-What is a Political Map?
5-What is a Physical map?
6-What is a Thematic Map?
7-What is a Climate Map?
8-What is a Road Map?
9-What is a General Reference Map?
10-What is a Navigational Chart Map?

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2.8 TERMINAL QUESTIONS

1-Explain in detail the meaning, importance and utility of maps.
2-Discuss the main characteristics of maps.
3-Discuss the classification of maps. Justify your base of classification.
4-Write an essay on the maps based on scale.
5-Discuss the types and characteristics of small scale maps.
6-Differentiate between climate maps and weather map.
7-Discuss various types of military maps.
8-Map is a true representation of the earth. Explain it.

UNIT3 - SCALE AND TYPES OF SCALE

3.1 OBJECTIVES

After studying this Unit, you should be able to:

- Understand the meaning and definition of Scale
- Explain the types of scale and its methods to show on the map
- Describe enlargement and reduction of maps

3.2 INTRODUCTION

Scale has the meaning of a ratio. It signifies the proportion of a length on the map which bears actual distance on the ground. To speak, the scale of one cm. to a km. means that if we measure two cm. as the distance between two buildings shown on the map, the actual distance would be two km. In determining the scales, it is necessary to bear in mind the purpose, for which the map is intended, as well as the amount and the character of the detail to be shown. Town plans require a large scale in order to show the layout of buildings and other related aspects. An Atlas map is designed to show the main details in a brief form. So, it is essential that on any plan or map there should be some indication of the scale so that the actual distances may be calculated.

3.3 SCALE AND TYPES OF SCALE

The distances on the map are smaller than the corresponding distance on actual ground. Maps always bear a definite proportion to the area shown on that. So, the scale is the proportion of the distance between any two points on the map, corresponding to the actual distance between these two points on the ground. Actually, scale is a ratio of two distances i.e. the map distance and the ground distance. Thus, the ratio between these two distances is the scale of the map. For example, if we say that scale is one cm. to one km., we mean that a length of one cm. on the map corresponds to a distance of one km. on the ground i.e. 1cm = 1km.

The scale we chose primarily depends on:

- The size of the area to be mapped
- The amount of details to be shown and
- The size of the paper

According to our need-we can have 'Small Scales' and 'Large Scales'

- Small scales show km. to the cm. such as 5kms to 1 cm.
- Large scales show cm. to the km. such as 10 cm. to 1 km.
- Small scale depicts large area covered on a small size of paper. The map with such scale shows only important features. It may have a loss of information.
- Large Scale depicts small area covered on a good size of paper. The map with such scale shows in detail the geographical features.

The choice of proper scale for a map always depends upon the purpose for which it is drawn.

METHODS OF EXPRESSING SCALE ON A MAP

There are three methods, by which the scale of map is expressed: (i) by a statement method, (ii) by a numerical fraction or (iii) by a graphical scale method:

(i) **By a Simple Statement Method :** In this method, the scale is expressed in words, such as one cm. to 1km. or 1 inch to 1 mile, etc. This indicates that one cm. on the map corresponds to one km. on the ground or so on. This method is easy and is understood well especially for those who are less educated. This method has two limitations. Firstly, it can be understood only by those who are familiar with the unit of measurement used. Secondly, when a map is reduced or enlarged from the original, the scale will not be the same. This creates problems in measurement.

(ii) **By a Representative Fraction Method:** This expresses the proportion of the scale by a fraction in which the numerator is one and the denominator is also in the same unit of length. For example, if the Representative Fraction (Commonly written as R.F.) is stated to 1/1,00,000 or 1:1,00,000 this means that one units on the map represents, 1,00,000 of the same unit on the ground. If it is an inch then 1" on the map represents 1,00,000 inch on the ground i.e. 1.578 miles. If it is in centimeter, then 1cm. on the map represents 1,00,000 cm. on the ground i.e., 1 cm represents 1 km.

$$\text{R.F.} = \frac{\text{Distance on the Map}}{\text{Distance on the ground}}$$

Hence, this method of stating the scale is independent of any particular unit of measurement. It is an universal unit. It can be converted into any unit. It can be used by any country according to its own unit of measurement. However, the R.F. will no longer be true, when the map is enlarged or reduced photographically. In that case, the linear method of scale will be better.

(iii) **By a Graphical Scale Method:** This is also known as a plain or a linear scale. This is merely a straight line divided at certain intervals, so that the distances on the map can easily be measured with the help of a scale in terms of distances on the ground. This scale is expressed as a horizontal or straight line. In the construction, a convenient length of the line should be drawn, so that the distance on the map can be easily read. The line is usually about 10 to 15 cm. in length. The units should be shown in round number in kms. The divisions are usually in multiples of tens so that further sub-divisions, if necessary become possible. For convenience, the primary divisions are shown on the right hand side of zero, while secondary divisions (sub-divisions of the primary division) are marked off to the left of the zero mark.

Draw a straight line AB, 12 cm. in length. From A draw another line AC making a convenient actual angle of about 20o to 25o BAC. On AC mark six equal division (a, b, c, d, e, f) by means of a pair of dividers, join the last point f to B and from the other points (a, b, c, d, e) drawn lines parallel to fB to meet the line AB. These parallel lines will cut AB into six divisions, each being equal to 5km. These are the primary division (Fig. 3.1).

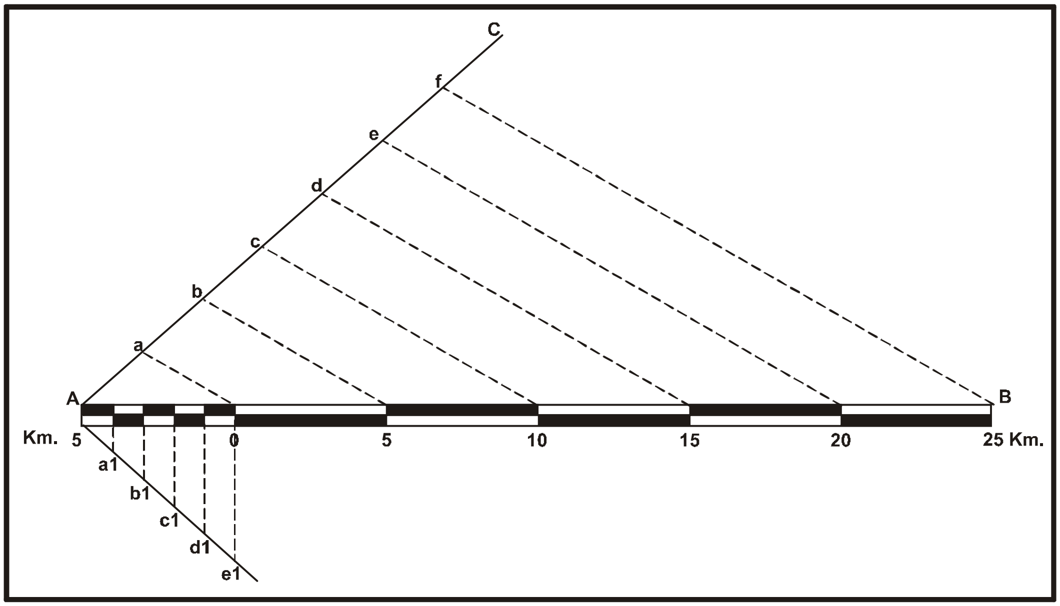


Fig. 3.1 Construction of Linear Scale

To obtain the secondary division, sub-divide the first primary division, i.e. the division on the extreme left into five equal parts as shown in Fig. 1.1 Each of the secondary division will represent one km.

While numbering the scale, zero should be marked after one interval from the left, so that the left hand end of the line can be numbered 5 and the primary divisions to the right of zero can have numbers 5,10,15,20 and 25. This method of numbering enables us to read off directly the whole numbers as well as the fraction from the scale.

Example 1: Construct a linear or graphical scale for a map drawn to a scale of 1:1,00,000 to read into km. and divide it into primary and secondary division.

Solution: If we take 10 cm. lines on the paper, it will represent 10 km. It is a convenient round number in scale because it can be divided into 10 primary divisions, and thus one division will represent one km. The first primary division on the left side of the linear scale is divided here in two equal parts, called as secondary division. Each secondary division will represent 500m, while numbering the scale, zero should be marked after one primary division from the left. This method of numbering enables us to read off directly the whole numbers as well as the fraction from the scale.

Example 2: If the scale of a map is 1:2,50,000, construct a graphical scale with primary and secondary divisions to read up to one km. Here 1cm. represents 2.5 km. or 2,50,000 cm.

Suppose, if we take a line of 12 cm. length, the length of the scale line will represent 12 × 2.5 cm. = 30 km.

This is an even number and is convenient for the construction of a scale. Now, to construct a linear scale for 30 km to read upto 1 km firstly we will have to determine the number of primary divisions. Here 12 cm. represents 30 km. It means that 1 cm will represent 2.5 km. We may conveniently divide 12 cm line into six divisions, so that each primary division reads 5 km. and to read secondary division, one primary division of the extreme left of the scale, is divided into five equal divisions to represent one small division equal to 1 km.

SCALE CONVERSION

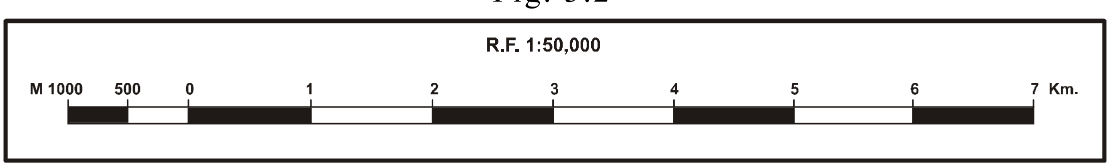
The statement scale and the representative fraction scale, both are substitutes of one other. So, both are not shown on the map at one time. Though there is a tradition that R.F. is shown along with the linear scale on the map. Sometimes, when the map is reduced or enlarged then, this R.F. needs the change, as because; the length of linear scale also gets changed. It is also to be noted that sometimes we need to change the statement scale into representative fraction or in ratio scale. Thus, it becomes necessary for us to acquaint ourselves with the technique of the conversion of all these methods of scale into each other. The following examples will be able to clarify these methods of all these changes.

1. Calculate the R.F. when the scale is 5” to one mile.
   5” = 1 mile or 63360”
   5” = 63360 or R.F. is 1:12672
2. Calculate the scale in inches, when the scale of map is one cm. = one km.
   1 cm. = 1 km. or 1,00,000 cm. or R.F. is 1:1,00,000
   In inches 1 inch = 1,00,000 inch
   63360 inch = 1 mile 1:100,000 × 63360 = 0.63” the scale is 0.63” to the mile or 1” = 1.578 miles
3. The distance between Meerut and Delhi is 60 km. This distance on a map is shown by a line of 6 cm. Find out the R.F. of the Map:
   : 6 cm. represents 60 km. or (60 × 1, 00,000) cm.
   : 1 cm. will represent = 60/10 = 10 km.
   : So the R.F. of the map is 1 : 1,00,0000
4. Find the R.F. when the scale is 1” to 3 miles
   1″ = 3 miles or 1″ = 3 × 63360″ = 190080
   So R.F. is 1 : 1,90,080
   R.F. of a map is 1:50,000, Draw a simple linear scale of this map.

   $1 \text{ cm.} = 50{,}000 \text{ cm.} \quad 1 \text{ cm.} = \frac{50000}{100000} \text{ km.}$

   1 cm. = ½ km. or 2 cm. = 1 km.

Fig. 3.2



Draw a line of 16 cm. length, and divide it into eight primary divisions, and thus one primary division will show a distance of 1 km.

GRAPHICAL SCALE

It is also known as linear scale, as it is shown with the help of a line. The length of the line is determined according to the size of paper. The following points should be kept in mind, at the time of construction of linear scale:

1. Linear scale should indicate the actual distance in round figure, such as 5, 10, and 15 and so on.
2. The length of linear scale may not be in round or full digit. It may be in decimal, which is obtained after the calculation.
3. The length of the graphical scale should be between 4 to 6 inch or 10 cm to 15 cm. This length may be adjusted with an addition of half inch or 1 cm.
4. The division of linear scale into primary and secondary divisions should be made by geometrical methods.
5. The value of each division should be mentioned on the upper side.
6. The left side of the scale has the secondary division, showing the smallest measurement of the scale.
7. The linear scale, if it is decorated with two parallel lines in that case the lower line should be thick. Each section of the scale may be shaded in alternate manner.

Types of Graphical Scale

This scale has so many specialized forms. These are based on various purposes:-1.Plain Scale, 2.Pace Scale, 3.Time Scale, 4.Comparative Scale, 5.Diagonal Scale, 6.Vernier Scale.

(1) Plain Scale

This scale simply represents the measurement of distances. In one scale, the measurement in two units can easily be shown, such as km. and meter, mile and furlong or yard, yard and feet. This scale is generally used on the maps. This scale may be drawn as a single or double line. Double lines scale with alternate spaces filled black, are commonly used for good effect.

Example 1: The R.F. of a map is 1:250,000. Construct a plain scale with primary and secondary divisions to read up to one km.

Solution: Here, one cm. represents 250,000 cm. if we draw a line of 12 cm. it will represent the number of km. in following way:

Here, 1 cm. represents 250,000 cm or $\frac{250000}{100000}$ km. = 2.5 km.

A line of 12 cm. will represent 2.5 km. × 12 = 30 km.

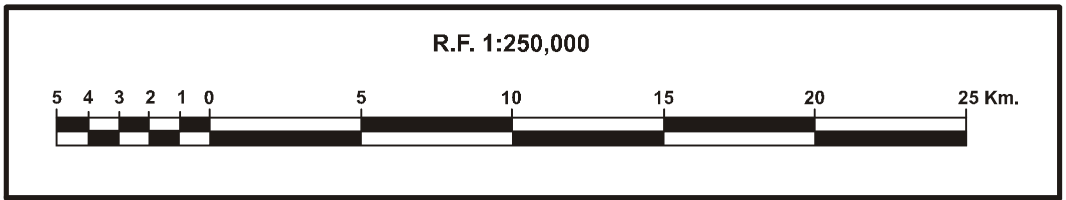


Fig. 3.3

This is an even number and is convenient for the construction of a scale. As we have to read up to 1 km. in this linear scale for 30 km, we will divide this scale into six primary divisions. Thus, each primary division will read 5 km. One primary division of extreme left of the linear scale, we will divide it into five equal divisions, so that these secondary divisions will give us to read a minimum distance of one km.

While numbering the scale, zero should be marked after one interval from the left, so that the left hand end of the line can be numbered 5 and the primary divisions to the right of zero can have number 5,10,15,20 and 25. This method of numbering enables us to read off directly the whole numbers as well as the fraction from the scale.

Example 2: The R.F. is 1:100,000. Construct Plain scale to read into miles and furlongs.

Here 1 inch represents 100,000 inches

If we draw a line of 6 inch then $\frac{100000\times 6}{63360}$ = 9.469 miles

Thus 6″ will represent 9.469 miles.

As 9.469 mile is not a round figure, in that condition we will take the round figure of 10 miles, then we will calculate the length of the linear scale for a distance to show 10 miles.

Now 9.469 miles in shown by = 6 inch

1 mile will be shown by = $\frac{6}{9.469}$ inches

10 mile will be shown by $\frac{6\times 10}{9.469}$ inch = 6.336” or 6.3”

Draw a line of 6.3″ and divide it into 10 equal parts. One part will represent the ground distance of one mile. The primary division of the left side will be divided into eight equal parts. This one small part as a secondary division will represent 220 yards or one furlongs.

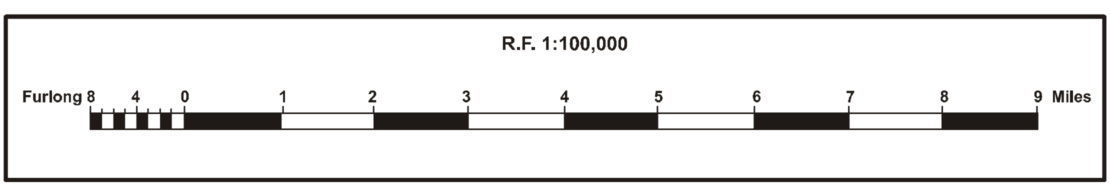


Fig.3 .4

Example 3: Draw a plain scale for R.F. 1:7920 and show the distance of 3 Furlong 165 Yards.
Solution :
1′′ represents 7920 inches   1 Furlong = 220×36=7920 inches

6′′ will represent $\frac{7920 \times 6}{7920}$ Furlongs

6" = 6 Furlong
Draw a line of 6" length and divide it into 6 equal parts, and each primary division will represent 1 furlong. Divide the first primary division into four secondary divisions, thus one secondary division will represent 55 yards, See Fig. 3.5.

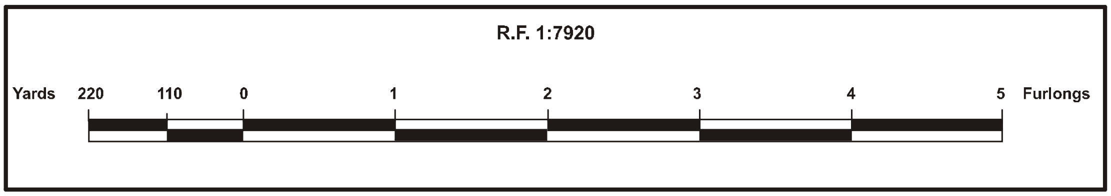


Fig. 3.5

Example 4: The distance between two places on the ground is 4 hectometer and 10 decameter, when the distance on the map is 5cm. Find out the R.F. of the map and also draw a plain scale to show 6 Hm. and 5 Dm. distance.
P.S. 1 HM = 10000 cm. or 100 m. / 1 DM = 1000 cm. or 10 M.
1 km. = 10 HM or 100 DM

Solution: Distance on Map is 5 cm.
Distance on Ground $= 4 \times 10000 + 10 \times 1000$ cm.
$= 40000 + 10000$
$= 50000$ cm.

R.F. = 5/50000 = 1/10,000
Draw a line of 15 cm. length, which will represent 15 Hm. It means that if 15 cm. line is divided into 15 equal parts than one cm. will represent 1Hm. Divide the first primary division into two equal parts i.e. into secondary divisions. Thus, one secondary division will represent 5 Dm. distance (Fig. 3.6).

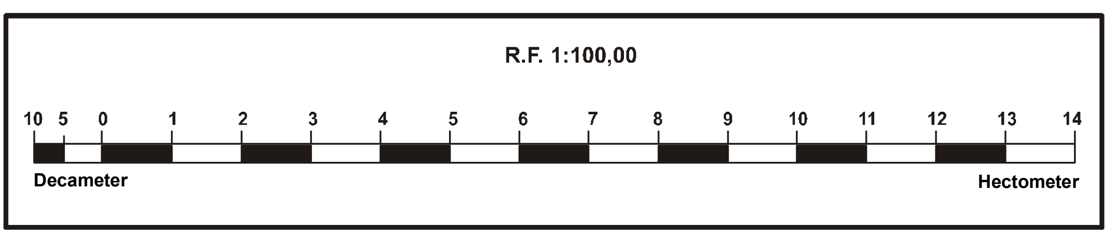


Fig. 3.6

Example 5: An area of 5 sq.cm. on the map represents an area of 2,50,000 sq.km. Draw a corresponding scale to read km. What is the R.F. of the scale.

Solution: 5 Sq.cm. = 250,000 sq. km. on ground

1 sq. km. = 50,000 sq.km.

Distance of one cm. on map = $\sqrt{50,000}$ =223.6 km.

= 223.6 km.

= 22,36,00,00 cm.

R.F. = 1:223600,00

1 cm. = 223.6 km.

15 cm. = 3354 km.

Here, 3354 km. are shown by a line of 15 cm.

1 km. is shown by a line of $\frac{15}{3354}$

3000 km. will be shown by = $\frac{15\times 3000}{3354}$ = 13.8 cm.

Draw a line of 13.8 cm. and divide it into six equal primary divisions. Thus, one primary division will represent 500 km. One primary division of extreme left, divide it into five secondary divisions. Thus, one secondary division will represent 100 km. (Fig. 3.7)

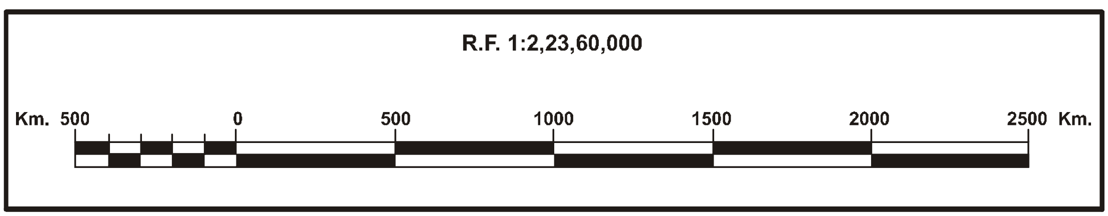


Fig. 3.7

(2) Comparative Scale

It is that graphical scale which measures the distances in the units of measurement of different length. The main aim of the construction of these scales is to know the distances such as in mile and km, meter and yard, time and distance. Following are the main points for the drawing of these scales:

The scale is drawn on the basis of one R.F.

The R.F. is converted into distance of both the different measurements.

Both the scales of different units are vertically aligned on the mark of zero of primary division for the drawing.

The calculation of both the scales is just the same as of the plain scale.

Example 1: Draw a comparative scale to show the distances in yards and meters for the R.F. 1:50,000.

For Yards : R.F. 1: 50,000 i.e. 1″ = 50,000″

Or $1'' = \frac{50000}{36}$ = 1388.88 Yards.

If we take a length of 6" of scale then it will represent 6 ×1388.88 yards = 8333.28 yards

Take a round number 8000 yards, the length of the line will be:

So, 8333.28 yards are represented by 6″

1 yard will be represented by $\frac{6 \times 8000}{8333.28}$ inches

8000 yards will be shown by = 5.07 inches

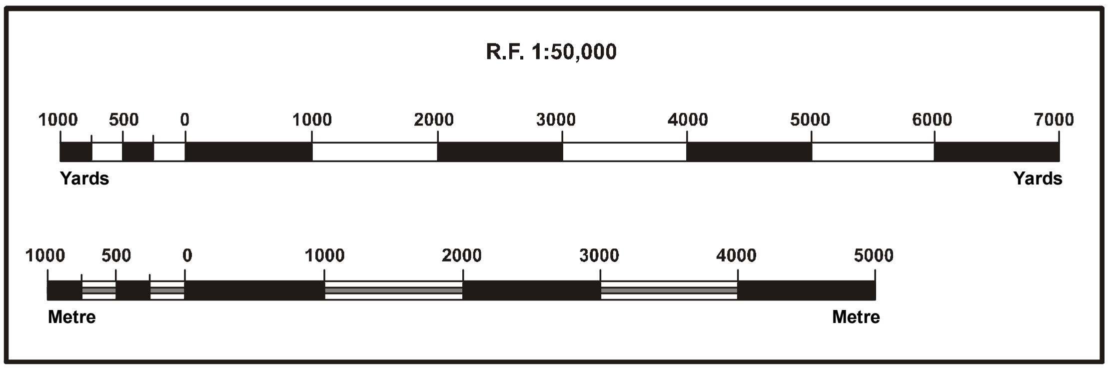


Fig. 3.8

Draw a line of 5.07 inches and divide it into eight equal parts and each primary division will represent 1000 yards. Divide the first left primary division into four parts and thus each part will represent 250 yards.

For metre : R.F. 1: 50,000

Or 1 cm = 50,000 cm. or 500 metres,

Suppose if we take a line of 12 cm. length, it will represent : 12cm × 500m = 6000m or 6 km.

Draw a line of 12cm. and divide it into 6 equal parts to represent one part or to say primary division 1000m. Divide the left side one primary division into 4 equal parts to represent one secondary division 250 metre. Draw this scale of metre just above the previous one. In this case, care should be taken that the zero point of the yard should coincide with the point of the metre scale.

Example 2: A map is on the scale of R.F. 1:100,000. Draw a comparative scale to read the distances in Mile-Furlong and Kilometer- Hectometer.

Solution: For mile: R.F. is 1:100,000

Thus 1 inch represents 100,000 inch

Then 6″ will represent $\frac{100000 \times 6}{63360}$ miles

$= \frac{625}{66} = 9.46$ miles

It is not the round figure.

If we take the round figure of 10 miles, in that case the length of the scale will be determined as follows:

$\because \frac{625}{66}$ miles are shown by a line of 6″

$\therefore$ 1 mile will be shown by a line of $\frac{6 \times 66''}{625}$

$\therefore$ 10 miles will be shown by $\frac{6 \times 66 \times 10''}{625} = 6.3''$

For km : 1 cm. represents 100,000 cm or 1 km.

Then 15 cm. will represent 1 km. × 15 = 15 km.

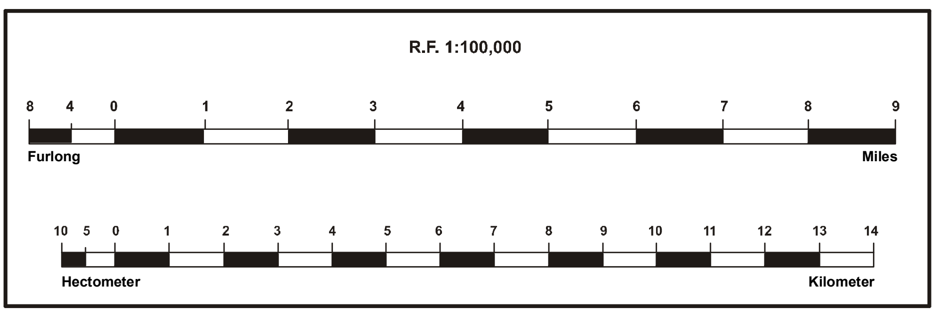


Fig. 3.9 Comparative Scale

Now, we will draw two straight lines separately. Firstly for mile, the length of the line is 6.3″. Divide this line into 10 equal parts to show the primary division of one mile distance. The left primary division will be divided into two equal parts. Thus, one secondary division will represent 4 furlongs. Secondly, for km. divide the line of 15 cm. into 15 equal parts. Thus one division as a primary division will represent 1km. To measure distance in hectometer, divide left primary division into two equal parts. Thus, one secondary division will measure the distance of 5 hectometer. Now draw the comparative scale on the basis that the zero of both the scales should coincide to each other.

Example 3: Draw a comparative scale for R.F. 1:1,000,000 to read the distances in Kilometer, statue miles and nautical miles.

For km. 1cm. represent 1000000 cm.

15 cm. will represent $\dfrac{1000000 \times 15}{100000} = 150$ km.

For Statue Mile : 1″ represents 100000 inches

6″ will represents $\dfrac{1000000 \times 6}{63360} = \dfrac{3125}{33} = 9469$ mile

Now $\dfrac{3125}{33}$ miles represented by 6″

1 mile represented by $\dfrac{6 \times 33 \times 100}{3125} = \dfrac{19800}{3125} = 6.336''$

100 miles will be represented by 6.3″

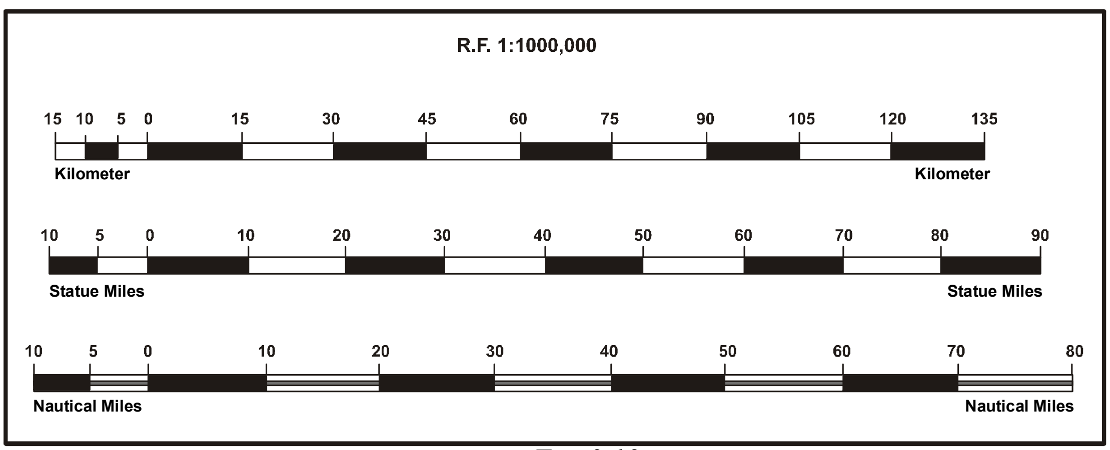


Fig. 3.10

For Nautical Miles :

Please see that one nautical mile = 72960 inches

1″ represents 1000000″

6″ will represent $\dfrac{1000000 \times 6}{72960}$ Nautical Mile $= \dfrac{100000}{1216}$

$= 82.236$

Take round figure of 90 nautical miles

$$\frac{100000}{1216} \text{ Nautical Miles are represented by } 6''$$

$$1 \text{ Nautical Miles are represented by } \frac{6 \times 1216}{100000}$$

$$90 \text{ Nautical Miles will be represented by } \frac{6 \times 1216 \times 90}{100000}$$

$$= \frac{729600}{100000} = \frac{656640}{100000} = 6.56''$$

90 Nautical Miles = 6.56″

For km. : Draw a line of 15 cm. and divide it into 10 equal parts, thus one part of primary division will represent 15km., divide one primary division into two secondary divisions of 500m each.

For Statue mile : Draw a line of 6.3″ and divide it into 10 equal parts and thus one primary division will represent ten miles, and divide one primary division into two equal parts and thus one secondary division will represent 5 miles.

For Nautical Mile- Draw a line of 6.56″ length and divide it into nine equal parts. Thus, one primary division will represent 10 nautical miles. Repeat the same process and divide one primary division into two equal parts, and it will give the measurement of one secondary division as 5 nautical miles.

(3) Diagonal Scale

Diagonal scale is that type of scale, by which we can read micro measurements. Besides giving primary and secondary divisions, a diagonal scale gives divisions which are smaller than secondary divisions. In a way, this scale is an elaboration of the graphical scale and brings considerable precision in map making. It can read upto three units of one measurement such as yard, feet, inch; km, hm and decameter; mile, furlong, yard.

A diagonal is conveniently used for dividing a short line into equal parts. Suppose the line AB is of one inch, and is to be divided into ten equal parts. Draw two perpendicular CA and DB of any convenient length and mark ten small equal division on both CA and DB. Now join the corresponding point of CA and DB by parallel lines. Now also divide CD and AB into ten small equal divisions. Now do draw diagonals join the C with the first division of AB line. Draw the other diagonals, repeat this process. In this way you will be able to measure the distances of 0.1 to 0.9 and 1.0.

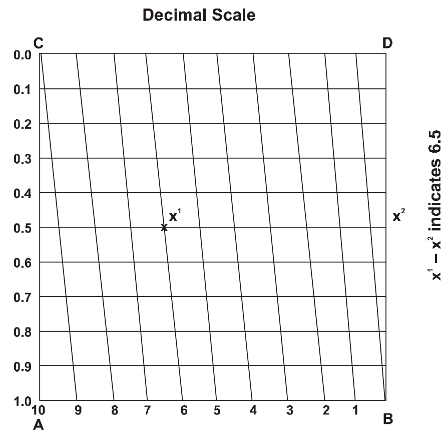


Fig. 3.11: Reading of Micro-Distance in a Diagonal

Example 1: Draw a diagonal scale for R.F., 1:50 to read the distances in hectometer and Decameter.

Here. 1cm.represents 50 cm.

15 cm. will represent $\frac{50\times15}{100}$ m = 7.50m

Suppose if we take the distance of 7m, then the length of the line will be

$=\frac{15\times7}{75}$ or $\frac{15\times10\times7}{75}$ = 14 cm.

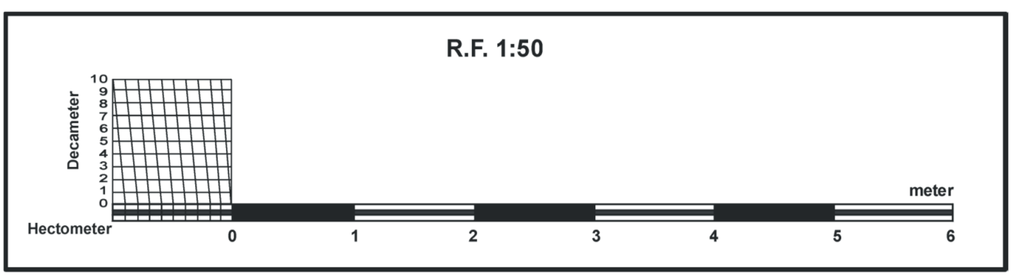


Fig. 3.12

Now draw a line of 14 cm. length, and divide it into 7 equal parts. One part will represent 1 metre as a primary division. Divide one primary division of extreme left into ten small divisions, thus one small division will give the measurement of 1 hectometer. To read one Decameter, draw 10 parallel lines of equal distance on the above of this primary division. And divide the top and bottom lines of this division into ten equal parts. Now draw diagonals on the basis as stated above, thus, one small part will give the measurement of one Decameter.

Example 2: Draw a diagonal scale for R.F. 1:36 to read the distances in yards, feet and inches. Mark the measurement of 3 yard, and 2 feet, 7 inches.

Here 1″ = 36″ or 1 yard, so that a line of 6″ length will represent 6 yards. Now draw a line of 6 inches and divide it into 6 equal parts. Each part as a primary division will represent one yard. Erect a rectangle ABCD as shown in Fig 1.13 and divide AB and CD draw 12 parallel lines to AB and CD with equal distances. Now divide the first primary division into three secondary divisions, thus one secondary division will represent one foot. To show the distance of one inch, join the diagonal lines as stated above. Now mark on the scale the distance of 3 yard 2 feet 7 inches.

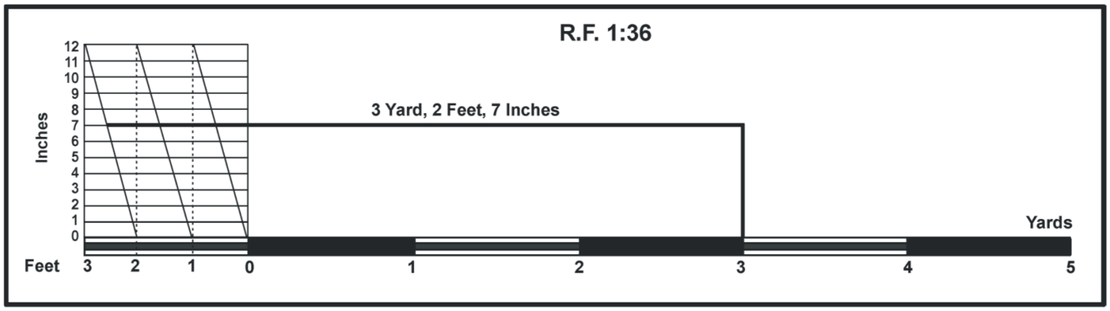


Fig. 3.13

Example 3: To read the distance of one hundredth part of a mile, draw a diagonal scale on R.F. 1:63360 and also show the distance of 1.56 mile on the scale.

Here 1″ represents 1 mile, as 1 mile is equal to 63360″. So now draw a line of 6″, and divide it into 6 primary divisions and thus, one primary division will represent one mile. Now divide the first primary division of the left side into ten secondary divisions, and, thus, the one secondary division will represent 0.1 mile distance. To read the distance of 0.01 mile draw 10 parallel lines to the main scale and on the left side primary division mark 10 points of equal distances on the upper most line of the scale. Join these 10 small distances with the diagonals.

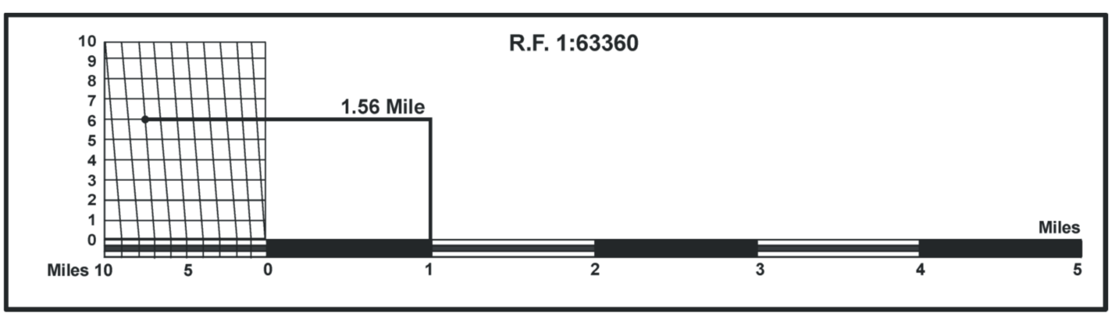


Fig. 3.14

3.4 SUMMARY

Map is the tool of a geographer. Map means its representation with certain scale. This scale has brought the earth or any part of it in a smaller size on the paper. Scale is the proportion of two distances, the distance between two points on the map and the corresponding distance on the ground. The scale that we choose, primarily depends on the size of area to be mapped, the amount of details to be shown and the size of our paper. Small scale represents the large area, while the large scale shows the small area. There are three methods of expressing the scale on the map. The statement method expresses the scale in words. The representation in the form of a fraction is known as Representative fraction, where the numerator denotes the distance on the map and the denominator indicates the distance on the ground. The graphical scale is the third method in which a straight line divided at certain intervals indicates the ratios of the ground and of the map. The linear scale is divided into primary and secondary divisions. The units of scale are shown in round figure on these divisions. The first primary division on the left side has the value of zero. The divisions on the scale are conveniently drawn with the help of a line of an acute angle.

The scale conversion in also necessary, as the statement scale and representative fraction scale both are substitutes to each other. But it is also important that the scale if it is shown by a line, in that condition, if the map is reduced or enlarged, it gives the correct measurement. In the case of R.F., it is not possible.

Graphical scale is also known as linear scale. The length of this scale depends on the size of paper, on which it is to be drawn. Linear scale shows the actual distances in round figure. It has primary and secondary divisions both, which help us to measure the small distances on the map. Linear scale has three main types-Plain, comparative and diagonal. Plain scale simply represents the measurement of distances. It shows the distances maximum in two units. Comparative scale measures the distances in two different units of measurement for example it shows the distances in km. and mile, meter and yard and so on. Diagonal scale is used to measure the micro-measurements. It gives the divisions smaller than the secondary divisions. It can read up to three units of measurements.

3.5 GLOSSARY

Scale: The ratio between two distances i.e. distance on a map and the actual distance on the ground between the corresponding points.

Linear Scale - A method of expressing scale with the help of a line.

One inch	= 25.4mm or 2.54 cm.
One mile	= 1.609347 km. or 1.61 km.
One foot	= 0.304801 metre
One square inch	= 6.452 sq. cm.
One square foot	= 0.09290 sq.m.

One square mile	= 2.59000 sq.km.		
One Acre	= 0.4047 hectare		
2.471 hectare	= one hectare		
One km.	= 10 Hectometer		
One Hm.	= 10 Decameter		
One Dm.	= 10 meter		
One M.	= 10 Decimeter		
One Dcm.	= 10 centimeter		
One Cm.	= 10 Millimeter		
One Nautical mile	= 72960 inches		
One Statue mile	= 63360 inches		
One Sq.km.	= 0.3861 sq.mile		
One Sq.m.	= 10.764 sq. feet		
One Sq. cm.	= 0.15500sq.inch		
Small scale means	=	5 km. to 1 cm.	Cover large area
Large scale means	=	10 cm. to 1 km.	Cover small area

Statement scale denotes the scale expressed in words such as

1cm to 1 km.

Representative fraction- A fraction of ratio between two distances, where numerator is one and denominator, in same units of length.

Graphical scale Means linear scale

Primary divisions	- The main divisions of the linear scale.
Secondary divisions	- The sub-division of a primary division.
Scale Conversion	- Denotes the conversion of scale in any method of expressing the scale.
Plain Scale	- represents the measurement of distance.
Comparative scale	- Measures distances in two different units of measurement.
Diagonal scale	- used to read the micro-measurements

3.6 ANSWER TO CHECK YOUR PROGRESS

- Scale is a ratio between two distances: Ground and Paper.
- Scale helps in true representation of the earth or part of it.
- The distances on the map are shown smaller because of the scale.
- Scale selection depends on size of area, details to be shown and size of paper.
- Small scale helps to show large area on a small size of paper.
- Large scale helps to show small area on a large size of paper.
- Statement method means to explain the scale in words.
- Fraction in the case of scale is called as representative fraction.
- Numerator of the fraction is always one,

- Denominator of the fraction is always in the same unit of length as is numerator.
- Denominator represents the distance on ground.
- The method of measurement of scale by R.F. is quite universal.
- R.F. is not fit or useable when the map is reduced or enlarged.
- Plain scale is a linear scale.
- Linear scale has primary and secondary divisions both.
- The divisions of linear scale are always put in round figure.
- The conversion of scale denotes that all the methods are substitutes of each other.
- Statement scale is conversable into representative fraction.
- Graphical scale is also called as linear scale.
- Graphical scale has specialized forms on the basis of various purposes.
- Plain scale simply represents the measurement of distances.
- Plain scale measures mainly the distances in two units of one length.
- Comparative scale measures the distances in two units of different length.
- Comparative scale has its drawing on one R.F.
- Diagonal scale helps in the measurements of micro-units.
- Diagonal scale is an elaboration of the graphical scale.
- Diagonal scale can read three units of one measurement length.
- Pace scale is based on the distance of the pace of man which is equal to 30 inches.
- Time scale shows the correlation between time or speed and distances.

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3.8 TERMINAL QUESTIONS

1. What is the meaning of scale. Explain it.
2. Discuss the methods to represent the scale with examples.
3. Discuss the importance of Scale.
4. Explain those factors, on which the scale depends.
5. What do you mean by statement, a method of scale.
6. What is representative fraction. Explain it with examples.
7. What is graphical scale. How a line of the scale is divided into primary and secondary divisions.
8. What is scale conversion. Define the conversion of scale into all three methods.
9. What points should be kept in mind at the time of construction of linear scale.

10. Discuss the various types of scale.
11. What is Plain scale. Discuss its chief characteristics.
12. Discuss the characteristics and importance of diagonal scale.
13. A comparative scale can be used for all units of measurements. Explain it.
14. A map is on scale 1:10,000, and the distance between A and B on the map is 5 cm. Find out the actual distance between these two points.
15. Draw a plain scale for R.F. 1:50,000 to read the distance in Km and metre.
16. An area of 81 sq. km. is shown by 9 sq.cm. on the map. Find out the R.F. of the map. Draw a plain scale to read the distance in km. and hectometer.
17. Draw a comparative scale for R.F. 1:200,000 to read the distances in km and miles.
18. Draw a comparative scale for R.F. 1:6000 to read the distances in yard and metre.
19. Draw a diagonal scale for R.F. 1:100 to read the distances in metre, cm and mm.
20. A train covers a distance of 100 km in 2 hours. This distance is shown by 5 cm. on the map. Find out the R.F. and draw a plain scale showing time also.
21. Draw a diagonal scale for R.F. 1:25, to read the distance in metre, decimeter and cm.
22. Draw a diagonal scale for R.F. 1:50 to read the distances in cm. Also mark the distance of 243 cm. on the scale.
23. Draw a diagonal scale for R.F. 1:36, to read the distances in yard, foot and inch. Also mark a distance of 4 yard 2 feet and 7 inches.
24. A map is on the scale of 1:25,000. Draw a diagonal scale to read the distances of hundred part of a km. Also mark the distance of 2.47 km. on the scale by a thick line.

BLOCK 2: MAP PROJECTIONS

UNIT 4: MEANING, DEFINITION, SHAPE, DISTANCE, AREA AND DIRECTION PROPERTIES

4.1 OBJECTIVES

In cartography, a map projection is a way to flatten a globe's surface into a plane in order to make a map. This requires a systematic transformation of the latitudes and longitudes of locations from the surface of the globe into location on a plane.

4.2 INTRODUCTION

To portray a spherical surface such as the Earth's simply, one could use a globe; this requires only a scale transformation. Relative distances and directions are not distorted. However, globes or even pieces of a spherical surface are not convenient and expensive. Thus we normally need a transformation to systematically handle the distortion when portraying a sphere on a flat surface.
Projections are methods for transforming the Earth's sphere like surface onto a flat plane in this systematic transformation locations in 3 dimensional spaces are made to correspond to a 2 dimensional representation.
The lines of latitude and longitude that appear on the map are called graticule. No graticule can be drawn without some kind of projection.

4.3 MEANING, DEFINITION, SHAPE, DISTANCE, AREA AND DIRECTION PROPERTIES

Quantitative properties of map projections

Map interpolation in the method by which round shape earth or any part of it is displayed on flat paper with the help of latitude longitude lines, map projection attempts to placing a right source in a globe and projecting shadows in cartography, a map projection is a way to flatter a globe's surface in to a plane in order to make a map. This requires a systematic transformation of the latitudes and longitudes of location from the surface of the globe in to location on a plane. There is no limit to the Number of possible map projection. The effect to display the round earth on flat paper with greater precision has started since then. Whereas Aristotle called the Earth as a proof round, after finding a local in Greek and Roman times used the latitude, longitude lines for the first plane. To make it on flat paper, by creating a distance of latitude, longitude, he created two conical projections.

Definition of map projection: -

- "A map projection is a means of representing the line of latitude and longitude of the globe on a flat sheet of paper "J.S.Stiers"

A map projection is an orderly system of Parallels and meridians used as a basis for drawing a map on a surface "A.N.Strawles"
Any regular system of parallel and meridians on which a map can be drawn, can be called a map projection "Erwin Raiza.

A sphere, unlike a polyhedron, cone, or cylinder, cannot be reformed into a plane, in order to portray the surface of a round body on a two-dimensional flat plane, you must first define a developable surface (i.e., one that can be cut and flattened onto a plane without stretching or creasing) and devise rules for systematically representing all or part of the spherical surface on the plane. Any such process inevitably leads to distortions of one kind or another. Five essential characteristic properties of map projection are subject to distortion: shape, distance direction, scale, and area. No projection can retain more than one of these properties over a large portion of the Earth. This is not because a sufficiently clever projection has yet to be devised; the task is physically impossible. The technical meanings of these terms are described below.

1-Shape (also called co formality)

Shape is preserved locally (within “small” areas) when the scale of a map at any point on the map is the same in any direction with this property are called conformal. In them, meridians (lines of longitude) and parallels (lines of latitude) intersect at right angles. An older term for conformal is orthomorphic (from the Greek authors, straight, and morpho, shape).

2- Distance (also called equidistance)

A map projection can preserve distances from the center of the projection to all other place on the map (but from the center only). Such a map projection is called equidistant. Maps are also described as equidistant when the separation between parallels is uniform (e.g., distance along meridians is maintained). No map projection maintains distance proportionality in all directions from any arbitrary point.

3. Direction

A map projection preserves direction when azimuths (angles from the central point or from a point on a line to another point) are portrayed correctly in all direction. Many azimuthally projection have this property.

In the third group of projection, correct bearings or azimuths are preserved. This quality is well achieved in zenithal projections in which the sphere is viewed from a point lying either at the centre of the globe, or at infinity. The line of sight in every case is normal to the map is required to show all directions correctly.

4. Scale

The second group of projection is known as conformal projection. It is relatively difficult to preserve the shape but for a very small area. Strictly speaking, only a few points of the sphere can be projected in their true form over a plane surface. In order to achieve the quality of orthomorphism, certain modifications need be mande. The scale is changed from point to point; it is true at one point in all the direction. It is possible to make some of the meridians and parallels true, i.e., equal in length to the corresponding one on the globe.

5.Area (also called equivalence)

A map can portray areas across it in proportional relationship to the areas on the Earth that they represent. Such a map projection is called equal-area or equivalent. Two older terms for equal-area are homolographic or homalographic (from the Greek homalos or homos-same, and graphs-write), and authalic (from the Greek autos same, and ailos-area). Note that no map can be both equal- area and conformal.

Of these, area and shape are considered major properties and are mutually exclusive. That means, that if area is held to its true form on a map, shape must be distorted, and vice versa. Distance and direction, on the other hand, are minor properties, and can coexist with any of the other projection properties. However, distance and direction cannot be true everywhere on a map as discussed below.

Anytime we create a flat map of a three-dimensional object, we must distort the three-dimensional object. Distortion is unavoidable when making flat maps of the earth. Distortion is not constant across the map, as distortion may take different forms in different parts of the map. There are few points were distortions are going to be zero, however. Distortion is usually less near the points or lines are placed will directly affect where the map will have the least and most amount of distortion.

A map can show one or more, but never all, of the following map projection properties at the same time: true direction properties and they remain mutually exclusive.

Preserving map projection properties

Here, we discuss different families of map projection which aim to preserve at least one of the map projection properties.

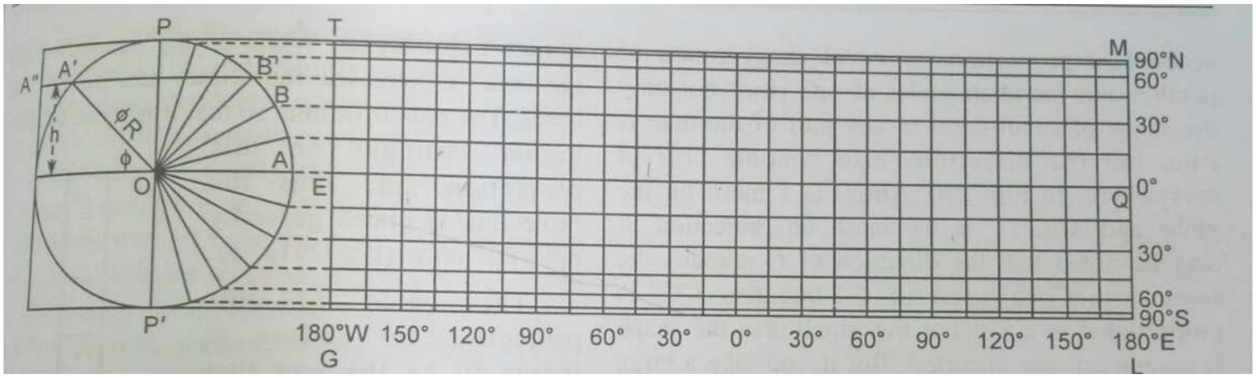
1. The equal area map projection, also known as the equivalent map projection, aims to preserve the area relationships of all parts of the globe. You can easily identify most equal area map projections by noting that the meridians and parallels are not at right angles to each other. Additionally, distance distortion is often present on equal area map projection, and, shape is often skewed.

   Even with the distortion of distance and shape. Equal area map projection is useful for genera quantitative thematic maps when it is desirable to retain area properties. This is especially useful for choropleth maps, when the attribute is normalized by area. Holding real properties. To be true, allows for an apple to apple comparison of density between different enumerations units, such as counties.

   The cylindrical equal area map projection is an example of an equal area, or equivalent map projection, which aims to keep the areal relationships of all parts of the globe correct.

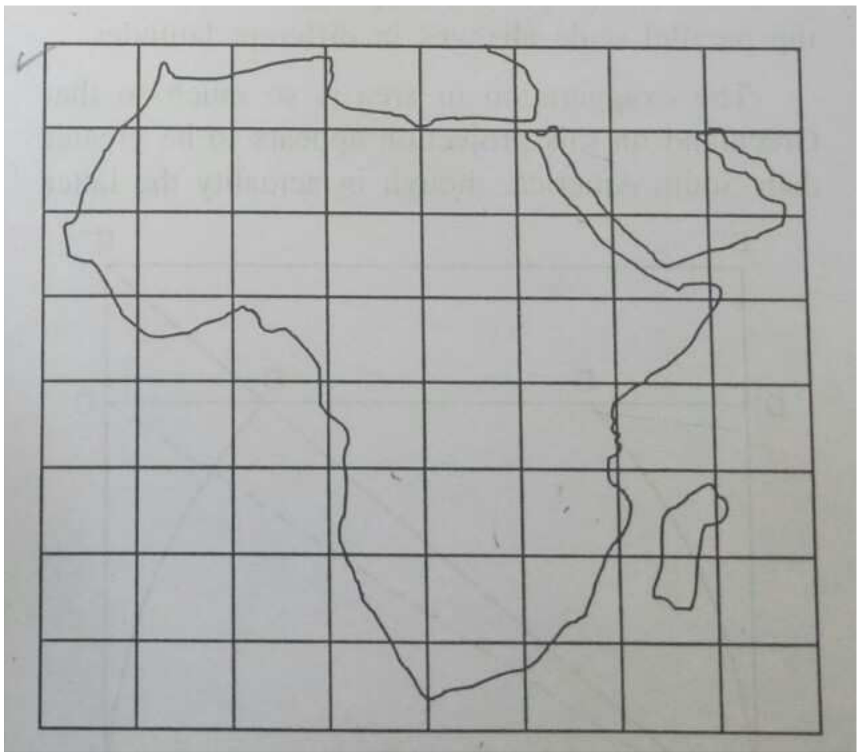
   A second example of an equal area projection is the hammer aitoff map projection. Again, like the cylindrical equal area projection, this map projection aims to hold areas true. Also note, that on this map projection, the parallels and meridians do not intersect at 90^0 angles, which is a hint that lets us know that this may be an equal area projection.

Fig-4.1 Cylindrical Equal (distance) Projection



Source; Elements of geography practical

Fig-4.2 Cylindrical Equal (Area) Projection



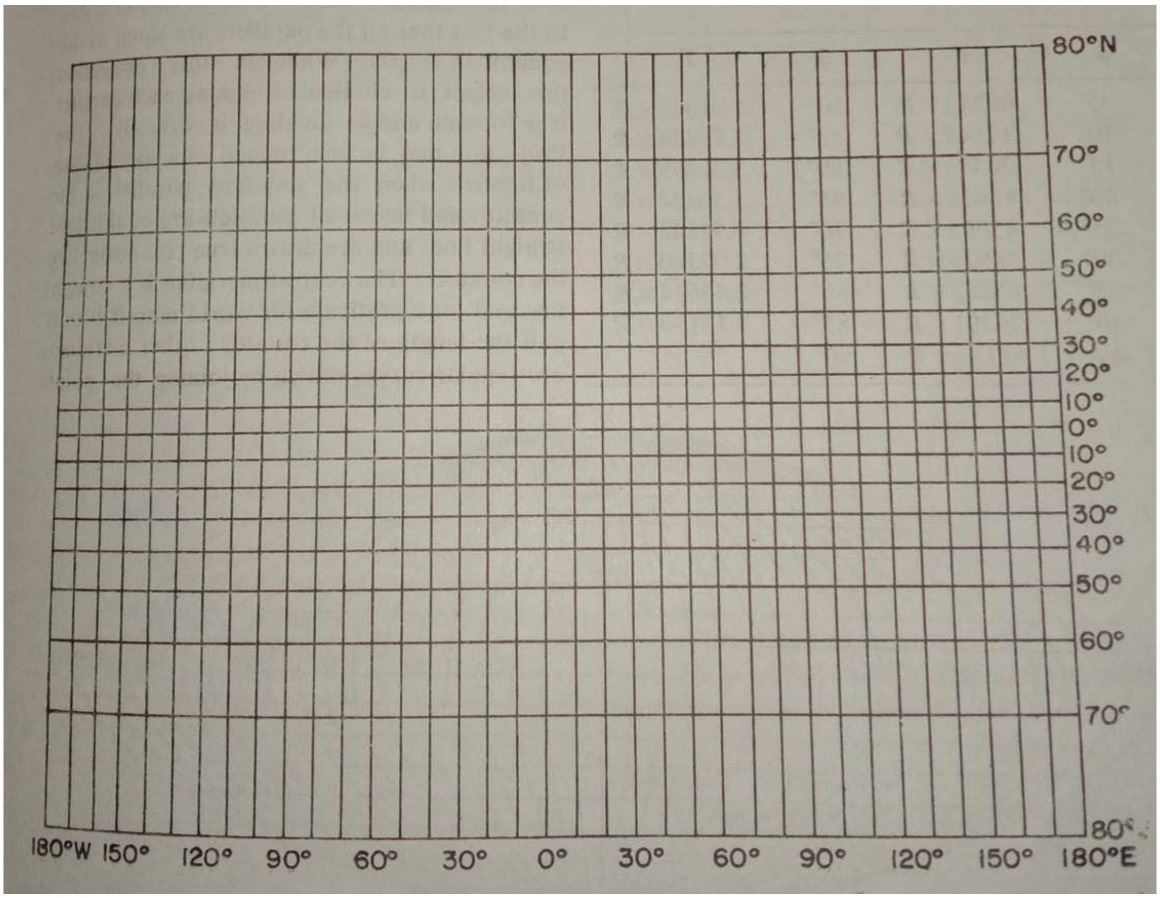
Source; elements of geography practical

2. Conformal map projection, also known as orthomorphic map projection preserves angles around points, and shape of small areas. Additionally, it allows for the same scale in all direction to or from a single point on the map. Conformal map projection can usually be identified by the meridians intersect parallels at right angles, areas are distorted significantly its small scales, and shapes of large regions may be severely distorted.

Even with the potential for large shape distortion. Conformal map projections are useful for large scale mapping and phenomenon with circular radial patterns such as radio broadcasts for average wind directions.

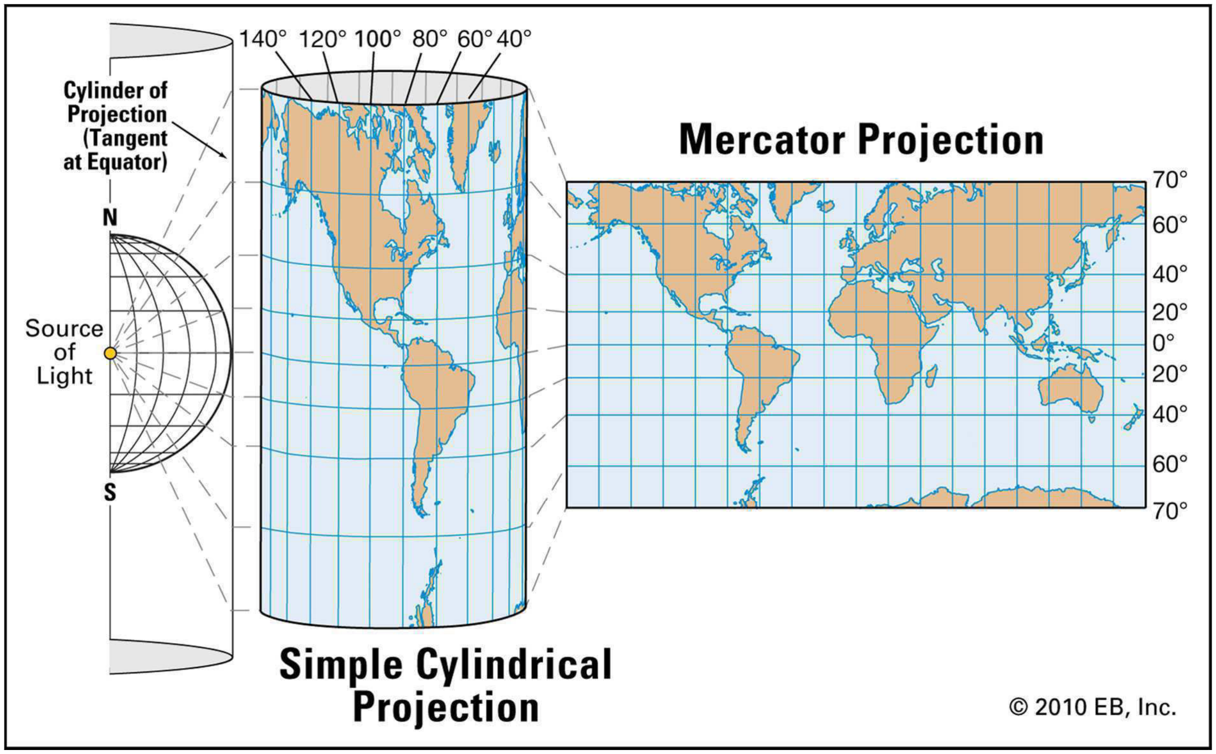
The Mercator projection, perhaps the most famous of all map projections, is a conformal map projection that preserves shape. However, notice the massive amount of distortion in the lower latitudes towards the South Pole, and the northern latitudes, near the North Pole. Also note that the parallels and meridians intersect at 90^0 angles.

Fig-4.3Mercator projection (distance)



Source; elements of geography practical

Fig-4.4 Mercator projection (Shape)



Source; elements of geography practical

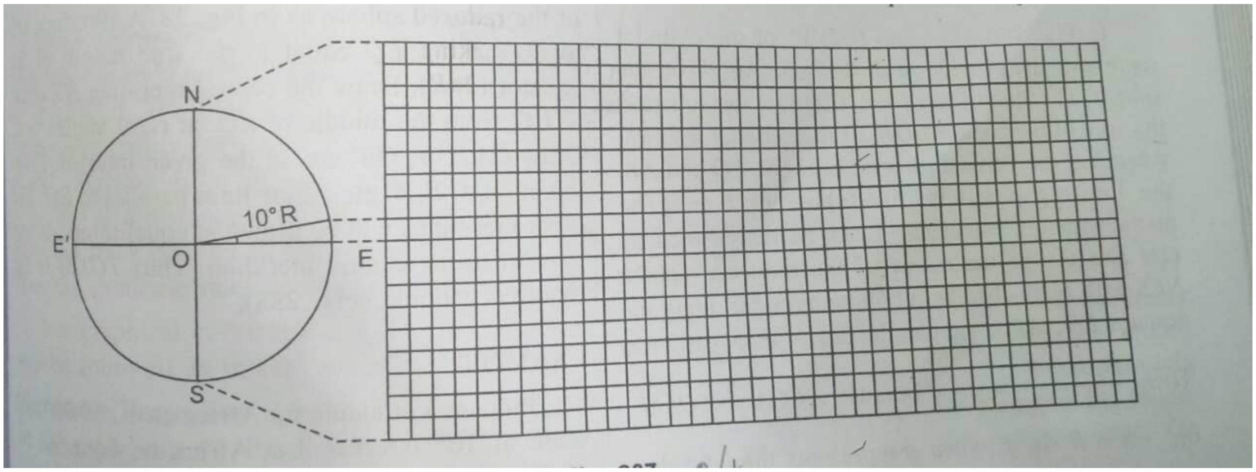
3. The third map projection family is the equidistant map projection which aims to preserve great circle distances. That means a distance can be held true from one point to all other points, or from a few select points, to others, but not from all points. It is also important to note the scale is uniform along these lines a true distance from the select points on the map. Identifying marks of the equidistant map projection are that they are neither conformal nor equal area and look less distorted.

Equidistant map projections are useful for general purpose maps and Atlas maps.

Example of an equidistant map projection is the equidistant cylindrical map projection. Notice that compared to the conformal map projection, there is less distortion at the North and South Pole, and the shapes also doing not look overly distorted.

The simple Cylindrical Projection is also known as the Equidistant Cylindrical Projection because in this projection both the parallels and meridians are equidistant. They are drawn as straight lines, cutting one another at right angles. As the distance between the parallels and meridians is the same, the whole network represents a series of equal squares. All the parallels are equal to the equator ($2\pi R$) and all the meridians are half of the equator in length. The scale along the equator is true. The meridian scale, i.e., the north-south scale is also correct everywhere on the map because the parallels are drawn at their true distances. But the latitudinal scale increases away from the equator; this leads to great distortion in shape and exaggeration of area in high latitudes. Therefore the projection is neither orthomorphic nor equal area.

Fig 4.5 Equidistant Cylindrical



Source; Elements of geography practical

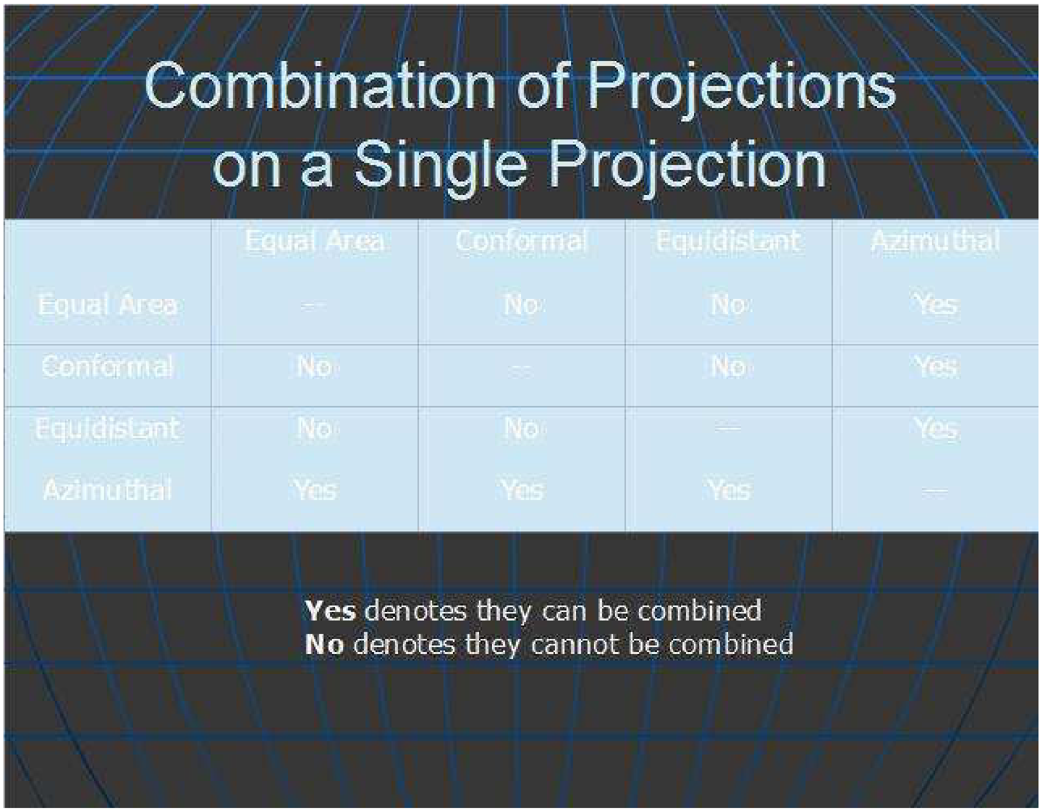
4. T1he azimuthal map projection, also known as the true direction map projection, preserves direction from one point to all other points in the map. Is important to note that direction is not true direction. Azimuthal map projection is most useful for preserving direction two or one from point, often used for navigation.
   The azimuthal equidistant map projection is an example of a true direction map projection that also holds distance to be true. While not all azimuthal map projections look like this, this map projection allows you to measure across the poles, and around the world, to determine true distance and direction from a single point.

Fig (4.5A) Azimuthally Equdistant Map Projection (Direction)

Source; Elements of geography practical

As seen on a few example map projection previously, we can combine map projectiles onto a single projection. For example, an equal area map projection can also combine parts of azimuthally map projection. Similarly, conformal can combine with azimuthally, and azimuthally can combine with equal area, conformal, and/or equidistant.

Fig (4.6)



	Equal Area	Conformal	Equidistant	Azimuthal
Equal Area	--	No	No	Yes
Conformal	No	--	No	Yes
Equidistant	No	No	--	Yes
Azimuthal	Yes	Yes	Yes	--

Source; Elements of geography practical

Fig (4.6A)

Source; Elements of geography practical

4.4 SUMMARY

In this chapter, we have given detailed information about map interpolation, under which the objective, introduction and construction of map interpolation, concept, definition, importance and shape of interpolation, distance area and the direction of each interpolation subject and the properties of each interpolation based on map interpolation. Detailed analysis is done. Under which it has been told about the composition and purpose of 8projection of map interpolation, which are the following.

1. Cylindrical Equal distance
2. Cylindrical Equal Area
3. Mercator Projection (distance)
4. Mercator Projection (Area)
5. Equidistant Cylindrical (Distance)
6. Azimuthally Equidistant Map Projection (Direction)
7. Comvination of Projections on a single projection
8. Robinson Map Projection

4.5 GLOSSARY

Quantitative= Measured by the quantity of something rather than its quality.
Projections= An image projected on a surface
Equidistance= “the line joins together all points which are equidistant from the two axes”
Orthomorphic= (of a map projection) preserving the correct shape of small areas.
Azimuthal= the azimuthal of a celestial body is the angle between the vertical plane containing it and the plane of the meridian.
Simultaneously= A file system which is simultaneously accumulated on multiple servers.
Cartography= The making of maps and charts.

4.6 ANSWER TO CHECK YOUR PROGRESS

Q1. What is a map interpolation?
Ans. Launching the line trap of the latitude and longitude limes of the globe on a flat paper is called map projection.

Q2. What is a line trap?
Ans. The line sequence formed by projecting the latitude and longitude lines of the cntire globe or any part of it on a flat paper is called a line mesh.

Q3. How many longitude lines?
Ans. The longitude lines are drawn 180^0 west from 0^0 longitude.

Q4. What is the net work of latitude and longitude lines called ?

Ans. A grid of latitude and longitude lines is called a gred.
Truth and false

- The longitude lines are 360^0 Yes/No
- The line drawn parallel to the globe at latitude $22\left(\frac{1}{2}\right)^0$ north of the equator is called the tropic of cancer. Yes/No
- Launching the line trap of the latitude and longitude limes of the globe on a flat paper is called map projection. Yes/No

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4.8 TERMINAL QUESTIONS

Q1. 01. Prepare a graticule for Africa on 1:50,000,000 scale at 10^0 intervals. Let Africa be bounded by 40^0S latitude and 20^0W and 60^0E long.

Ans. Trigonometrically Construction

According to the given scale the radius of the reduced sphere, i.e.,

$$R = \frac{250,000,000}{50,000,00} = 5''$$

Now with the formula H=R sinϕ, the intervals between the equator and the parallels may be calculated as in the

Table:1

ϕ	Sinϕ	R	h
10	0.17	5”	0.85”
20	0.34		1.70”
30	0.50		2.50”
40	0.64		3.20”

The distance between two meridians

$$=\frac{2\pi R(d)}{360} = \frac{2\times22\times5\times10}{7\times360} = \frac{2,200}{2,520} = 0.87''$$

Draw EQ and NS from the point O intersecting each other at right angles. Mark-off the points along NS at 0.85". 1.70", 2.50"and 3.20" distance from O. From these points draw the lines parallel and equal to EQ . Starting from O, also mark-off the point along EQ at a distance of 0.87". From these points draw the lines parallel to central meridian NS. Thus the graticule may be completed (Fig.02).

For graphical construction the same procedure may be followed as in Fig 1.1.

Q.2 Draw a graticule for the world map on 1:250,000,000 scale at 10^0 intervals.

Ans. On the given scale R= $\frac{250{,}000{,}000}{250{,}000{,}000} = 1"$

The length of the equator $= 2\pi R = \frac{2\times 22\times 1}{7} = 6.3"$

The interval between the meridians

$= \frac{6.3}{36}$ =0.175"

And 2.3026 R=2.3026"

Y, the distance between the parallels and the equator is given in Table 2.

TABLE -2

ϕ	45+ϕ/2	(45+ϕ2)	Y
10	50	0.07619	0.175"
20	55	0.15477	0.356"
30	60	0.23856	0.549"
40	65	0.33133	0.763"
50	70	0.43893	1.011"
60	75	0.57195	1.317"
70	80	0.75368	1.735"
80	85	1.05805	2.436"

Draw the equator, EQ=6.3". From the middle point O on it, erect perpendicularly the central meridian NS. Mark off the Y distance from O along ON and OS. From these points draw lines parallel to EQ . Divide EQ at equal distances of 0.175. From these points of division draw the meridians parallel and equal to NS. Thus the construction of graticule may be completed [see Fig 5.3].

Q.3 Prepare a graticule for the world map on the scale of 1:250,000,000 at 10^0 intervals.

Ans. On the given scale R=1" and the length of the equator $=\frac{2\times 22\times 1}{7} = 6.3"$

The true distance at which the parallels and meridians will be spaced is equal to $\frac{6.3\times 10}{360} = 0.17"$.

This may also be found out graphically. Draw a circle from the centre Q with 1 radius (Fig.5.4). Make the angle ROE=10^0. Now ER is the true distance at 10^0 intervals between the parallels and the meridians. Let the equator be represented by EQ. from its middle point O draw the central meridian NS at right angles to it. Make NS equal to half of EQ. divide EQ and NS into 36 and 18 equal division respectively. Each division will be equal to 0.17” or ER. From the points of division marked along them, draw lines parallel to the central meridian and the equator respectively so as to obtain other meridians and parallels. In this way the graticule may be completed as in Fig. 4.5

UNIT 5: CLASSIFICATION OF PROJECTION

5.1 OBJECTIVES

The purpose of map interpolation is to make a large terrain on a flat paper, whether is political or economic or related to the distance of a place through the latitude and longitude of that place. The map of the terrain is to be prepared by projection.

5.2 INTRODUCTION

The subject of map projection has itself expanded is harmony with the new needs consequent upon the expansion of sea, land and air travel, Man's activity is largely confined to the outer surface of the earth and he must, therefore, design plans and maps regarding the configuration of the earth and its parts for his numerous requirements. Thus a large number of projections were devised to represent the spherical surface on maps, charts and plans based on various map projections. There are now available a large number of projections out of which the geography may choose the most suitable for his purpose. Broadly speaking, equatorial regions are satisfactorily mapped on a cylindrical projection and Polar Regions on zenithal projection; several modifications of these projections have been made according to the purpose of the map. An important development has been the use of modified polyconic or international (I/M) projection for mapping the world in 2,222 independent sheets which can be assembled together.

Although for many mapping applications the earth can be assumed to be a perfect sphere, there is a difference between the distances around the earth between the poles versus the equator. The circumference of the earth is about 1/300th smaller around the poles. This type of figure is termed an oblate ellipsoid or spheroid, and is the three-dimensional shape obtained by rotating an ellipse about its shorter axis. An estimate of the earth's surface based on an ellipsoid provides a determination of the elevation of every points on the earth's surface, including sea level, and is often called a datum. Over time, and in different countries, many datum's have been developed and used. With more accurate means of measurement today (i.e. satellite and GPS), recent datum's are referenced from the center of the earth rather than a theoretical surface. The resulting North American Datum of 1983 (NAD83) and the slightly refined World Geodetic system(WGS84), from the U.S. Military in 1984, are internationally accepted as the geodetic reference system (GRS80). Map projection are used to transfer or "project"

5.3 CLASSIFICATION OF PROJECTION

Types of Map Projection

Many types of map projection are being used for map making. They are basically classified into four groups in accordance with the map projection Theory or the types of surfaces that are tangent with the globe. The four categories are planar, Azimuthally or Zenithal projection, Conic Projection, Cylindrical projection and Mathematical or Conventional projection. Map projection varies with the size and location of different areas on the earth's surface. While conical and

Zenithal projection are commonly used for mid-latitudes and polar regions, cylindrical projection are referred for equatorial lands. Not only that, projection also vary with purpose of the map.
1.Equal area or homolographical Projection.
2.Correct shape or orthomorphic projection.
3.;True bearing or azimuthal projection.

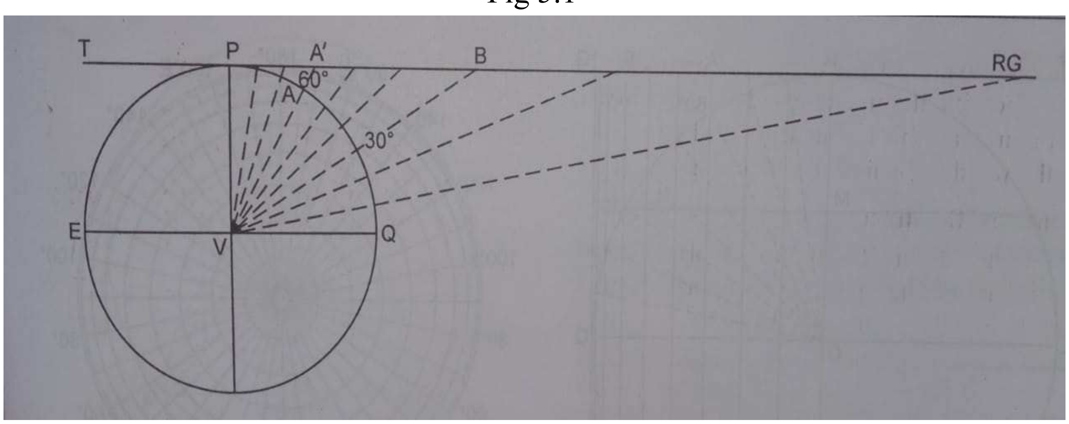
1.**Planar,Azimuthal or Zenithal projection**

This type of map projection allows a flat sheet to touch with the globe, with the light being cast from certain positions, including the centre of the Earth, opposite to the tangent area, and from infinite distance. This group of map projections can be classified into three types: Gnomonic projection, Stereographic projection and Orthographic projection. The latitude and longitude line mesh formed on a flat surface touching a globe any point is called Zenithal projection. Two groups are zenithal projection 1. Non-Perspective. 2. Perspective

A. Gnomonic Polar Zenithal Projection

In this projection the source of light is supposed to be at the centre of the sphere and the tangent touches either of the poles. Like the stereographic, it is also a perspective projection. It is impossible to draw the map of one hemisphere on this system because the equator becomes infinite (Fig 5.1). The scale increases very rapidly towards the margins of the map, and therefore the projection is suited only for small areas round the pole. There is one special merit in it due to which it is mostly used in charts for navigation: all great circles appear as straight lines because their planes pass through the centre of the sphere, where lies the source of light for this perspective projection. That is, if you want to find the shortest distance between two points on the map you need join them by.

Fig 5.1

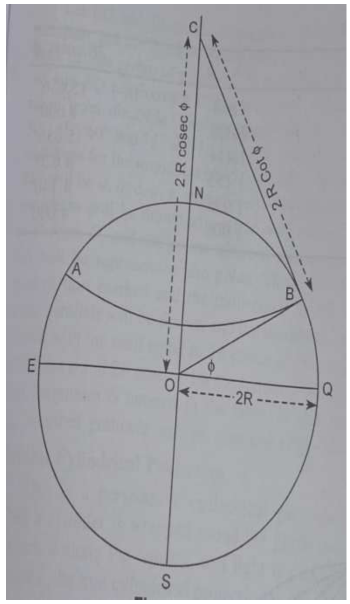


Source: Elements of Practical Geography

B. Stereographic Normal Zenithal Projection:

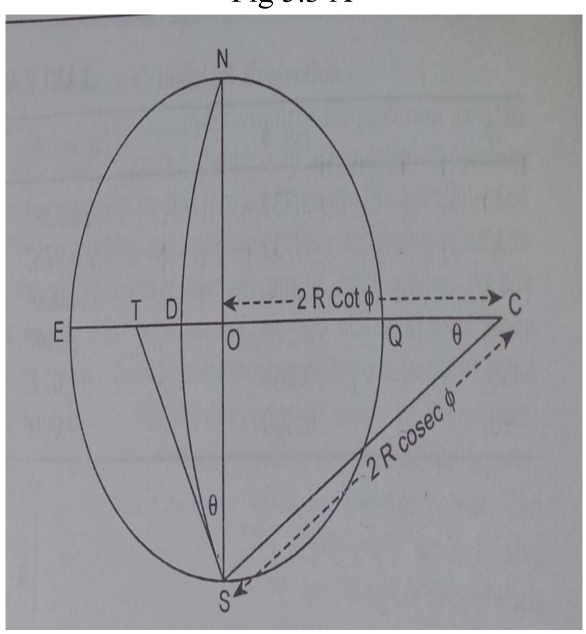
The Stereographic projection has its origin of light on the globe surface opposite to the tangent point. Like all other normal zenithal projections, in stereographic zenithal projection, the central meridian and the equator both are straight lines cutting each other at right angles. The globe is represented in hemispheres on this projection. But in all the stereo-pheres projections all angles on the sphere are reproduced equally in the projection and all the circular arcs are projected as circular meridian. The projection is, therefore, orthomorphic

Fig.5.2



Source; Elements of Practical Geography

Fig 5.3 A



Source; Elements of Practical Geography

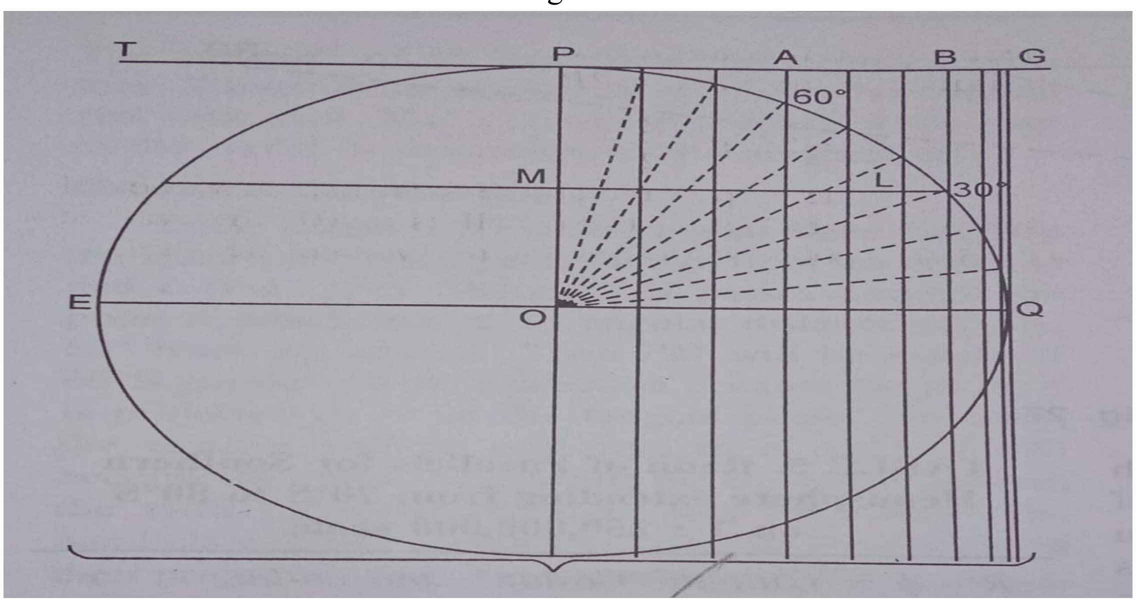
C. Orthographic Projection:

The scale of orthographic projection is most accurate at the tangent area. The more distant it is from the tangent points the more errors will occur. This type of map projection is commonly used for the Earth mapping

In this case light is thrown from a point at infinity, on the tangent plane touching the sphere at the pole. The rays of light passing through the latitude are parallel to each other (Fig 5.4).

In Fig 09 the rays from infinity pass through the latitudes and the point L is projected to B, the LB being perpendicular to TG, the parallel L(30^0) similarly the radii of other parallels may be found by dropping perpendiculars to the tangent plane from the corresponding points of latitudes, through which they are supposed to pass.

Fig.5.4



Source: Elements of Practical Geography

2.<u>Conic Projection:-</u>

This type of projection uses a conic surface to touch the globe when light is cast. When the cone is unrolled, the meridians will be in semicircle like the ribs of a fan. The tangent areas of conic projection can be classified as Simple Conical Projection with one standard Parallel, Simple Conical Projection with two Standard Parallel, Polyconic Projection.

- **<u>Simple Conical Projection with one standard parallel:-</u>**

In this interpolation, the contraction of the globe touches the clock at one latitude. This interpolation can be composed by leaving the latitude standard to any latitude circle except the equator and pole. The composition of this interpolation is very simple as compared to other cone projections. This interpolation is used to make maps of small countries located in the middle latitudes. In addition, maps of such territories are also made on this earth. Those who have less latitudinal expansion.

- **Simple Conical Projection with two Standard Parallel:-**

This interpolation is a modified form of ordinary cone interpolation with standard latitude. The composition of this interpolation is based on the assumption that the paper cone enters the globe and cuts or touches the surface of the globe using two latitude circles, both of which are considered standard latitudes. The cone interpolation of two standard latitudes is sometimes called the boreal conic interpolation. But it is flawed to say so. Because the distance between the two standard latitudes in the same as the distance between them. While the arcular distance is used in cone interpolation of two standard latitudes.

In this map on the interpolation, as the distance from the standard latitudes increases, the shape of the regions and the deformation in the area begin to increase. In Europe and Australia, this projection has been used a lot to make maps of different countries or states.

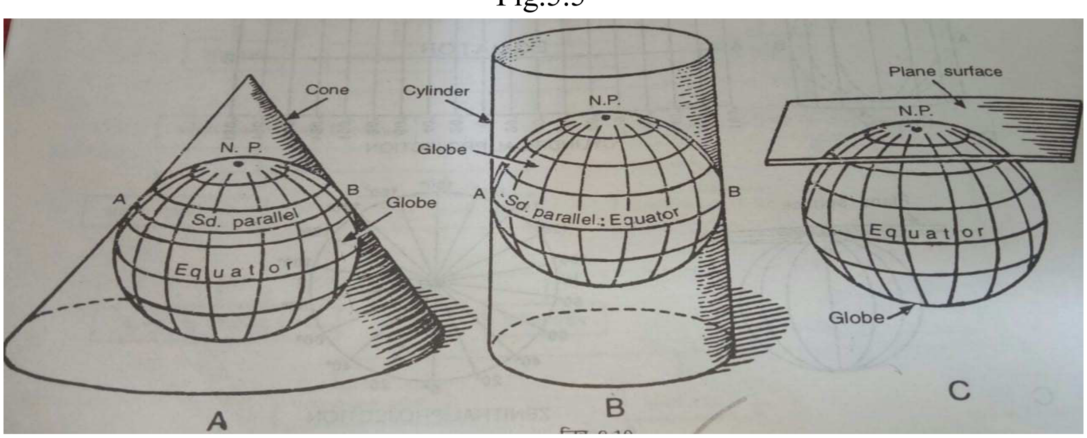
- **Polyconic Projection:-**

The polyconic projection was developed by Ferdinand Hassler, an American cartographer and surveyor. In principle it represents the piling up of as many hollow cones as the circles of latitude to which they closely correspond. Thus all the cones are tangent to the sphere along the corresponding parallels of latitudes, all of which subsequently become standard parallels.

3. Cylindrical Projection

After projection a geo grid on the outer surface of a hollow cylinder of paper, the latitude and longitude line mesh obtained from spreading the paper flats is called cylindrical interpolation. The area close to tangent point will be more accurate. The more distant it is from tangent points the more distortion will be shown. This type of projection is typically used to map the world in particular areas between 80 degrees north and 80 degrees south latitudes. The cylindrical projection is classified into three types:

Fig.5.5



Source; practical geography J.P.Sharma

❖ **Cylindrical equal area projection**

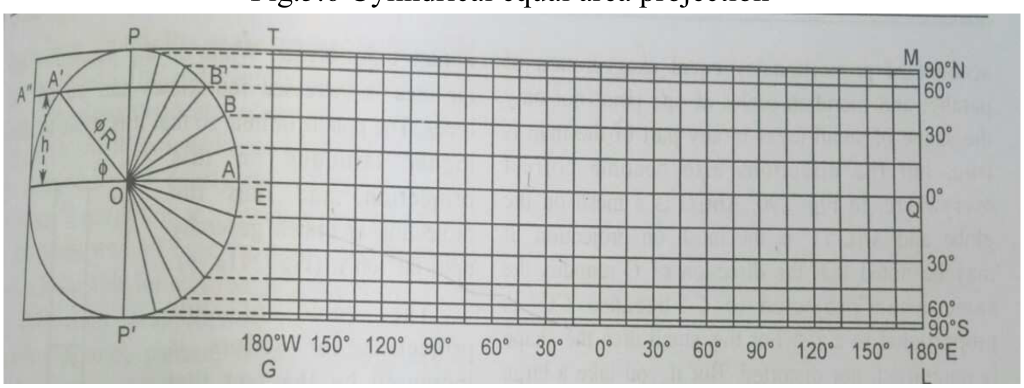
The equal area map projection, also known as the equivalent map projection, aims to preserve the area relationships of all parts of the globe. You can easily identify most equal area map projections by noting that the meridians and parallels are not at right angles to each other. Additionally, distance distortion is often present on equal area map projection, and, shape is often skewed.

Even with the distortion of distance and shape. equal area map projection is useful for genera quantitative thematic maps when it is desirable to retain area properties. This is especially useful for choropleth maps, when the attribute is normalized by area. Holding areal properties. To be true , allows for an apple to apple comparison of density between different enumeration units, such as counties.

The cylindrical equal area map projection is an example of an equal area, or equivalent map projection, which aims to keep the areal relationships of all parts of the globe correct.

A second example of an equal area projection is the hammer aitoff map projection. Again, like the cylindrical equal area projection, this map projection aims to hold areas true. Also note, that on this map projection, the parallels and meridians do not intersect at 90^0 angles, which is a hint that lets us know that this may be an equal area projection.

Fig.5.6 Cylindrical equal area projection



Source: Elements of Practical Geography

❖ <u>**Gall's stereographic cylindrical projection**</u>

This is a stereographic cylindrical projection quite akin to Mercator's but it differs from the latter in that it is not ortomorphic. In Gall's the distance between the parallels is reduced to avoid too much exaggeration of area towards the poles; while in Mercator's the distance between the parallels increases proportionately so that shape may be truly preserved. Gall's projection is also not equal in area, but as the distortion in higher latitudes is not much, it is used for general world maps in preference to other cylindrical projections. This projection is made on a cylinder which is supposed to pass through the globe halfway in all cylindrical projections, are equidistant vertical straight lines. The 45^0N and 45^0S parallels are true to scale and all other parallels are equal to its length. Thus from these two parallels meridian and parallel scales decrease towards the equator and increase towards the poles.

- **Mercator Projection**

Mercator invented this type of projection in the 16th century and it has been commonly used ever since. This projection uses a cylinder to touch a globe at the equator plane and cast the light for meridians and parallels to appear on cylindrical surface. Meridians are straight lines and equally spaced, while parallels are straight lines but their spacing increases as they get closer to the poles.

Shapes are represented more accurately in tangent point area. However, the closer to the poles, the more distortion occurs. Therefore, it is not typically used to make a map in areas above 80 degrees north latitude and below 80 degrees south latitude.

The Mercator projection is being applied in varying patterns, such as by taking a cylinder to touch a globe with the axis of cylinder intersecting that of globe at the right angle, leaving the cylinder to touch any single meridian. By that way, a central Meridian is created. When the cylinder is unrolled, the area adjacent to the central meridian will have constant scales. This type of projection is called Transverse Mercator projection, which is used in the making of Thailand's geographic map.

4 Mathematical or Conventional Projection

These projections are obtained from mathematical calculation and classified into three types.

a. **Mollweide homolographic Projection**

This type of projection is commonly used to display different parts of the Earth. It maintains area around the central meridian. The equator is a straight horizontal line intersecting the central meridian at a right angle. Other meridians are curved lines, while other parallels are straight lines. This map projection was initiated by Karl B. Mollweide in 1805. Its disadvantage is the distortion at the Earth's polar regions. However, there is more scale accuracy in the equatorial regions. The projection is ideal for making global maps.

b. **Sinusoidal projection or Samson Flamsteed Projection**

All the parallels are straight lines perpendicular to a central meridian, while other lines are curved like those in the Mollweide projection. The values of sine curves are used to create meridians, making the meridian spacing wider than that of the Mollweide projection. The Sinusoidal projection is typically used for map making of the equatorial regions such as in South America And Africa.

c. **Homologize projection**

This type of equal-area projection is a combination of the Homolographic and the Sinusoidal. Normally, the Sinusoidal projection is applied between the 40 degrees south and 40 degrees north latitudes, grafted to the Homolographic in the areas out of the abobe-mentioned range. As the two projection cannot match perfectly, small kinks are seen on the meridians where the two projections match.

Projection Distance, Area, and Shape

- Equal area projections preserve the property of area. On an equivalent projection all parts of the earth's surface are shown with the correct area, however, latitudinal distances are never accurate.
- Conformal projection preserves right angles between lines of latitude and longitude and is primarily used because they preserve direction. Area is always distorted on conformal maps. Because of GIS'S emphasis on cartographic shapes, GIS systems often use conformal projections.
- Some projections only preserve correct distance relationships along a few lines on the map. For example, an equidistant azimuthally projection has the distance to the outside of the map portrayed correctly. These are seldom used in GIS.
- A final category is compromise maps. They may be the average of two or more projections or interrupted or broken in order to minimize certain distortions.

Common GIS Projections

- Mercator- A conformal, cylindrical projection tangent to the equator. Originally created to display accurate compass bearings for sea travel. An additional feature of this projection is that all local shapes are accurate and clearly defined.
- Transverse Mercator- Similar to the Mercator except that the cylinder is tangent along a meridian instead of the equator. The result is a conformal projection that minimizes distortion along a north- south line, but does not maintain true directions.
- Universal Transverse Mercator (UTM)- Based on Transverse Mercator Projection centered in the middle of zones that are 6 degrees in longitude wide. These zones have been created throughout the world.
- Lambert Conformal Conic- A conic, conformal projection typically intersecting parallels of latitude, standard parallels, in the northern hemisphere. This projection is one of the best for middle latitudes because distortion is lowest in the band between the standard parallels. It is similar to the Albers Conic Equal Area projection except that the Lambert Conformal Conic projection portrays shape more accurately than area.
- State Plane- A Standard set of projection for the United States Based on either the Lambert Conformal Conic or transverse Mercator projection, depending on the orientation of each state. Large states commonly require several state plane Zones.

- Lambert Equal area- An equidistant, conic projection similar to the Lambert Conformal conic that preserves areas.

- Albers Equal Area Conic- This conic projection uses two standard parallels to reduce some of the distortion of a projection with one standard parallel. Shape and linear scale distortion are minimized between standard parallels.

Fig.5.7

Source; elements of geography practical

5.4 SUMMARY

Whatever interpolation is used for map-making, the countries in the middle latitude, the area of the standard latitude and the standard latitude, the net area, the net area, the met shape. Useful to show the right direction and make a general map

The use of pure measurements in mapping all the Earth and continents in the mapping of tropical regions of south America concerning the Arctic regions of Namonic interpolation. Malvular trajectories and net maps for Atlas construction to show the distribution of the world to make hemispherical maps Sinusailled trajectories are constructed to make the trajectories Though the maps can be properly studied and constructed and through projection, we can get special information.

5.5 GLOSSARY

- **Non-prospective**= A technique of depicting volumes and spatial relationships on a flat surface.
- **Perspective =** A particular attitude towards or way of regarding something; a point of view.
- **Stereographic=** The stereographic projection is a particular mapping that projection a sphere onto a plane.
- **Conventional projection=** It is a pure mathematical constructions designed to map the entire sphere with minimal distortion.
- **GIS=**Geographical Information Systems

5.6 ANSWER TO CHECK YOUR PROGRESS

Q1. What is cylindrical interpolation?
Ans. The process of displaying a network of latitude and longitude lines on a globe through a cylindrical plane is called cylindrical interpolation.

Q2. Describe the major types of conical side?
Ans. Conical projection is as follows.
Simple Conical Projection with one standard Parallel.
Simple Conical Projection with two Standard Parallel.
Bone projection.
Polyconic Projection.
International projection.

Q3. How is the length of the equator found?
Ans. Equator lines =$2\pi R$
Where $the\ value\ of \pi \frac{22}{7}$ and R is the radius.
Q4. which projection is best for the projection of rubber in the world?
Ans. Cylindrical equal area projection is best for showing the production of rubber in the world.

Q5. What is the different type of projection based on light?
Ans. There are two types of projection based on light.
1. Perspective 2. Non- perspective.

True and False

- When the conical of the Paper touches the globe on one of the latitude lines, it is called a standard normative latitude projection. True / False
- The distance between the latitude lines decreases when the equator to the pole. True/ False
- The pole is represented by a straight line. True/False

- The latitude lines are parallel and equal to the equator. True/ False
- Is there are 5 types of conical projections. True/ False

5.7 REFERENCES

- Elements of Practical Geography (R.L.Singh and Rana P.B. Singh) 2019.
- Elements of Practical Geography (R.L.Singh) 1979.
- Practical Geography (J.P. Sharma 2008-09)
- Practical Geography (Dr. Chaturbhuj Mamoriya and Dr. M.S.Sisodiya) Specimen copy S.B.P.D Publications.

5.8 TERMINAL QUESTIONS

Q1. If a graticule is prepared for north polar region on polar Gnomonic projection, (a) what will be the extent of error in the area in the zone lying between 65^0N and 75^0N latitude, and (b) what will be the error in the scale along 65^0N latitude ?

Ans. As per example

A=$2\pi R^2(sin75^0 - sin65^{0)}$

And A1=$\pi R^2(cot^2 65^0 - cot^2 75^0)$

=$\pi R^2(cot65^0 - cot75^0)\ (cot65^0 + cot75^0)$

=$\pi R^2(0.4663 + 0.2679)(0.4663 - 0.2679)$

=$R^2 \times 0.7342 \times 0.1984 = R^2 \times 0.1457$

Therefore, percentage error in area

=$\frac{(A1-A)\times 100}{A}$

=$\frac{\{\pi R^2 \times 0.1457 - 2\pi R^2(\sin 75^0 - sin65^0)\}}{2\pi R^2(\sin 75^0 - sin65^0)} \times 100$

=$\frac{\{\pi R^2 \times 0.1457 - 2\pi R^2(0.9659 - 0.9063)\} \times 100}{2\pi R^2 \times 2(0.9659 - 0.9063)}$

$$= \frac{2\pi R^2(0.1457 - 0.1192) \times 100}{2\pi R \times 0.1192}$$

$$= \frac{0.0265 \times 100}{0.1192} = \frac{2.6500}{0.1192} = 22.2315\%$$

Therefore percentage error in the area will be 22.315%

(b) As per example

L=$2\pi R.cos65^0$

L1=$2\pi R.cot65^0$

Therefore percentage error in scale

=$\frac{(L_{1-L)}\times 100}{L}$

=$\frac{(2\pi R.cot65^0 - 2\pi R.cos65^0)\times 100}{2\pi R\ cos65^0}$

$=\frac{(0.4663-0.4226)\times 100}{0.4226}$

$=\frac{0.0437\times 100}{0.4226}$

$=\frac{4.3700}{0.4226} = 10.3407\%$

Percentage error in the scale= 10.3407%

Q2. To construct a graticule on simple conic projection on 1.25,000,000 scale at the interval of 5^0 for an area stretching between 50^0N 70^0N and 5^0E-35^0E,

Ans. Let the standard parallel be 60^0N which will be the central parallel of the area and 20^0 E be the central meridian. The radius of the sphere on the given scale

$$= \frac{250{,}000{,}000}{25{,}000{,}000} = 10''$$

Graphical Construction

Draw a circle AEQ with 10" radius. From its centre O draw OA, making them $< EOA = 60^0$. From the point A, drawn AV as tangent to the circle at A to meet the polar diameter produced at V. Now VA is the projected radius of the 60^0north latitude line. Make the $< rOQ = 5^0$, the given interval between two parallels. Or is the true distance between two parallels at 5^0 interval. With centre O and radius Or describe a semi-circle which centre OA at the point a. from a draw ab parallel to EO, the line ab meeting OV at b. Thus ab is the longitudinal distance between two meridians at the interval of 5^0 along standard parallel (Fig 13).

Then draw VO in the centre of the paper. With centre V and radius VA draw the are ACB. From C mark-off the points Y, Z, M, L along VO, making, CY, CM, YZ and ML equal to Qr. With centre V draw concentric arcs passing through L, M, Y, and Z respectively. Similarly mark along the are ACB longitudinal points at distance equal to ab. Draw straight line from V passing through the points thus marked. In this way complete the graticule for the area.

Trignometrical Construction

The projection radius of the standard parallel

=R cot 60^0 = $10 \times 0.58 = 5.8''$

The length of the standard parallel

$= 2\pi r \cos 60^0$

$$\frac{2 \times 22 \times 10 \times 0.5}{7} = 31.4''$$

The distance between the two meridians along the standard parallel

$$\frac{31.4}{360} \times 5 = 0.44''$$

The true distance between the two parallels at 5^0 interval

$$= \frac{2\pi R}{360} \times 5 = \frac{55}{63} = 0.87''.$$

The construction may now be completed as in the foregoin, to produce the require graticule (Fig 13A)

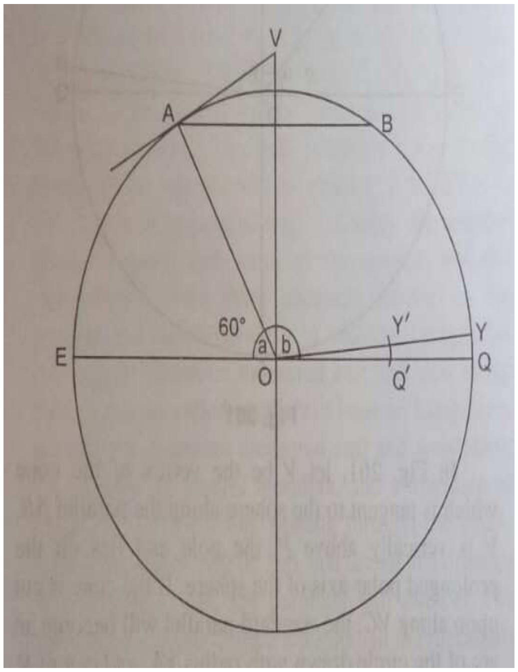


Fig (13)

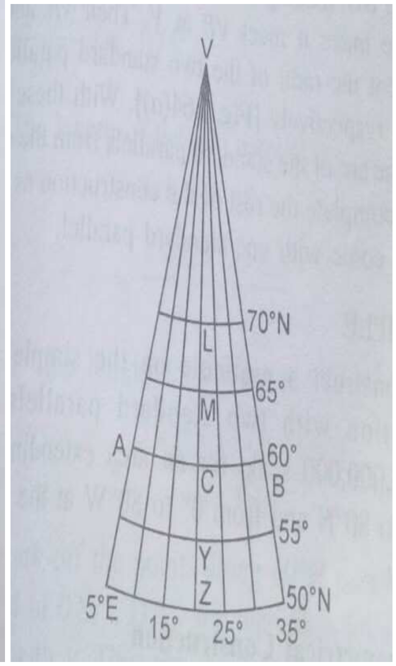


Fig (13A)

Source Elements of Practical Geography

Q3.To constructs a Galls projection for the world map on 1:250,000,000 scale at 15^0interval.

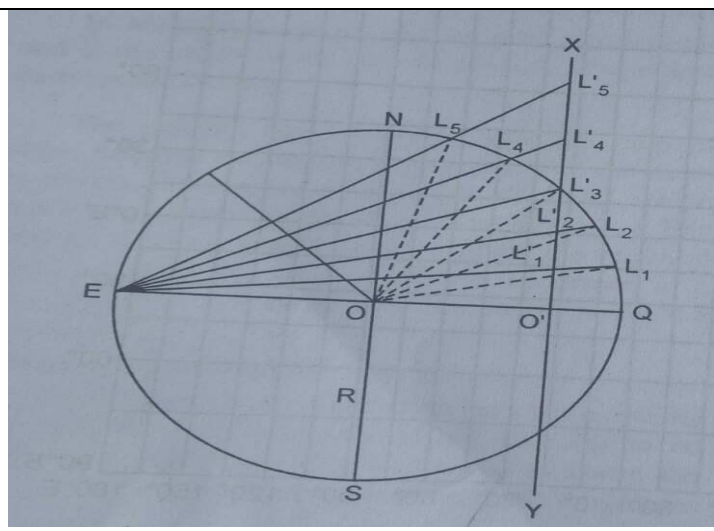
Ans. Let NES be a circle with one inch radius, according to the given scale. Draw EQ and NS to represent the equatorial and polar diameters respectively. Mark the angles 15^0,30^0,45^0,60^0,75^0 along NQ and Qs arcs. Let the cylinder pass vertically through 45^0N and 45^0S, cutting EQ at A and B. Let the rays of light pass from E through the various latitudes. Thus N is projected to N' and S to S' a, b, c latitudes 75^0, 600, 450, etc., a,b,c, etc. along N'S' which is equal to the length of a meridian. From the points a,b,c, etc. straight lines parallel to EQ may be drawn to represent the parallels which will be equal in length to that of 45^0 parallel. The length of the parallel of 45^0 may be easily found out. Measure OB which is the radius of the latitudinal circle of 45^0 and multiply it by 2π to get its length. It may also be calculated as follows:

In the right- angled triangle OBC, OC=R and $< Boc = 45^0$. Thus BO=R $\cos 45^0$. Therefore the length of the circumference of the circle drew with the radius OB and R, the radius of the reduced sphere. Now, the distance between the parallels and the equator may also be calculated. The formula 2R tan Z/2 has been used for this purpose in the stereographic polar zenithal projection. In this case it will be a little different. In the right angled $\Delta CBE, = tan < CEB = tan^{1/2}$ϕ when ϕ the latitude is.

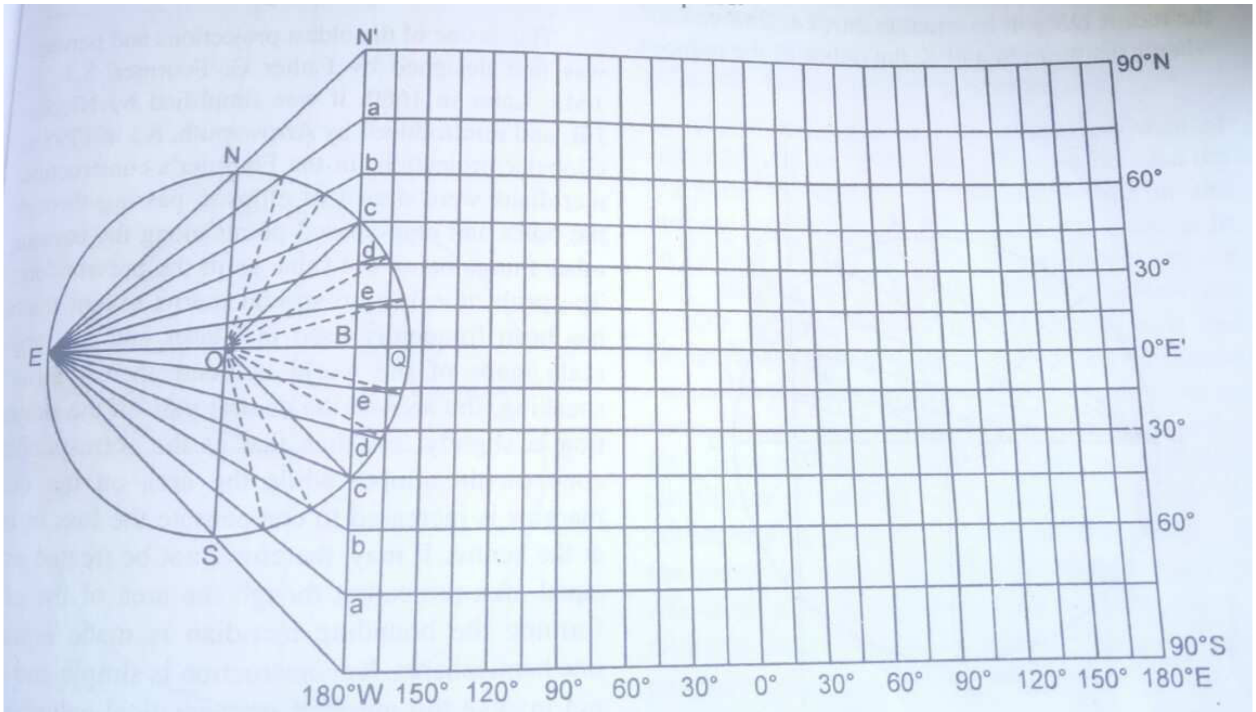
Therefore BC=EB tanϕ2=(EO+OB) tanϕ/2=(R+Rcos45^0) tanϕ/2 = 1.7071, R=1. With this formula the value of Bc, Bb, Ba, etc., may be found out as shown in the Table16.

TABLE 3

ϕ	ϕ/2	tanϕ/2	Y=(distance between parallel and equator)
15	$7^0 30'$	0.132	0.23”
30	$15^0 0'$	0.268	0.46”
45	$22^0 30'$	0.414	0.71”
60	$30^0 0'$	0.577	0.99”
75	$37^0 30'$	0.767	1.31”
90	45^0	1.000	1.71”
The table has been reproduced from Element of Map Projection by Steers, J.A.,			



(Fig. 14) Source; elements of geography practical



Source Elements of Geography (Fig 14A)

UNIT 6: SELECTION OF A PROJECTION

6:1 OBJECTIVES

Based on the population projections made by the Jordanian, Palestinian and Israeli departments of statistics, an assessment has been made of the total population. Objectives can be a single lens or mirror is elements. There are used in microscopes telescopes, cameras, slide projection CD players and many other optical instruments, objectives are also called objective lenses, glasses and Eyepiece.

6:2INTRODUCTION

Projection is used to project required column data from a relation. Note: By Default projection removes duplicate data. Selection is used to select required tuples of the relations. Will select the tuples which have c more than three

To map tropical regions, use a cylindrical projection
To map middle latitude, use a conic projection
To map a polar region, use an azimuthally projection

6:3 SELECTION OF A PROJECTION

Choice of the map Projection

The study of projection may lead us to think that a variety of projection has been evolved not by chance but under the spur of some specific purpose and difficulty which we are confronted with while transferring the various parts of the globe over a plane surface. As we have already seen, some projection truly represents the equatorial land and others may conform with the polar areas. Moreover, some are true to area and some, to shape and direction. At the same time while it is easier to draw some and also simple to find out calculation for others, we may also find that certain projections are too complicated.

Arc Map can help. Arc Map has a large number of predefined projections organized by world, continent, and country. You can navigate quickly to appropriate projection for any of the world.

Distortion is often insignificant. When you're working at large scales-for example, provinces or district within countries- distortion doesn't play a significant role, and almost any projection that is centered on your area of interest is okay. To put it more picturesquely, you can't flatten a beach ball without a lot of distortion, but you can flatten a postage stamp on a beach ball.

You're not stuck with a bad choice. It's easy to change projections and to modify projection parameters in Arc Map. So it's almost never too late to correct a flawed choice.

You don't always have to choose. You may be working on a projection or for an organization where the question of which map projection to use has already been decided. For example, the State plane and UTM coordinate systems are established standards for many large and medium-scale maps of U.S. states. (you'll learn about these coordinate systems and the projection they are based on in the next module.

Concepts:

(1) Whether it is required to project the globe as a whole or a part of it and what is the size and extent of the area for which the graticule is needed?
(2) What is the purpose of the map?
(3) Whether it is easier to calculate and to draw the graticule?

The first problem implies the consideration of the following : (i) The world maps, continuous or in two hemispheres. (ii) Regions greatly extending north and south of the equator, such as, Africa, south America. Indian Pacific and Atlantic Oceans, (iii) Regions with large extant north and south of Equator, e.g. China, U.S.A., Australia. (iv) Regions with their greater extent near the poles. (v) Small countries, (vi) Topographical maps.
For the construction of the world maps, the main projection generally used in atlases is: (1) Zenithal, (2) Mollweide's Elliptical, (3) Mercator's (4) cylindrical Equal Area, Gall's and (5) Sanson- Flamsrteed. Of these Zenithal Projections are used for the world in two hemispheres.

Why are most large-scale conformal?

At large scale, a conformal projection centered on the area of interest produces insignificant errors in distance and area. These errors are often smaller than what D.H. Maling , about of Coordinate Systems and map projection distortion is less than the error caused by physical properties of the map (paper shrinkage, pen width, and so on)
" Large-scale" is not an exact term, but in this context it should hold for scales of 1:100,000 or larger. It may also apply to smaller scales if the area of interest has a compact shape. For example, Maling says that the area distortion in 1:500,000 Transverse Mercator projection of England is trivial,says that the area distortion in a 1:500,000 Transverse Mercator projection of England is trivial.

Maps that preserve area

On an equal- area projection, the size of any area on the map is in true proportion to its size on the earth , you should use equal- area projections to show:
The density of an attribute with dots (for example, population density)
The spatial extent of a categorical attribute (for example, land use maps)
Quantitative attributes by area (for example. Gross Domestic Product by country)
Equal- area maps have also been used as world political maps to correct popular misconceptions about the relative size of countries.
Dot density map of federally- owned and Indian land in the U.S. by departmental jurisdiction. Albers Equal- area conic projection.
Why equal- area projections are essential for dot – density maps?
Dot-density maps show the concentration of an attribute in an area. The map of world population density you looked at before (shown again below) uses one dot to represent every one million people. If areas are not in true proportion, the map will give false impressions. Countries that

draw larger than their area scale will look less dense than they should. Countries that draw smaller than their true area scale will look too dense.
The Eckert IV projection applied here is used by the National Geographic Atlas, 7th edition, for several of its world thematic maps.

Maps that preserve shape

On a conformal projection, all local angles measured from a point are correct and all local shapes are true. You should use a conformal projection when the map's main purpose involves measuring angles, showing accurate local directions, or representing the shapes of features or contour lines. This category includes:

- Topographic maps and cadastral (land parcel) maps
- Navigation charts (for plotting course bearings and wind direction)
- Civil engineering maps
- Military maps
- Weather maps (for showing the local direction in which weather systems are moving)

Most of the maps in the list above would be large or medium-scale. In fact, most large-scale maps nowadays are conformal, regardless of their purpose.

Why are most large-scale maps conformal?

At large scales, a conformal projection centered on the area of interest produces insignificant errors in distance and area. These errors are often smaller than what D.H. Maling, author of *Coordinate Systems and Map Projections*, calls the "zero dimension"—the point at which projection distortion is less than the error caused by physical properties of the map (paper shrinkage, pen width, and so on).
"Large-scale" is not an exact term, but in this context it should hold for scales of 1:100,000 or larger. It may also apply to smaller scales if the area of interest has a compact shape. For example, Maling

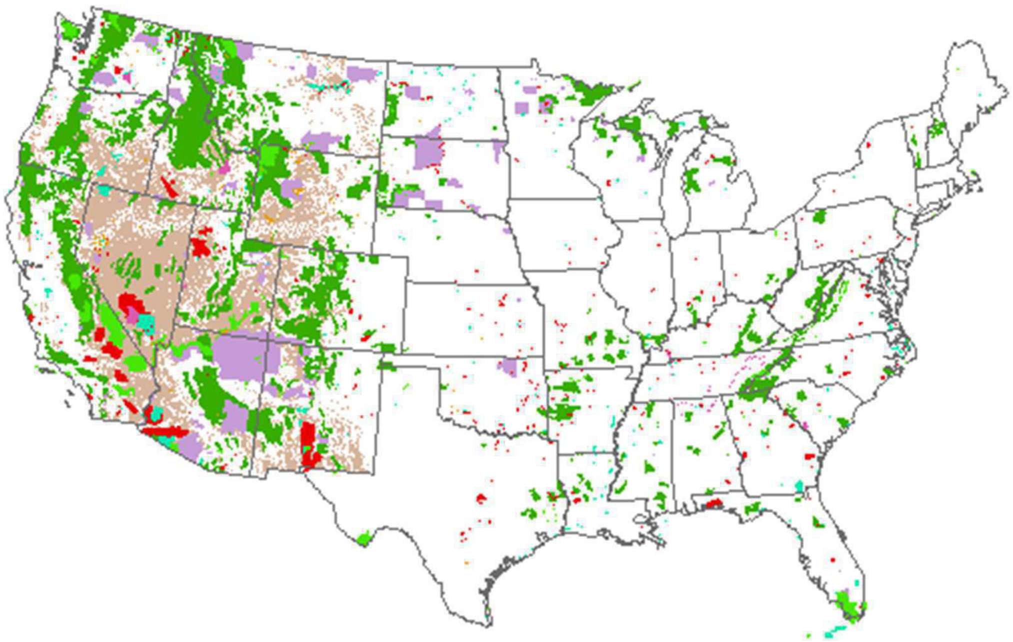
Maps that preserve area

On an equal-area projection, the size of any area on the map is in true proportion to its size on the earth. You should use equal-area projections to show:

- The density of an attribute with dots (for example, population density)
- The spatial extent of a categorical attribute (for example, land use maps)
- Quantitative attributes by area (for example, Gross Domestic Product by country)

Equal-area maps have also been used as world political maps to correct popular misconceptions about the relative sizes of countries.

Figure 6.1 Dot density map of federally-owned and Indian land in the U.S. by departmental jurisdiction.Albers Equal-Area Conic projection.

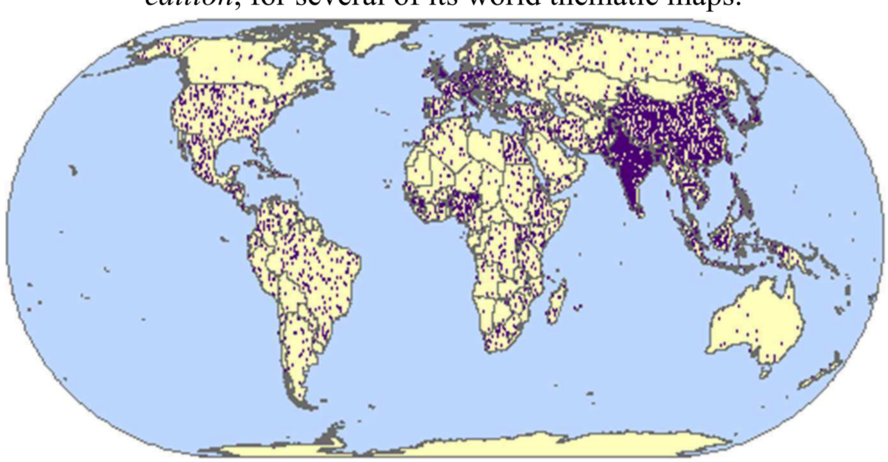


Source -National Geography: map of discovery

Why equal-area projections are essential for dot-density maps?

Dot-density maps show the concentration of an attribute in an area. The map of world population density you looked at before (shown again below) uses one dot to represent every one million people. If areas are not in true proportion, the map will give false impressions. Countries that draw larger than their true area scale will look less dense than they should. Countries that draw smaller than their true area scale will look too dense.

Fig.6.2 The Eckert IV projection applied here is used by the *National Geographic Atlas, 7th edition*, for several of its world thematic maps.



Source -National Geography: map of discovery

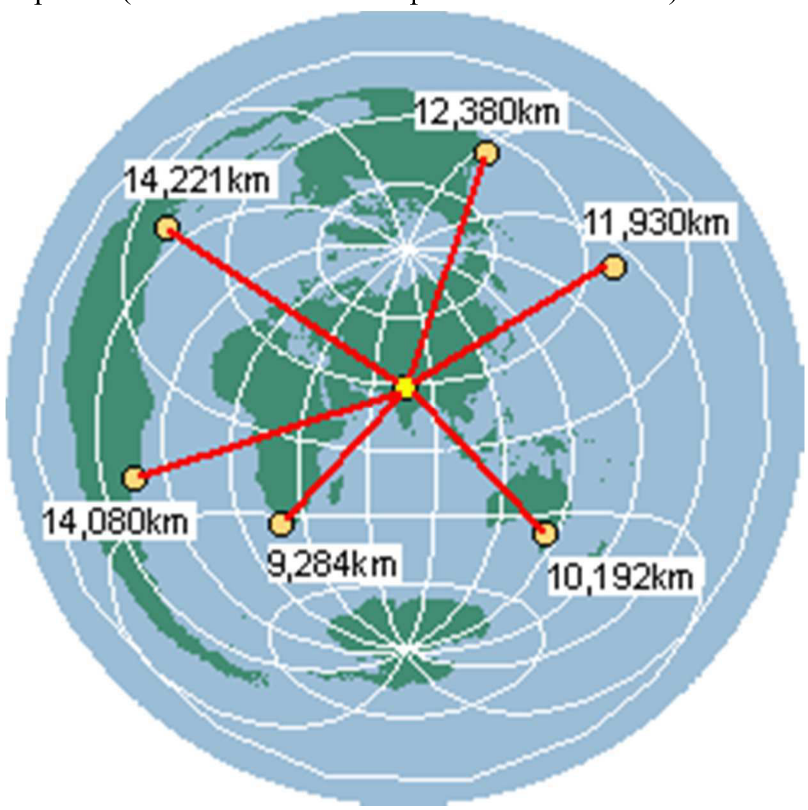
Maps that preserve scale

No map provides true-to-scale distances for any measurement you might make. The Azimuthally Equidistant projection preserves true scale *from a single specified point* on the projection to all other points on the map. Possible uses for this property include:

- Maps of airline distances from a single city to several other cities
- Seismic maps showing distances from the epicenter of an earthquake
- Maps used to calculate costs or charges based on straight-line distance from a source
- Maps used to calculate ranges, for example, the cruising ranges of airplanes or the habitats of animal species

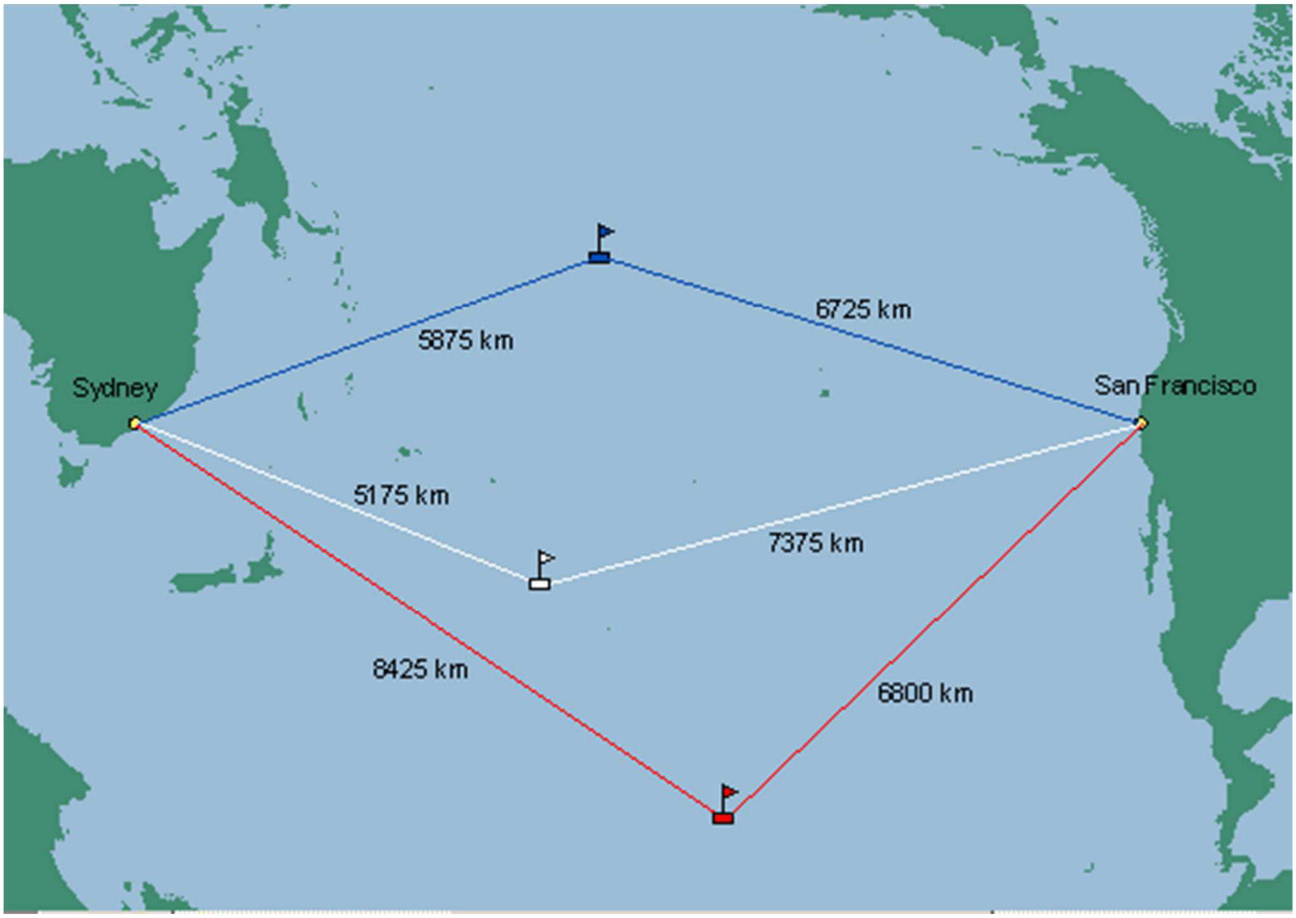
The Two-Point Equidistant projection preserves true scale *from two specified points* on the projection to all other points on the map. This projection could be used to determine the distance of a ship at sea from the start and end of a voyage.

Fig 6.3 An Azimuthal Equidistant projection centered on New Delhi. Scale from New Delhi to all points (and likewise from all points to New Delhi) is correct.



Source -National Geography: map of discovery

Fig 6.4 A Two-Point Equidistant projection. Scale is correct from both Sydney and San Francisco to all other points.



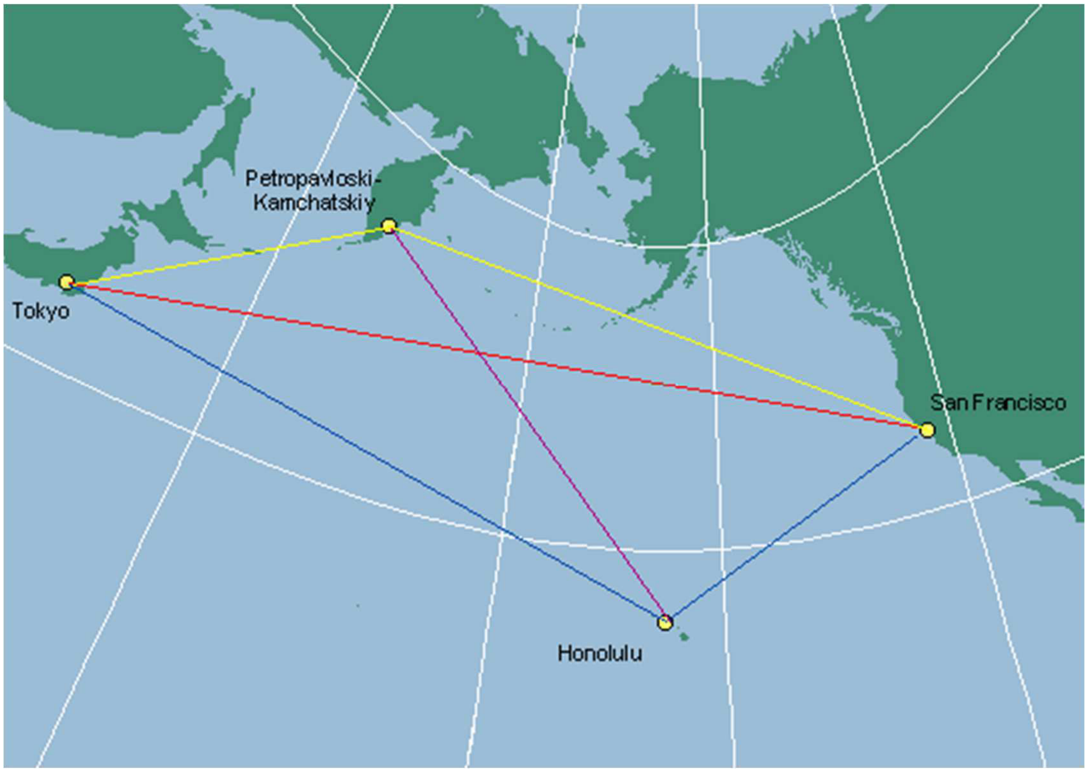
Source -National Geography: map of discovery

Maps that preserve direction

On any azimuthal projection, all azimuths, or directions, are true from a single specified point to all other points on the map. (On a conformal projection, directions are locally true, but are distorted with distance.) Direction is not typically preserved for its own sake, but in conjunction with another property.

In navigation and route planning, however, direction matters for its own sake. The Gnomonic projection is unique among azimuthals in that every straight line drawn on it represents the arc of a great circle. Since a great circle is the shortest distance between two points, Gnomonic projections are useful for planning air and sea routes and for mapping phenomena, like radio waves, that follow shortest-distance paths.

Fig 6.5 A Gnomonic projection. Every straight line on the map is the shortest distance between two points. The lines do not have true scale, however.



Source -National Geography: map of discovery

True direction and constant direction revisited

On the Gnomonic projection, any straight line between two points is the arc of a great circle. While good for route planning, this property is not good for practical navigation, because to follow a great circle, you have to keep changing your bearings.

On the Mercator projection—which is not azimuthal—any straight line between two points is a line of constant bearing: you follow a single compass heading to get from one point to another, but the route is longer than a great circle.

For short routes, navigators rely on the Mercator. For long routes, they may plan their course on the Gnomonic, then convert the great circle path to a series of shorter rhumb lines on the Mercator.

General purpose maps

Many compromise projections have been developed to show the world with a balanced distortion of shape and area. Among the most successful are:

- Winkel Tripel (currently used by the National Geographic Society for world atlas maps)
- Robinson
- Miller Cylindrical

For larger-scale maps, from continents to large countries, equidistant projections (equidistant in the sense of true scale along the meridians) are good at balancing shape and area distortion. Depending on your area of interest, you might use:

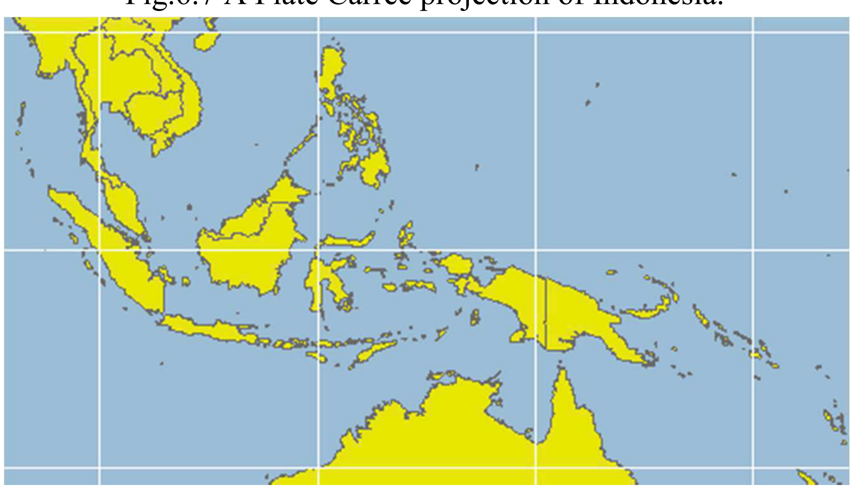
- Azimuthal Equidistant
- Equidistant Conic
- Plate Carrée

The National Geographic Society uses the Two-Point Equidistant projection to balance shape and area distortion for some maps of Asia.

Fig.6.6 An Equidistant Conic projection of South America.

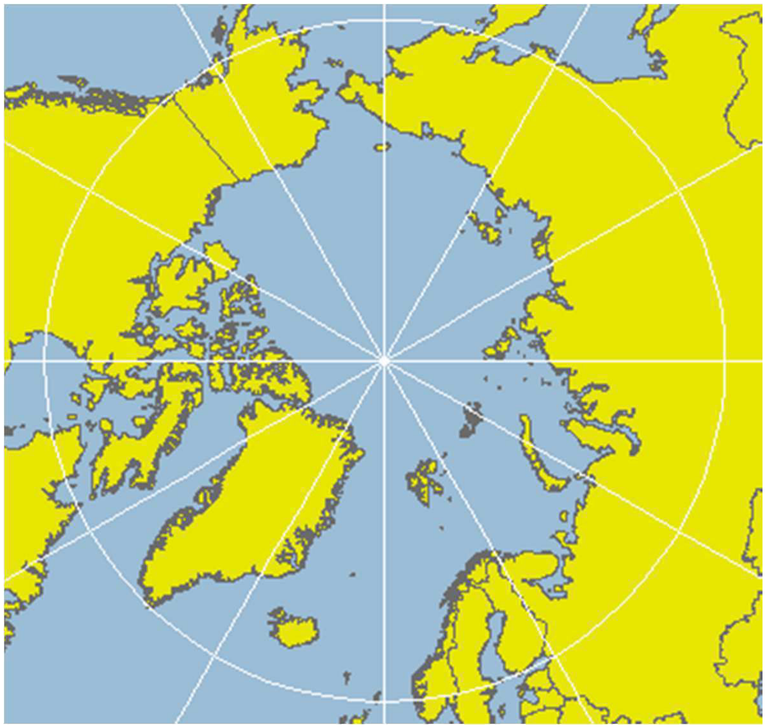
Source -National Geography: map of discovery

Fig.6.7 A Plate Carree projection of Indonesia.



Source -National Geography: map of discovery

Fig 6.8 An Azimuthal Equidistant projection of the North Pole.



Source -National Geography: map of discovery

Which part of the world does your map show?

The map's purpose narrows your choices but doesn't determine a projection. After all, there are many conformal projections, many equal-area projections, and many compromise projections.

The next step in choosing a projection is to decide on the class of projection: cylindrical, conic, or azimuthal. A time-honored rule–dating to the 16th century–is to choose according to the latitude of your area of interest. The rule says:

- To map tropical regions, use a cylindrical projection
- To map middle latitudes, use a conic projection
- To map a polar region, use an azimuthal projection

The rule makes sense if you think about the line (or point) of zero distortion for each class of projection. In cylindrical projections, the line of zero distortion is the equator; in conic projections, it's a parallel of latitude; in azimuthal projections, it's one of the poles. Using a projection from the right class minimizes distortion for your area of interest.

But the rule applies only to the normal aspect of projections. For example, a cylindrical projection, free of distortion along the equator, obviously makes a better map of the tropics than an azimuthal projection centered on the North Pole. But does it make a better map than an oblique azimuthal projection centered on the equator? Not necessarily.

The latitude rule meant a lot before the computer age, when cartographers worked from base maps drawn in a limited number of standard projections. Changing aspect or standard lines could take weeks or months of work and might be hard to justify for the sake of experimental or limited use. Nowadays, computer software makes it easy to change aspect and to modify projection parameters so that different classes of projection can be optimized for an area of interest.

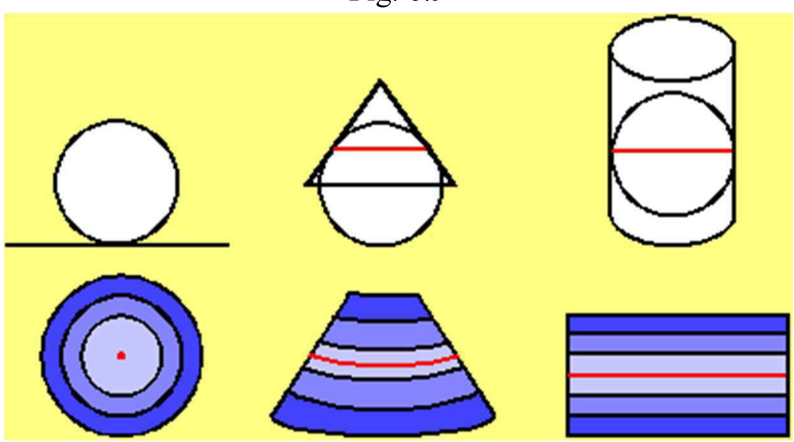
Does the latitude rule still matter?

It's still a good rule of thumb, especially if you want to choose a projection quickly and not worry about customizing the parameters. Just don't think of the rule as a limitation on your options.

What shape is your area of interest?

Although the latitude rule you just read about is less important than it used to be, the idea behind it—that of minimizing distortion for your area of interest—is still relevant. Azimuthal, conic, and cylindrical projections each have a distinct pattern of distortion.

Fig. 6.9



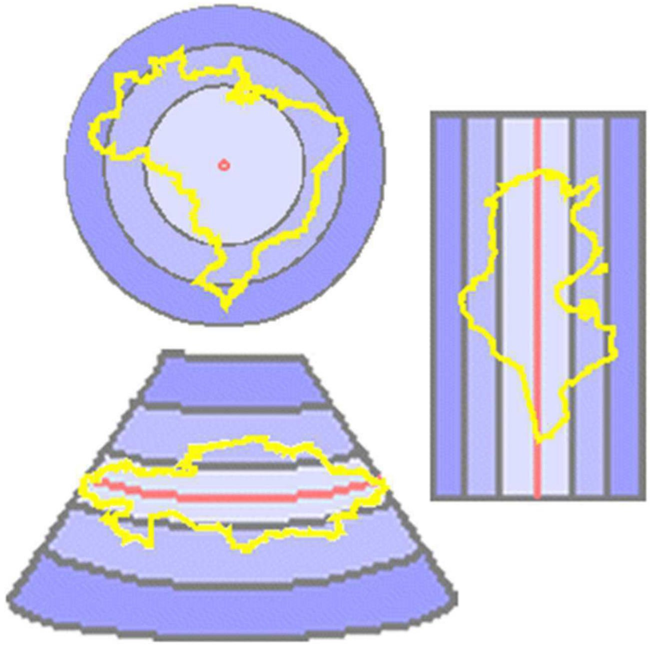
Source -National Geography: map of discovery

Top row: Conceptual drawings of tangent azimuthal, conic, and cylindrical projections. Bottom row: The corresponding distortion patterns. Darker blue shading represents increasing distortion. Black lines represent lines of equal distortion. Red points and lines represent zero distortion. Distortion contours for secant projections are much the same.

So a useful selection principle is to match the shape of your area of interest to a distortion pattern. The old latitude rule has been given a new formulation by Frank Canters, author of *Small-scale Map Projection Design*, (in slightly different words than these):

- To map areas that extend along a great circle, use a cylindrical projection
- To map areas that extend along a small circle, use a conic projection
- To map areas that are approximately circular (or have equal extent in all directions), use an azimuthal projection

Fig: 6.10



Source -National Geography: map of discovery

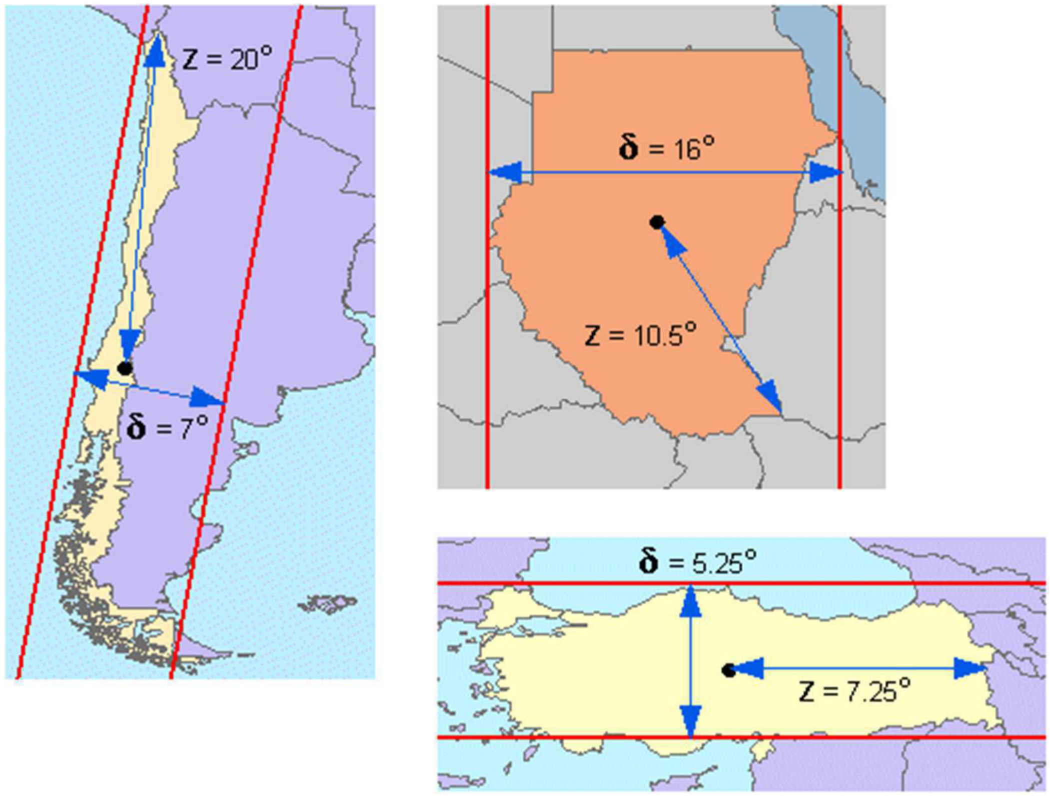
Brazil's outline superimposed on an azimuthal distortion pattern (upper left); Kazakhstan's on a conic distortion pattern (lower left), and Tunisia's on a transverse cylindrical pattern (right).

It's not always easy to tell which distortion pattern is best-suited to a shape. Looking at China, for instance, it's not obvious whether an azimuthal or a conic projection would be better. (In fact, both are reasonable.) Experts can analyze distortion values in detail across a map, but that's too much work—and too much math—for most of us. Luckily, visual judgment usually gives decent results. Make sure you look at a globe, tough—don't rely on the way shapes look on a map or a computer screen.

Young's Rule for selecting class of projection

In 1920, A.E. Young developed a formula for deciding when to use an azimuthal projection. It works like this: suppose you draw two parallel lines—actually, two parallel small circles on the earth's surface—that bound your area of interest in the direction of its narrowest extent. These may be parallels of latitude, but they may just as well be transverse or oblique lines. Call the angular distance (the distance in degrees) between these lines **δ**. Now measure the angular distance from the center of your area of interest to the point farthest from the center. Call this value **z**. Young's rule says that if z/δ is less than 1.41, an azimuthal projection is the most suitable. If z/δ is greater than 1.41, you should use a conic or cylindrical projection instead.

Fig:6.11

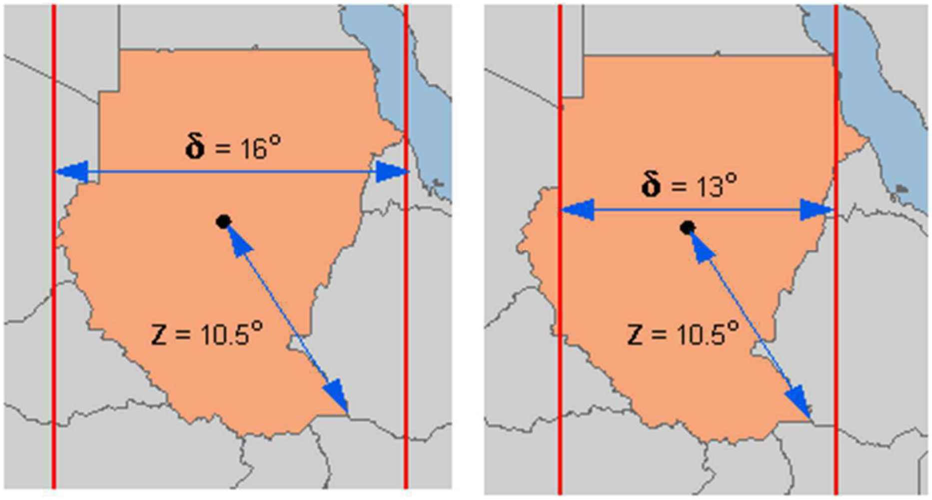


Source -National Geography: map of discovery

Chile's value is 2.85, double Young's threshold, so an azimuthal projection is clearly unsuitable. For Sudan, which has a value of 0.66, an azimuthal projection is the right choice. Turkey's value is 1.38, a borderline case.

Country and region outlines may have all sorts of protrusions, hollows, and weird dangling appendages. Such irregularities may be small in area but have a large effect on the spacing of your bounding parallel lines. You can adjust the value of δ by deciding how far to respect these irregularities. Likewise, the value of z is variable according to how you determine the center of the area of interest. In ArcMap, for example, polygon centroids don't always fall within the polygon boundary (Vietnam's centroid is in Laos), but you may want to stipulate that the center of an area must lie within the area's boundary.

Fig 6.11



Source -National Geography: map of discovery

Left: The bounding lines fully respect Sudan's outline. The value for this calculation is 0.66. Right: Moving the bounding lines closer together may give a truer, if less strictly accurate, picture of Sudan's shape. The value for this calculation is 0.81; an appreciable change, though an azimuthal projection is still recommended. Similarly, the value for Turkey can be plausibly adjusted to be either greater or less than 1.41. As a final example of measurement variability, Maling calculates the value for Chile as 2.3 (16 divided by 7), a good bit lower than the 2.85 value arrived at above.

Young's rule tells you when to use an azimuthal projection versus a conic or cylindrical projection, but it doesn't tell you how to choose between a conic and a cylindrical when an azimuthal has been ruled out. To help make this choice (repeating what was said above), look at the area of interest on a globe and see if its longer axis more closely conforms to the arc of a great circle or a small circle. Again, it's not always easy to tell, but a good look should be enough to rule out a plainly bad choice.

Using Young's Rule with Arc Map

You can calculate z/δ in ArcMap with a little work:

1. Set the data frame to no projection or to a geographic projection, such as WGS84. **Note:** Your display units will default to decimal degrees. If no projection is set, Arc Map will perform your subsequent measurements on a sphere. If a geographic projection is set, the measurements will be done on a spheroid. (Either method should give good results.)
2. Draw a pair of parallel graphic lines that bound the area of interest as narrowly as possible.
3. Use the Measure tool to measure the angular distance between the lines. This is **δ**. (**Note:** Your graphic lines are lines—not parallel small circles—and may not have constant

angular distance between them. Therefore, make your δ measurement across the center of the area of interest.)

4. Calculate the centroid of your area of interest. (For help, see the Arc GIS online help topic *making field calculations*.) **Note:** If your area of interest includes two or more polygons, you'll have to dissolve them.

5. Add a graphic point at the centroid's coordinates. (**Hint:** Use the Size and Position tab of the graphic's Properties dialog.)

6. Measure the angular distance from the graphic point to the farthest boundary of the area of interest. This is **z**.

7. Calculate **z /δ**.

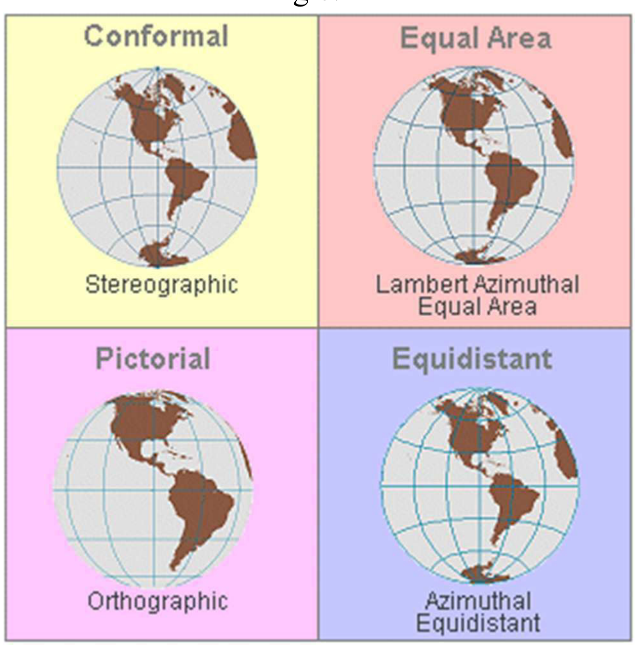
Recommended projections

After taking into account the purpose of your map and the shape of your area of interest, you should be able to narrow down the possibilities… if not to a single projection, then at least to a short list of all good choices.

These projections are among the best of their kind, but they are not a complete list of suitable projections. With a few exceptions, these recommendations have been taken from John Snyder, *Map Projections: A Working Manual*, pp. 34-35.

Recommended projections for hemisphere maps

Fig 6.12



Source -National Geography: map of discovery

Recommended hemisphere projections. The Orthographic projection does not preserve shape, area, or distance, but it has a natural appearance and is often used for illustrations.

Table 6.1 **Recommended projections for maps of continents and smaller areas**

Property	Area of interest extends mainly ...						
	north to south	east to west ...		equally in all directions ...			obliquely
		along equator	*away from equator*	*centered on pole*	*on or along equator*	*between pole and equator*	
Conformal	Transverse Mercator	Mercator	Lambert Conformal Conic	Stereographic (polar)	Stereographic (equatorial)	Stereographic (oblique)	Hotine Oblique Mercator
Equal-area	Sinusoidal	Cylindrical Equal Area	Albers Equal Area Conic	Lambert Azimuthal Equal Area (polar)	Lambert Azimuthal Equal Area (equatorial)	Lambert Azimuthal Equal Area (oblique)	

Property	Center of projection is ...		
	at pole	at equator	between pole and equator
Equidistant (true scale on meridians)	Azimuthal Equidistant (polar aspect)	Plate Carree	Equidistant Conic

Source; elements of geography practical

For equal area maps of north-south and oblique extents, Snyder recommends transverse and oblique aspects of the Cylindrical Equal Area. These aspects of the Cylindrical Equal Area are not supported by Arc Map.

Projection properties summarized

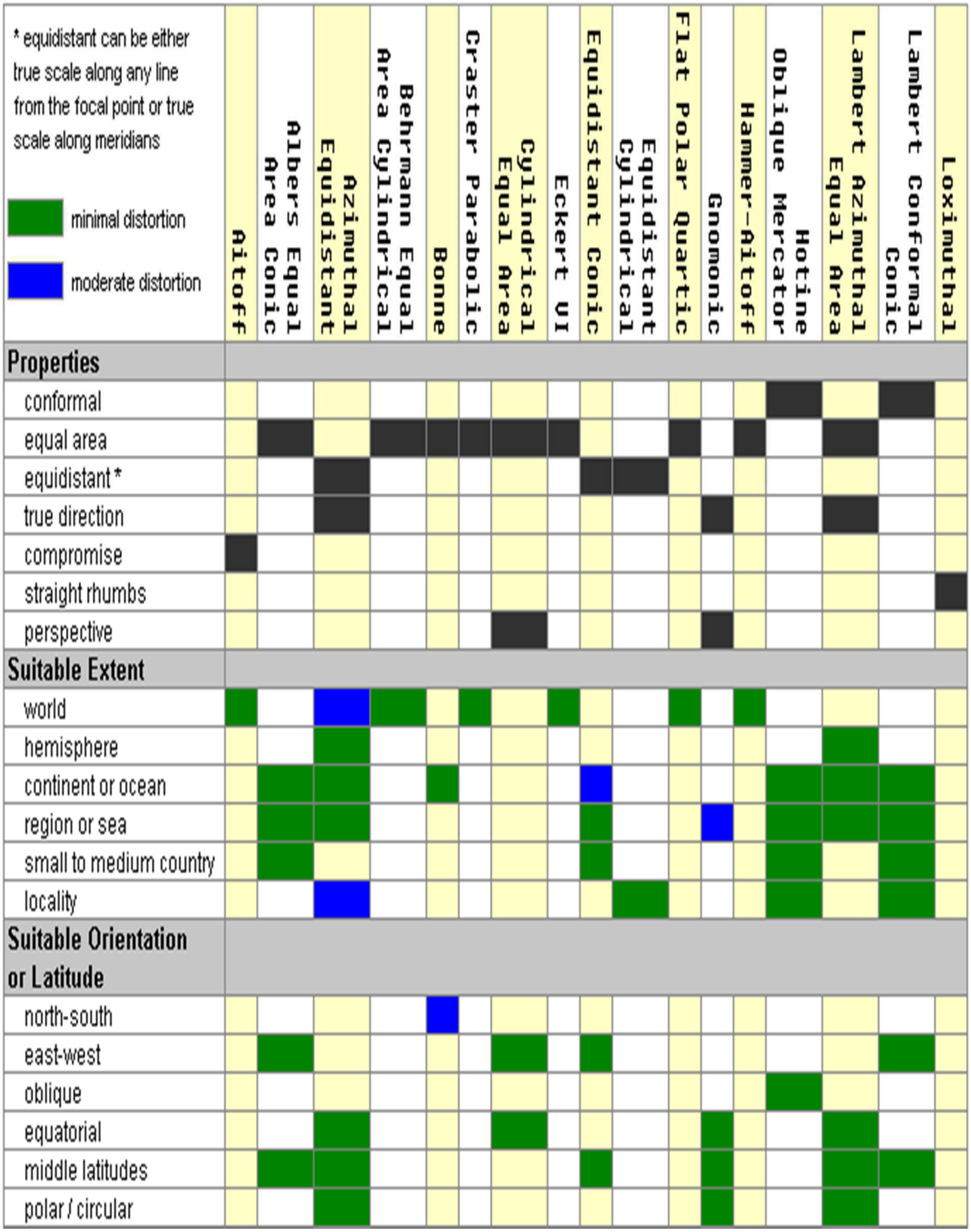
The two graphics below summarize properties for several popular projections. They are adapted from the fold-out chart in *Understanding Map Projections* (Kennedy, 1994-2000). This chart itself is adapted from a U.S. Geological Survey poster called *Map Projections*.

Projection names are listed across the top and projection properties along the side. The properties include the spatial property preserved by the map; the projection's appropriate extent (what size area it can cover); its appropriate spatial orientation (for instance, areas lying east–west); and its appropriate zone (for instance, mid-latitudes).

A black square means that the projection preserves a spatial property. A green square means the projection is highly suitable for a spatial extent or orientation. A blue square means lower, but still acceptable, suitability.

Orientations are a restriction on suitable extents. For example, if "continent" is a suitable extent and "east–west" is a suitable orientation, it means the projection is good for continents with an east–west orientation—not for all continents plus all areas that lie east–west.

Table 6.2



Source; elements of geography practical

Table 6.3

* equidistant can be either true scale along any line from the focal point or true scale along meridians

minimal distortion (green)

moderate distortion (blue)

	Mercator	Miller Cylindrical	Mollweide	Orthographic	Plate-Carree	Polyconic	Robinson	Sinusoidal	Stereographic	Transverse Mercator	Two-Point Equidistant	Van Der Grinten I	Vertical Near-Side Perspective	Winkel Tripel
Properties														
conformal	●								●	●				
equal area			●					●						
equidistant *					●						●			
true direction				●					●				●	
compromise		●				●	●					●		●
straight rhumbs	●													
perspective				●					●				●	
Suitable Extent														
world	moderate	minimal	minimal				minimal	minimal			moderate	moderate		minimal
hemisphere				minimal					minimal					
continent or ocean				minimal				minimal	minimal	minimal	minimal		minimal	
region or sea	minimal								minimal	minimal	minimal		minimal	
small to medium country	minimal					moderate				minimal				
locality	minimal				minimal	moderate				minimal				
Suitable Orientation or Latitude														
north-south						minimal		minimal		minimal				
east-west	minimal													
oblique											minimal			
equatorial	minimal			minimal				minimal	minimal	minimal			minimal	
middle latitudes				minimal					minimal	minimal			minimal	
polar / circular				minimal					minimal				minimal	

Source; elements of geography practical

6.4 SUMMARY

On the basis of how we choose maps, for that the area of which we have to make a map projection will first have to know the shape of the map through a scale, only then we can create a good map projection. First of all, we will need to know what kind of shape the map projection are being created for, and what is the specific area in which the map projection is being made. If we have to make map projections related to the selection of crops, then equidistant cylindrical projection and latitude longitude and the importance of the sailor should be made. So the Namonic polar-ended projections have to be selected. To make a very good world class-map, we have to choose the intentional Mercator projection. The distance size, type and measure of each projection vary. This selects map projection with the help of a mesh and measure of latitude and longitude lines. Each map projection has its own distinct significance which is planned systematically. Even if is cylindrical projection, cone projection or Zenithal projection.

6.5 GLOSSARY

Predetermined = (of an outcome or course of events) determined in advance by divine will or fate; predestined
Conformal = (of a map or mathematical mapping) preserving the correct angle between directions within small areas (though distorting distances).
Preserve scale = If you enable the preserve scale option, then the Warp Stabilizer will not attempt to correct with scale adjustments.
Revisited = Considered (a situation or problem) again or from a different perspective.
Distortion= It is the alteration of the original shape of something.
Zero dimension = It is a topological space or nil dimensional that has dimension zero with respect to one of several inequivalent notions of assigning a dimension to a given topological space.

6.6 ANSWER TO CHECK YOUR PROGRESS

Q.1. Who constructed the 1st globe? When did he die?
Ans. Crates of Malthus constructed the 1st globe. He died in 145 B.C.
Q.2.Who predicted the solar eclipse for the 1st time and when?
Ans. Thales of Miletus predicted the solar eclipse for the 1st time and it was successful. About 600 B.C.
Q.3 Who maintained that the earth was a sphere?
Ans. In 500 B.C. Pythagorus of Samos maintained that the earth was a sphere.
O.3.What are the types of the projections on the basis of the quality the projections preserve?
Ans. The projections are of three types on the basis of the quality they preserve:

1. **Equal area** or **Homolographical Projection**
2. **Correct shape** or **Orthomorphic Projection**
3. **True bearing** or **Azimuthal Projection**

True or False

1. Germanus in 1466 produced the trapeziform map which later on led to the Flamsteed projection. True/False
2. Projection for mapping the world in 2,222 independent sheets which can be assembled together. True/False
3. The second group of projections is known as *conformal projection.* True/False
4. In the third group of projections, correct bearings or azimuths are preserved. True/False

6.7 REFERENCES

- " Robinson, Arthur Howard. (1960). Elements of cartography, second edition. New York: John Wiley and Sons.p.82.
- Robinson, Arthur (1990). "Rectangular world maps- No!. Professional Geographer.42 (1): 101-04.
- Geographers and cartographers Urge End to Popular Use of Rectangular Maps ". American Cartographer.16:222-222.1989.
- Fran Evanisko , American River College, lectures for Geography 20:" Cartographic Design for GIC", Fall 2002
- Elements of practical Geography (1979 R.L. Singh).
- Elements of practical Geography (2019 R.L. Singh, Rana P.B. Singh)

6.8 TERMINAL QUESTIONS

Q1. What are the concepts of map?

Ans. When you choose a projection, the first thing to consider is the purpose of your map. For general reference and atlas maps, you usually want to balance shape and area distortion. If your map has a specific purpose, you may need to preserve a certain spatial property—most commonly shape or area—to achieve that purpose.

Maps that preserve shape

On a conformal projection, all local angles measured from a point are correct and all local shapes are true. You should use a conformal projection when the map's main purpose involves measuring angles, showing accurate local directions, or representing the shapes of features or contour lines. This category includes:

· Topographic maps and cadastral (land parcel) maps
· Navigation charts (for plotting course bearings and wind direction)
· Civil engineering maps
· Military maps
· Weather maps (for showing the local direction in which weather systems are moving)

Most of the maps in the list above would be large or medium-scale. In fact, most large-scale maps nowadays are conformal, regardless of their purpose.

Q2. What is the General Purpose Maps?

Ans. Many compromise projections have been developed to show the world with a balanced distortion of shape and area. Among the most successful are:

· Winkel Tripel (currently used by the National Geographic Society for world atlas maps)
· Robinson
· Miller Cylindrical

For larger-scale maps, from continents to large countries, equidistant projections (equidistant in the sense of true scale along the meridians) are good at balancing shape and area distortion. Depending on your area of interest, you might use:

- Azimuthal Equidistant
- Equidistant Conic
- Plate Carrée

Q3. What is the recommended projections ?

Ans. After taking into account the purpose of your map and the shape of your area of interest, you should be able to narrow down the possibilities… if not to a single projection, then at least to a short list of all good choices.

These projections are among the best of their kind, but they are not a complete list of suitable projections. With a few exceptions, these recommendations have been taken from John Snyder, *Map Projections: a Working Manual*, pp. 34-35.

Recommended hemisphere projections. The Orthographic projection does not preserve shape, area, or distance, but it has a natural appearance and is often used for illustrations.

For equal area maps of north-south and oblique extents, Snyder recommends transverse and oblique aspects of the Cylindrical Equal Area. These aspects of the Cylindrical Equal Area are not supported by ArcMap.

BLOCK 3: MAP COMPILATION AND DESIGN

UNIT 7 – BASE MAP CONCEPTS, SCANNING AND DIGITIZATION: PLANIMETRIC, TOPOGRAPHIC AND THEMATIC

7.1 OBJECTIVES

After studying this unit, you should be able to:

1. digitisation: basics, concept and need;
2. steps in the process of digitisation;
3. technology of digitisation;
4. Uses of digitization.

7.2 INTRODUCTION

All recorded information in a traditional library is analogue in nature. The analogue information can include printed books, periodical articles, manuscripts, cards, photographs, vinyl disks, video and audiotapes. However, when analogue information is fed into a computer, it is broken down into 0s and 1s changing its characteristics from analogue to digital. These bits of data can be re-combined for manipulation and compressed for storage. Voluminous encyclopaedias that take-up yard of shelf-space in analogue form can fit into a small space on a computer drive or stored on to a CD ROM disc, which can be searched, retrieved manipulated and sent over the network. One of the most important traits of digital information is that it is not fixed in the way that texts printed on a paper are. Digital texts are neither final nor finite, and are not fixed either in essence or in form except, when it is printed out as a hard copy. Flexibility is one of the chief assets of digital information. An endless number of identical copies can be created from a digital file, because a digital file does not decay by copying. Moreover, digital information can be made accessible from remote location simultaneously by a large number of users. Digitisation is the process of converting the content of physical media (e.g., periodical articles, books, manuscripts, cards, photographs, vinyl disks, etc.) into digital format. In most library applications, digitisation normally results in documents that are accessible from the web site of a library and thus, on the Internet. Optical scanners and digital cameras are used to digitise images by translating them into bit maps. It is also possible to digitise sound, video, graphics and animations, etc. Digitisation is not an end in itself. It is the process that creates a digital image from an analogue image. Selection criteria, particularly those, which reflect user needs, are of paramount importance.

7.3 BASE MAP CONCEPTS, SCANNING AND DIGITIZATION-PLANIMETRIC, TOPOGRAPHIC AND THEMATIC

BASE MAP

A base map is the graphic representation at a specified scale of selected fundamental map information used as a framework upon which additional data of a specialized nature may be compiled (American Society of Photogrammetry, 1980). The term base map is seen often in GIS and refers to a collection of GIS data and orthorectified imagery that form the background setting for a map. The function of the base map is to provide background detail necessary to orient the location of the map. Base maps also add to the aesthetic appeal of a map.

A base map provides the context for a map to general users. One can add information to a base map by overlaying other information on it. Base maps contain reference information that may provide different basic geospatial information, which cartographers try to communicate to general users. For example, the National Hydrography Dataset (NHD) base map has Watershed Boundaries, country and state boundaries, city names, and generalized rivers. Someone interested in viewing hydrography may not be interested in major highways or National Park boundaries so these layers are excluded from the base map.

Base maps are also pre-authored datasets that can be pulled from various online sources. ESRI's Arc GIS, various open source GIS and remote sensing software offers a selection of predefined base maps that can be used for creating online maps. These can be further pulled into Arc GIS to be used as a base map for other mapping needs.

CONCEPT

A base map is a layer with geographic information that serves as a background. A base map provides context for additional layers that are overlaid on top of the base map. Base maps usually provide location references for features that do not change often like boundaries, rivers, lakes, roads, and highways. Even on base maps, these different categories of information are in layers. Usually a base map contains this basic data and then extra layers with a particular theme or from a particular discipline are overlaid on the base map layers for the sake of analysis.

For example, for showing all the different types of endangered plants within a region, one can use a base map showing roads, provincial and state boundaries, waterways and elevation. Onto this base map, layers can be added to show the location of different categories of endangered plants. One added layer could be trees, another layer could be mosses and lichens, another layer could be grasses.

- Base maps are used to give engineers and designers detailed information they need to plan for improvements while avoiding conflicts with existing infrastructure, property and common facilities.
- Base map content may vary according to the needs of the improvement for which it was created.

BASE MAP PREPARATION

The base map establishes the geometrical and orientational reference for the viewer of a thematic map. Familiar features such as lakes & rivers, place names, localities & mountains, administrative boundaries, terrain shape, transportation routes, forests & land cover can help the map viewer for orientation.

When designing a base map, the following aspects should be considered.

- Should be tailored to the thematic content; however, a complete matching with the topic should be avoided
- Should complement the included topic in the most reasonable way, while distracting as little as possible
- Must correspond to the current state

- Must match the scale and the degree of generalization of the thematic content to be included.
- Should not exceed twice the scale and miniaturization should be avoided completely

Scanning

The primary function of any scanner is to convert measured quantities of light to electrical analogs. The light that is measured may be light that has been transmitted through the material, as would be the case when film transparencies are scanned, or the light that is measured could be that which is reflected from the surface of a map or photograph. For GIS and other computer applications, the electrical analogs are subsequently converted to a binary form suitable for computer processing. If the output of the scanner is to be used as input to a GIS, care must be taken to preserve the spatial integrity of the item being scanned. Preservation of the spatial integrity is normally accomplished by describing the scanned document as an orthogonal array of grid cells (raster array). Each grid cell represents an instantaneous field of view within which the scanner makes a measurement. The manner in which the grid cell is defined depends upon the particular scanner being used. How- ever, scanners, in general, fall into one of three types: flying spot, push-broom, or rotating drum.

1. Flying spot scanner: A typical flying spot scanner (Figure 7.1) is mounted on a rack in such a way that the scanner's optical system can view a document located on a flat surface beneath the scanner. The distance from the scanner to the document can be varied to facilitate encoding documents of different sizes. A view finder located on the scanner allows the document to be viewed and properly aligned by an operator before encoding is accomplished. Encoding takes place when a light-sensing spot (the instantaneous field of view) is deflected systematically over the document. As the spot is deflected, light reflected from the document is detected by a light-sensing device, such as an image orthicon tube, a vidicon tube, or a charge-coupled diode (CCo) detector array. In the scanning process, the document is described as a set of contiguous pixels in an orthogonal array. Each pixel in the array is given a value that depends upon the amount of reflected light that is detected. The source of illumination is normally two or more lights that can be positioned manually to provide the best overall illumination for the geometry of the scan. Typically, a flying spot scanner describes a document being encoded as a 512- by 512- or a 1024- by l024-pixel grid array.

The size of the document that can be encoded and the area covered by each grid cell (resolution element) depend upon the distance from the scanner to the document. If the scanner model includes appropriate filters, color separations can be produced from the scanned data. However, it is important to know that detectors commonly used in flying spot scanners may be spectrally less sensitive to-blue and green than to other colors. As a result, some type of compensation may be required to correct for this trait. The basic output from flying spot scanners is in a raster format. However, some models provide the capability to convert the data to a vector (or arc-node) format internally before the data are available for output. Data from flying spot scanners have been used for many years as input to image processing and remote sensing software systems, and more recently for GIS applications.

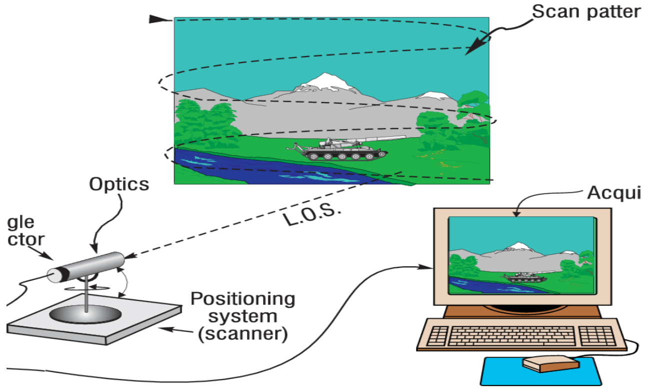
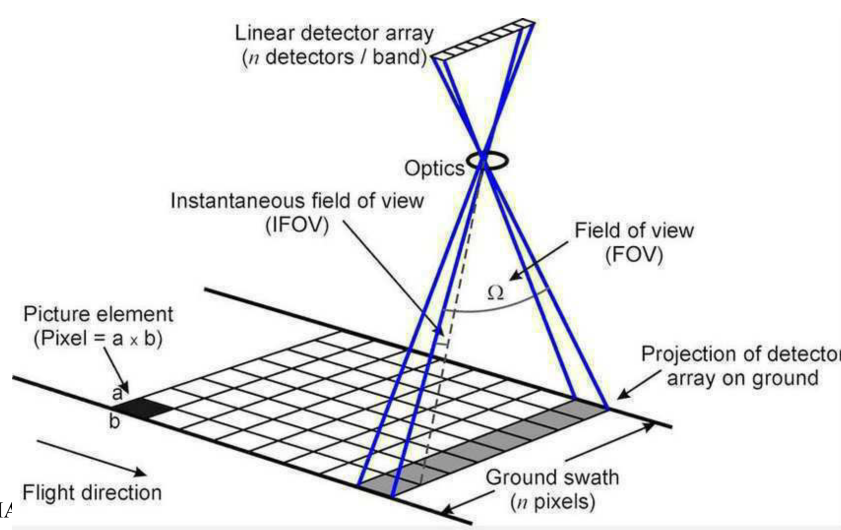


Figure 7.1 Flying spot Scanner

2. **Push-broom scanner:** Push-broom scanners (Figure 7. 2) typically are comprised of a linear array of CCD detectors located at a fixed distance from an aperture over which the document to be digitized is passed. Illuminating and digitizing geometry are fixed and cannot be changed by the operator. During encoding, the document is moved over the aperture at a constant rate of speed by a set of pinch rollers. A typical push-broom scanner can accommodate a document up to 36 inches wide. The maximum length of the document is determined by the storage capacity of the computer controlling the scanning process. Once scanned, the document is represented digitally by a raster array of grid cells arranged in an orthogonal array. Some models convert the data to vectors before the output is available to the user. The normal output resolution is either 200 or 400 dots per inch. As with many light sensing detectors, the CCDs used in push broom scanners are only minimally sensitive to the blue and green wavelengths and have maximum sensitivity to the longer wavelengths of red and near-infrared. There are no push-broom scanners known to be capable of producing color separations.

Figure 7.2 Push-Broom Scanner



3. **Drum scanner**: A typical drum scanner (Figure 7.3) is comprised of a drum, a carriage, and associated electronic control equipment. The document to be scanned is mounted on the drum. The detector and associated electronic components and the illuminating source are mounted on the carriage in such a way that the instantaneous field of view of the optical system will be uniformly illuminated. As the drum rotates, a measurement is made of the reflectance within each pixel in a series of contiguous pixels defining a single scan line. If the drum scanner is capable of doing color separations, the measurements along the first scan line are made through an appropriate color filter, and then repeated for each of either two or three additional filters. The carriage is then advanced one increment and the scanning process is repeated for the next line. The process is repeated until the desired area of the document has been covered. One large format scanner now on the market actually measures 1000 scan lines at a time. At the end of each scan line, the carriage advances a distance equal to 1000 scan lines before beginning measurements on the next 1000 scan lines. A typical scanner is designed to encode a document in no more than 10 minutes. The pixel size may be as small as 1.5 lLm. The largest known scanner can encode a document as large as 1.1 m by 1.6 m. As with other scanners, the drum scanners may have reduced sensitivity to the shorter wavelengths of blue and green light depending upon the type of detector used. The basic output of a drum scanner is a raster format, but some drum scanners can convert from raster to vector and can degrade the effective pixel size by re-sampling before producing an output to be used in a GIS.

Figure 7.3 Drum Scanner

The National Science Foundation defines a GIS as "a computerized database system for capture, storage, retrieval, analysis, and display of spatial (locationally defined) data." If we accept this definition, we find that, in order to meet the data requirements for a GIS, our scanner must be able to faithfully capture the details of our map or chart, as well as retain the spatial integrity of the data, preferably to within established USGS map accuracy standards. There are, indeed, a number of other factors that should be considered before a commitment is made to scanning as the data input method of choice. The initial product derived from all scanners is a digital record of the gray shade (or, in some cases, black versus white) measured for each pixel in an orthogonal array of pixels that combine to describe the encoded document. However, some scanners (and scanner service companies) are equipped with the capability to do specific data processing during the scanning process before the data are made available to the user. For example, data processing may be accomplished to produce an output in vector form. Or, processing may be accomplished to resample the basic output data to, in effect, enlarge the size of each pixel. Because scanners can produce very large data files, some data compression may be done before the output is available.

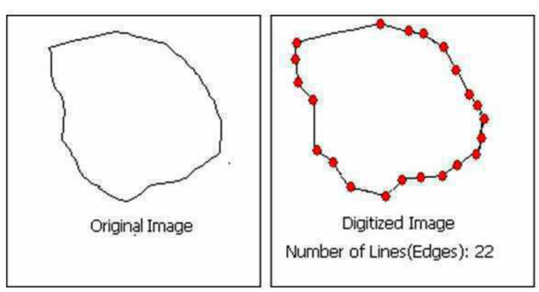
Typically, a GIS user wants to use scanner output data to (a) produce a digital replication of a document or a photograph that will accurately overlay an existing USGS or other map, or serve as a backdrop for other digital information; (b) convert maps or other manuscripts to a digital form for input to a GIS; or (c) extract from scanned documents specific information that may be distinguished by colors, textures, symbols, or combinations of these variables. Production of a digitized replication that can be used as an overlay or as a backdrop is the least demanding of any of the uses mentioned. No scale changes are required, no resolution changes are required, and corrections are seldom needed for digitizing errors, Le., speckling, skewing, and surface deformation.

Digitization

The word "digital" describes any system based on discontinuous data or events. Computers are digital machines because at their most basic level they can distinguish between just two values, 0 and 1, or off and on. All data that a computer processes must be encoded digitally as a series of zeroes and ones.

Digitization is quite simply the creation of a computerized representation of a printed analog. There are many methods of digitizing and varied media to be digitized. However, the main focus rests primarily on texts and images, as these are the main objects in the digitization process; therefore, it refers to the conversion of materials that were originally created in another format. Technically, the process of digitization involves converting an analog image into its corresponding numeric values1. In this context, some of the fundamental issues like, scanning and image capture, necessary hardware and software selection that are crucial for the process of digitization are briefly discussed in the succeeding sections.

Figure 7.4 Digitization: Converting Raster Image into Vector



Digitization is the creation of digital objects from physical, analogue originals by means of a scanner, camera or other electronic device. It is undertaken as part of a process that includes:

- Selection
- Assessment, including of needs

- Prioritization
- preparation of originals for digitization
- metadata collection and creation
- digitization and creation of data collections
- Submission of digital resources to delivery systems and repositories.

Need for Digitisation: Digitising a document in print or other physical media (e.g., sound recordings) makes the document more useful as well as more accessible. It is possible for a user to conduct a full-text search on a document that is digitised and OCRed. It is possible to create hyperlinks to lead a reader to related items within the text itself as well as to external resources. Ultimately, digitisation does not mean replacing the traditional library collections and services; rather, it serves to enhance them. A document can be converted into digital format depending on the objective of digitisation, end user, availability of finances, etc. While the objectives of digitisation initiatives differ from organisation to organisation, the primary objective is to improve the access. Other objectives include cost savings, preservation, keeping pace with technology and information sharing. The most significant challenges in planning and execution of a digitisation project relate to technical limitations, budgetary constraints, copyright considerations, lack of policy guidelines and lastly, the selection of materials for digitisation.

Figure 7.5 Process and Steps in Digitization Process

There are several reasons for libraries to go for digitisation and there are as many ways to create the digitised images, depending on the needs and uses. The prime reason for digitisation is the need of the user for convenient access to high quality information. Other important considerations are:

- Quality Preservation: The digital information has potential for qualitative preservation of information. The preservation-quality images can be scanned at high resolution and bit depth for best possible quality. The quality remains the same inspite of multiple usages by several users. However, caution needs to be exercised while choosing digitisation for preservation of information.
- Multiple Referencing: Digital information can be used simultaneously by several users at a time.
- Wide Area Usage: Digital information can be made accessible to distant users through the computer networks over the Internet.
- Archival Storage: Digitisation is used for restoration of rare material. The rare books, images or archival material are kept in digitised format as a common practice.
- Security Measure: Valuable documents and records are scanned and kept in digital format for safety and security

Selection of material for digitization: The documents to be digitised may include text, line art, photographs, colour images, etc. The selection of documents needs to be reviewed very carefully considering all the factors of utility, quality, security and cost. Rare and much–in-demand documents and images are selected as first priority without considering the quality. Factors that may be considered for selecting appropriate media for digitisation include the following: Audio: The sound quality has to be checked and required corrections made together by the subject expert and computer sound editor. Video: The video clippings are normally edited on Beta max tapes, which can be used for transferring on to digital format. While editing colour tone, resolution is checked and corrected. Photographs: The selection of photographs is very crucial process. High resolution is required for photographic images and slides. Also, the quality and future needs are to be checked and the copyright aspects are to be taken care of. Documents: Documents which are much in demand, too fragile to handle, and rare in availability are reviewed and selected for the process. If the correction of literary value demands much input, then documents are considered for publication rather than digitisation. Moreover, the purpose of all digitisation is related to increased access to digitised materials and value addition. The first consideration for digitisation of documents should be intellectual significance of contents in terms of quality, authority, uniqueness, timeliness, and demand. The intellectual contents, physical nature of the source materials, number of current and potential users are therefore, major considerations.

Process of Digitization: This process is accompanied along the way by management, including intellectual property rights management and quality control, and evaluation at the end. These steps are essential to ensure that the digital object remains accessible in the long-term.

1. **Fundamentals:** Generally, digitization in itself is not a method of preservation of documentary heritage although it does help to protect precious documents from

excessive handling. It allows the preservation of a facsimile of the document (not the document itself) and ensures multiple access, with due respect for intellectual property and other rights, to the content. Documents with text and images that are to be kept as originals after digitization may be digitized to a higher or lower level of detail. The reason for making the digital copies will define the choice of resolution and bit depth which may have an impact on costs, production flow as well as the long-term preservation. For audio and video documents, however, digitization is the only viable method for long-term preservation, because, apart from carrier instability, dedicated replay equipment is rapidly vanishing. The time window left for the replay of audio and video originals may only be 15 years, which adds urgency to the situation. Audiovisual documents must be digitized with appropriate digital resolution, and that capture resolution must equal or exceed the quality of original as, in the long-term, the digital master file will be the only version available. Film preservation is adopting digitization out of necessity as manufacture of analogue photochemical film is fading. Digital master files are a facsimile of the original document; they must not be enhanced, restored, or otherwise altered. Digitized materials should enjoy the same intellectual property copyright protection level as the original.

Primary consideration should be accorded to accessibility and traceability of information when digitizing important the process including technical specifications and resolution settings. Digital conversion and metadata creation should be synchronized as far as possible thus enabling permanent access to all the relevant attributes of the object.

Digitization is also not a method for the intellectual property protection of documentary heritage; digitization raises intellectual property issues, which should be identified and managed. Digitization should take into consideration and be done in respect of intellectual property law. When digitizing material, preference should be given to openly defined formats which are widely used and supported. They should be suitable for long-term preservation have a long life expectancy and be easily migrated as when the need arises. Ideally, multiple copies should be made and stored in professional repositories at different locations and regularly checked.

The digital master that is created should not be enhanced or altered. It should represent the original as closely as possible. The budget allocation for digitization must allocate funds for long-term preservation. The digitized collection will require permanent management to ensure its safety. It will also have to adapt to new preservation standards and practices that take into account technological developments.

2. **Main steps in digitization:** Planning; pre-digitization; digital conversion; post-digitization processes.
   - The planning process includes:
     - Identification of material to be digitized and rights related thereto.
     - Assessment of resources needed.

  - Decisions on standards.
  - Definition of methods and timing of quality control.
  - Assessment of risks, including current and future drawbacks
- The pre-digitization process includes:
  - The selection of materials to be digitized.
  - Quality control of the objects to be digitized - an assessment of their state of preservation and need of cleaning.
  - Prioritisation of digitization.
  - Any treatment that may be required or possible.
  - The collection of metadata (especially descriptive and structural metadata).
  - Bibliographic and archival preparation.
- Digital conversion includes:
  - Digitization.
  - Availability of professional equipment.
  - Quality control.
  - The creation of digital masters from which access copies are made.
- The post digitization process includes:
  - Control of metadata related to long-term preservation.
  - Submission of information to delivery and repository systems, data collection and management.
  - Making digitized copies and metadata available online.
  - Assessment and evaluation of the project.
  - Quality control.

3. **Descriptive Metadata:** Metadata, in a broader sense than descriptive, plays a significant role in the preservation, provenance, exchange, compatibility, and long term sustainable access of and to digital information. Most of this metadata is created for specialist needs or specific types of materials (technical metadata) or communities of expertise (e.g. linguistic, music, etc). All such metadata should be created in accordance with the technical standards or user community defined guidelines, and all processes of creating, maintaining, and sustaining digital information should be mindful of protecting this data in a usable form.

4. **Digital preservation:** This includes the processes needed to maintain access to information and the essential elements that make up digital objects. If access cannot be maintained the information carried by the object is effectively lost. Preservation is ensured through appropriate management practices which may be conducted in-house or may be outsourced. It is essential to identify the various stakeholders involved and their responsibilities for preservation and management along with the procedures to be implemented as well as the associated costs, etc, Access of digital information should be guaranteed for everyone as a human right. Digital infrastructure and technology should consider digital divided and sustainable accessibility.

5. **Digital repositories:** Trusted digital repositories should be established to house digitized resources, ensure their authenticity and long term accessibility.
6. **Economic aspects:** On average, digitization will require 1/3 of project time and funding. Organising and describing materials, creating indexing and making the collection searchable by users will require the remaining 2/3rds of the project time and funding. It must be noted, however, that the long-term preservation of digitized objects is a permanent additional cost factor.

Tools of Digitization: Digital imaging is an inter-linked system of hardware, software, and image database and access sub-system with each having their own components. Tools used for digitisation include several core and peripheral systems. An image scanning system may consist of a stand-alone workstation where most or all the work is done on the same workstation or as a part of a network of workstations with imaging work distributed and shared amongst various workstations. The network usually includes a scanning station, a server and one or more editing, retrieval stations. A typical scanning workstation for a small, production level project could consist of the following:

1. Hardware (Scanners, computers, data storage and data output peripherals)
2. Software (image capturing and image editing)
3. Network (data transmission)
4. Display and Printing technologies

Benefits of digitization

Digitization enables to complete preservation of the basic image data and part of the secondary image data. From the physical data it is possible to preserve only information about brightness and colors of the original. However, this information is deformed by the attributes of all of the used techniques. Certain exactitude can be reached by digitizing the calibrated areas with defined colors along with the originals. The digital facsimile can be considered as a certain safety archival dimension of this original, of its image. The further development, experience and measures, which will be available, will show how much and at what price the secondary image data should be preserved. However, it is to be emphasized again that the originals are irreplaceable, and therefore, access to them should be limited as quickly and as widely as possible. The other advantages are as follows:

1. **Increased Productivity-** It takes an employee an average of 12 minutes to find the paper document they are looking for. With a well-executed digitalization and document imaging plan, this can be reduced to a few seconds or less. Document Imaging allows the stake holder ability to share, collaborate, exchange and access documents in seconds, reducing the turnaround time further increasing the efficiency for your business.
2. **Cost efficiency-** The cost of printing and paperwork can be exorbitant. It involves various sub costs like equipment management, paper records maintenance and cost of space. Document Imaging with Aptara can help reduce these costs to minimal levels,

helping you focus on core business areas and increasing the investments for value adding verticals.

3. **Easy to access and always accessible-** Documents that have been converted can be easily accessed through the cloud or system using any device that has internet, anywhere or anytime.
4. **Enhanced security-** A scanned document is trackable document. If needed, only certain users can access the documents and workflows can be set up along with permission groups for an individual, which enhances the security and maintains the confidentiality of the document.
5. **Enhanced Information Preservation-** Information stored in paper formats is degradable information, and degrades further every time it is handled manually. Document imaging ensures that your business's most important data is saved and preserved for the future.
6. **Disaster recovery-** There is always a risk of disaster, whether it is natural or manmade. Fire, flood, earthquakes or other destructive phenomenon may cause a major disaster for your paper documents seriously affecting your business. Document imaging offers you to have a safe repository of your data which can also be shared on cloud or your local document management system, enabling you recovers precious documents with a simple click.
7. **Saves space-** Real Estate space is expensive, Eliminating paper storage can give you with more space, reduction in rent, reduced off-site document storage fees or potential to open up a new office.
8. **Stay Competitive-** From multinational firms to small organization, digitization has been the mantra of the new age document management. Document digitization efforts have repaid businesses in reduced costs, efficient workflows and satisfied customers.
9. **Environmentally friendly-** Document Imaging and overall document digitizing process adds to your green credits and is an environment friendly initiative. It removes the needs of creating multiple backup copies and unnecessary printing, increasing the eco-friendly quotient of your company.
10. **Digital Transformation –** Image scanning is a first step in building a digital transformation plan. Early adoption is the key for organizations to ensure digital success and focus on cost savings and standardization.

Issues faced in digitization process

Digitization faces many problems apart from the technical point of view. Required staff expertise and additional resources are often the greatest costs in digitization. Not only are large budget allocations needed to fund research and intellectual selection, but also time must be spent for feasibility assessments, training, and methodical prioritization of items or collections to be digitized. These requirements pull staff away from their regular workloads. Apart from this digitization faces challenges in several areas like:

¬ Storage

¬ Compression techniques save storage

¬ User interface

¬ Classification and Indexing
¬ Information retrieval
¬ Content delivery
¬ Presentation
¬ Administrative
¬ Ease of access to a digital collection leads to high expectations of end-users.

Figure 7.5 Process and Steps in Digitization Process

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Apart from this digitization faces challenges in several areas like

1. Storage
2. Compression techniques
3. User interface
4. Classification and Indexing
5. Information Retrieval
6. Presentation
7. Administrative

Types of digitization

The process of representing an analogue signal or an image by a discrete set of its points is known as Digitizing. This data after conversion is in the binary format, which is directly readable by computer. The data to be converted can be a text, an image, audio or a video. The analogue signals are variable whereas the digital format is the discrete one. These discrete units are called as bits. These bits (8) organized in groups are known as byte. The digital signals are mainly represented in the form of sequence of integers. These integers can be converted back to analogue signal that are approximately similar to the original analogue signals. Digitizing is done by reading an analogue signal 'A', and at regular time intervals, representing the value of 'A' at that point by an integer.

1) **Manual Digitizing:** It is done using digitizing tablet. The operator manually traces all the lines from his hardcopy map and creates identical digital map on the computer. It is very time consuming and level of accuracy is also not very good.
2) **Heads-up Digitizing:** It is similar to manual digitizing in the way that lines have to be drawn manually but directly on the computer screen. So in this level of accuracy increases and time taken decreases.
3) **Interactive tracing method:** It is improvement over Heads-up digitizing in terms of speed and accuracy.
4) **Automatic Digitizing:** It is automated raster to vector conversion using image processing and pattern recognition techniques. In this technique computer traces all the lines, which results in high speed and accuracy along with improved quality of images.

Device used for digitization is known as digitizer. It is an electromagnetic device consisting of a table upon which a map or a document to be scanned is placed. This device enters the spatial coordinates of mapped features from a map or a document to the computer. It is done with the help of a mouse or a hand held magnetic pen. The most commonly used digitizers are:

- Electrical orthogonal fire wire grid digitizer.
- Electrical wave phase type digitizer.

These digitizers can be supplied in various formats and are either in the form of a table or freestanding models with or without back lighting. A device known as "puck' is used in cases where high degree of precision is required. It is made up of a coil embedded in plastic with an accurately located window with cross hairs. Digitizing of the coordinates is done, by placing cross hairs over them and pressing control button on the puck. The process of digitizing begins with the set of control points. At the later stages these points are used for converting the digitized map to the coordinates of the real world.

Map making

A map showing only the horizontal position of features on the Earth's surface which show geographic objects, natural and cultural physical features, and entities without topographic features such as roads, buildings, and water bodies that are visible and identifiable on aerial photographs, but which can be compiled into map features through photogrammetric or surveying procedures. A planimetrically accurate map showing planimetric detail and other general features shows accurate horizontal distances between features.

Map features show roadway feature details as roads, sidewalks, streets, highways and alleys including curb lines, edge of paved surfaces or edge of traveled way, and general feature details as building footprints, reservoirs, tanks, docks, piers, airports, bridges, overpasses, underpasses, railroads, parking lots, driveways, other impervious surfaces, streams, lakes, drainage courses, holding basins, shorelines, other watercourses, vegetation outlines, elevations, fence lines, drainage, and other similar construction or terrain features.

Digital planimetric mapping provides accurate yet simple horizontal distance measurement. Applications are varied. They include planning for new projects as well as assessment of existing properties by government tax agencies, maintenance agreement by service companies, and cataloguing of assets by utility companies.

1. **Topographic Maps:** Topography concerns the shape and character of the Earth's surface and maps were amongst the first artifacts to record these observations. In modern mapping, a topographic map or topographic chart is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines (connecting points of equal elevation), but historically using a variety of methods. Traditional definitions require a topographic map to show both natural and man-made features. A topographic survey is typically based upon systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodetic datum. Official topographic maps also adopt a national grid referencing system.

   The distinctive characteristic of a topographic map is the use of elevation contour lines to show the shape of the Earth's surface. Elevation contours are imaginary lines connecting points having the same elevation on the surface of the land above or below a reference surface, which is usually mean sea level. Contours make it possible to show the height and shape of mountains, the depths of the ocean bottom, and the steepness of slopes.

   Topographic maps have multiple uses in the present day: any type of geographic planning or large-scale architecture; earth sciences and many other geographic disciplines; mining and other earth-based endeavours; civil engineering and recreational uses such as hiking and orienteering.

2. **Thematic Maps:** A 'thematic map' is a map that focuses on a specific theme or subject area. This is in contrast to *general reference maps*, which regularly show the variety of phenomena—geological, geographical, political—together. The contrast between them lies in the fact that thematic maps use the base data, such as coastlines, boundaries and places, only as points of reference for the phenomenon being mapped. General maps portray the base data, such as landforms, lines of transportation, settlements, and political boundaries, for their own sake.

A 'thematic map' addresses a specific theme, such as health or climate. In both function and content, thematic maps are fundamentally different from navigation maps, which serve the way-finding needs of drivers, pilots, and tourists, and general-purpose or reference maps, which portray a diverse set of basic features such as coastlines, terrain, and transport routes. Thematic maps have two main components: a thematic overlay, and a base map. Typically, the base map is already available in a cartographic database or collection of general-purpose maps and the map author adds the graphic symbols and labels that portray the map's unique theme. Important decisions in the design of a thematic map include the choice of data, a projection, and visual variables, and the composition of the map's title and legend. The most common thematic map is the 'choropleth map,' in which area symbols representing specific categories completely fill the boundaries of countries, provinces, census tracts, and other areal units.

Types of Thematic Maps

Although cartographers can use data sets in different ways to create thematic maps, five thematic mapping techniques are used most often:

- The most common is the **choropleth map**, which portrays quantitative data as a color and can show density, percent, average value, or quantity of an event within a geographic area. Sequential colors represent increasing or decreasing positive or negative data values. Normally, each color also represents a range of values.
- **Proportional or graduated symbols** are used in another type of map to represent data associated with locations, such as cities. Data is displayed on these maps with proportionally sized symbols to show differences in occurrences. Circles are most often used, but squares and other geometric shapes are also suitable. The most common way to size these symbols is to make their areas proportional to the values to be depicted using mapping or drawing software.
- Another thematic map, is **contour map**, uses isolines to depict continuous values such as precipitation levels. These maps also can display three-dimensional values, such as elevation, on topographic maps. Generally, data for isarithmic maps is gathered via measurable points (e.g. weather stations) or is collected by area (e.g. tons of corn per acre by county). Isarithmic maps also follow the basic rule that there are high and low sides in relation to the isoline. For example, in elevation, if the isoline is 500 feet, then one side must be higher than 500 feet and one side must be lower.
- A **dot map**, another type of thematic map, uses dots to show the presence of a theme and display a spatial pattern. A dot can represent one unit or several, depending on what is being depicted.
- Finally, **dasymetric mapping** is a complex variation on the choropleth map that uses statistics and additional information to combine areas with similar values instead of using the administrative boundaries common in a simple choropleth map.

Thematic maps serve three primary purposes.

1. They provide specific information about particular locations.
2. They provide general information about spatial patterns.

3. They can be used to compare patterns on two or more maps.

Common examples are maps of demographic data such as population density. When designing a thematic map, cartographers must balance a number of factors in order to effectively represent the data. Besides spatial accuracy, and aesthetics, quirks of human visual perception and the presentation format must be taken into account.

7.4 SUMMARY

Scanning has the potential for substantially reducing the costs of encoding maps for GIS input. However, care should be exercised in selecting this option. If the intended use of scanned data is to obtain a backdrop or overlay for other GIS data, required preprocessing of the scanner-produced data before data entry into a GIS will be minimal. However, if scanner-produced data are to be used to extract information that is represented by colors, textures, or symbols; or if the scanner data are to be merged with other scanner data in a GIS, extensive data processing may be required. In addition, preprocessing may be required in order for the scanner data to conform to the input data format, scale, resolution, and projection requirements of the GIS.

Manuscripts are important source of invaluable information and need to be preserved for the present as well as future generations. Ever since efforts are being made in one way or the other to preserve the valuable collection. With the advent of information technology, the use of latest technologies of reformatting i.e digitization, microfilm, microfiche, to preserve the collection, is looked upon as a solution to the problems of preservation of the manuscripts. Digitization, no doubt has its own advantages as it improve the access, limit the handling of the original document. Digitization cannot be relied upon as preservation medium. After digitizing the collection, preservation of the digitized collection i.e., digital preservation, becomes more important. Digital preservation does not end with the careful storage of the digital objects. In order to keep these objects accessible, a continuous effort toward the development of strategies for the permanent access is required. The usability of the digital object is threatened by rapid innovations, new systems, new software, and making the existing technologies obsolete. The innovations are done for the betterment of the system and to give better services but long term preservation is not assured. Digital preservation is thus a problem specifically for the cultural heritage sector, where long term preservation is the main and only focus. In order to achieve the target of preservation, a hybrid solution, digitizing as well as microfilming of the manuscripts can be trusted

7.5 GLOSSARY

1. **Digitization:** Digitization is the process of converting information into a digital format.
2. **Digitization and Digitalization:** Digitization is the conversion of analog to digital, whereas digitalization is the use of digital technologies and digitized data to impact how work gets done, transform how customers and companies engage and interact, and create new (digital) revenue streams.

3. **Need of Digitization:** Digitization is of crucial importance to data processing, storage and transmission, because it "allows information of all kinds in all formats to be carried with the same efficiency and also intermingled".
4. **Image:** An image (from Latin: imago) is an artifact that depicts visual perception, such as a photograph or other two-dimensional picture, particularly one that resembles a subject (usually a physical object).
5. **Map:** A map is a symbolic depiction emphasizing relationships between elements of some space, such as objects, regions, or themes. Many maps are static, fixed to paper or some other durable medium, while others are dynamic or interactive.

7.6 ANSWER TO CHECK YOUR PROGRESS

1) GIS is a user support tool not only to manage attribute data but also for collecting, storing, retrieving, transforming and displaying spatial data.
2) General users are those people who use GIS for general purpose such as business, professional services and for decision making. People who plan and develop GIS software for viewers and general users and also provide technical support to them are called GIS specialists.

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7.8 TERMINAL QUESTIONS

1) Define digitisation. What are the major steps of digitization?
2) Describe the steps involved in the process of scanning a document using a flatbed scanner.
3) What are the major advantages and disadvantages of digitization?
4) Define maps. Explain various types of Maps.

UNIT8 - INFORMATION: SAMPLE AND CENSUS SURVEYS ATTRIBUTE DATA TABLES, ELEMENTS OF MAPS, MAP LAYOUT PRINCIPLES

8.1 OBJECTIVES

After reading this unit you will be able to:

1. To study the types of data
2. To study the elements of maps
3. To study the map layout and designing

8.2 INTRODUCTION

Map making is significantly influenced by current information technology that allows the compilation of maps using different software products as a way of displaying individual data layers. The availability of this software allows the compilation of maps by nonprofessional map makers from different occupations. However, without cartographic knowledge, the final products are often artefacts that do not meet one of the main functions of the map—to provide truthful information.

Map design is the aggregate of all the thought processes that cartographers go through during the abstraction phase of the cartographic process. Map design is a complex activity involving intellectual and visual, technological and non-technological, and individual and multidisciplinary aspects. For map design, it is necessary be knowledgeable about map projections and reference systems and geographical names. There are different forms of map design—for topographic maps and for thematic maps. The most complex process of map design is for atlases. The topographic map is an essential reference map product. A fundamental aspect of map design for topographic maps is the most accurate recording of planimetric (two-dimensional location) and hypsographic (height above sea level) situations on the scale of a map.

8.3 INFORMATION- SAMPLE AND CENSUS SURVEYS ATTRIBUTE DATA TABLES, ELEMENTS OF MAP, MAP LAYOUT PRINCIPLES

8.3.1 Types of data

The real world, the world in which we live in, is so irregular, complex and dynamic that the accurate and precise representation is a Herculean task. GIS through mapping tools and techniques has been able to represent a simplified view of the world. Despite the heterogeneity of the information that can be stored in GIS, there are only a few common methods of representing spatial information in mapping database.

Geospatial data or geographic information it is the data or information that identifies the geographic location of features and boundaries on Earth, such as natural or constructed features, oceans, and more. Spatial data is usually stored as coordinates and topology, and is data that can be mapped. A common example of spatial data can be seen in a road map. A road map is a two-dimensional object that contains points, lines, and polygons that can represent cities, roads, and political boundaries such as states or provinces. A road map is a visualization of geographic information. Spatial data comprise the relative geographic

information about the earth and its features. A pair of latitude and longitude coordinates defines a specific location on earth. Spatial data are of two types according to the storing technique, namely, raster data and vector data.
The second one is attribute data, the data which include any other non-location information related to a point, a line, or a polygon for example comprises numbers, characters or logical type.

8.3.2 Sample and census survey data

A census is the procedure of systematically acquiring and recording information about the members of a given population. This term is used mostly in connection with national population and housing censuses; other common censuses include traditional culture, business, supplies, agricultural, and traffic censuses. The United Nations defines the essential features of population and housing censuses as "individual enumeration, universality within a defined territory, simultaneity and defined periodicity", and recommends that population censuses be taken at least every ten years. United Nations recommendations also cover census topics to be collected, official definitions, classifications and other useful information to co-ordinate international practices.
A census can be contrasted with sampling in which information is obtained only from a subset of a population; typically main population estimates are updated by such intercensal estimates. Modern census data are commonly used for research, business marketing, and planning, and as a baseline for designing sample surveys by providing a sampling frame such as an address register. Census counts are necessary to adjust samples to be representative of a population by weighting them as is common in opinion polling.
Early censuses in the 19th century collected paper documents which had to be collated by hand, so the statistical information obtained was quite basic. The government owned the data could publish statistics on the state of the nation.[22] The results were used to measure changes in the population and apportion representation. Population estimates could be compared to those of other countries.
By the beginning of the 20th century, censuses were recording households and some indications of their employment. In some countries, census archives are released for public examination after many decades, allowing genealogists to track the ancestry of interested people. Archives provide a substantial historical record which may challenge established views. Information such as job titles and arrangements for the destitute and sick may also shed light on the historical structure of society. Political considerations influence the census in many countries. In Canada in 2010 for example, the government under the leadership of Stephen Harper abolished the mandatory long-form census. This abolition was a response to protests from some Canadians who resented the personal questions.[23] The long-form census was reinstated by the Justin Trudeau government in 2016.
As governments assumed responsibility for schooling and welfare, large government research departments made extensive use of census data. Population projections could be made, to help plan for provision in local government and regions. Central government could also use census data to allocate funding. Even in the mid 20th century, census data was only directly accessible to large government departments. However,

computers meant that tabulations could be used directly by university researchers, large businesses and local government offices. They could use the detail of the data to answer new questions and add to local and specialist knowledge.

Nowadays, census data are published in a wide variety of formats to be accessible to business, all levels of government, media, students and teachers, charities and any citizen who is interested; researchers in particular have an interest in the role of Census Field Officers (CFO) and their assistants.[24] Data can be represented visually or analysed in complex statistical models, to show the difference between certain areas, or to understand the association between different personal characteristics. Census data offer a unique insight into small areas and small demographic groups which sample data would be unable to capture with precision.

It contains data on population growth, fertility and mortality serves as the starting point for population projections. Apart from these vital indicators, an adequate evaluation of a number of programs in the health sector, including family planning, maternal and reproductive health, immunization programs, is dependent upon the availability of accurate, up-to-date fertility and mortality data.

8.3.3 Map and map making

A map is defined as a representation, usually on a flat surface, of a whole or part of an area. The job of a map is to describe spatial relationships of specific features that the map aims to represent. There are many different types of maps that attempt to represent specific things. Some of the most common types are political, physical, topographic, climate, economic, and thematic maps.

A thematic map is a map that focuses on a specific theme or subject area such as physical phenomena like temperature variation, rainfall distribution and population density in an area. Thematic maps emphasize spatial variation of human issues like population density or prevalence of diseases.

Cartography is the study and practice of making maps. Combining science, aesthetics, and technique, cartography builds on the premise that reality can be modeled in ways that communicate spatial information effectively.

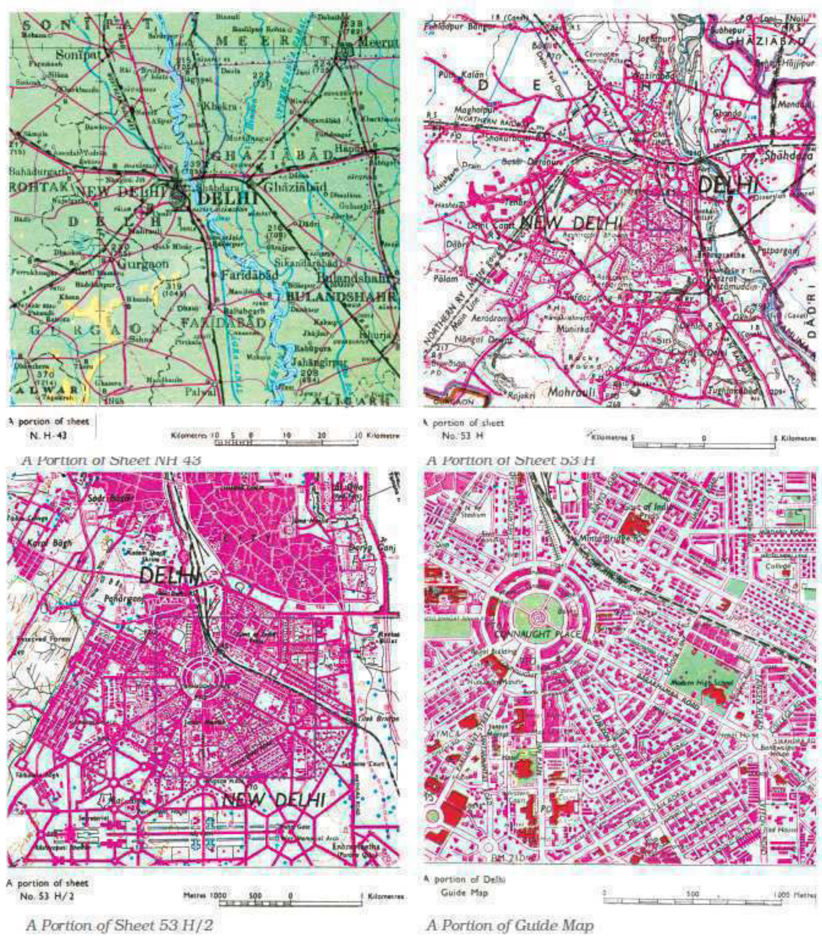
8.3.4 Elements of maps

In view of the variety of maps, we may find it difficult to summarise what they all have in common. Cartography, being an art and science of map-making, does include a series of processes that are common to all the maps. These processes that may also be referred to as elements of maps are: Scale, Map Projection "Map Generalisation, Map Design, Map Construction and Production

- **Title:** The title of a map is usually one of its most essential features. As such, it should receive very careful attention so as to match the needs of the theme and audience. A short title might suffice if readers can be assumed to be familiar with the theme being presented; more information is needed for less experienced readers. The content of the title should also be measured against other lettering applied to the map, for example in the legend or annotations. Sometimes, legends and annotations supplant much of the content of a title. Also, be aware that captions usually take the place of titles for maps appearing in publications such as books and journals.

- **Legend:** The legend lists the symbols used on a map and what they depict. These symbols should appear in the legend exactly as they are found in the body of the map and be described clearly and fully. Do not treat the legend as an afterthought; it should receive careful attention. Be aware, however, that not all maps require legends. Sometimes the necessary information is put in a caption, or subsumed by textual annotations placed directly on the body of the map. If possible, try to give the legend a more creative title than "Legend".
- **Scale**: We know that all maps are reductions. The first decision that a map-maker has to take is about the scale of the map. The choice of scale is of utmost importance. The scale of a map sets limits of information contents and the degree of reality with which it can be delineated on the map.

Figure 8.1: Effect of Scale on Mapped Information



- **Map Design**: The fourth important task of a cartographer is the map design. It involves the planning of graphic characteristics of maps including the selection of appropriate symbols, their size and form, style of lettering, specifying the width of lines, selection of colours and shades, arrangement of various elements of map design within a map and design for map legend. The map design is, therefore, a complex aspect of mapmaking and requires thorough understanding of the principles that govern the effectiveness of graphic communication.

- **Map Construction and Production**: The drawing of maps and their reproduction is the fifth major task in the cartographic process. In earlier times, much of the map construction and reproduction work used to be carried out manually. Maps were drawn with pen and ink and printed mechanically. However, the map construction and reproduction has been revolutionalised with the addition of computer assisted mapping and photo-printing techniques in the recent past.
- **Date of production:** The meaning and value of some maps--such as those relating to current affairs or weather--are times sensitive. The reader must know when they were produced to gauge whether to trust them. An out-of- date road atlas or city map can cause tremendous frustration. Other maps are less sensitive to the passage of time, but the date of production can still be important if, for example, better information becomes available in the period after publication. Be sure to indicate the date of production for your map, or make sure that it can be inferred from the context in which it is to appear (maps that appear in newspapers, magazines, and journals can be dated in this way). The detail with which you specify the date of production will depend again on the nature of your theme and audience.
- **Disclaimer:** Often, a disclaimer stating proper use of the map will be necessary. Many organizations and cartographers have developed standard disclaimers. One I use often is: “This is not a map, and should not be used as a map in any way”. Disclaimers can be extremely important depending upon the map audience and the data you are mapping. Another example I used often when mapping septic suitability “Data on this map do not preclude an on-site investigation.” Clearly, your disclaimer should have close ties to your sources of information statement.
- **Projection:** We also know that maps are a simplified representation of the three-dimensional surface of the earth on a plane sheet of paper. The transformation of all-side-curved-geoidal surface into a plane surface is another important aspect of the cartographic process. We should know that such a radical transformation introduces some unavoidable changes in directions, distances, areas and shapes from the way they appear on a geoid. A system of transformation of the spherical surface to the plane surface is called a map projection. Hence, the choice, utilisation and construction of projections is of prime importance in map-making.

Other Map Elements used selectively to Enhance Communication

- **Neat lines:** Neat lines or clipping lines are used to frame a map and to indicate exactly where the area of a map begins and ends. The outer neat line of a map--its border--helps to frame the entire map composition to draw the reader's attention to the various elements of information. Neat lines are also used to "clip" the area of the body of the map and of locator, inset, and index maps. Neat lines are not always needed to trim the body of the map. Some geographic areas can, so to speak, be suspended in space without a neat line. In other cases, the areal extent of a map can be made apparent in other ways.

- **Locator Map:** Some maps portray areas whose locations may be unfamiliar to readers. In such cases, the cartographer adds a "helper" or locator map that places the body of the map within a larger geographical context with which the reader can be expected to be familiar. For example, a detailed map of trees on the Mount Holyoke campus, may require a locator map the campus's position within the town of South Hadley.
- **Inset Map:** Sometimes observations and data are so densely clustered in small sections of a larger map that the cartographer must provide the reader with additional close-up, "zoomed-in" maps of these smaller areas. Otherwise the data will obscure itself. These close-up detailed maps are called insets.
- **Index Map:** There are limits to the amount of information that can be placed effectively in the body of a map, even though this information is useful to readers. Sometimes labels and other information have to be moved to an index map.
- **Visual Hierarchy:** As one considers each map element, the cartographer must determine its importance to and priority within the overall map design. The most important elements in a given design should be featured in more prominent positions and perhaps occupy a larger area within the map frame. As a first approximation, the most important information should be featured near the top or to the left of the map. Less important and ancillary map elements can be positioned toward the bottom and right. In this way, the importance of the various map elements can be matched to the visual hierarchy of the map itself. In general terms, the importance of a given map element should be reflected in its position and the amount space it occupies on the map.

8.3.5 Map design

Ideally, thematic maps are the result of creative collaboration of experts from two professions. The first is a thematic content expert; the second is a *cartographer* (a visualization expert). A thematic content expert can be a climatologist, geologist, demographer, urbanist, political scientist, ecologist, botanist, hydrologist, tourist, soldier, economist or other professional who is required to express "his/her thematic information" on a map. A cartographer is responsible for the correct visualization, thus ensuring a process in which the reader gains from the map exactly the same information that the thematic expert was required to insert into the map. Cooperation between the two experts is necessary in most cases—a thematic expert would not display his/her data correctly without a cartographer, and a cartographer would not know without a thematic expert what the map should convey and why. Map design passes through three phases—map proposal, map drafting and map compilation.

8.3.5.1 Map Proposal: A mapping assignment is always the beginning of map design. A map assignment is essentially a special type of order. The execution of such a contract requires professional solutions based on the nature of the map project. A thematic map assignment is formulated by a customer expressing the intention with which each map is to be compiled and published. The map assignment must include a clearly defined objective and purpose for the map, as well as other requirements, such as the volume of the information or the expected map use.

The objective of the map is a key point of the map assignment. The objective of a topographic map is to provide the most accurate display of a topographic and hypsographic situation on the scale of the map. The objective of a thematic map is defined by a thematic expert (or by a contracting authority) in the form of which their visualised portrayal is intended. According to the map assignment, a cartographer draws up a *project map* and elaborates important items of map design. It consists of two main parts, namely, the objective specification and the project specification.

When the objective of a map is specified, the target group of users, the way of working with the map and the volume of conveyed information are carefully formulated. There are many possible user groups, characterized by age, education, cartographic literacy and previous experience of working with maps:

- school groups (pupils and students) often use school wall maps and atlases;
- professional groups (experts and officers) often use scientific maps with specialized content, including administrative maps, topographic maps and cadastral maps;
- public groups (the general public, including interest groups) often use tourist maps, road maps, maps of wine regions, maps of fishing grounds, etc.

The manipulation of a map involves specifying the expected time available for viewing the map (a map on the wall permanently or a short map display on TV), the form of the map (paper or digital) and the conditions for viewing the map (for walking, in low light, in a wet environment, etc.).

8.3.5.2 Map Drafting:

- **Topographic Maps:** At the beginning of topographic map compilation, astronomical measurements are necessary for determining the exact position of selected points which are used to define coordinate systems. These are followed up by geodetic measurements generating the network of triangulation points with which all objects on the Earth's surface are mapped in the field—buildings, roads, rivers, forests, borders, etc. Cartographers compile topographic maps according to the rules and regulations set through which all maps in a topographic map series are identical in projection, content, detail, labelling and symbology. Topographic maps are frequently updated and constantly improved.
- **Thematic Maps:** Thematic maps are compiled in a different way. Thematic content (geology, climate, population, transportation, etc.) is drawn on a *base map*, which is most often either a simplified topographic map or a set of data layers. This creates *a working map*. The results of field surveys or other existing thematic data such as statistical data are added to it. In this working map, the cartographic rules (on colours, labelling, etc.) may not be strictly observed because the working map is only for the author, not for the end users. The cartographer and thematic expert work together to

define its content, methods, symbology, etc. If the map is compiled in GIS, the working map is a simple data view or visualization of the data.

The cartographer and thematic expert can redraw, refine, supplement or generalize this working map several times. The final working map is called the author's original, which is a master for further cartographic processing

8.3.5.3 Map Content: The features on a map are the *map content*. Map content is compiled sequentially to be fully in line with the map objective. Features are displayed in the map content according to one of the following criteria:

- Qualitative: the species are expressed (e.g. language map);
- Quantitative: the quantifiable properties (e.g. population density map) are displayed;
- Topological: the features are represented by their ground nature (the way they relate to the Earth surface) by point, line and areal symbols (e.g. road map);
- Developmental: the changes in space and time are displayed (e.g. troop movement map);
- Meaning: or significance and the significance of a small settlement in the desert is higher than that of a similar settlement in a well-populated area) and
- Structural: the feature as a unit together with its sub-components and interrelationships are represented (e.g. map of the age structure of the population).

In compiling the map contents, the first task is to distinguish primary features (resulting from the map assignment) from secondary ones (used to supplement the information on the map). A topographic base of the thematic map is created to allow for spatial localization and to find mutual topological relations of the primary features.

8.3.6 Map symbol and cartographic methods

There are a number of methods for map visualization of map contents. The selection of methods is determined by the nature of the displayed features (which can either be related to points, lines or areas) and the objective of the map.

1. Point map symbols—a simple geometric, figurative or alphanumeric picture allow for the expression of feature characteristics at a particular location. Using the shape, size, structure, fill and orientation, both qualitative and quantitative characteristics can be expressed. Qualitative feature characteristics are mostly expressed by the shape of the point symbol. The size of the map symbol is used mainly for expressing amounts, importance or super ordination of the features. The size of a symbol is proportional to the quantity of the feature and is related to the measurable parameter of the symbol mostly the radius of a circle, the side of a square, the height of a column or picture. The structure (internal graphical breakdown) of the symbol is used to express the internal feature structure, such as the ethnic structure of the population or the sectorial structure of manufacturing. The fill of the symbol by colours or by hatching is used mostly to express the qualitative feature characteristics. The orientation of the symbol (rotation around its centre point) is most commonly used to express the direction of movement, such as wind direction, migration of animals or sight line.

2. Line map symbols—various forms of lines express both qualitative and quantitative characteristics of linear features by thickness, structure, colour and orientation. Simple lines (solid, dotted, dashed, dash-and-dot) and complex lines (with various supporting map symbols crosses, "teeth," ripples, images) are used to express the quality of linear features. The thickness of the line symbol is determined by the relationship to the quantity of the feature (e.g., traffic volume) or importance or super-ordination (e.g., state, provincial, municipal borders). The qualitative characteristics of linear features are mostly expressed through colour (another feature = other colour). The longitudinal orientation of the symbol expresses the direction "forward/backward" such as animal migration or the movement of troops, and the transverse orientation expresses the fact that boundaries separate areas with different characteristics.
3. Quantitative characteristics of large-scale features by fill (colours or hatching) and outline. The fill is used more frequently, although outline provides the structure, thickness, colour and orientation.

8.3.7 Colour

The colour parameters include hue, value and saturation. Hue can be defined as the various colours we perceive (red, blue, green, yellow, orange, etc.). Millions of hues arise by combining various percentages of the primary hues and altering their value and saturation. Value is the lightness or darkness of a hue and is affected by background: the value looks lighter when surrounded by darker shades of grey colour. Saturation means intensity or purity of a colour and ranges from 0% (neutral grey) to 100% (maximum saturation). Finding the right colour combination or colour harmony is not a trivial issue. Colour is used differently for expression of quality (species) and quantity (amount) of the feature characteristics. When distinguishing the features according to their qualitative characteristics (e.g., countries of the world, soils, language), a cartographer expresses these qualities primarily by differences in hue, then by saturation and value. Lighter colours are applied for larger map areas to be visible and identifiable relative to darker colours. Darker colours appear much more dominant than lighter colours within the same area size. Some colours permit us to perceive less contrast than others because two or more colours interact and influence each other's appearance.

When using colour to express feature quantities in the map, cartographers distinguish amounts of features (more—less; most important—unimportant, etc.) by changing the colour intensity, the combination of colour saturation and brightness according to the following rule: the higher the intensity of the feature, the higher the colour intensity.

The representation of quantitative features on maps involves the use of a single hue or a limited number of hues to unify a feature. For example, with an air temperature map, the hue progression (colour ramp) represents air temperature, and varied values and saturation within the hue creates a graded series from light to dark showing degrees of Celsius. With such a scheme it is easy to associate the feature with the hue and the different quantities with the lightness or darkness of the hue. Lighter hues normally represent lower quantities while darker hues are for higher quantities. The reverse may be applied, however, when it is desirable to emphasize the lower quantities (e.g., to highlight areas of extreme poverty [low income] with the strongest colour in the graded series).

8.3.8 Labelling or map text

All maps but orienteering maps contain text. Place names must be easy to read and be placed at the right location also when you zoom in or out on your computer screen. The first thing that catches the eye is that there are so many printing typefaces. The development of typefaces has a long history; its main purpose has been to create texts easy to read in books and newspapers. The typefaces used in advertising have other characteristics, chosen in order to convey an impression of the objects the advertisement deals with. In this section we will handle typography and how to print the text on the map. Different typefaces are used to label different types of map objects, and of course texts are also used the title, legend, imprint and text boxes. By changing type parameters, we can distinguish features by labelling the map content and thus improve the map readability and attractiveness. The readability and clarity of each letter symbol or character are provided by the basic parameters of type—family, size, colour, etc.

Map typography includes all the letters (regardless of language or writing system) and numbers on the map sheet that are classified according to the features to which they are related .The labelling must always be formally and linguistically correct. For the spelling of the names see chapter 8 on toponymy.

Each type is created in four forms. Firstly, the normal form in uppercase and lowercase letters, and secondly the italic form also in uppercase and lowercase letters. The size of the letters is measured in points. The Anglo-Saxon point is 0.375 millimetre, and the American pica point 0.351 millimetre. The latter one is mostly used in computer graphics. Text in five points is readable, but six points is the smallest recommended.

8.3.9 Placement of text

After the typography has been chosen it is time to place the name in the map. For a settlement or a single object six locations can be considered. Place a rectangle around the object and consider the four corners, and above and under. The text with a corner as a reference point should end or start close to the reference point. The text above or under should have the reference point in the middle. For large cities the text can cover some of the area. Names of populated settlements are normally in black colour. Name placement also involves work with reduction of part of other elements but not more than necessary to make the letters free. The text placement is computerized and needs good cartographic software.

There are many rules for text placement. The name of a river should follow the river line and be placed north of the river. If the river is broad enough the name can be placed in the river. The river name can also be placed on many locations and especially at the end of the river. Names of settlements along the river should be placed on the same side as the settlement is located. A harbour city may have its name in the Sea (or in the lake). An inland city may have its name on land. Name labels may not be placed upside down. The only text that can be placed upside down is the height figures of elevation lines. The labelling is mainly positioned

horizontally, only the line and area features are labelled along geographic grids or along their axes. The labelling is always placed so that it is clear to which feature it belongs.
The labelling is mainly positioned horizontally, only the line and area features are labelled along geographic grids or along their axes. The labelling is always placed so that it is clear to which feature it belongs.

8.3.10 Map generalization

Map generalization is the process that simplifies visualization to produce a map at a certain scale with a defined and readable legend. To be readable at a smaller scale, some objects are removed, enlarged, aggregated, displaced or simplified. During generalization, map information can be globally simplified but has to stay readable and understandable. Map generalization includes several methods for reducing the complexity of the real world by strategically reducing unnecessary details:

- Selection—the most important features stand out while lesser ones are left out entirely. For example, a directional map between two points may have lesser and untraveled roadways omitted so as not to confuse the map reader. The selection of the most direct and uncomplicated route between the two points is the most important data, and the cartographer may choose to emphasize this;
- Simplification—the shapes of retained features are altered to enhance visibility and reduce complexity. Smaller scale maps have more simplified features than larger scale maps because they simply exhibit more area;
- Combination—the features are combined when their separation is irrelevant to the objective of the map. A mountain chain may be isolated into several smaller ridges and peaks with intermittent forest in the natural environment, but shown as a continuous chain on the map, as determined by scale;
- Smoothing—is reducing the angularity of line work to exhibit it in a much less complicated and less visually disruptive way. An example is the smoothing of a meandering river so that the generalized line of the river contains less bends, is less curved and follows the main flow direction; and
- Enhancement—is used to show the primary nature of features and to highlight specific details that would otherwise be left out.

8.3.11 Map composition

Map composition is the first image the reader sees on the map. Map composition means the distribution of the graphic elements on the map sheet. It depends primarily on the objective and scale of the map, map projection, the shape and size of the mapped area and the format of the map sheet. The map composition of the thematic maps is very varied and diverse, unlike the topographic maps with uniform map composition based on official rules and regulations.
Map composition must meet three basic requirements:

- To include all the basic composition elements;
- To be balanced, without empty or overfilled areas; and

- To present aesthetically pleasant conditions for map reading.
- The basic elements of composition are:
    - Map area;
    - Map title;
    - Map legend;
    - Map scale (graphical, verbal);
    - Imprint.

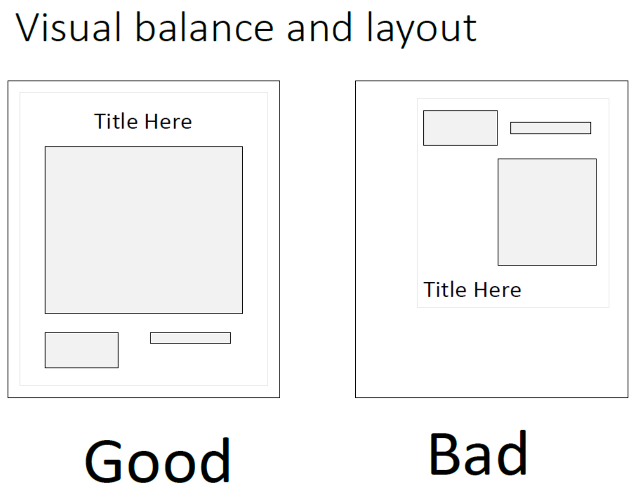
The map title contains the main textual information on the map. The theme of the map, which the cartographer receives from the map assignment, should be briefly but clearly expressed in the map title. It is then placed on the top of the map legend. The map title must contain main theme of the map. If the map title is too long, part of the title is given as the subtitle. The title usually contains the thematic determination of the feature and it is always written in uppercase letters. The subtitle contains the spatial and temporal determinations of the features and it is always written under the title and in lowercase and smaller letters than the title. The map legend is an overview of the symbology used on the map in easily readable and understandable form, from which the map reader correctly decodes information stored in the map. The map legend is placed near the map area. The map legend must be:

- Complete —"what is in the map is then in the legend." The map legend must contain all map symbols that are in the map. The map legend does not contain information on construction elements (map projection, geographic grid, etc.). The legend of thematic maps does not include the symbols of the topographical base;
- Independent —one feature has only one symbol in the map legend;
- Ordered —the map legend map must be arranged in a logical structure, usually by hierarchy of the features;
- In accordance with the symbol appearance in the map—the symbols in the legend and in the map must be rendered identically (the same shade of colour, the same size, the same thickness, the same width, etc.); and
- Understandable—the explanation of all symbols must be clear and easy to understand.

An imprint always contains the author's name, publisher, place and year of publication. It may also contain names, copyright, etc. In addition to basic composition elements, a map can contain other additional composition elements to increase the information value of the map and its attractiveness, such as a north arrow, insets, charts, profiles, explanatory texts, tables, etc.

8.3.12 Map compilation

Once a cartographer generalizes the map content and interprets it in the map at the scale of issue, this result in an *editorial original*. The content of the editorial original is drawn with the prescribed graphical accuracy in all details in accordance with a map project. The thematic content of the editorial original is taken from the authors' originals, which are compiled by thematic experts rather than cartographers. The compilation of the thematic map requires a skilled cartographer, who addresses a number of cartographic tasks in accordance with the map project, especially map composition, generalization, map content maps and symbology. A cartographer is fully responsible for the quality of visualization of the editorial original, which is the final form of the map design. The editorial original is first elaborated in the areas with the richest map content in order to determine the optimal graphic complexity of these areas and their readability. Symbology and level of generalization are adjusted according to these areas. Other features of the map content are then drawn according to their importance. Finally, the labelling and additional composition elements are drawn. The thematic expert is involved in the compilation of the editorial original primarily as a consultant on the map content and symbology.



8.4 SUMMARY

The maps presented in this monograph suggest just a few of the numerous ways that demographers can use contour maps to clearly, efficiently, and simultaneously display both persistent global and prominent local patterns in population rates or levels over two dimensions. In particular, contour maps can strikingly reveal the interaction between age, period, and cohort patterns. By using small multiples, computer movies, or ratio surfaces demographers can use the maps to gain access to several dimensions.

Even in cases where some demographic data already have been carefully scrutinized by perceptive analysts who have uncovered most of the interesting patterns, contour maps may be useful in highlighting these patterns. With contour maps, what was before understood now can be seen. Furthermore, the maps, by giving demographers a new perspective on data, may focus attention on some neglected aspects and patterns in even thoroughly studied data.

Beyond efficient description, contour maps can help demographers with exploratory data analysis and with model building. Surfaces can be computed relative to some part of the surface or to another surface; and different surfaces can be placed next to each other and compared. The patterns produced by a model can be displayed for different parameter values as can the fit of the model to some empirical data. If the data are defined over two dimensions, then a contour map can be used to display the residuals, i.e., the differences between the actual values and the values predicted by the model. By scrutinizing the pattern of the residuals, an analyst may glean some clues as to how to improve the model. Tukey (1977) and Mosteller and Tukey (1977) provide clear discussions of the use of residuals in data analysis and model building and several statistical software packages enable users to conveniently plot contour maps of residents.

8.5 GLOSSARY

1. **Cadastral Map:** A large-scale map drawn at a scale of 1: 500 to 1: 4000 to show property boundaries, designating each parcel of land with a number.
2. **Cardinal Points:** North (N), South (S), East (E) and West (W).
3. **Cartography:** Art, science and technology of making maps, charts, plans and other modes of graphical expression as well as their study and use.
4. **Generalization-Map:** A simplified representation of the features on the map, appropriate to its scale or purpose, without affecting their visual form.
5. **Geoid:** An oblate spheroid whose shape resembles the actual shape of the Earth.
6. **Map:** A selective, symbolized and generalized representation of the whole or part of the earth at a reduced scale.
7. **Map series:** A group of maps produced at same scale, style and specifications for a country or a region.
8. **Projection-Map:** The system of the transformation of the spherical surface onto a plane surface.
9. **Scale:** The ratio between the distances of two points on the map, plan or photograph and the actual distance between the same two points on the ground.
10. **Sketch Map:** A simplified map drawn freehand which fails to preserve the true scale or orientation.

8.6 ANSWER TO CHECK YOUR PROGRESS

Choose the right answer from the four alternatives given below:

1) Which one of the following is essential for the network of lines and polygons to be called a map?
a) Map Legend
b) Symbols
c) North Direction
d) Map Scale
2) A map bearing a scale of 1 : 4000 and larger is called :
a) Cadastral map
b) Topographical map
c) Wall map
d) Atlas map
3) Which one of the following is NOT an essential element of maps?
a) Map Projection
b) Map Generalisation
c) Map Design
d) History of Maps

8.7 REFERENCES

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8.8 TERMINAL QUESTIONS

1- Write an explanatory account of types of maps.
2- Explain elements of maps in detail with suitable diagrams.

UNIT 9: MAP DESIGN FUNDAMENTALS, SYMBOLS AND CONVENTIONAL SIGNS, GRADED AND UNGRADED SYMBOLS, COLOR THEORY, COLORS AND PATTERNS IN SYMBOLIZATION, MAP LETTERING

9.1 OBJECTIVES

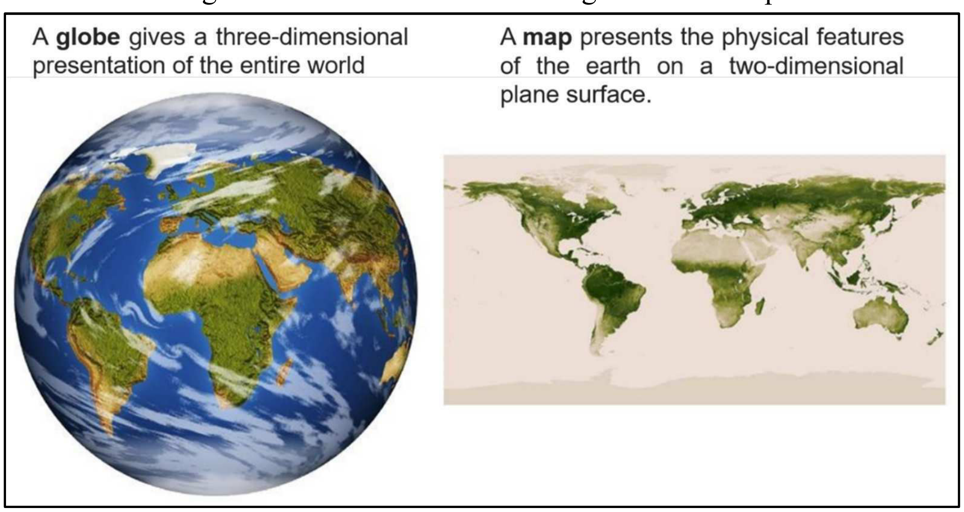
By the end of this unit you will be able to understand the:

- Fundamentals of map design
- Different map elements
- Conventional symbols and signs used in map making
- Different techniques to calculate area

9.2 INTRODUCTION

A map is a simplified representation of whole or part of the earth on a piece of paper. In other words, it is a two-dimensional representation of the three-dimensional earth (Fig.9 1). As it is impossible to represent all features of the earth's surface in their true size and form, a map is drawn at a reduced scale. If a map of your neighborhood is to be drawn in its actual size, it will be as large as the neighborhood itself. Hence, maps are drawn at a reduced scaleso that each point on the paper corresponds to the actual ground objects. Also, to represent different earth objects, simplified symbols andcolorsare used. It may also be understood that a simple network of lines and polygons without a scale shall not be called a map. It is only referred to as "the sketch".

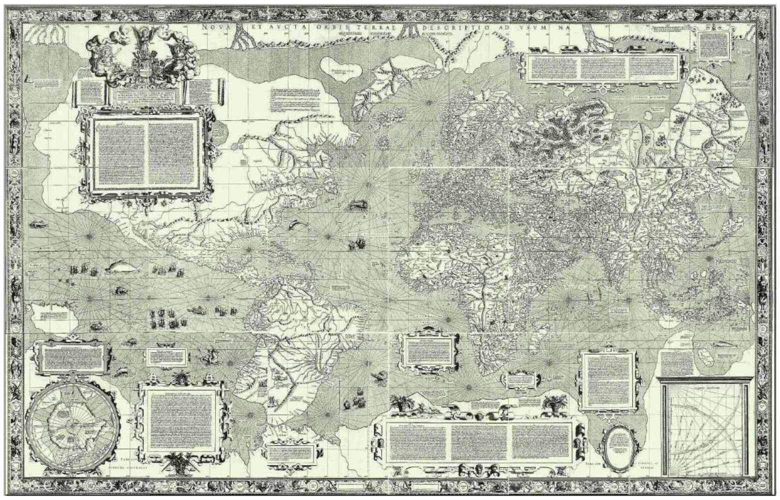
Figure 9.1: Difference between a globe and a map.



History of Maps

Old Maps have been part of human history for thousands of years, and are said to date back as early as 16,500 B.C. However, the oldest known maps are preserved on Babylonian clay tablets from about 2300 B.C. It was not until the early 16th century that the first world maps began to appear, Gerardus Mercator from Belgium was the leading cartographer of the mid-16th century (Fig. 9.2).

Figure 9.2: Mercator World Map 1569



The fact that towns as far apart as Mohenjodaro near the Indus and Lothal on the Saurashtra coast were built in the second millennium BCE with baked bricks of identical size on similar plans denotes a widespread recognition of the need for accuracy in planning and management. In the 8th century CE the Kailas temple at Ellora in Maharashtra was carved down into mountain for 100 feet, with intricate sculptures lining pillared halls, exemplifies the use of maps in ancient India.

9.3 MAP DESIGN FUNDAMENTALS, SYMBOLS AND CONVENTIONAL SIGNS, GRADED AND UNGRADED SYMBOLS, COLOR THEORY, COLORS AND PATTERNS IN SYMBOLIZATION, MAP LETTERING

Map design fundamentals

The art and science of map-making is called Cartography and it involves a series of processes that are common to all the maps. These processes that may also be referred to as essentials of maps are:

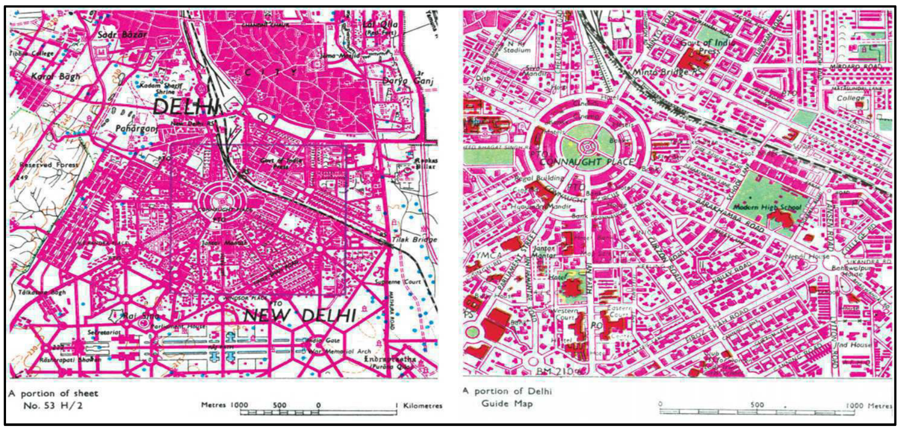
i. **Scale -** The scale of a map is the ratio of a distance on the map to the corresponding distance on the ground. A map is classified as small scale or large scale. Small scale refers to world maps or maps of large regions such as continents or large nations. In other words, they show large areas of land on a small space. They are called small scale because the representative fraction is relatively small. Large scale maps show smaller areas in more detail, such as county maps or town plans. Such maps are called large scale because the representative fraction is relatively large. For instance (Fig. 9.3),a town plan, which is a large-scale map, might be on a scale of 1:5000, whereas the state map, which is a small-scale map, might be on a scale of 1:50,000.

   The scale represents the ratio of a distance on the map to the actual distance on the ground. A standard Canadian topographic map is produced at 1:50 000, where 2 cm on the map represents 1 km on the ground. Medium-scale maps (e.g. 1:50 000) cover smaller areas in greater detail, whereas small-scale maps (e.g. 1:250 000) cover large areas in less detail.

$$\frac{\text{MAP DISTANCE}}{\text{GROUND DISTANCE}} = \frac{2\text{ cm}}{1\text{ km}} = \frac{2\text{ cm}}{100\,000\text{ cm}} = \frac{1}{50\,000}$$

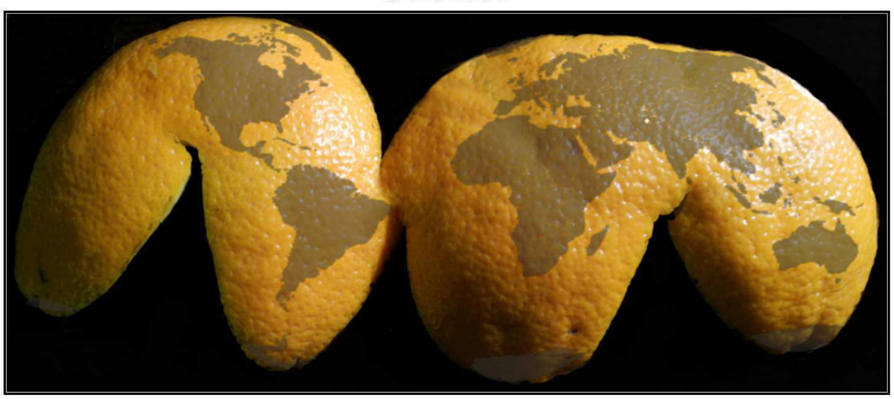
SCALE ⇨ 1:50 000

Figure 9.3: Different Scale of Mapped Information



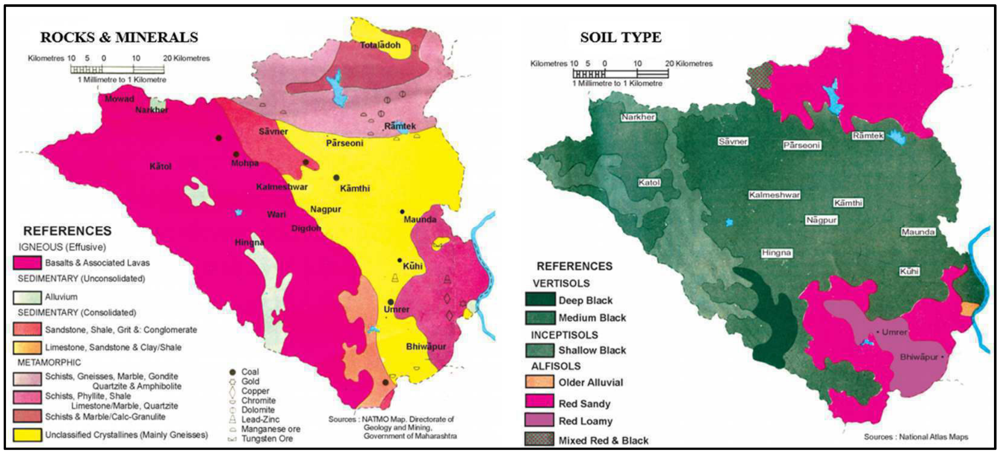
ii. **Map Projection** – As maps are a simplified representation of the three-dimensional surface of the earth on a plane sheet of paper. This transformation from three-dimensional surface into a two-dimensional plane is an important aspect of the cartographic process. And this transformation introduces some unavoidable changes (Fig. 9.4) in directions, distances, areas and shapes from the way they appear on a globe. A system of transformation of the spherical surface to the plane surface is called a map projection.

Figure 9.4: Distortion due to transformation from three-dimension into a two dimension



iii. **Map Generalization** - Map generalization is the process that simplifies the representation of geographical data to produce a map at a certain scale with a defined and readable legend pertaining to a particular objective. As maps are drawn at a reduced scale to serve a definite purpose, the cartographer is to generalize the map contents. In doing so, a cartographer must select the information (data) relevant to the selected theme and simplify it as per the needs.

Figure 9.5: Different thematic maps of the same location



For example, in Fig.9.5 see the difference in the color and the legend between both the maps. The differences are due to the thematic objective of the maps, the first map describe rocks and minerals in Nagpur, whereas the second map describes the soil types in Nagpur.

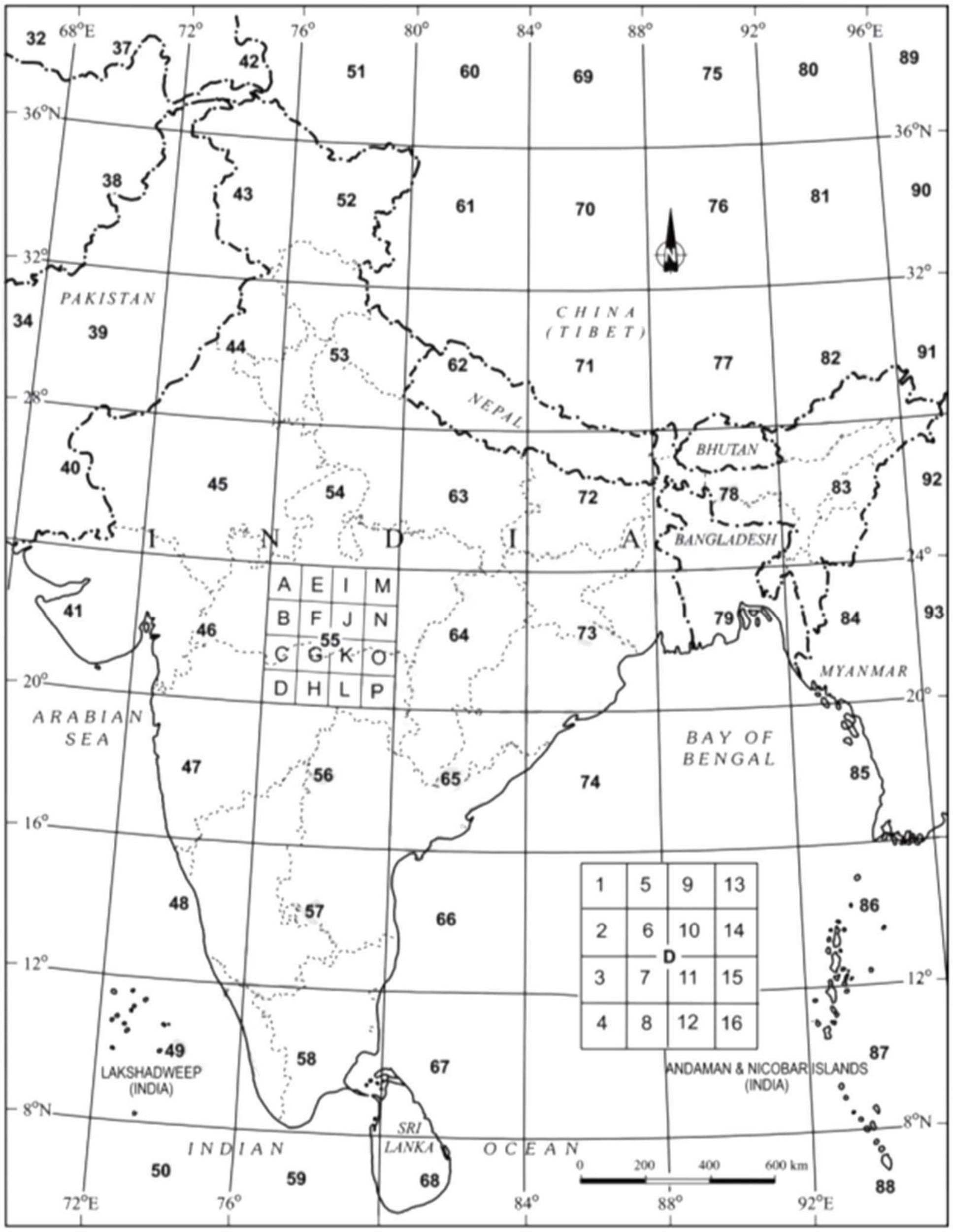
iv. **Map Design** - It involves the planning of graphic characteristics of maps including the selection of appropriate symbols, their size and form, style of lettering, specifying the width of lines, selection of colors and shades, arrangement of various elements of map design within a map and design for map legend. The map design is, therefore, a complex aspect of mapmaking and requires thorough understanding of the principles that govern the effectiveness of graphic communication

v. **Map Construction and Production** -In cartography, technology has continually changed in order to meet the demands of new generations of mapmakers and map users. The first maps were produced manually, with brushes and parchment; so, they varied in quality and were limited in distribution. The advent of magnetic devices, such as the compass and much later, magnetic storage devices, allowed for the creation of far more accurate maps and the ability to store and manipulate them digitally. In the 20th century, aerial photography, satellite imagery, and remote sensing provided efficient, precise methods for mapping physical features, such as coastlines, roads, buildings, watersheds, and topography.

Symbols and Conventional Signs

Topographical maps, also known as general purpose maps, are drawn at relatively large scales. These maps show important natural and cultural features such as relief, vegetation, water bodies, cultivated land, settlements, and transportation networks, etc. In India, these maps are prepared and published by the Survey of India. The topographical maps are drawn in the form of series of maps at different scales. Hence, in the given series, all maps employ the same reference point, scale, projection, conventional signs, symbols and colors.

Figure 9.6: Reference Map of Topographical Sheets Published by Survey of India



The topographical maps of India are prepared on 1:10,00,000, 1:250,000, 1:1,25,000, 1:50,000 and 1:25,000 scale. The numbering system of each one of these topographical maps is shown in Fig. 9.6 and the general characteristics of SOI's topographical maps are shown in Table 9.1. The topographical maps must provide a detailed picture of an area and must show all the features (natural or man-made) in it. Since it is impractical to write all the observed details on a map, a standard system of symbols, conventional signs, letters and colors are used to illustrate topographical map features. Before studying a topographical map, it is imperative that the user should get familiar with the conventional signs, legend, marginal information, map scale, and map orientation shown on the topographical maps. Some of the common conventional symbols and colors are shown in Fig. 9.7.

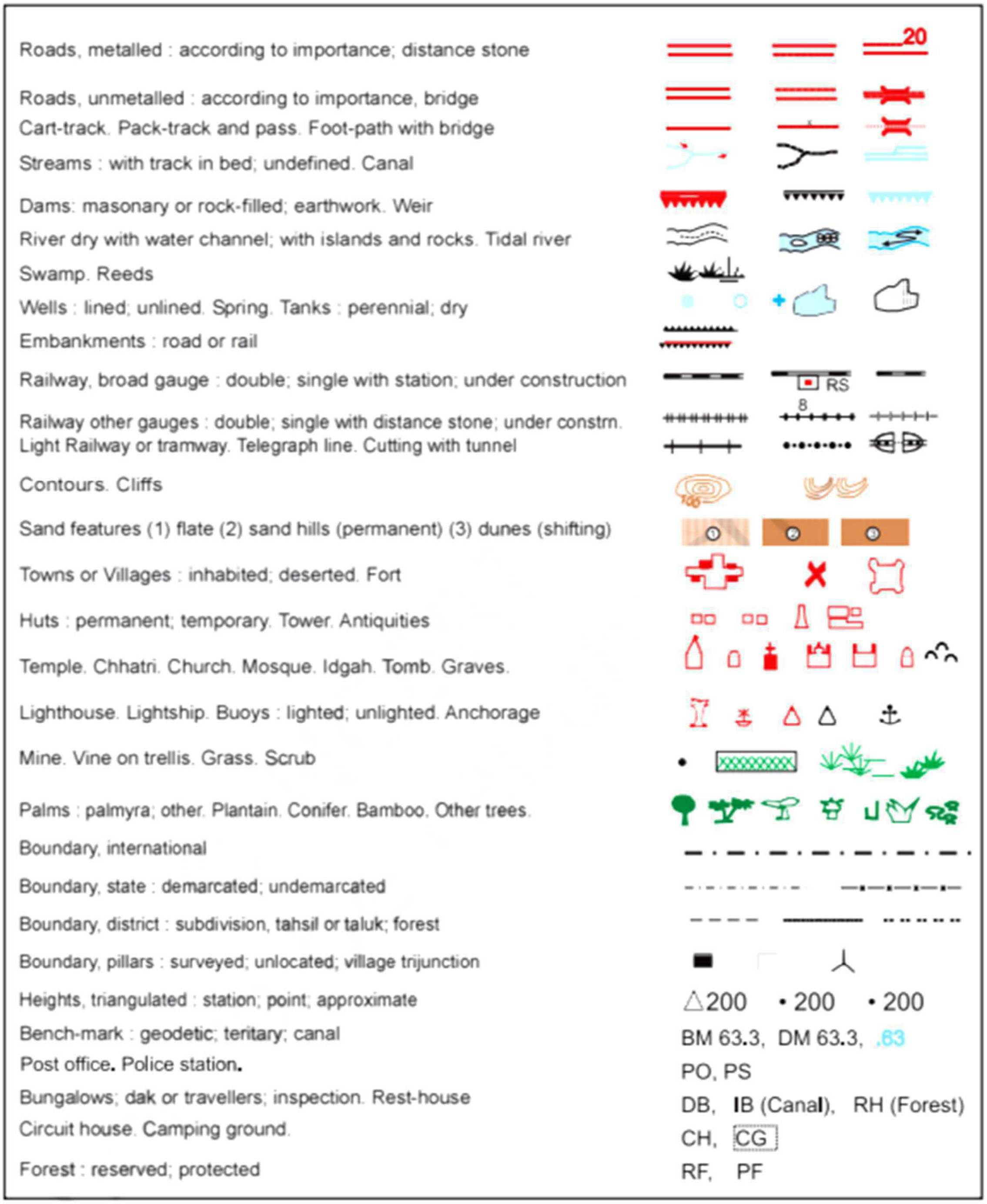
Table 9.1 Types and characteristics of topographic maps

No	Type of Topo-Map	Scale	Latitudinal & Longitudinal extent	Contour Interval	Example of Map series
1.	Million Map	1:10,00,000	4^o x 4^o	Depends on Topography	55
2.	Degree Map	1:2,50,000	1^o x 1^o	100m	55D
3.	Quarter Degree Map	1:50,000	15’ x 15’	20m	55D/1
4.	Special Map*	1:25,000	7’30” x 7’30”	10m	55D/1/SW

*The mapping at 1:25,000 scale is still in progress and is not yet published.

Contours are imaginary lines joining places having the same elevation above mean sea level. A map showing the landform of an area by contours is called a contour map. The method of showing relief features through contour is very useful and versatile. The contour lines on a map provide a useful insight into the topography of an area.

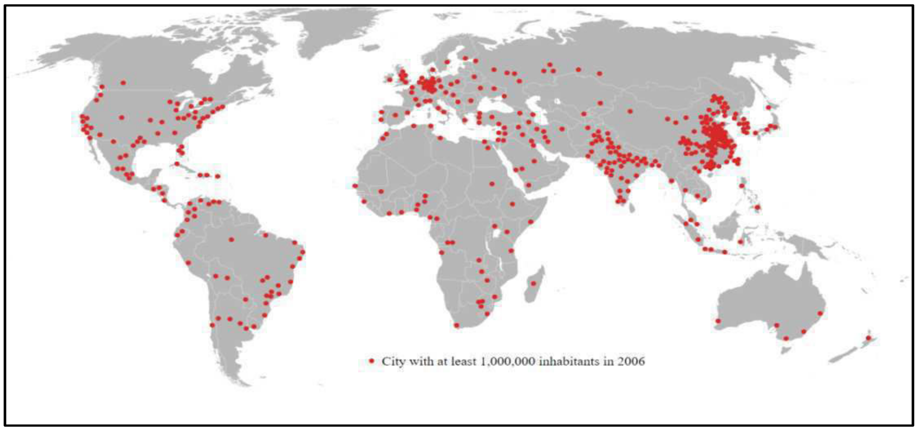
Figure 9.7: Conventional Signs and Symbols



Graded and Ungraded Symbols

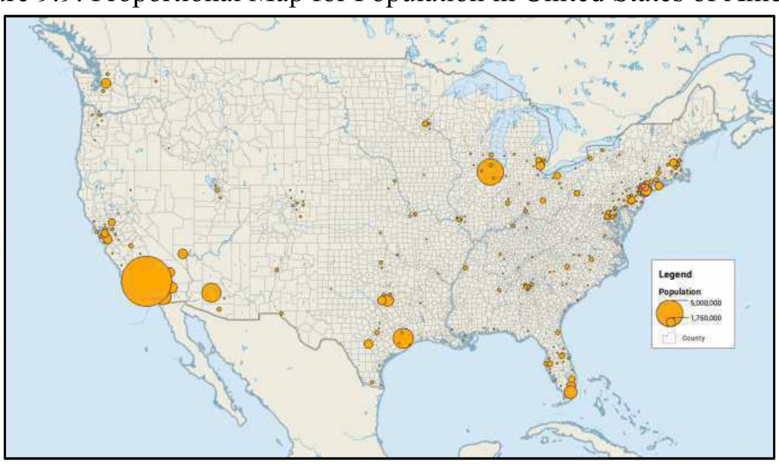
The graded and ungraded symbols are also called as graduated symbols and proportional symbol. While dot distribution maps use multiple dots to represent quantity, graduated and proportional symbol maps adjust the size of a single dot based on quantity. Dot distribution maps (or dot density maps) represent a quantity for a given area by filling it in with small dots. Because each dot represents a quantity, you can expect that quantity every time you see that dot on the map. For example, Fig.9.8 is a dot distribution map for cities with over 1,000,000 inhabitants in 2006 where each dot is 1,000,000 people. If the city doesn't reach 1,000,000 people, then the city doesn't get a dot at all. One of the disadvantages of dot density maps is that it's difficult to extract quantities from it.

Figure 9.8: Dot Distribution Map for cities with over 1,000,000 inhabitants in 2006



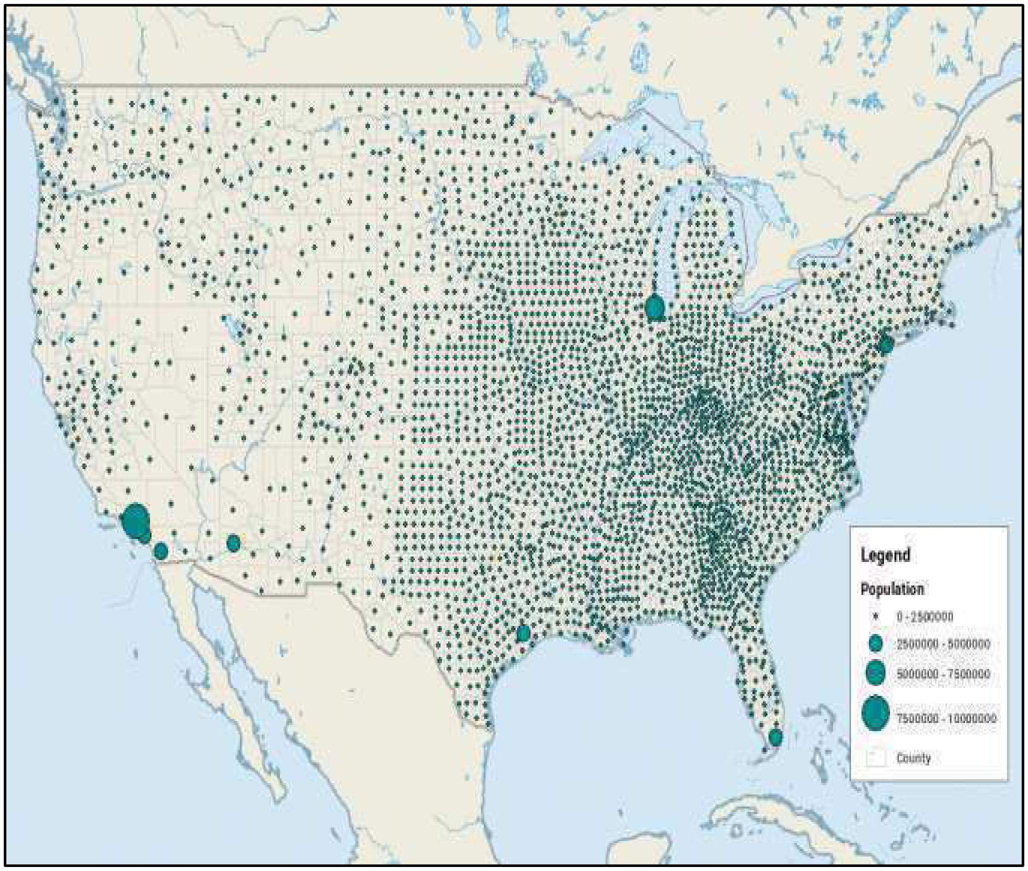
For graduated symbols or proportional symbols, it's easy to estimate value based on the size of the symbol. The main idea behind graduated and proportional symbol maps is that a larger symbol means "more" of something at a location. In the population proportional symbol map (Fig. 9.9), New York will have a larger dot than San Francisco because it has a larger population. And this is also true for a graduated symbol map. But how proportional symbol maps are different from graduated symbol maps is that symbology is unclassed. In other words, proportional symbol maps scales dots with absolute magnitude. While proportional symbol maps scale symbols with an absolute magnitude, graduated symbol maps divide quantities into classes. It creates classes using data classification techniques like equal interval, quantile and natural breaks.

Figure 9.9: Proportional Map for Population in United States of America



For example, the graduated symbol map (Fig. 9.10) has population in 4 separate classes. And each of these classes has a specific size dot depending on where the city population falls in.

Figure 9.10: Graduated Map for Population in United States of America



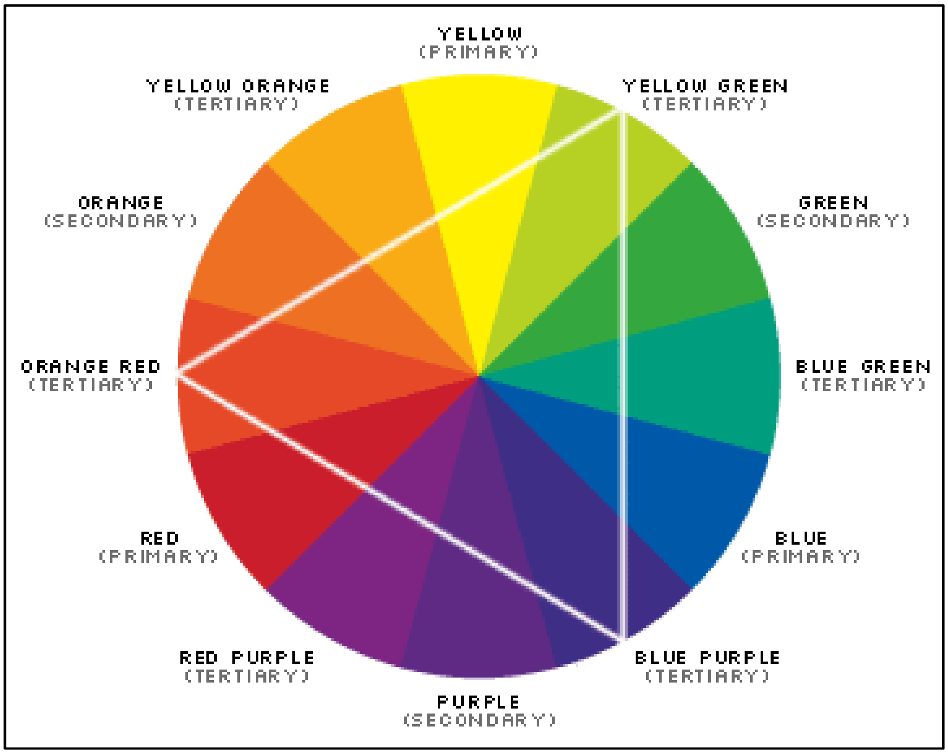
Color Theory

Color theory is the science behind how we interpret the colors we see in the world, and how we respond to specific color combinations and proportions. Often, color theory starts at the color wheel, a sort of road map for understanding color combinations. The first color wheel is attributed to Sir Isaac Newton and has been used and developed by artists and scientists to define how we interact with color. There are a variety of color combinations that are created and used across many fields. The color wheel includes the following types of colors (Fig. 9.11)

- Primary colors are viewed as the three colors that cannot be created by mixing two other colors together. They are the building blocks of all other colors on the wheel. For painting and most artistic uses, these are the colors red, yellow, and blue.
- Secondary colors are the ones that can be created by mixing two primary colors. These colors are orange, green, and purple.
- Tertiary colors are often explained in two different ways. A tertiary color is created by mixing one secondary color with one primary color and/or a tertiary color is two primary colors mixed at a 2:1 ratio. Tertiary colors are yellow-orange, red-orange, red-violet, blue-violet, blue-green, and yellow-green.

- Complementary colors are the two colors across from one another on the color wheel, like red and green, blue and orange or purple and yellow. When mixed with each other, they will effectively cancel one another out, creating a muddy brown or black color.

Figure 9.11: Color Wheel showing Primary, Secondary, and Tertiary colors

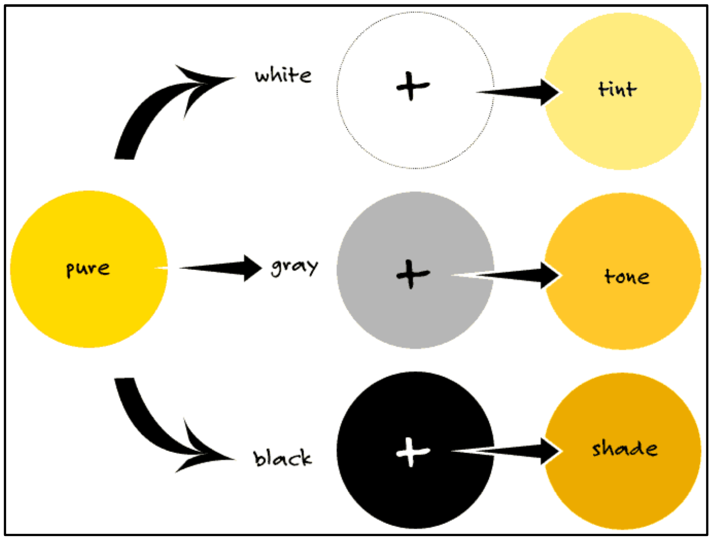


Monochromatic Colors

A monochromatic color scheme is created when you use a single color and add white, black, or gray to it to create various hues/colors (Fig. 9.12). This brings up the point of tints, tones, and shades.

- A tint is where white is added to a particular color, and new colors are created by increasing the percentage of white to that hue.
- A tone is where gray are added to a color. An entire color palette can be created through the full saturation of a hue along with various tints, shades, and tones.
- A shade is a similar process, but by adding black rather than white, the hue becomes darker with the percentage of black that is added.

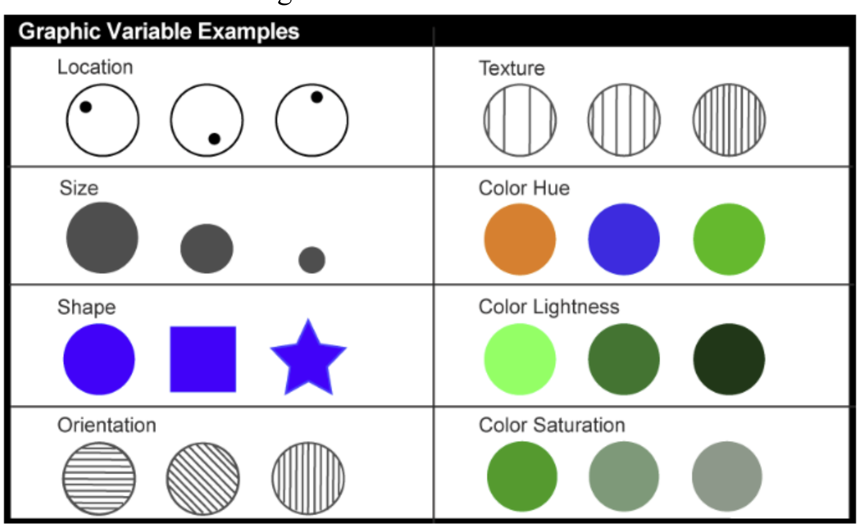
Figure 9.12: Difference between Tint, Tone and Shade



Colors and Patterns in Symbolization

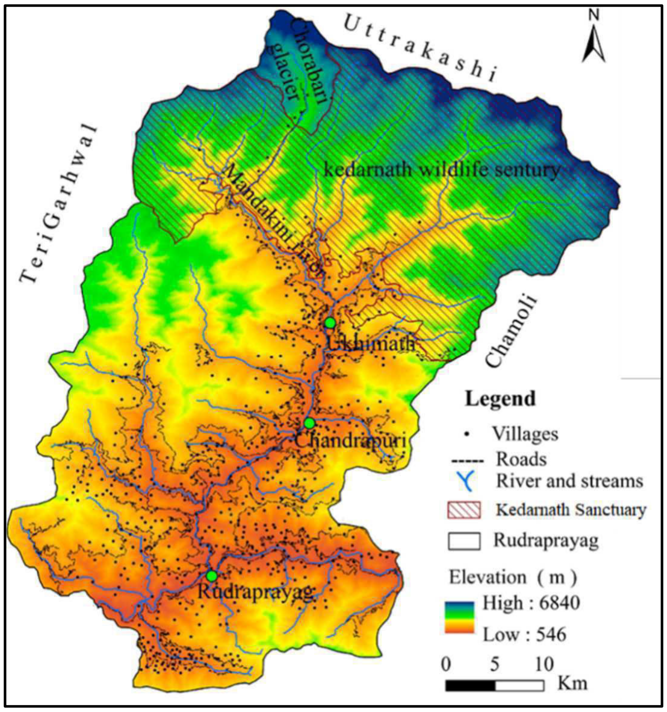
In general points, lines, and polygons can be symbolized in a innumerable of ways. While color is an integral variable when choosing how to best represent spatial data on a map, making informed decisions on the size, shape, and type of symbols is equally important. Like color, cartographers must take care to use symbols thoughtfully in order to most effectively communicate the meaning and purpose of the map to the viewer. The primary visual variables associated with symbolization include color, size, texture, pattern, and shape (Fig. 9.13 "Visual Variables").

Figure 9.13: Visual Variables



Change of symbol size and texture are most effectively used in conjunction with numerical (quantitative) data. Changes to symbol pattern and shape are preferred in conjunction with nominal (qualitative) data. See the following example (Fig. 9.14) and notice how different colors and shapes are used to represent the different spatial features. The different colors represent the elevation zones, the spacing (hashing) that is used to differentiate the Kedarnath Wildlife Sanctuary from the other areas.

Figure 9.14: Map showing part of Uttarakhand (Batar, A., Watanabe, T. and Kumar, A., 2017)



Shapes such as Points and Lines are the most common ways to represent any spatial features, and in the example the points are used to represent village locations where as lines are used to represent roads and river network. Notice how the same line feature is used to represent two different feature using different colors (Road as black lines and river network as blue lines)

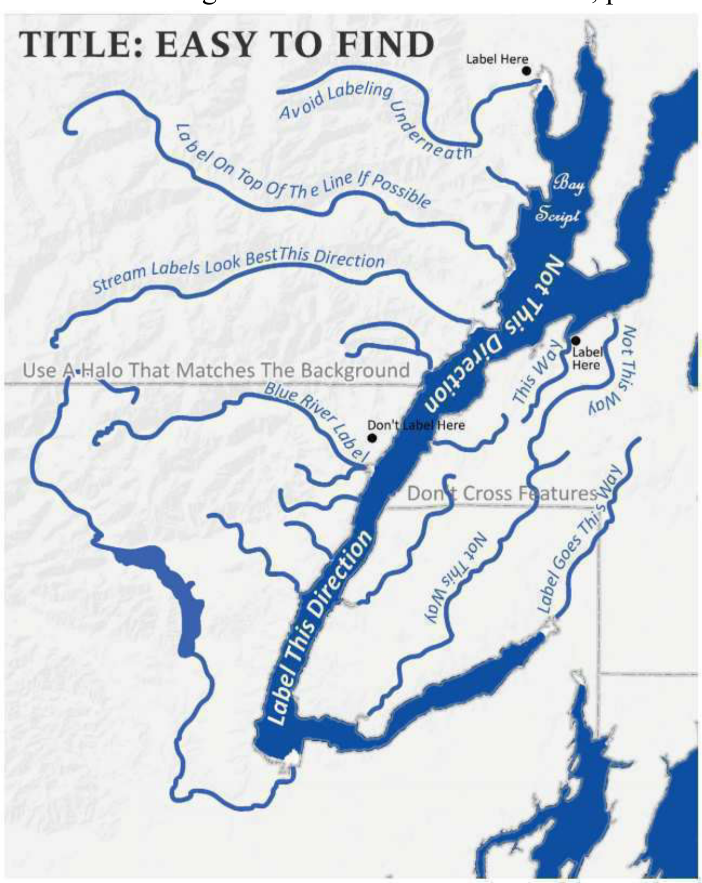
Map Lettering

Lettering is found throughout all the elements of a map. Lettering or Font or Text is similar to map symbols in many senses. Coloring effects alter typographic hierarchy as lighter type fades into the background and dark type jumps to the fore. Using all uppercase letters and/or bolded letters will result in more pronounced textual effects. Larger font sizes increase the hierarchical weight of the type, the size of the type corresponds with the importance of the map feature. Use of decorative fonts, bold, and italics should be sparing. These fonts, as well as overly small fonts, can be difficult to read if overused. Kerning is an effective typographic effect that alters the space between adjacent letters in a word (Fig. 9.15). Decreasing the kerning of a typeset is useful if the text is too large for the space given. Alternatively, increasing the kerning is an effective way to label large map areas, particularly in conjunction with all-uppercase lettering. All of these effects serve to increase the visibility and importance of the text to which they are applied.

Figure 9.15: Typographic Effects

In addition to the general typographic guidelines, there are specific typographic suggestions for feature labels (Fig 9.16). Labels must be placed proximal to their symbols, so they are directly and readily associated with the features they describe. Labels should maintain a consistent orientation throughout, so the reader does not have to rubberneck about to read various entries. Also, overprinting labels on top of other graphics or typographic features should be avoided. If that is not possible, use of a halo, mask, callout, or shadow to help the text stand out from the background should be used. In the case of maps with many symbols, care should be taken that no features intervene between a symbol and its label.

Figure 9.16: Common labeling standards in terms of direction, placement and color.



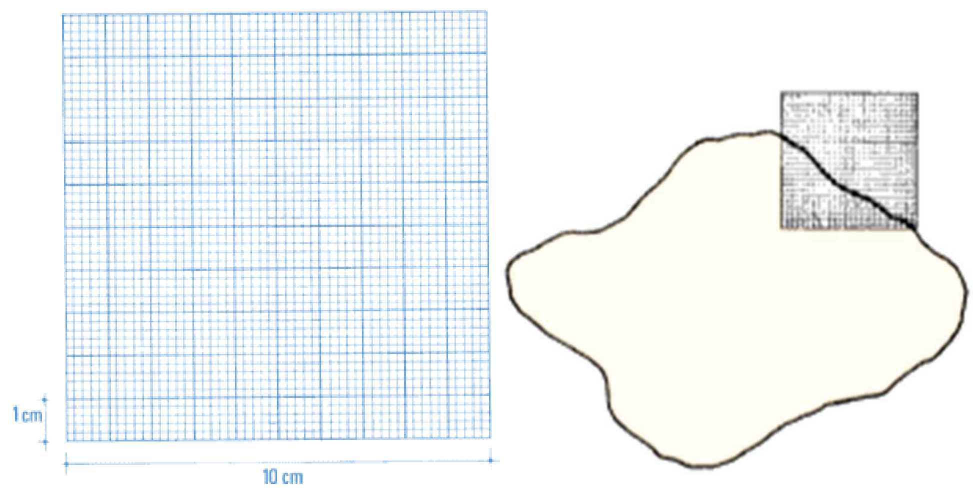
Different Tools & Techniques for Area Estimation

One of the main purposes of your topographical survey may be to determine the area of a tract of land. The area can be determined either directly from field measurements, or indirectly, from a plan or map. In the first case, all the measurements of distances and angles are measured by surveying and using arithmetic formulae the area can be calculated. In the second case, a plan or a map needs to be drawn and from measuring the dimensions from the scale, the area can be determined. There are several simple methods available for measuring areas. Some of these are graphic methods, where the plan or map of the area that need to measure is compared with the drawn pattern of known unit sizes. Others are geometric methods, where by using simple mathematical formulas the area of regular geometrical figures, such as triangles, trapeziums, or areas bounded by an irregular curve is calculated.

i. Square-grid for measuring area

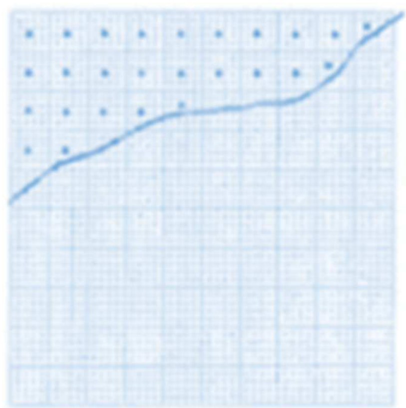
1. Get a piece of transparent square-ruled paper or draw a square grid on transparent tracing paper yourself. To do this, trace a grid made of 2 mm x 2 mm squares inside a 10 cm x 10 cm square, using the example given on the page.

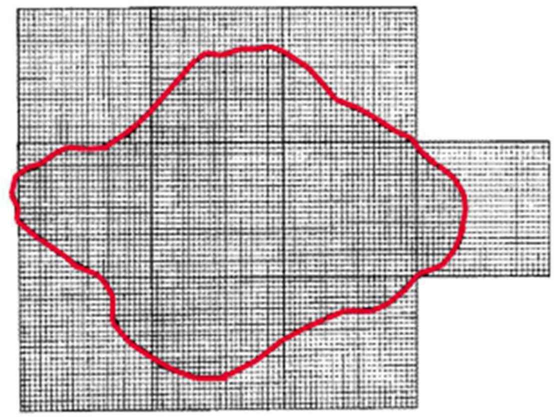
   Note: if you use smaller unit squares on the grid, your estimate of the land area will be more accurate; but the minimum size you should use is 1 mm x 1 mm = 1 mm2.



2. Place this transparent grid over the drawing of the area you need to measure and attach it to the drawing securely with thumbtacks or tape. If your grid is smaller than this area, start at one edge of the drawing. Clearly mark the outline of the grid, then move to the next section and proceed in this way over the entire area.
3. Count the number of full squares included in the area you need to measure. To avoid mistakes, mark each square you count with your pencil, making a small dot.

   Note: towards the centre of the area, you may be able to count larger squares made, for example, of 10 x 10 = 100 small squares. This will make your work easier.





Scale:

1 cm = 20 m

1 mm = 2 m

2 mm = 4 m

2 mm x 2 mm = 4 m x 4 m = 16 m^2

4. Look at the squares around the edge of the drawing. If more than one-half of any square is within the drawing, count and mark it as a full square. Ignore the rest.

5. Add these two sums (steps 3 and 4), to obtain the total number T of full squares.
6. Add the sums again at least once to check them.
7. Using the distance scale of the drawing, calculate the equivalent unit area for your grid. This is the equivalent area of one of its small squares.

   Example

   Scale 1:2000 or 1 cm = 20 m or 1 mm = 2 m

   Grid square size is 2 mm x 2 mm

   Equivalent unit area of grid = 4 m x 4 m = 16 m2
8. Multiply the equivalent unit area by the total number T of full squares to obtain a good estimate of the measured area.

   Example

   Total count of full squares T = 256

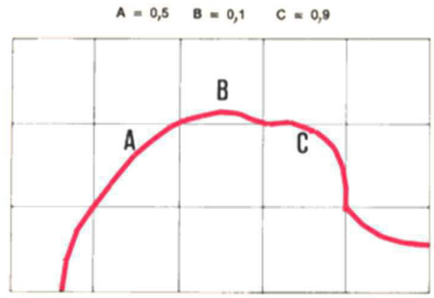
   Equivalent unit area = 16m2

   Total area = 256 x 16 m2 = 4096 m2

Note: when you work with large-scale plans such as cross-sections, you can improve the accuracy of your area estimate by modifying step 5, above. To do this, look at all the squares around the edge of the drawing which are crossed by a drawing line. Then, estimate by sight the decimal part of the whole square that you need to include in the total count (the decimal part is a fraction of the square, expressed as a decimal, such as 0.5, 0.1 and 0.9).

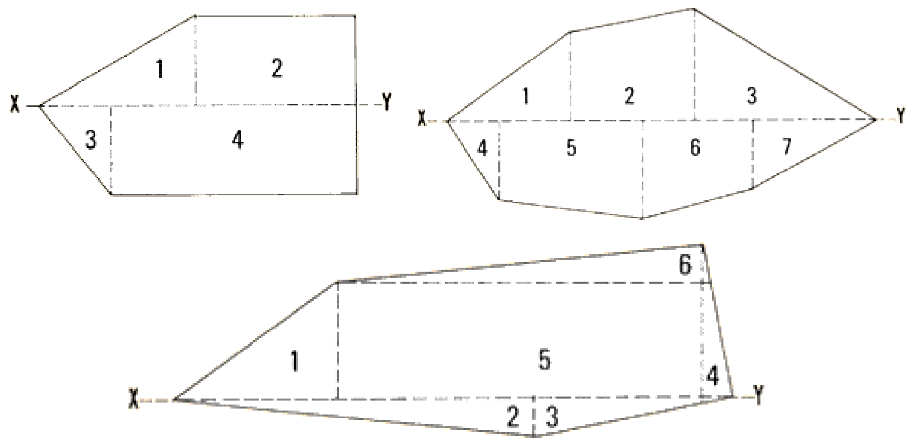
Example

Square A = 0.5; B = 0.1; C = 0.9.

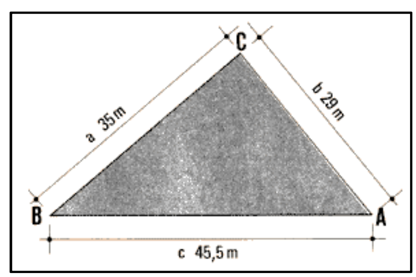


ii. By measuring the regular geometrical figures

When you need to measure areas directly in the field, divide the tract of land into regular geometrical figures, such as triangles, rectangles or trapeziums. Then take all the necessary measurements and calculate the areas according to mathematical formulas. If a plan or map of the area is available, you can draw these geometrical figures on it, and find their dimensions by using the reduction scale.



1. You can easily calculate the area of any triangle when you know the dimensions of:



a) If all three sides a, b and c are known

Area = √s (s - a) (s - b) (s - c);

where s = (a + b + c)/2;

<u>Example</u>

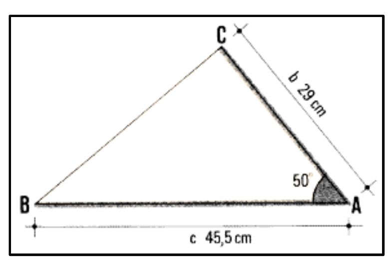
If a = 35m; b = 29m; and c = 45.5m.

Then s = (35+ 29+ 45.5)/2 = 54.75 m

Area = √54.75 (54.75 - 35) (54.75 - 29) (54.75 - 45.5)

= 507 m2

b) If two sides (b, c) and the angle BAC between them (called the included angle) are known



Area = (bc sin BAC) / 2

<u>Example</u>

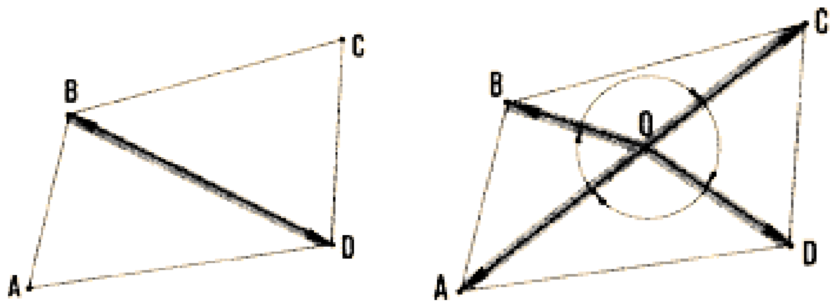
If b = 29m; c = 45.5m; and angle BAC = 50°.

Then sin BAC = 0.7660

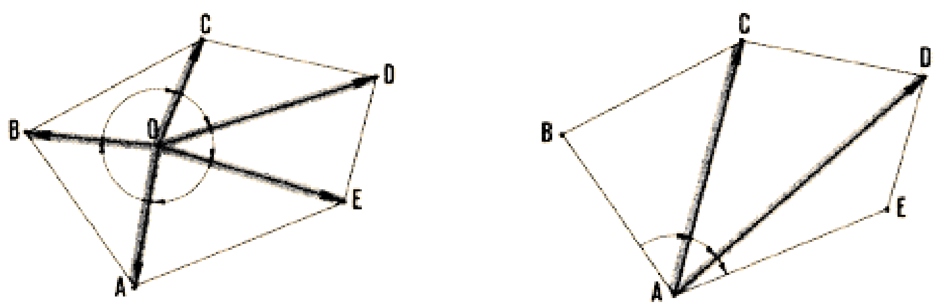
Area = (29x 45.5 x 0.7660) / 2

= 505.3685 m2

2. Subdivide the tract of land into triangles. For a four-sided area, you can do this in two ways.
   a) You can join two opposite angles with a straight-line BD. Measure the length of BD to find the length of the three sides of each of the two triangles, then calculate their areas (see step 3, above). The sum of the two triangular areas is the total area.
   b) You can proceed by radiating from central station 0. Measure consecutive angles AOB, BOC, COD and DOA. Then measure distances OA, OB, OC and OD from 0 to each corner of the site and calculate the area of each triangle (see step 3, above). The sum of the four triangular areas is the total area.



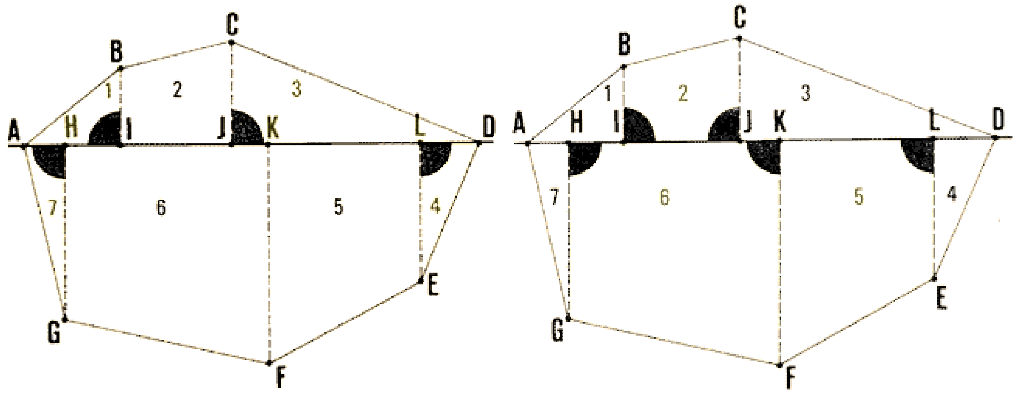
3. On a land tract with more than four sides, you can subdivide its area into triangles:
   a) by radiating from a central station 0 (see step 4, above); or
   b) by radiating from a lateral station, such as A.



4. Check on your calculations. If you have found the area by using two opposite angles, use the first procedure. If you have proceeded by radiating, use the second.
   - Repeat the measurement of the total area by using the other two triangles ABC and ACD, formed by straight line AC.
   - Alternatively repeat the measurements of angles and lengths from either the same station or a different one.

iii. Using a base line to subdivide land areas

5. When the shape of the land is polygonal, you should usually subdivide the total area you need to measure into a series of regular geometrical figures from a common base line (AD- in the figure). You will lay out offsets from the other summits of the polygon which are perpendicular to this base line to form right triangles 1,3,4 and 7, and trapeziums 2, 5 and 6.



6. When you are choosing a base line, remember that it should: be easily accessible along its entire length; provide good sights to most of the summits of the polygon; be laid out along the longest side of the land area to keep the offsets as short as possible; join two polygon summits.
7. Calculate the area of each right-angled triangle*, using the formula:
   Area = (base x height) / 2
8. Calculate the area of each trapezium, using the formula:
   Area = Height x (Base 1 + Base 2) / 2
   where: Base 1 is parallel to Base 2;
   Height is the perpendicular distance from Base 1 to Base 2.

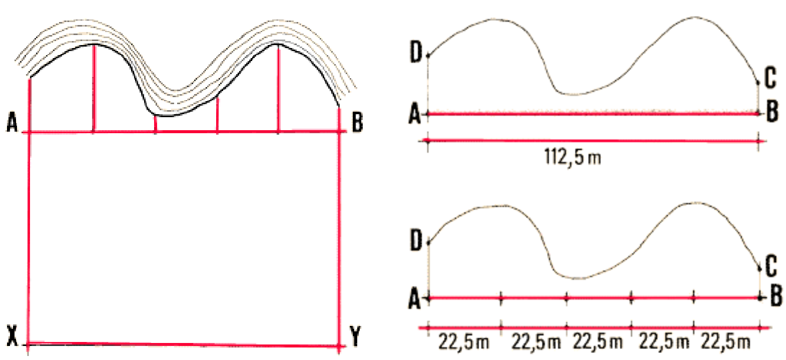
9. Add together all these partial areas to find the total land area.

iv. By Trapezoidal rule

If part of the land tract is bounded on one side by an irregular curve, such as a road or river, you can find its area by using the trapezoidal rule as explained in this section.

1. Set out straight line AB joining the sides of the tract of land and running as closely as possible to the curved boundary. To determine the irregular area ABCDA, proceed as follows.
2. Measure distance AB and subdivide it into several regular intervals, each, for example, 22.5 m long. Mark each of the intervals on AB with ranging poles.

Note: the shorter these intervals are, the more accurate your area estimate will be.



3. At each of these marked points, set out a perpendicular line joining AB to the curved boundary. Measure each of these offsets.
4. Calculate area ABCDA using the following formula:

Area = interval x (h_o + h_n + 2h_i) / 2

where:

h_o is the length of the first offset, AD;

h_n is the length of the last offset, BC; and

h_i is the sum of the lengths of all the intermediate offsets.

Example

Interval = 112.5m / 5 = 22.5m

h_o = 20m and h_n = 10 m

h_i = 27m + 6m + 14m + 32m = 79m

Area ABCDA = 22.5m x (20m + 10m + 158m) / 2

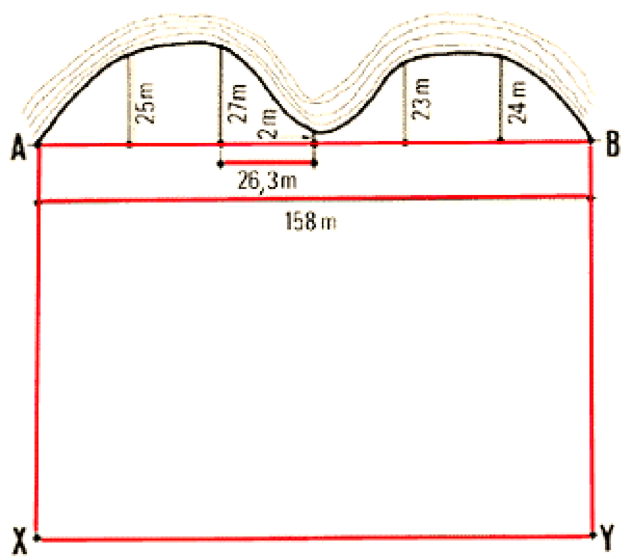
= (22.5m x 188m) / 2 = 2115m2

Note: remember that you must still calculate the area of AXYBA and add it to the area of ABCDA to get the total area DAXYBCD.

5. If you can lay out line AB so that it touches the two ends of the curved boundary, your calculations will be much simpler. In this case, ho and hn are both equal to zero, and the formula becomes:

   Area = interval x h_i

   where hi is the sum of the lengths of all the intermediate offsets.



Example

Interval = 158m / 6 = 26.3m

hi = 25m + 27m + 2m + 23m + 24m = 101m

Area= 26.3m x 101m = 2 656.3m2

Note: remember that you must still calculate the area of AXYBA and add it to the area of the curved section to get the total area.

9.4 SUMMARY

In this Unit, you have learned the following:

1. A topographical map is the three-dimensional representation of surface features of the Earth.
2. Topographic maps are prepared on large and small scales and thus classified into various types according to their scale.
3. In India, Survey of India is the nodal agency for preparing and publishing the topographical maps of India at various scales.
4. The topographical maps of India are prepared at 1:1,000,000 (million map), 1:250,000 (degree map), 1:50,000 (quarter map) and 1:25,000 (special map) scale providing latitudinal and longitudinal coverage of 4° × 4°, 1° × 1°, 15' × 15' and 7' 30" × 7' 30", respectively.
5. Interpretation of topographical map requires a thorough understanding of conventional signs, symbols, colors and key given in the map showing various features.
6. Map design fundamentals includes Scale, Map Projection, Map Generalization, Map Design, Map Construction and Production.
7. To determine the area of a tract of land either directly from field measurements, or indirectly, from a plan or map.

9.5 GLOSSARY

1- Cartography- It is art or science of making and study of maps.
2- Topographic Map- A map of a small area drawn on a large scale depicting detailed surface features both natural and manmade. Relief in this map is shown by contours
3- Contours- These are imaginary lines that join points of equal elevation on the surface of the land above or below a reference point. Mean sea level is the most common reference point.
4- Geodesy- It is the discipline that deals with the measurement and representation of the earth, its gravity field and geodynamic phenomena (polar motion, earth tides, and crustal motion) in three-dimensional time varying space.
5- Geoid- It is a three-dimensional shape approximated by mean sea level, on which the gravity force is constant and equal to its strength at mean sea level.
6- Map design- This involves the planning of graphic elements (symbols, style of font, colors, legend) of maps.
7- Map Projection- It is a systematic transformation that allows the orderly representation of earth's spherical graticules on a flat map.
8- Scale- It is the relationship between the map distance and the corresponding ground distance in units of length.

9.6 ANSWER TO CHECK YOUR PROGRESS

1. What is scale in a map?

2. Name the organization which prepares the topographical maps of India.
3. What are the common symbols and signs used in a map?
4. Explain the concept of color theory.
5. List common labeling standards to be used in mapping.

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9.8 TERMINAL QUESTIONS

1. What are the different map design fundamentals?
2. Explain the various techniques to estimate area in map.
3. Explain what is meant by 'map interpretation' and what procedure is followed for its interpretation.
4. Draw the conventional signs and symbols for the following features

- International Boundary
- Villages
- Metaled Road
- Places of Worship
- Railway line

5. How will you measure the area of an irregular tract of land using geometric shapes?

BLOCK 4: MAP MAKING

UNIT 10 - DEFINITIONS OF CHLOROPLETH, DASYMETRIC AND ISOPLETH MAPS

10. 1 OBJECTIVES

By the end of this unit you will be able to understand the:

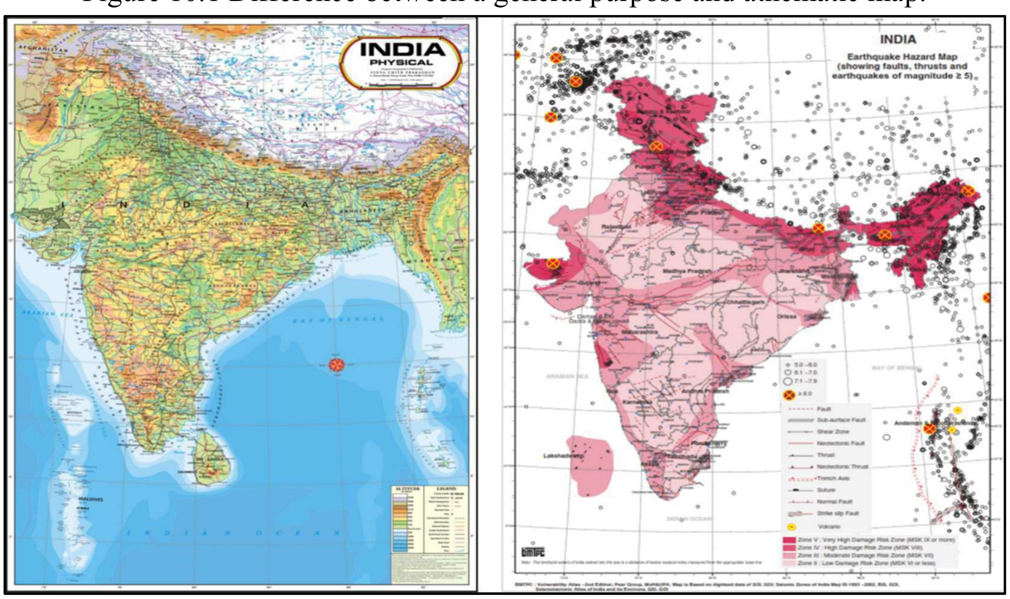
- The difference between the thematic map and a general purpose map.
- Quantitative & Qualitative thematic map
- Concepts of chloropleth, dasymetric and isopleth maps
- Importance of base data in thematic mapping.

10.2 INTRODUCTION

The general purpose maps represent the large physical character of the earth's surface. As we have noted already, in addition to representing the topography, the Survey of India topographical maps also show a considerable amount of information about the physical environment in general and about human activity as well. For example, lakes are shown as enclosed blue areas, forests by a green pattern, rivers by blue lines, and houses, churches, post offices, roads, bridges, water towers, quarries, and so on, are depicted by a variety of other special symbols. We must now turn our attention to maps which depict just a single theme. These thematic maps, as they are called, use a variety of cartographic symbolization to depict the spatial pattern of a particular geographic quality or quantity rather than a variety of information of different sorts. The purpose of a thematic map is to give exclusive emphasis to a particular subject; its success is measured by the clarity, directness, accuracy and impact of the particular pattern being communicated to the map reader.

Note the difference in the Fig.10.1, the map in the left is a general map showing roads, elevation, state boundaries, rivers etc., whereas the right map represents just one theme that is earthquake hazards.

Figure 10.1 Difference between a general purpose and athematic map.



Many types of information can be called thematic. The themes may relate to environmental attributes, such as land cover, soils, vegetation or climate, or to demographic attributes such as population density, cultural type etc. or political attributes such as voting characteristics, government areas etc. The theme may be qualitative (as in the case of land use subclasses, soil types or political boundaries) or quantitative (as in demographic mapping or temperature). The main objective of thematic maps is to commentate geographical concepts such as the distribution of densities, relative magnitudes, gradients, spatial relationships, movements and the numerous interrelationships among the distributional characteristics of the Earth's phenomena.

Essentially thematic maps can display the data and concepts that cannot be shown easily on topographic maps. To portray the positional relationships of a variety of different geographical phenomena on one map, thematic maps concentrate on the spatial variations of a single phenomenon or the relationship between phenomena. In thematic maps, the objective is to portray the structural characteristics of the geographical distribution of the theme. Accuracy in thematic mapping is of less concern than portrayal of the basic structural characteristics of the distribution. Thematic maps aim to provide immediate answers and are sometimes called 'topical', 'single factor', 'statistical', 'special-purpose', or a 'distribution' map. Many strategies are used to present these, such as dots, choropleths, isopleths and superimposed diagrams. Such maps are in demand by a wide variety of specialists such as geoscientists, regional planners, economists, statisticians, agronomists, architects and hydrologists.

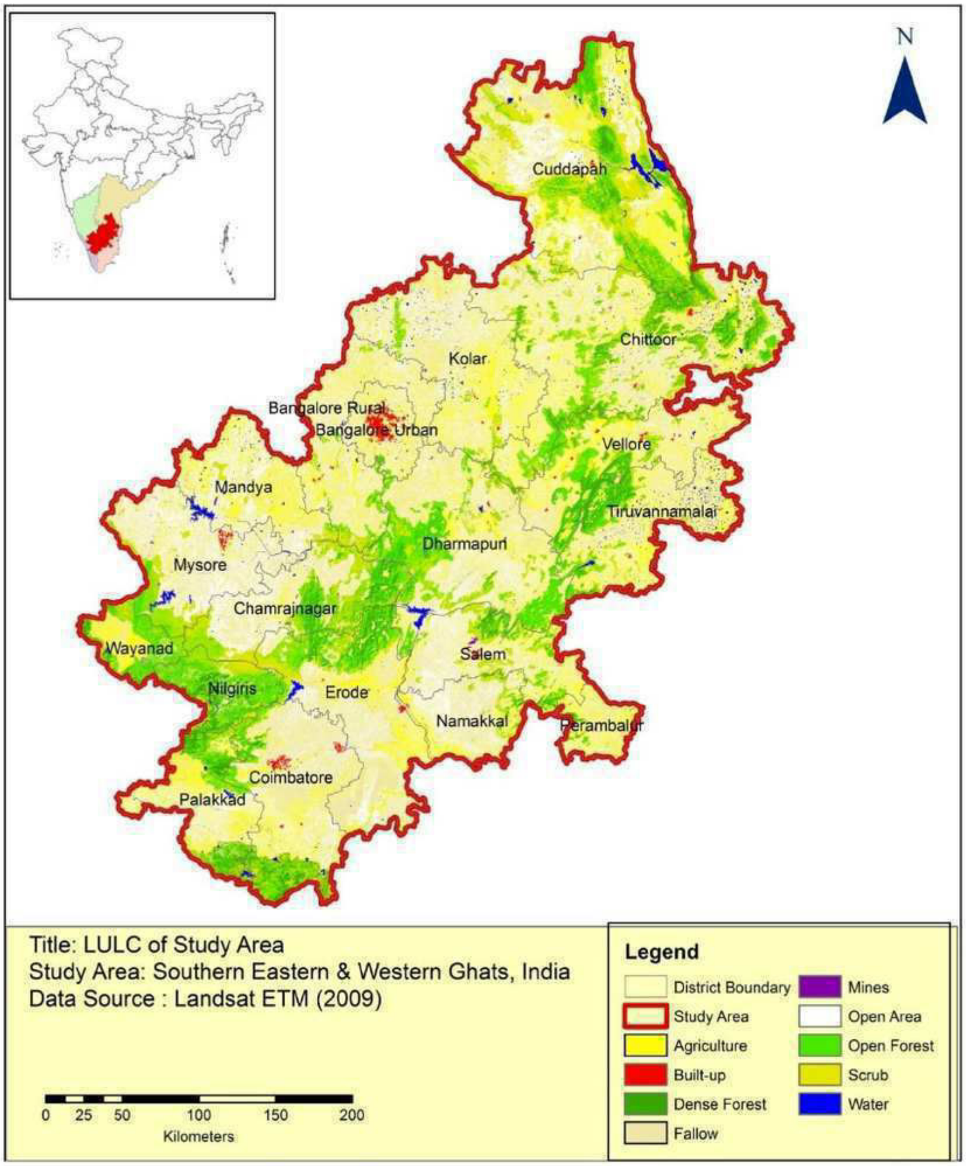
Measurement Scales for Spatial Data

Standardized scales are needed to measure non-spatial attributes as well as spatial features. Unlike positions and distances, however, attributes of locations on the Earth's surface are often not amenable to absolute measurement. In a 1946, a psychologist named S. S. Stevens outlined a system of four levels of measurement meant to enable social scientists to systematically measure and analyze phenomena that cannot simply be counted. The levels are important to specialists in geographic information because they provide guidance about the proper use of different statistical, analytical, and cartographic operations. The following are the Stevens' original four levels of measurement: nominal, ordinal, interval, and ratio.

1. Nominal Data

The term nominal simply means to relate to the word “name.” Simply put, nominal level data are data that are denoted with different names (e.g., forest, water, cultivated, wetlands), or categories. Data produced by assigning observations into unranked categories are nominal level measurements. Nominal data are a type of categorical (qualitative) data. Specifically, nominal level data can be differentiated and grouped into categories by “kind,” but are not ranked from high to low. For example, one can classify the land cover at a certain location as dense Forest, Open Forest, Agriculture, Built-up Area, etc (Fig.10.2).

Figure 10.2 Land Use Map showing Nominal data.



2. Ordinal Data

Like the nominal level of measurement, ordinal scaling assigns observations to discrete categories. Ordinal categories, however, are ranked, or ordered –as the name implies. The act of prioritizing nominal categories transforms nominal level measurements to the ordinallevel.Because the categories are not based upon a numerical value (just an indication of an order or importance), ordinal data are also considered to becategorical (or qualitative).

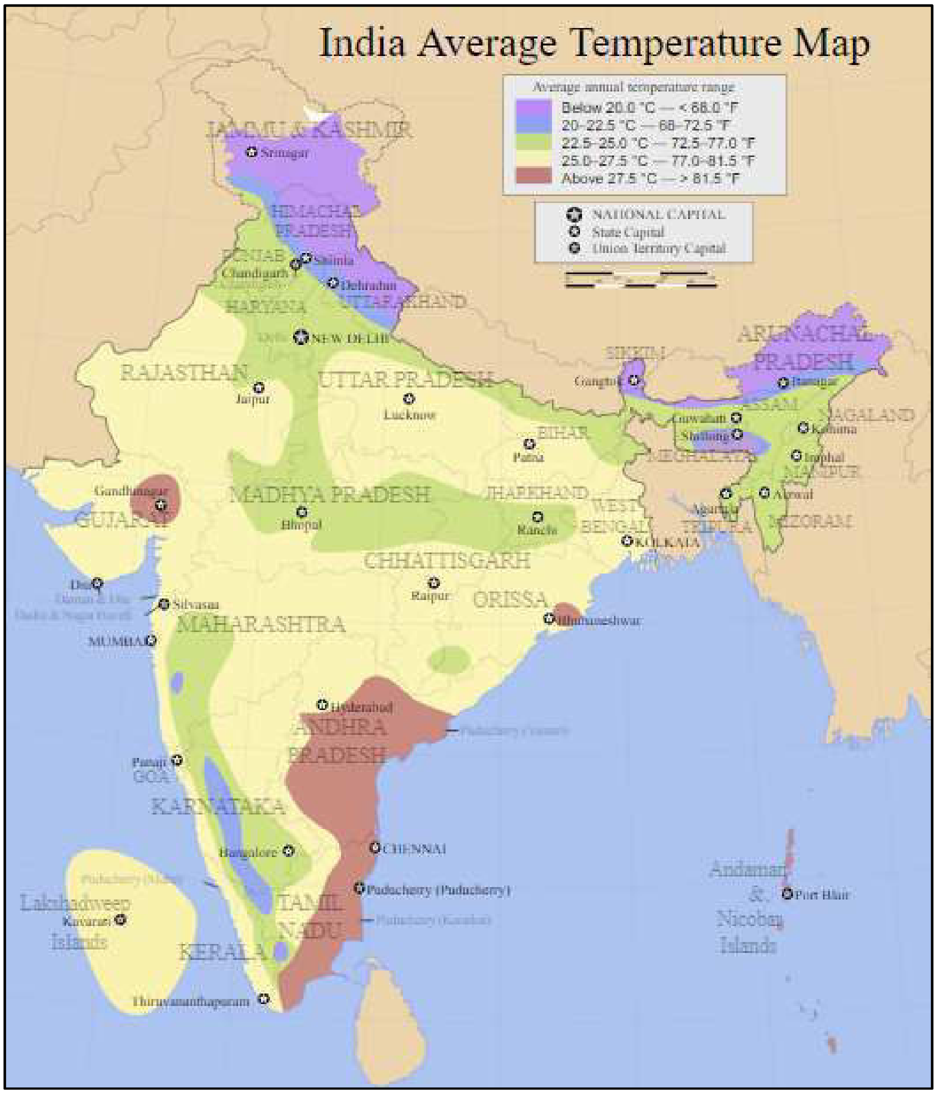
Examples of ordinal data often seen on reference maps include political boundaries that are classified hierarchically (national, state, county, etc.) and transportation routes (NationalHighway, State Highway, District Road, Village Road (Fig. 10.3).

Figure 10.3 Major Road Network Map showing Ordinal data.

3. Interval Data

Unlike nominal- and ordinal-level data, which are categorical (qualitative) in nature, interval level data are numerical (quantitative). Examples of intervallevel data include temperature and year. With interval level data, the zero point is arbitrary on the measurement scale. For instance, zero degreesFahrenheit and zero degrees Celsius are different temperatures. In Interval data, information that can be arrangedusing a standard scale along which operations of addition and subtraction have meaning. Example: Temperature is an interval measure (Fig. 10.4).

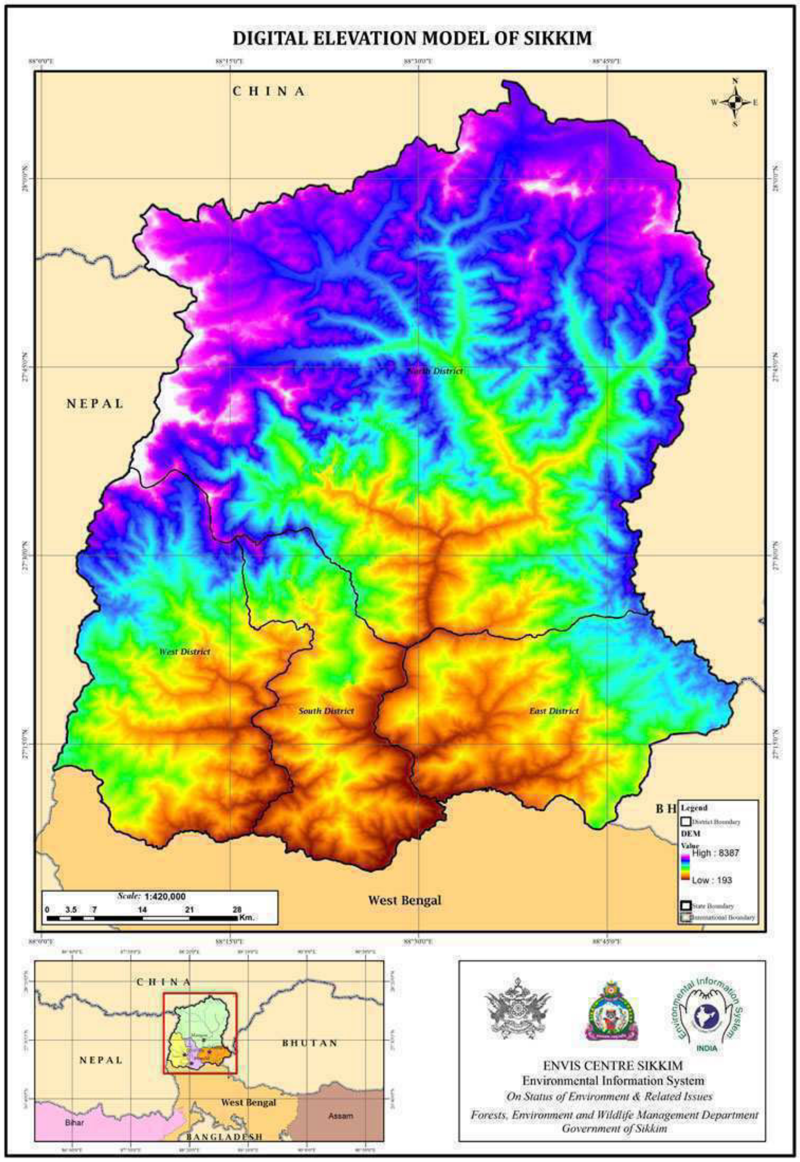
Figure 10.4 Map showing average annual temperature displaying Interval data.



4. Ratio Data

Similar to interval level data, ratio level data are also numerical (quantitative). Examples of ratio level data include distance and area (e.g., acreage).Unlike the interval level measurement scale, the zero is not arbitrary for ratio level data. For example, zero meters and zero feet mean exactly the samething, unlike zero degrees Fahrenheit and zero degrees Celsius (both temperatures). Ratio level data also differs from interval level data in themathematical operations that can be performed with the data. An implication of this difference is that a quantity of 20 measured at the ratio scale is twicethe value of 10 (20 meters is twice the distance of 10 meters), a relation that does not hold true for quantities measured at the interval level (20 degrees isnot twice as warm as 10 degrees).

Figure 10.5 Digital Elevation Map of Sikkim showing Ratio data.



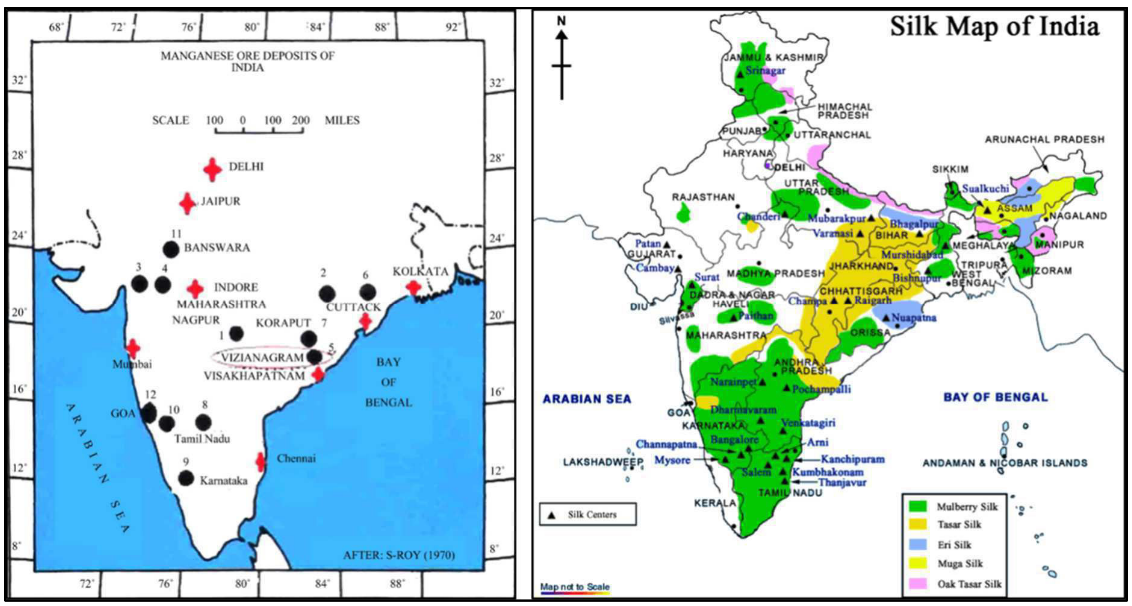
Thematic Map Group

There are two groups of thematic maps, qualitative and quantitative.

1. Qualitative thematic map shows the spatial distribution or location of data in nominal scale. Qualitative information is expressed by boundaries separating different values. e.g. soil mapping, and geological boundaries (i.e. geology maps). Qualitative thematic maps display descriptive (nominal) data such as the locations of particular features on a base map. Examples include maps showing the locations of public facilities in a municipality, the locations of capital cities, maps of resorts, road maps, maps showing the principal rivers of a region, geology maps, soil maps, vegetation maps, and so on. If the features in question are at precise points, at the scale of the base map (such as the location of a house on a 1:50 000 map), they can be shown by a nominal point symbol. For example, a

house might appear as a round or square dot, churches in a region might be depicted by small crosses, campgrounds might be marked by a small tent symbol. In Fig. 10.6a, point symbols are used to locate particular types of mineral resource in India. It is very important that nominal linear and area symbols are drawn so that they do not imply quantity. For example, line pattern might be varied (solid, broken, alternating dots and dashes) but thickness of a given line pattern should not vary systematically across nominal classes because it may convey some sense of unimplied increasing importance to the symbols. Similarly, area symbols should not take the form of graded shading (increasing density) within the same shading pattern; they should be random rather than sequentially patterned. It also is important to remember that, invariably, some degree of averaging or generalization is involved in applying area symbols.

Figure 10.6 Qualitative thematic maps
6a. Manganese Ore deposits of India; 6b. Silk production map in India.



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For example, in Fig. 10.6b, a map showing the areas of different silk produced in India, this might include areas with many cities which do not produce silk. Such a map simply generalizes at a regional level to include areas in which silk is produced.

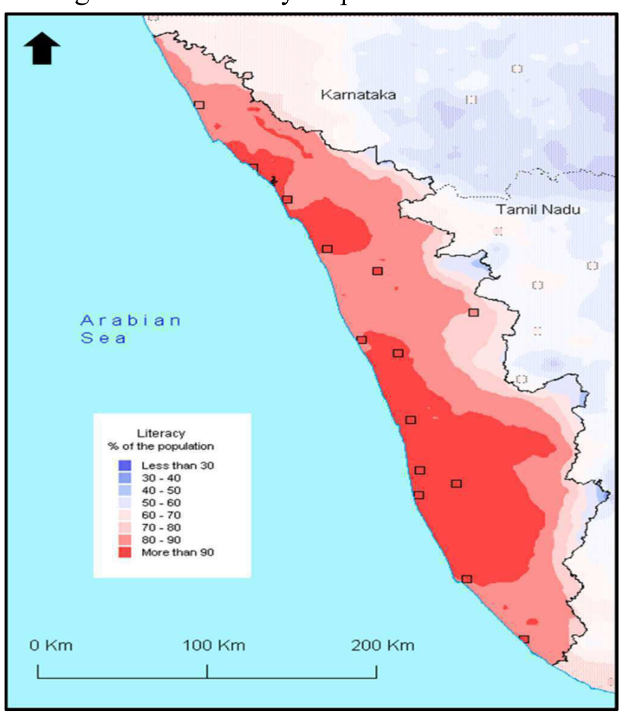
2. Quantitative thematic maps depict ordinal, interval, or ratio data on a base map (Fig. 10.7). Ordinal data involve ranked values rather than absolute measurements. For example, highways might be distinguished from secondary roads by using a bolder linear symbol for the former. National boundaries might similarly be distinguished from Provincial boundaries to reflect the administrative hierarchy. Ordinal-scale symbols convey relative importance rather than strictly mathematically comparable measures.

Interval-scale and ratio-scale data are similar in the sense that both refer measurements to some standard scale. A ratio scale is a measurement scale such as length in metres, mass in kilograms, areas in hectares, etc. These and all other ratio scales have a non-arbitrary zero corresponding to a complete absence of the quantity being measured. Consequently, ratio-scale measurements can be compared directly with each other as a true ratio of quantity. Thus, 200 m is twice as long as 100 m, 50 kg is one quarter of 200 kg, 1000 hectares is ten times the area of one hundred hectares, and so on.

Interval-scale data refer to measurements on a scale with a non-zero arbitrary datum. A good example of such a scale is the commonly used Celsius and Fahrenheit temperature scales. Temperature is a measure of heat but each of these two scales employs an arbitrary non-zero datum. In the case of Celsius, zero is arbitrarily defined as the temperature at which water freezes and not to the condition corresponding to an absence of heat. Indeed, absolute zero temperature (no heat) on the Celsius scale is -273^o C. Similarly, the Fahrenheit scale arbitrarily starts at a zero which gives the freezing temperature of water as 32^o F and the boiling point as 212^o F (100^o C). Only the Kelvin scale, which has a non-arbitrary zero (at -273^{o}C), is an absolute or ratio scale of temperature. Therefore, temperature comparisons on the commonly used scales are not true ratios of heat. In other words, it is not valid to say that when the temperature is 30^o C, it is twice as hot as when the temperature is 15^o C.

Although the distinction between interval and ratio scales is important, it turns out that almost all quantitative data in geography are represented on ratio scales. Indeed, temperature constitutes one of the few examples of a commonly used interval scale measure. The main classes of quantitative thematic maps are isopleth maps, choropleth maps and dasymetric map.

Figure 10.7 Literacy map of Kerala.

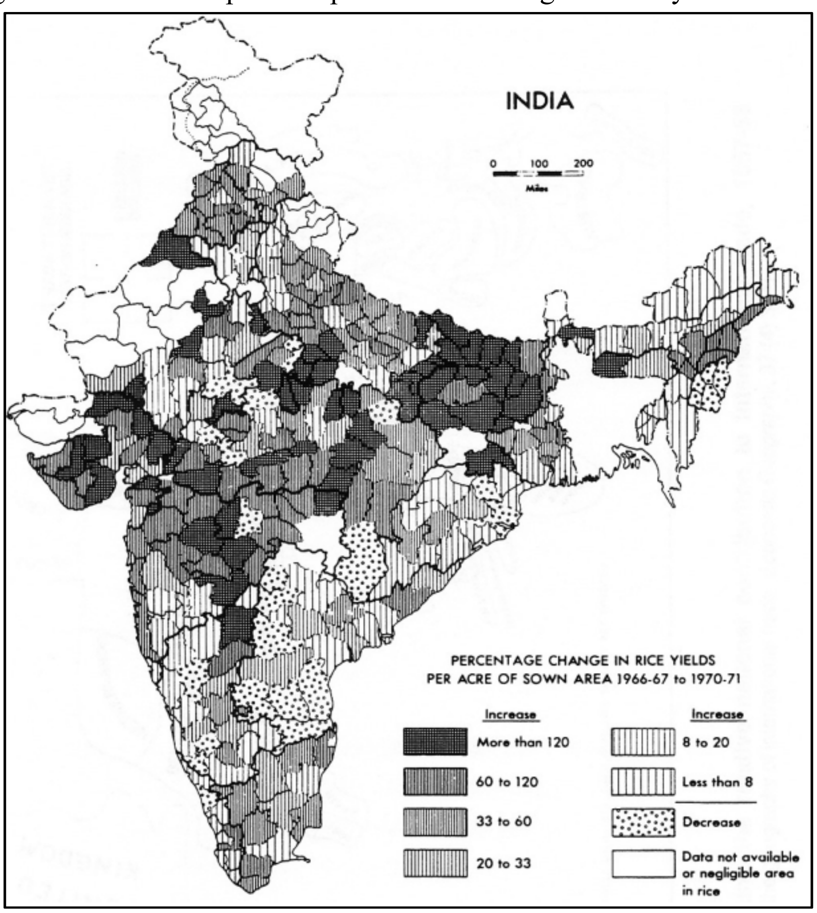


10.3 DEFINITION OF CHLOROPLETH, DASYMETRIC AND ISOPLETH MAPS

i. Chloropleth Map

Choropleth maps are commonly employed to display spatially averaged ratio data such as population density (population/km2), crop yields (kilograms/hectare), and average incomes (Rs. per capita) rather than the corresponding absolute values (total population, total weight or volume of production, and total income). They are maps which employ shading of relatively small statistical divisions such as census tracts or counties to depict geographic patterns in a larger region; choropleth maps of entire countries might be based on the correspondingly larger statistical divisions of state or province (Fig.10. 8). Once the range of the data for the area to be mapped has been determined, divisions are established to partition the range into about six to eight classes. The shading scheme used is graded so that low values appear lightly shaded and high values are densely shaded. When each statistical division of a region is mapped with its appropriate shading, the general pattern of spatial variability for the entire region should become apparent. Using much fewer than six classes results in too much information loss and employing many more than this number makes it difficult to distinguish between the shading of adjacent classes.

Figure 10. 8: A choropleth map of relative changes in rice yields in India.



There is a great deal of judgment and subjectivity involved in selecting the appropriate shading patterns. If the classes of grouped data are formed as a linear division of the range, then it is important that the shading is perceived to increase in a linear fashion through the classes. An example of a set of linear classes is 0-9; 10-19; 20-29; 30-39; and so on; the ratio of the mid-point values of any adjacent pair of classes is constant throughout the range. It should be noted that, in this regard, the eye is easily deceived; linear perception does not necessarily imply a linear increase in shading density. Trial and error are an important route to success here. Pitfalls include the use of solid black (which overemphasizes the highest class with respect to the others) and unfilled (white) classes which are underemphasized.

If the data are not subdivided into linear classes, choice of appropriate shading becomes a much more complex task. For example, sometimes the range of the data is so large, perhaps because of the occurrence of a few very high values, that a geometric scale might better be suited to the task of choropleth mapping than is a linear scheme. An example of a set of geometric classes is 10-19; 20-39; 40-79; 80-159; and so on; the ratio of the mid-point values of adjacent classes is changing at a geometric rate throughout the range (by a factor 2.0 in this case). Clearly, the scope for invention and creativity here is considerable! Nevertheless, whatever basis is chosen for establishing the choropleth classes, the overriding goal must remain the pursuit of effective and honest communication to the map user. In general, this goal is best met through the use of the simplest and most direct methods of data processing. Figures 9.8 show a common use of choropleth maps: displaying agricultural statistics.

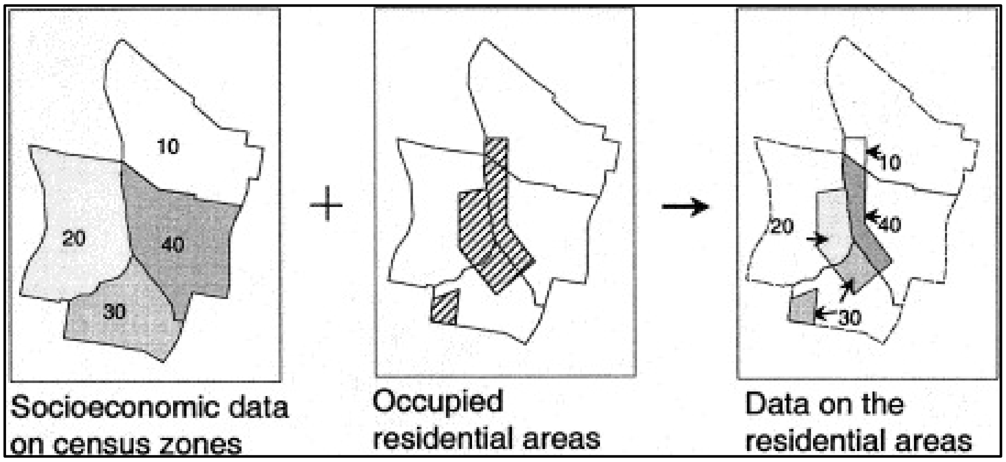
Choropleth maps should not be used to depict absolute quantities because such data are not area-controlled. For example, a large statistical division with the lowest crop yield in a region may still produce the largest amount of crops and mapping this high absolute value over such a large area would produce a quite distorted view of the spatial pattern of production.

ii. Dasymetric Map

A dasymetric map is a method of thematic mapping in which a choropleth map is refined by incorporating additional geographic information. In a dasymetric map, boundaries are modified to conform to known areas of homogeneity and are not restricted to administrative or statistical boundaries. Choropleth maps have a number of inherent issues due to the district boundaries being arbitrary with respect to the data variable, so that nothing is known about the variation within each district, and the boundaries affect the apparent spatial pattern (the Modifiable areal unit problem). The dasymetric technique uses geographic information about the distribution of the phenomenon of interest to refine the district boundaries so they better reflect the real-world patterns. The resultant map is somewhere between a choropleth map and an Isarithmic map (discussed in next section).

Fig. 10.9 shows the transformation of socioeconomic data from census tracts to residential areas with dasymetric mapping. The numbers in the figure (i.e. 10, 20, 30 and 40) refer to the numbers of dwellings in each of the four zones.

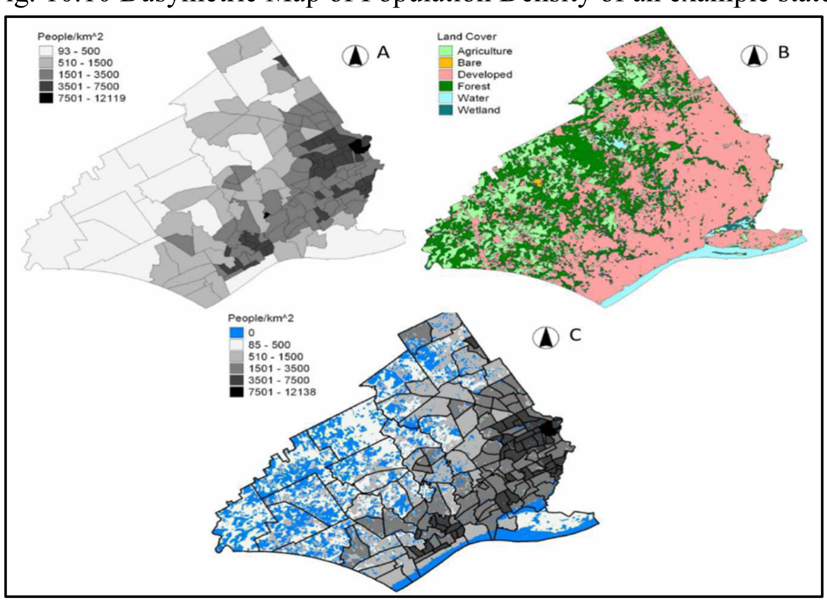
Figure 10.9 Dasymetric Map of Census Tracts to Residential Areas



Although dasymetric maps are closely related to choropleth maps, they mainly differ in following ways. First, zonal boundaries on dasymetric maps are based on sharp changes in the statistical surface, obtained via ancillary data (see above), while zonal boundaries on choropleth maps have units established for more general purposes (e.g., state, districts, etc.). Ancillary information can be both objective and subjective, depending on other available data and the cartographer's knowledge of the area. Second, individual dasymetric zones are developed to be internally homogeneous. In contrast, choropleth zones are not defined based on the data and, thus, have varying levels of internal homogeneity.

The population density of an example state is shown in Fig. 10.10A, the population/km2 is shown per district, in Fig. 10.10B, the various land cover categories of the state is mapped. Fig. 10.10C. Shows the results of dasymetric mapping using a preset value of zero population density for agriculture, bare, water, and wetlands land covers, and forest land covers.

Fig. 10.10 Dasymetric Map of Population Density of an example state.



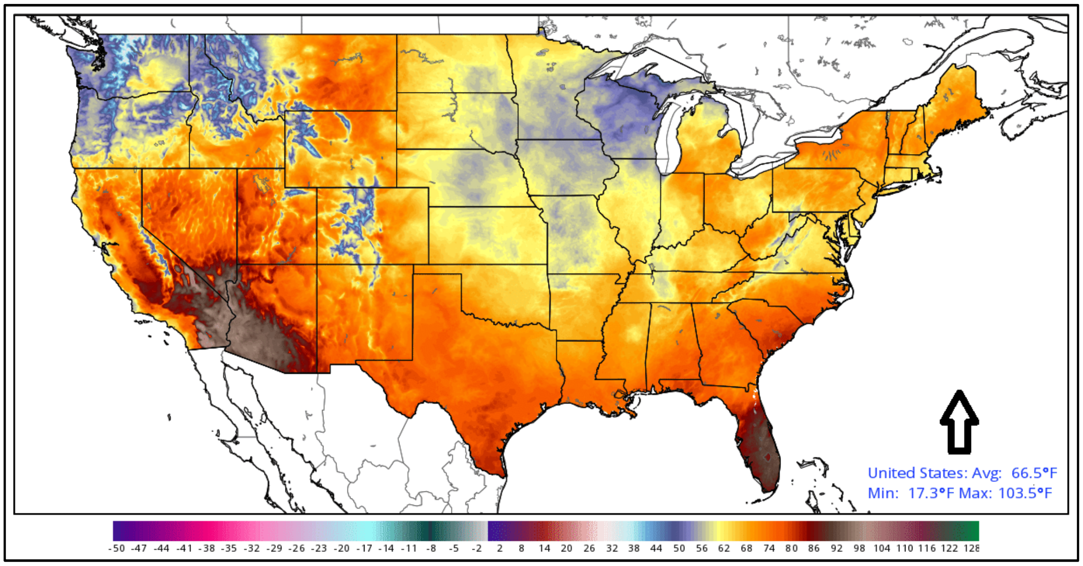
Like other forms of thematic mapping, the dasymetric method was created and historically used because of the need for accurate visualization methods of population data. An example would be a map depicting population density from census information, while taking into account geographical features such as lakes or parks--places in which people do not live.Dasymetric maps are not widely used because of the limited options for producing them with automated tools such as geographic information systems. Although fields such as public health still rely on choropleth maps, dasymetric maps are becoming more prevalent in developing fields such as conservation and sustainable development. Dasymetric mapping has long been favored by earth scientists such as geologists and ecologists.

iii. Isopleth Map

Isolines - are lines joining equal quantities measured above some common and arbitrary datum. Ona topographic map, a given contour joins points which are the same height above sea level. The contours describe the three-dimensional surface that is the ground. This concept easily can be extended todescribe any three-dimensional surface. For example, a mapof meteorological stations for which annualaverage rainfall data are available, provides the basis for an isoline map of a statistical surface which iscompletely analogous to our ground surface example. Instead of heights above sea level we have rainfall in mm (above zero datum - no rainfall) and the isolines are not contours but isohyets.Similarly, a barometric surface representing atmospheric pressure might be described by isobars and anair temperature surface by isotherms.

Isometric lines are isolines along which all points represent equal quantities on a continuoussurface. Thus, contours, isohyets, isobars and isotherms are isometric lines. Isopleth maps differ from choropleth maps in that the data is not grouped to a pre-defined unit like a city district. These maps can take two forms:Lines of equal value are drawn such that all values on one side are higher than the "isoline" value and all values on the other side are lower, orRanges of similar value are filled with similar colors or patterns.This type of map is ideal for showing gradual change over space and avoids the abrupt changes which boundary lines produce on choropleth maps. Temperature, for example, is a phenomenon that should be mapped using isoplething, since temperature exists at every point (is continuous) yet does not change abruptly at any point (like population density may do as you cross into another census zone). The disadvantage of isopleths are that they are unsuitable for showing discontinuous or 'patchy' distributions and a large amount of data is required for accurate drawing.

Fig. 10.11 Isopleth Map showing the Temperature of United States of America on 24-05-2017.



<u>Thematic Map Design</u>

As a thematic map is aimed at a particular user, consultation with that user shouldoccur during the initial planning and specification stages of the map. This will enablea more complete understanding of the kind and scope of data that is to be recorded, the symbolization types and the type of graphics that are needed.

Some design considerations include:

- Symmetry: This relates to the placement of the graphic and marginal information on the sheet to achieve a balanced appearance (i.e. good aesthetics).
- Theme emphasis: The main theme or foreground data should appear more dominant. A large body of water (background) should be less dominant than the information being portrayed (e.g. tourist data or hydrographic navigational information).
- Continuity: This applies especially to connectivity symbols such as roads or rivers. These meander across a graphic and often cross or intersect each other. A continuity of appearance should be maintained.
- Similarity: While symbol size may change (e.g. town symbol) the same type of symbol should be associated with the same type of data (e.g. a town area) right across the graphic. This helps them to be seen as belonging together.
- Proximity: This refers to the spatial arrangement or grouping of an element e.g. arrange the grouping of crops into a single area symbol rather than show each individually.
- Continuity or Closure: Ensure that a symbol retains its closed appearance or continuity e.g. if a name cuts across a boundary it breaks the boundary but should not be seen as a natural break.

Using these design considerations will enable you to emphasize those elements thatfit together in harmonious organization and produce a harmonious, balanced andaesthetically pleasing graphic.

Other specific considerations include:

- Nominal and differential scaling: Similar symbols represent similar features, while different symbols mean differences in reality (slight or as strong as the situation demands).
- Ordinal scaling, Emphasis the relative ordering through the use of size, lightness/darkness, texture variation and orientation.
- Interval scale proportioning: The size of a symbol can be used to demonstrate relative proportion.
- Symbol meaning: Wherever possible the meaning of the symbol should be as similar as possible to the item it is representing or a 'nationally' recognizable symbol.

Technology in Thematic Map Production

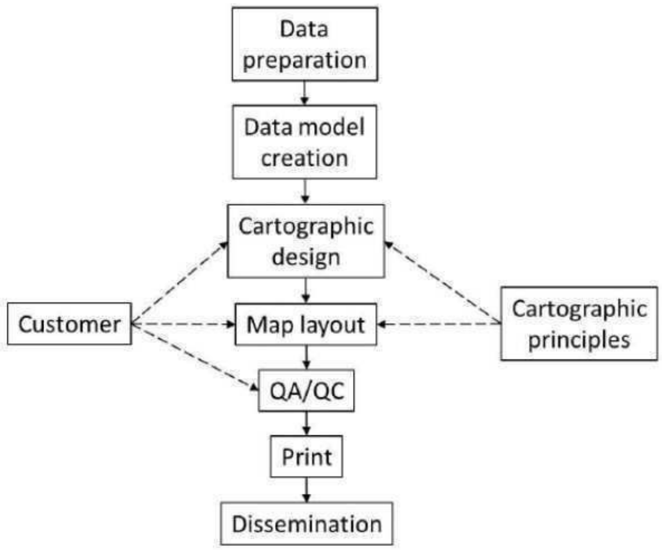
1. Standard procedure

Over the years the standard procedure of map production has evolved, and it was common for all the map types. This procedure was published already in the 1970's by Lauermann and it was copied by many authors since then. It started with customer requirements for a map title, map purpose, geographic extent, map content, formal map arrangements, and so on. Then these requirements had to be clarified by the mapmaker (or the mapmaking organization) in order to refine specification of a thematic focus, map scale, cartographic projection, map frame and a structure of map series, draft of a map content, draft of a symbol set, etc. After that the cartographic project was elaborated into the detailed technical project laying out the detailed specification of individual steps within the whole technology. And then the production of the map could finally start. The cartographic principles and rules are general and should be respected during production of each map. They describe the ways of selecting the elements of the map content; their classification and visualization; their relation to the topographic background; the ways ofgeneralization; requirements for the map layout and its fundamental elements; requirements for a legend; etc. It is important to consider that this applies also for production of thematic maps based on digital technologies. These technologies allow producing maps very easily virtually to anyone which leads to enormous amount of poor maps that we see in our daily life.

2. GIS technology

There are basically two possible ways of the thematic map production using digital technologies: the technology employing various tools of geographic information systems (GIS) and the method using so-called desktop publishing (DTP) applications. Let us consider that the phase of clarification of customer's requirement has been completed and also the cartographic project has been created. The cartographic project describes the product to be created in detail by specifying issues such as main theme, title, scale, projection, map content, composition, symbol sets and so on. Then we can focus on a process of map creation using the GIS technology. Kraak and Ormeling present the thematic map production scheme as a five-step process: (i) setting map objectives and specifications; (ii) data collection and combination; (iii) creating the map image; (iv) adapting the map to the medium; (v) dissemination. Considering the standard procedure, recent solutions and the specifics of the GIS technology, the general scheme of the thematic map production technology can be created (Figure 10.12). The technology comprises the following steps:

Figure 10.12 General scheme of the thematic map production



i. Data preparation. This step represents the data collection and its analysis, sometimes also creation of new data. According to the customer requirements and the type of the map that will be created, the suitable data should be collected.
ii. Data model creation. Through creation of a data model the geometric base of a map is set. The map projection, coordinate system, map scale and data layers are determined.
iii. Cartographic design. The main goal of cartographic design is to communicate the information in the map in the most efficient manner, with simplicity and clarity. Using the data model, the concrete content of the thematic map is created within this step.
iv. Map layout. Creating a map layout is the most complicated step of the process. Although a technical part of the process (i.e. placing, arranging and modifying map elements) is made easy by sophisticated tools provided by GIS applications, there is a number of cartographic principles that should be respected.
v. Quality control. Quality assurance and quality control is (or should be, at least) an essential part of any production process. Before printing and delivering the product a thorough quality control should be performed.
vi. Print. The map can be printed applying various printing techniques which would also depend on a number of copies required. The map can be also produced in other formats rather than in a printed one, this would require transformations, export and adapting to the final format.
vii. Dissemination. The final step of the map production technology. Delivering the map in a printed or electronic form

Base Data on Thematic Maps

Whatever information is being portrayed the thematic map requires base data i.e, basic positional data (which normally come from either topographic maps orbathymetric charts). The amount and detail of base data will vary from map to map depending on the scale, purpose and needs of that thematic map. Generally, the thematic map must have on its coastlines, the major rivers and lakes, and at least thebasic road or rail networks and major towns. For larger scale maps e.g. a city environment where buildings are the theme, streets and street names may beadequate. A geological map, depending on scale, would have major roads, towns and rivers as base data to which geological classifications are added.

The base map provides:

- a guide for accurate compilation
- a guide for thematic information positioning
- background detail
- spatial relationships and connectivity
- regional continuity.

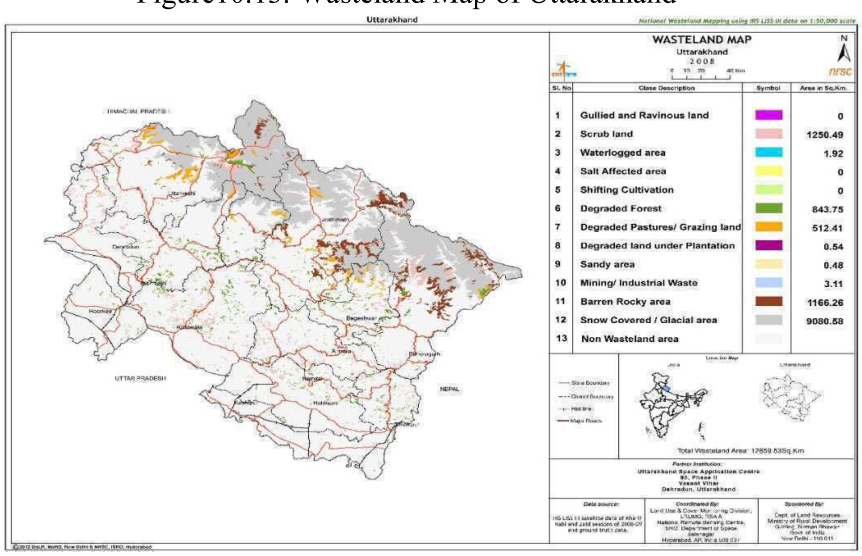
Large-scale topographic maps are particularly useful because of their inherentaccuracy provided they are functionally related to the thematic data being represented e.g. administrative boundaries, communication networks, etc, and they fit an existingmapping structure.

The following features are commonly used as base data:

- Administrative boundaries
- Highway
- Coastlines
- Hydrographs
- Landforms

In the following Fig. 10.13, note the information on state and district boundaries along with the major roads and railway lines.

Figure10.13. Wasteland Map of Uttarakhand



10.4 SUMMARY

In this Unit, you have learned the following:

1. The differences between the general purpose maps and thematic maps.
2. The concepts of qualitative and quantitative thematic maps and the differences between the two and usage.
3. Definition of chloropleth, dasymetric map and isopleth maps.
4. The differences between the dasymetric map and chloropleth maps and isopleth maps.
5. The design considerations to produce an efficient thematic map.
6. The common base data that are to be used in every thematic map.

10.5 GLOSSARY

1. Cartography- It is art or science of making and study of maps.
2. Thematic Map- A map that use a variety of cartographic symbolization to depict the spatial pattern of a particular geographic quality or quantity rather than a variety of information of different sorts.
3. Isoline- Lines drawn to link different places that share a common value. For example, a line drawn on a map to join up all the places that are the same height above sea level is called a contour (Isoline of elevation).
4. Nominal Data- Nominal data describe different kinds of different categories of data such as land use types or soil types.
5. Ordinal Data- Ordinal data differentiate data by ranking relationship. For example- cities may be grouped into large, medium and small cities by population size.
6. Interval Data- Interval data have known intervals between values such as temperature reading. For example, a temperature reading of 70^{o} F is warmer than 60^{o} F by 10^{o} F.
7. Ratio Data- Ratio data are the same as interval data except that ratio data are based on a meaningful or absolute zero value.
8. Isorhythmic Map- It is a type of thematic map that represents a continuous field using line and/or region symbols to connect places of similar value. It is sometimes called a heat map that represents density. In general, these maps are used to help visualize continuous data sets by utilizing color

10.6 ANSWER TO CHECK YOUR PROGRESS

1. What is a thematic map?
2. How is qualitative thematic map different from quantitative map?
3. What is a chloropleth map?
4. Differentiate interval and ratio data.
5. What are the key design considerations for a thematic map?
6. What are the two standard procedures to produce a thematic map?
7. What is a base data on a thematic map?

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Image Credits

- Fig. 10.1 (Pg. No - 2) http://www.surveyofindia.gov.in/pages/display/238-physical-map-of-india &Building Materials and Technology Promotion Council
- Fig. 10.2 (Pg. No - 4)Naithani, Suneet. (2013). GapAnalysisin South Eastern and Western Ghats using geoinformatics. International Journal of Asian Academic Research Journal of Multidisciplinary. Volume 1,pp. 180-189.
- Fig. 10.3 (Pg. No - 5) https://kurukshetra.gov.in/map-of-district/
- Fig. 10.4 (Pg. No - 6)https://commons.wikimedia.org/wiki/File:India_average_annual_Temp
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10.8 TERMINAL QUESTIONS

1. What are the different types of data that can be mapped?
2. Explain the various types of thematic maps.
3. What is the difference between the chloropleth and dasymetric map?
4. What is Isoline? Explain the Isopleth Map with an example.
5. Explain why a base data on a thematic map is important.

UNIT 11 - CLASS INTERVAL SELECTION AND SHADING

11.1 OBJECTIVES

By the end of this unit you will be able to understand the:

- Mapping Categorical Data
- Mapping Numerical Data
- Different Measurement values and types used
- Various Data Classification Method

11.2 INTRODUCTION

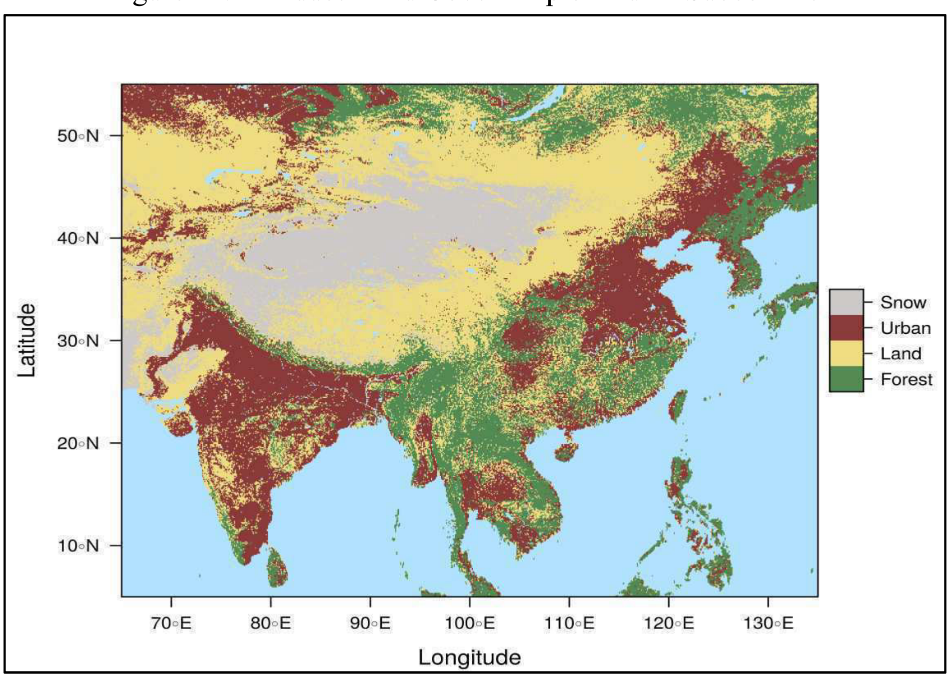
Unlike reference maps, thematic maps are usually made with a single purpose in mind. Often, that purpose has to do with revealing the spatial distribution of one or two attribute data sets (e.g., to help readers understand changing demographics as with the population change map). Alternatively, thematic maps can have a decision-making purpose (e.g., to help users make travel decisions as with the real-time traffic map).

Here, we will explore different types of thematic maps and consider which type of map is conventionally used for different types of data and different use goals. A primary distinction here is between maps that depict categorical (qualitative) data and those that depict numerical (quantitative) data.

Mapping Categorical Data

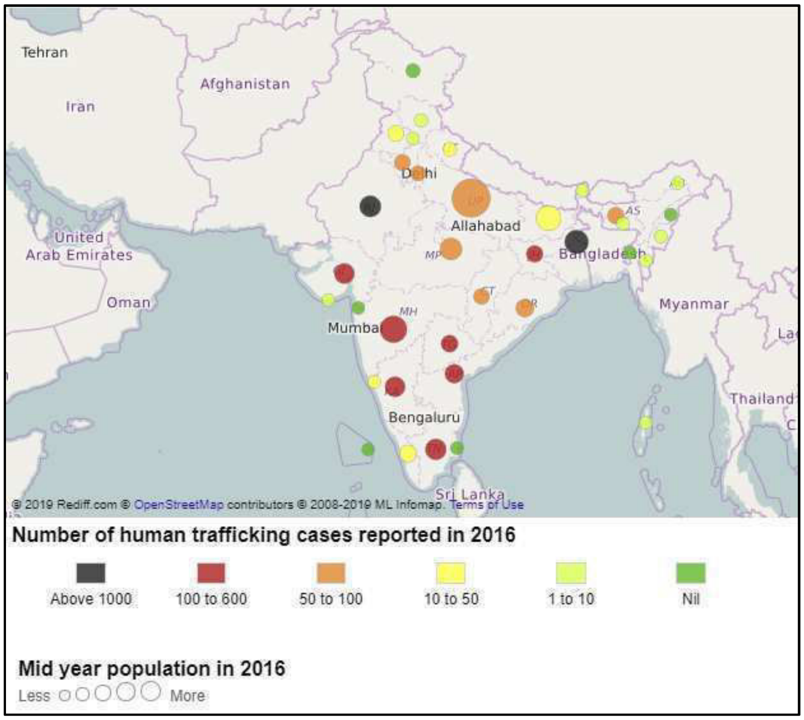
Categorical data are data that can be assigned to distinct non-numerical categories. For example, the category of a beach could not be described as two times the value of a wetland; it is different in kind rather than amount. In mapping categorical data, cartographers often focus on displaying the different categories or classes through shape or color or hue. In fig. 11.1, different categories are represented in different colors.

Figure 11.1Landuse Land Cover Map of Indian Subcontinent



Aside from altering color to represent different categories on a map, changing the shape of a point symbol can help map users differentiate different groups.

Figure 11.2 Map showing the number of human trafficking cases reported in 2016



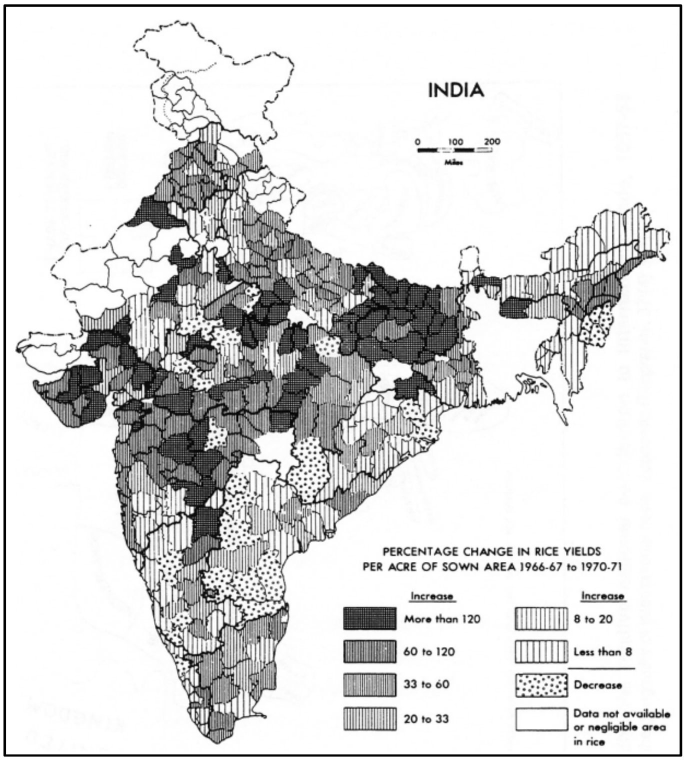
Mapping Numerical Data

When data are numerical, the mapping focus is typically on representing at least relative rank order among the entities depicted, with some maps trying to represent magnitudes in a direct way. A wide array of map types has been developed over the years to represent numerical data. Here, we will introduce some of the most common map types you are likely to encounter. There is a growing number of online tools that you can use to generate these common map types yourself.

We begin by introducing one of the most common thematic map types for numerical data, the choropleth map. This is followed by a brief discussion of the U.S. Census as an important source of numerical data that is depicted on choropleth thematic maps as well as on other thematic map types. We then introduce three important additional map types you are likely to encounter frequently: proportional symbol maps, dot maps, and cartograms. The choropleth map is one of the most common thematic map types for numerical data. Choropleth maps represent quantitative data that is aggregated to areas (often called "enumeration units"). The units can be countries of the world, states, districts, or any other regional division that divides the whole territory into distinct areas.

Choropleth maps depict quantities aggregated to their regions by filling the entire region with a shade or color. Typically, the quantities are grouped into "classes" (representing a range in data value) and a different fill is used to depict each class (fig. 11.3). The goal of choropleth maps is to depict the geographic distribution of the data magnitudes; ideally the choice of fill will communicate the range from low data magnitudes to high magnitudes through an obvious change from light to dark as in fig. 11.3.

Figure 11.3 A choropleth map of relative changes in rice yields in India.



Choropleth maps are most appropriate for representing derived quantities. Derived quantities relate a data value to some reference value. Examples include density, average, rate, and percent. A density is a count divided by the area of the geographic unit to which the count was aggregated (e.g., the total population divided by the number of square kilometers to produce population/square meter). An average is a measure of central tendency, specifically the mean value calculated as a total amount divided by the number of entities producing the amount (e.g., the average income for a county calculated by totaling the income of all people in the country and dividing by the number of people). A rate is a quantity that tells us how frequently something occurs, a value compared to a standard value (e.g., India has a rate of 450.1/100,000 deaths due to cancer among women over the period of 1994-2002). A percent is the proportion of a total (and can range from 0-100%). While choropleth maps are best for these derived quantities, you will also encounter choropleth maps used for counts (e.g., the number of crimes committed, votes cast in an election, etc.).

Measurement systems

The type of measurement system used may have a dramatic effect on the interpretation of the resulting values. A distance of 20 kilometers is twice as far as 10 kilometers, and something that weighs 100 pounds is one-third as much as something that weighs 300 pounds. But someone who came in first place in a race may not have done three times as well as someone in third place, and soil with a pH of 3 is not half as acidic as soil with a pH of 6. To carry this even further, someone that is 60 years old is twice as old as someone that is 30 years old. But the older of the two individuals can only be twice as old as the younger individual just once in a lifetime.

Spatial Analyst does not distinguish between the four different types of measurements when asked to process or manipulate the values. Most mathematical operations work well on ratio values, but when interval, ordinal, or nominal values are multiplied, divided, or evaluated for the square root, the results are typically meaningless. On the other hand, subtraction, addition, and Boolean determinations can be meaningful when used on interval and ordinal values. Attribute handling within and between raster datasets is most effective and efficient when using nominal measurements. Since all numbers cannot be treated the same, it is important to know the type of measurement system being used in the raster dataset so that the appropriate operations and functions can be implemented, and the results will be predictable. Measurement values can be broken into four types: nominal, ordinal, interval and ratio.

Nominal

Values associated with this measurement system are used to identify one instance from another. They may also establish the group, class, member, or category with which the object is associated. These values are qualities, not quantities, with no relation to a fixed point or a linear scale. Coding schemes for land use, soil types, or any other attribute qualify as nominal measurements. Other nominal values are social security numbers, ZIP Codes, and telephone numbers.

Ordinal

Ordinal values determine position. These measurements show place, such as first, second, and third, but they do not establish magnitude or relative proportions. How much better, worse, prettier, healthier, or stronger something is cannot be demonstrated from ordinal numbers. For example, a runner who was first place in a race probably did not run twice as fast as the second-place runner. Knowing the winners only by place, you do not know how much faster the first-place runner was compared with the second-place runner.

Interval

Time of day, calendar years, the Fahrenheit temperature scale, and pH values are all examples of interval measurements. These are values on a linear calibrated scale, but they are not relative to a true zero point in time or space. Because there is no true zero-point, relative comparisons can be made between the measurements, but ratio and proportion determinations are not as useful.

Ratio

The values from the ratio measurement system are derived relative to a fixed zero point on a linear scale. Mathematical operations can be used on these values with predictable and meaningful results. Examples of ratio measurements are age, distance, weight, and volume.

Discrete data

Discrete data, sometimes called categorical data, most often represents objects. These objects usually belong to a class (for example, soil type), a category (for example, land-use type), or a group (for example, political party). A categorical object has known and definable boundaries.

An integer value is normally associated with each cell in a discrete raster dataset. Most integer raster datasets can have a table that carries additional attribute information. Floating-point values can be used to represent discrete data, but this is not common. Discrete data is best represented by ordinal or nominal numbers.

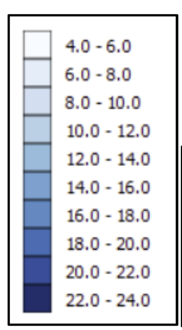
Continuous data

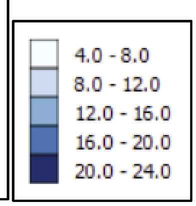
A continuous raster dataset or surface can be represented by a raster with floating-point values (referred to as a floating-point raster dataset) or occasionally by integer values. The value for each cell in the dataset is based on a fixed point (such as sea level), a compass direction, or the distance of each location from a phenomenon in a specified measurement system (such as the noise in decibels monitored at various sites near an airport). Examples of continuous surfaces are elevation, aspect, slope, the radiation levels from a nuclear plant, and the salt concentration from a salt marsh as it moves inland.
Floating-point raster datasets do not have a table associated with them because most, if not all, cell values are unique, and the nature of continuous data excludes other associated attributes. Continuous data is best represented by ratio and interval values. Many times, meaningless results will occur when combining discrete and continuous data, for instance, adding land use (discrete data) to elevation (continuous data). A value of 104 on the resulting raster dataset could have been derived from adding single-family housing land-use type, with a value of 4, to an elevation of 100.

11.3 CLASS INTERVAL SELECTION AND SHADING

When the quantitative data is to be mapped, data classification has to be carried out to generate the many colors of choropleth maps. Equal intervals, quantile, natural breaks, etc. are some of the various classification used to create choropleth maps. First number of Classes to be decided. More number of classes brings more variation sometimes making it harder to separate shading. While fewer classes provide less separation between classes such as 5 classes below. The number of classes depends on the purpose of your map.

Figure 11.4 (10 Classes) Figure 11.5 (5 Classes)

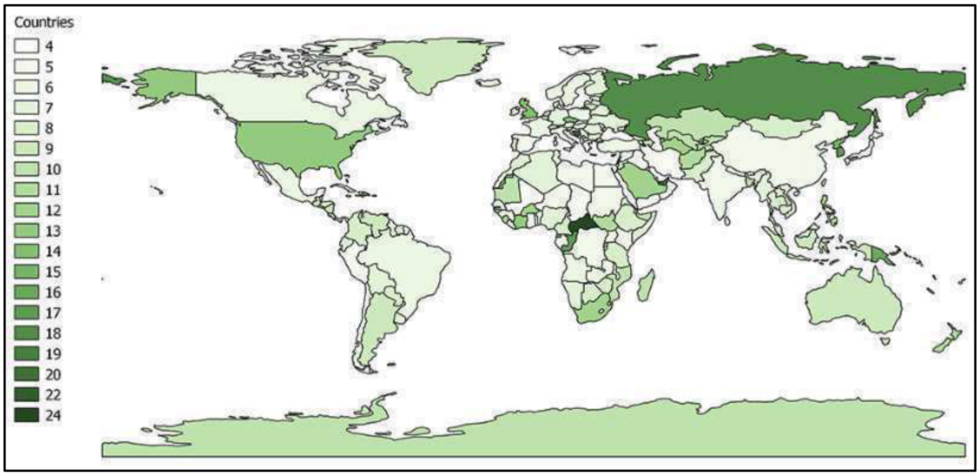




Data Classification Method

The data classification arranges the data with boundaries to separate classes. Here in the example, same data set is used with different classification schemes. The number of letters in country names is counted. For example: Mali, Cuba and Peru and others are four letter countries. Whereas, Bosnia and Herzegovina have 22 characters. If you plot out 4 to 22 characters, it will have a lot of colors (fig. 11.6).

Figure 11.6 Choropleth map shading by countries number of characters



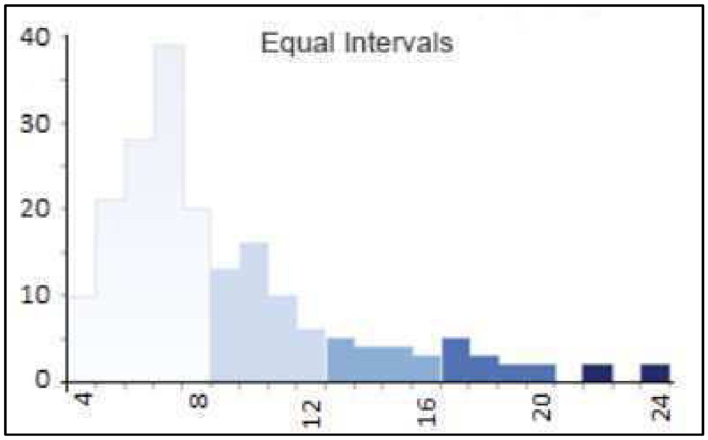
For example, the four-letter countries are the lightest shades of green. As the letter count increases, the shading gets darker. Since it is hard to tell which country belongs to which group, a classification scheme should be used. When we group by classes, there is less shading, and we aggregate the data by group.

i. Equal Interval Data Classification

Equal interval is cut and dry. All it really does is divide the classes into equal groups (fig. 13.7).

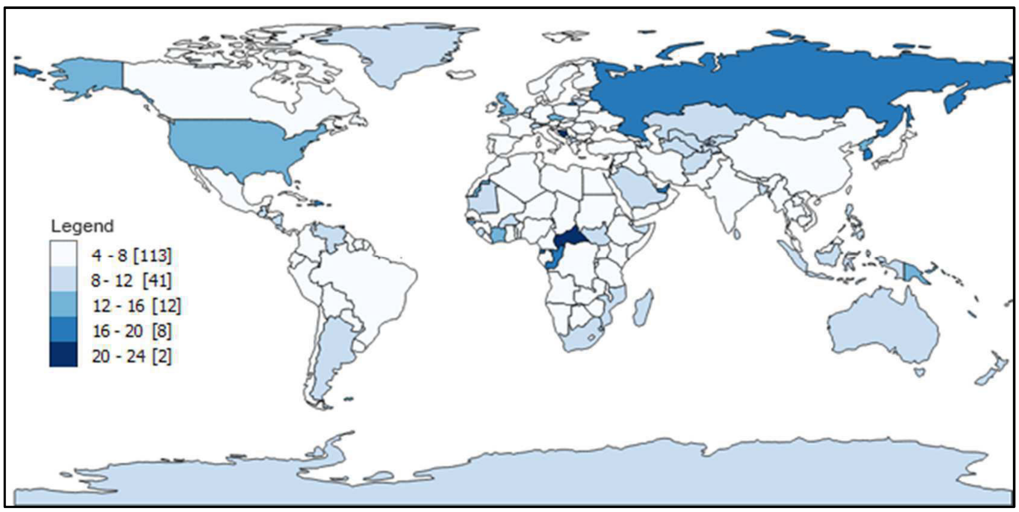
- **Class 1**: 4 – 8 (113 countries have four, five, six, seven or eight letters)
- **Class 2**: 8 – 12 (41)
- **Class 3**: 12 – 16 (12)
- **Class 4**: 16 – 20 (8)
- **Class 5**: 20 – 24 (2)

Figure 11.7 Equal Interval Mode Classifications



The minimum number of characters of a country is 4 such as Peru. The maximum number of characters is 24, which is Central African Republic. When you plot each country and their number of characters on a map, it looks like this (the brackets indicate the count) (fig. 11. 8):

Figure 11.8 Choropleth map shading by countries number of characters (Equal Interval)

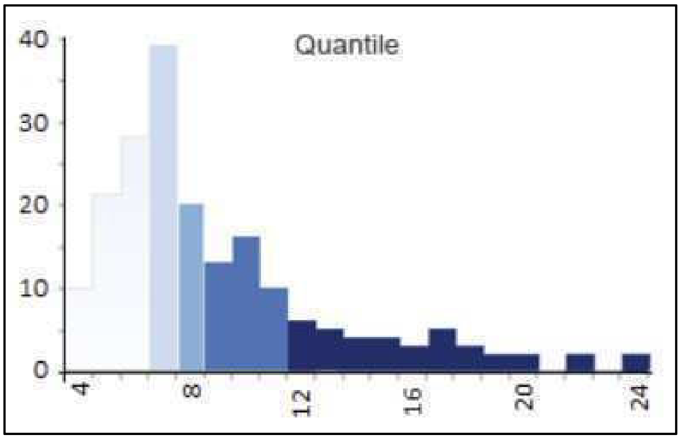


Equal interval data classification subtracts the maximum value from minimum value (24-4=20). In our example, we generated 5 classes, but the number of classes is entirely up to you. Then, it divides 20 by 5 and you get an interval (20/5=4). Almost always, equal interval choropleth maps result in an unequal count of countries per class. For example, class 1 has 113 countries out of 176 countries with four, five, six and seven letters. However, only 2 countries have more than 20 letters. As a result, this map displays more light shaded colors compared to only 2 with the dark shading.

ii. Quantile (Equal Count) Classification

The quantile map tries to bin the same count of features in each of the 5 classes. In other words, quantile maps try to arrange groups, so they have the same quantity (Fig.11.9). As a result, the shading will look equally distributed in quantile types of maps.

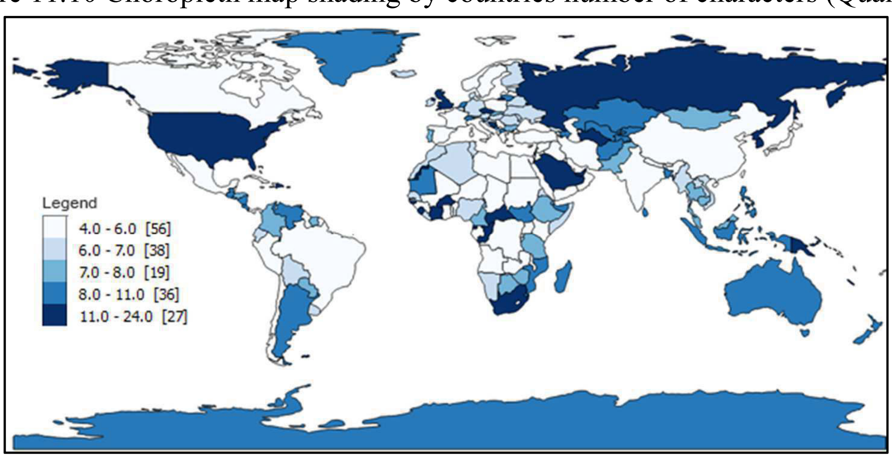
Figure 11.9 Quantile Mode Classifications



- **Class 1: 4 – 6 (56 countries have 4, 5 or 6-letter names)**
- **Class 2: 6 – 7 (38)**
- **Class 3: 7 – 8 (19)**
- **Class 4: 9 – 11 (36)**
- **Class 5: 12 – 24 (27)**

Quantile maps take the total of number of features (176 countries in our case). Then, it divides the total by the number of classes to get the average (176/5=35.2). Finally, quantile maps count the quantity in each group and arranges them as close to the average as possible (fig. 11.10). Here the count of each class looks very similar and are close to 35.2. They are misleading because people tend to look at a shade and group it in the same category. For example, a 12-letter country gets the same dark shading as a 24-letter country.

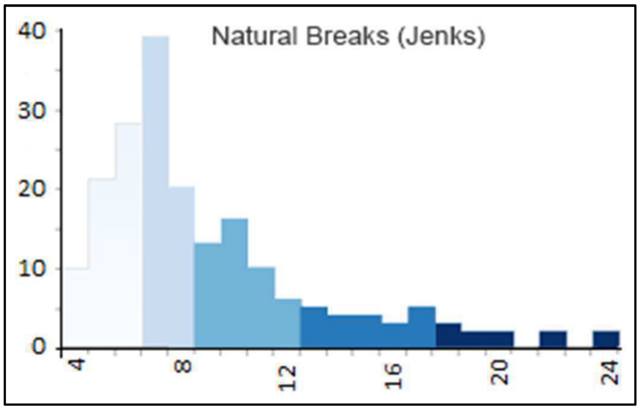
Figure 11.10 Choropleth map shading by countries number of characters (Quantile)



iii. Natural Breaks Classification

The Natural Breaks classification arranges each grouping so there is less variation in each class or shading.

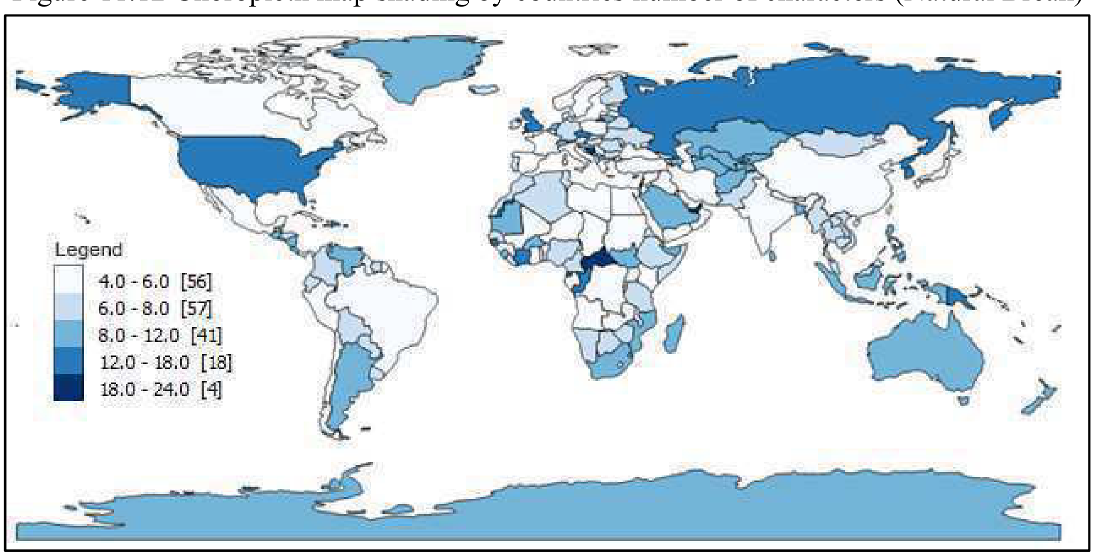
Figure 11.11 Natural Breaks Classification



- **Class 1: 4 – 6 (56)**
- **Class 2: 6 – 8 (57)**
- **Class 3: 8 – 12 (41)**
- **Class 4: 12 – 18 (18)**
- **Class 5: 18 – 24 (4)**

Natural Breaks compares the sum of squared deviations between classes to the array mean. Then, the algorithm uses a goodness of variance fit with 1 as a perfect fit and 0 as a poor fit (fig.11.12).

Figure 11.12 Choropleth map shading by countries number of characters (Natural Break)



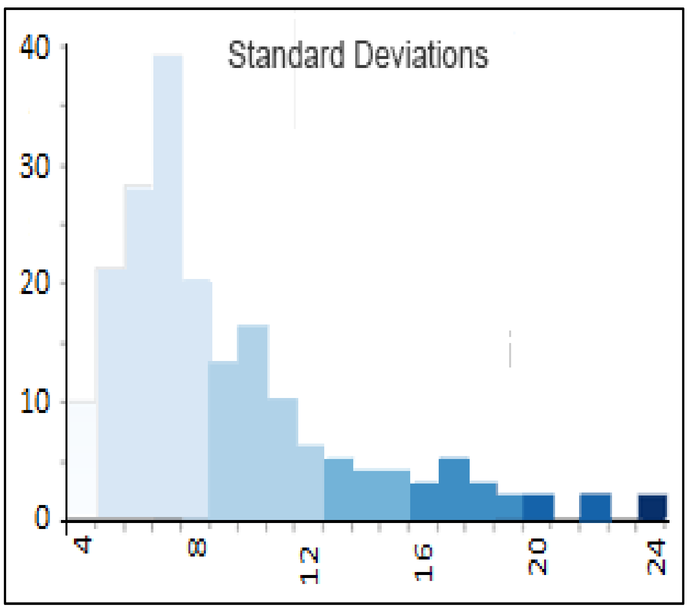
This data classification method minimizes variation in each group. As we have lots of shorter country names, it finds suitable class ranges. But it still manages to group outliers with longer country names in a class of its own.

iv. Standard Deviation Classification

Standard deviation is a statistical technique type of map based on how much the data differs from the mean. You measure the mean and standard deviation for your data. Then, each standard deviation becomes a class in your choropleth maps (fig.11.13).

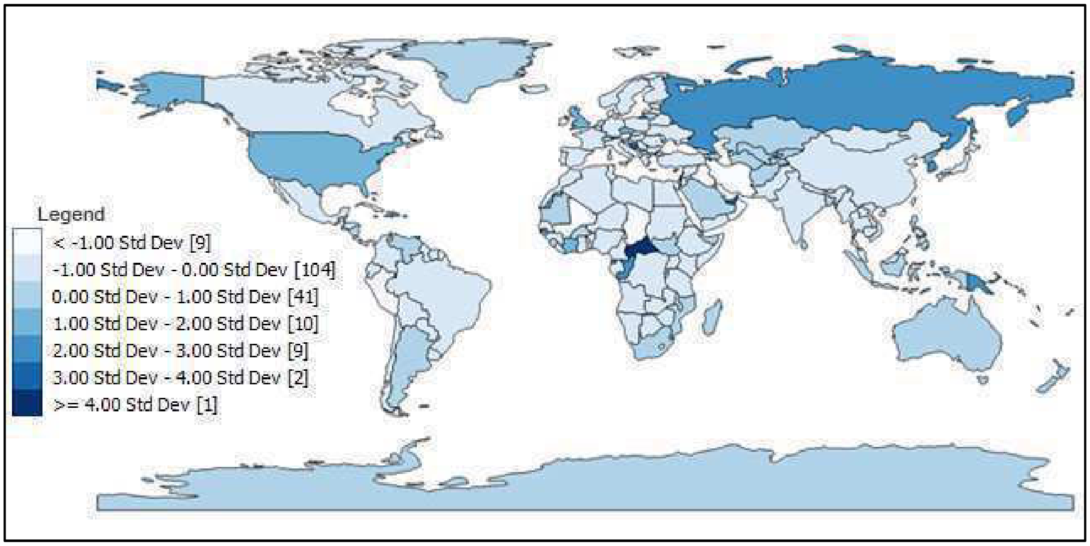
- **Class 1: <-1 σ (9)**
- **Class 2: -1 to 0 σ (104)**
- **Class 3: 0 to 1 σ (41)**
- **Class 4: 1 to 2 σ (10)**
- **Class 5: 2 to 3 σ (9)**
- **Class 6: 3 to 4 σ (2)**
- **Class 7: >=4 σ (1)**

Figure 11.13 Standard Deviation Classification



In this case, the mean number of characters is about 8.5 with a standard deviation of 3.7 characters. As a result, all countries with 5 to 8 characters will be placed in the 0 to -1 standard deviation grouping. Likewise, countries with 9 to 12 letters are grouped in 0 to 1 standard deviation range (fig. 11.14).

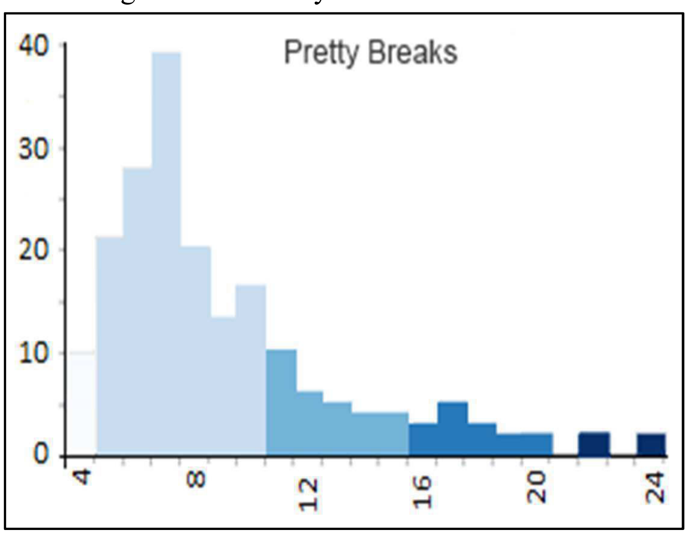
Figure 11.14 Choropleth map shading by countries number of characters (Standard Deviation)



v. Pretty Breaks Classification

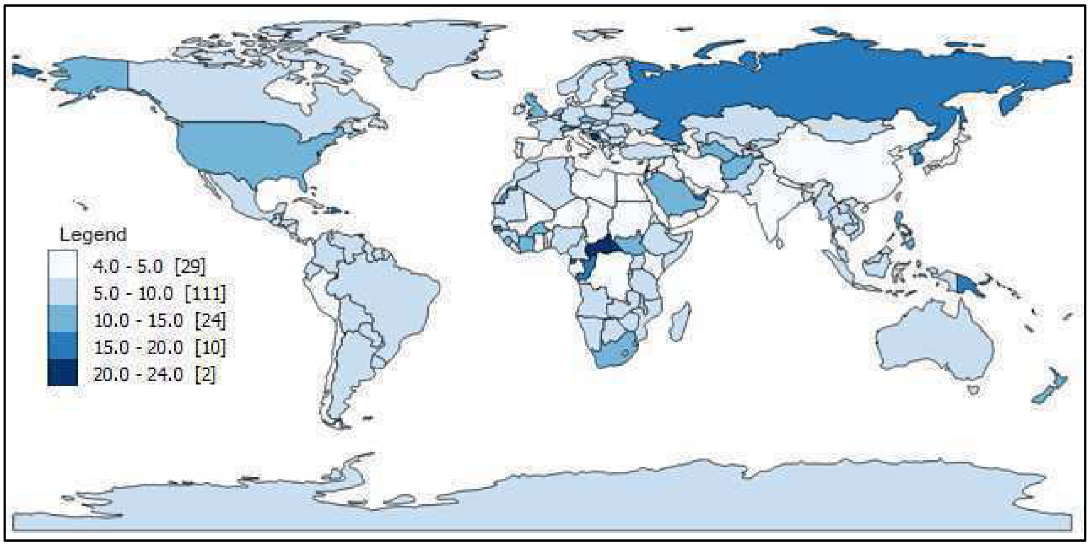
If you want round numbers in your ranges, then you should choose pretty breaks. All pretty breaks does is rounds each break-point up or down. So instead of having a break point as 599.364 it will become 600,000 with pretty breaks.

Figure 11.15 Pretty Break Classifications



It's a bit hard to see how round the numbers are (it's grouping by 5's) in this example because all the examples above also produce round numbers. But when you have large numbers like population estimates (see below), it will generate some very pretty breaks (Fig. 11.15).

Figure 11.16 Choropleth map shading by countries number of characters (Pretty Breaks)

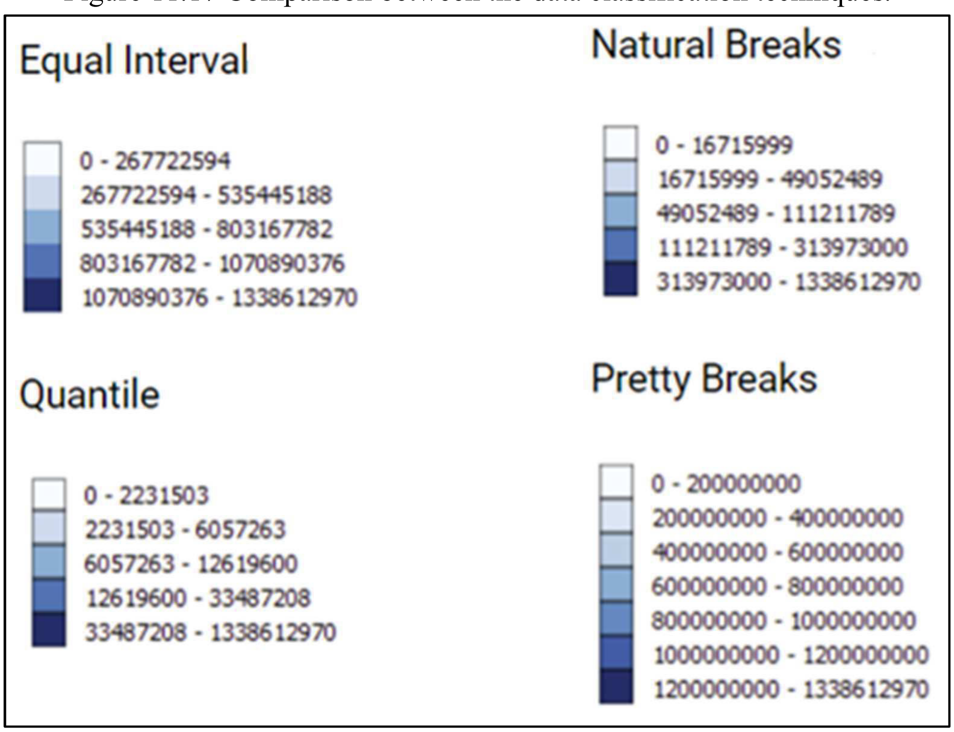


- **Class 1: 4 – 5 (29)**
- **Class 2: 5 – 10 (111)**
- **Class 3: 10 – 15 (24)**
- **Class 4: 15 – 20 (10)**
- **Class 5: 20 – 24 (2)**

As a result of making rounded numbers, pretty breaks will also be very picky for the number of classes you decide.

Here's how population estimates compare between the data classification techniques:

Figure 11.17 Comparison between the data classification techniques.



11.4 SUMMARY

In this Unit, you have learned the following:

1. Thematic maps are usually made with a single purpose of revealing the spatial distribution of one or two attribute data sets.
2. Mapping of categorical data and numerical data is different. Mapping categorical data means displaying the different categories or classes through shape or colors. The numerical data mapping typically represents relative rank order among the entities depicted.
3. Choropleth maps depict quantities aggregated to their regions by filling the entire region with a shade or color.
4. Different type of measurement system requires different interpretation of resulting values.
5. Quantitative data is mapped through data classification to generate the many colors of choropleth maps
6. To determine the area of a tract of land either directly from field measurements, or indirectly, from a plan or map.

11.5 GLOSSARY

- Thematic Map- Map that's purpose has to do with revealing the spatial distribution of one or two attribute data sets.
- Topographic Map- A map of a small area drawn on a large scale depicting detailed surface features both natural and manmade. Relief in this map is shown by contours
- Class- A class is a set of objects that within a given context is recognized as similar. Such a class has usually a unique name, the class name.
- Class frequency- The frequency of which objects of a particular class in a dataset. It can be used as an estimate for the class prior in case the dataset is representative for the classification problem.
- Classification- The assignment of a class (in fact a class name) to an object by evaluating a trained classifier for that object.

11.6 ANSWER TO CHECK YOUR PROGRESS

1. What is a Thematic Map?
2. Difference between numerical and categorical data mapping.
3. Difference between continuous and discrete data.
4. Explain the concept of data classification.
5. List common types of data classification.

11.7 REFERENCES

- https://geodacenter.github.io/workbook/3a_mapping/lab3a.htmlhttps://www.ttu.ee/public/e/ehitusteaduskond/Instituudid/Teedeinstituut/Geodeesia_oppetool/oppematerjalid/8_Map20generalisation.pdf
- http://wiki.gis.com/wiki/index.php/Classification
- https://pro.arcgis.com/en/pro-app/help/mapping/layer-properties/data-classification-methods.htm
- https://saylordotorg.github.io/text_essentials-of-geographic-information-systems/s10-03-data-classification.html

Image Credits

- Fig. 11.1 (Pg. No - 2) National Remote Sensing Centre
- Fig. 11.2 (Pg. No - 3) National Crime Records Bureau
- Fig. 11.3 (Pg. No - 4) http://www.sfu.ca/~hickin/Maps/Chapter%209.pdf
- Fig. 11.4 - Fig. 16 https://gisgeography.com/

11.8 TERMINAL QUESTIONS

1. What are the different data types, explain?
2. Explain the various techniques to classify the data.
3. What is the different measurement systems used to define spatial data?
4. Elaborate on the following classification schemes

- Equal Interval
- Natural Break
- Quantile
- Pretty Break

5. Explain how continuous data and discrete data are different and how are they mapped?

UNIT 12 - ISOPLETH MAPS AND INTERPOLATION STRATEGIES, FLOW MAPS, CADASTRAL MAPS

12.1 OBJECTIVES

By the end of this unit you will be able to understand the:

- Difference between thematic and general reference map
- Basics of Isarithmic maps
- Different methods of interpolation used in cartography
- Basics of flow maps
- Basics of cadastral maps

12.2 INTRODUCTION

A 'Thematic map' is a map that focuses on a specific theme or subject area. This is in contrast to general reference maps, which regularly show the variety of phenomena - geological, geographical, political—together. The contrast between them lies in the fact that thematic maps use the base data, such as coastlines, boundaries and places, only as points of reference for the phenomenon being mapped. General maps portray the base data, such as landforms, lines of transportation, settlements, and political boundaries, for their own sake.

Thematic maps emphasize spatial variation of one or a small number of geographic distributions. These distributions may be physical phenomena such as climate or human characteristics such as population density and health issues.

Thematic maps serve three primary purposes.

- They provide specific information about particular locations.
- They provide general information about spatial patterns.
- They can be used to compare patterns on two or more maps.

When designing a thematic map, cartographers must balance a number of factors in order to effectively represent the data. Besides spatial accuracy, and aesthetics, quirks of human visual perception and the presentation format must be taken into account. In addition, the audience is of equal importance. Who will "read" the thematic map and for what purpose helps define how it should be designed. A political scientist might prefer having information mapped within clearly delineated county boundaries (choropleth maps). A state biologist could certainly benefit from county boundaries being on a map, but nature seldom falls into such smooth, man-made delineations. In which case, a dasymetric map charts the desired information underneath a transparent county boundary map for easy location referencing.

Isarithmic maps, also known as contour maps or isoline maps depict smooth continuous phenomena such as precipitation or elevation. Each line-bounded area on this type of map represents a region with the same value. For example, on an elevation map, each elevation line indicates an area at the listed elevation. An Isarithmic map is a planimetric graphic representation of a 3-D surface. Isarithmic mapping requires 3-D thinking for surfaces that vary spatially.

12.3ISOPLETH MAPS AND INTERPOLATION STRATEGIES, FLOW MAPS, CADASTRAL MAPS

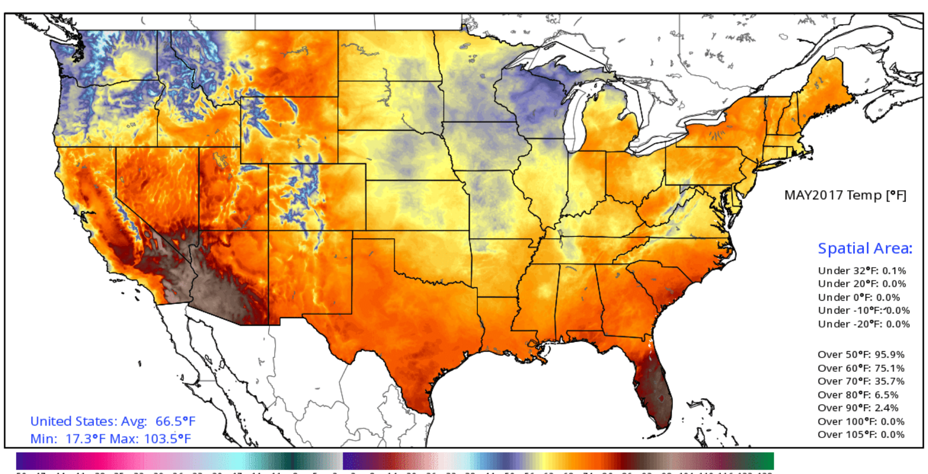
An isarithmic map is a two-dimensional representation of a three-dimensional volume. Two types exist: an isometric form that is constructed from data at points and an isoplethic form constructed from data that occur over geographic areas. The purpose of an isopleth thematic map is to show how features differ in quantity as a surface. This can be achieved through representing the volume using contour lines or by using filled contours that are shaded according to the quantitative value being mapped.

Data: Isopleth maps are generated from data that occur over geographical areas and values represent numerical (quantitative) differences between features on an interval or ratio scale of measurement. Absolute values cannot be illustrated isoplethically due to the inherent problems of using totals for areas that might vary in size or which contain an unequal denominator of the data being mapped. This is the issue that prevents choropleths from being used to map totals and the same occurs for isopleths. It is important to ensure that contours represent convenient and easily understood values.

Symbols: The contours represent line of equal value threaded through the data. Contours are nested. While it's reasonable to assign the same color and line style to all contours, we can use different lightness (or value) of the symbol's hue to highlight them. For example, lines representing the smallest contour values can be lighter and those representing the largest contour values can be darker. Crucially for a map of contours, they are labeled with the contour value. Normally, labels match the line color for each value and have a mask specified as the same color as the background to ensure they knock-out the contour line immediately underneath.

Legend: Since the contours are labeled and the data values are therefore encoded in the map it is not always necessary to include a legend. The map should be finished with a brief title, source details and relevant credits.

Figure 12.1: Map showing temperature for the USA on 24th May 2017



Map Use: When viewed, the map reader should be able to efficiently recognize the different contours mapped across the map and to see the peaks and troughs in the surface. At the very least, relative differences should be obvious, and the reader should be able to determine a pattern across the map. We visually interpret the symbols to perceive areas of higher values and areas of lower values. At the smallest scale, the contours are more generalized.

<u>Interpolation strategies</u>

Interpolation predicts values for cells in a raster from a limited number of sample data points. It can be used to predict unknown values for any geographic point data, such as elevation, rainfall, chemical concentrations, and noise levels.

The assumption that makes interpolation a viable option is that spatially distributed objects are spatially correlated; in other words, things that are close together tend to have similar characteristics. For instance, if it is raining on one side of the street, you can predict with a high level of confidence that it is raining on the other side of the street. You would be less certain if it was raining across town and less confident still about the state of the weather in the next county.

Using the above analogy, it is easy to see that the values of points close to sampled points are more likely to be similar than those that are farther apart. This is the basis of interpolation. A typical use for point interpolation is to create an elevation surface from a set of sample measurements. Geostatistical Analyst also provides and extensive collection of interpolation methods.

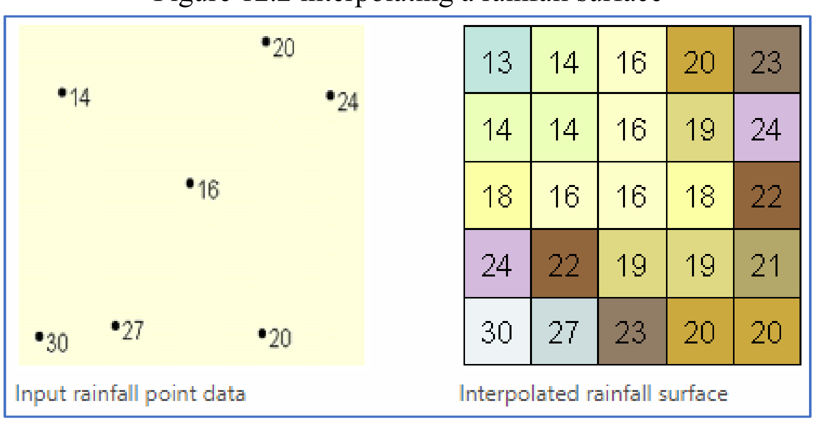
<u>Examples of interpolation applications</u>

Some typical examples of applications for the interpolation tools follow. The accompanying illustrations will show the distribution and values of sample points and the raster generated from them.

- **<u>Interpolating a rainfall surface</u>**

The input here is a point dataset of known rainfall-level values, shown by the illustration on the left. The illustration on the right shows a raster interpolated from these points. The unknown values are predicted with a mathematical formula that uses the values of nearby known points.

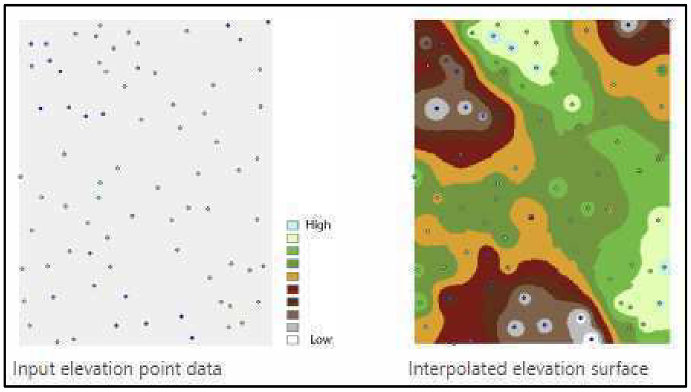
Figure 12.2 interpolating a rainfall surface



- **Interpolating an elevation surface**

A typical use for point interpolation is to create an elevation surface from a set of sample measurements. In the following graphic, each symbol in the point layer represents a location where the elevation has been measured. By interpolating, the values for each cell between these input points will be predicted.

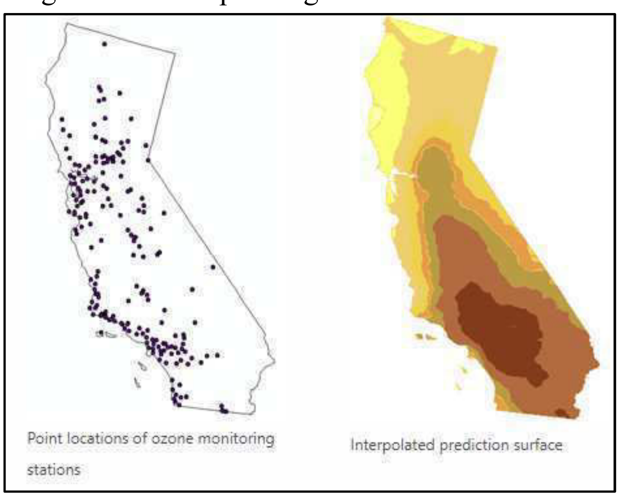
Figure 12.3 Interpolating an elevation surface



- **Interpolating a concentration surface**

In the example below, the interpolation tools were used to study the correlation of the ozone concentration on lung disease in California. The image on the left shows the locations of the ozone monitoring stations. The image on the right displays the interpolated surface, providing predictions for each location in California. The surface was derived using kriging.

Figure 12.4 Interpolating a concentration surface



The available interpolation methods are listed below.

i. The IDW (Inverse Distance Weighted) tool uses a method of interpolation that estimates cell values by averaging the values of sample data points in the neighborhood of each processing cell. The closer a point is to the center of the cell being estimated, the more influence, or weight; it has in the averaging process.

ii. Kriging is an advanced geostatistical procedure that generates an estimated surface from a scattered set of points with z-values. More so than other interpolation methods, a thorough investigation of the spatial behavior of the phenomenon represented by the z-values should be done before you select the best estimation method for generating the output surface.

iii. Natural Neighbor interpolation finds the closest subset of input samples to a query point and applies weights to them based on proportionate areas to interpolate a value). It is also known as Sibson or "area-stealing" interpolation.

iv. The Spline tool uses an interpolation method that estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points.

v. The Spline with Barriers tool uses a method similar to the technique used in the Spline tool, with the major difference being that this tool honors discontinuities encoded in both the input barriers and the input point data.

vi. The Topo to Raster and Topo to Raster by File tools use an interpolation technique specifically designed to create a surface that more closely represents a natural drainage surface and better preserves both ridgelines and stream networks from input contour data.

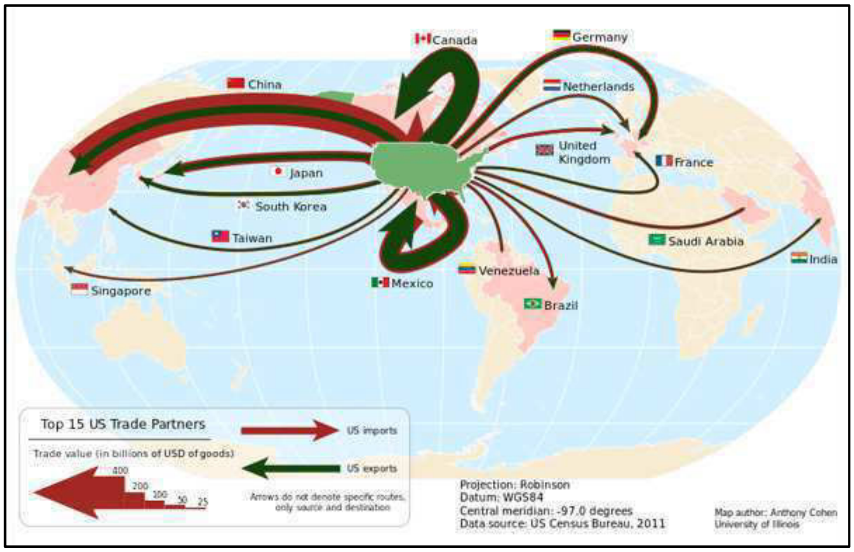
vii. Trend is a global polynomial interpolation that fits a smooth surface defined by a mathematical function (a polynomial) to the input sample points. The trend surface changes gradually and captures coarse-scale patterns in the data.

Flow Maps

Is a type of Thematic map that hybridizes maps and flow charts, showing the movement of objects from one location to another such as the number of people in a migration, the amount of goods being traded, or the number of packets in a network. Flow maps are useful when one needs to show any of the following: a) the presence or absence of a connection between places; b) the route taken from one place to another; c) the (qualitative) kind of movement taking place; d) the direction of movement; or e) the (quantitative) amount of movement taking place.

When properly designed, flow maps are beneficial because they allow cartographers, GIS analysts and map users alike to easily see the differences in magnitude of a wide variety of items across space with very little map clutter. This in turn allows businesses to see where the majority of their products are going, commuters to see traffic patterns, and meteorologists to see wind patterns.

Figure 12.5 Flow Map of USA's imports and exports to its top 15 trade partners



How Flow Maps Work

Flow maps typically use lines to show the movement of people and goods between various locations. The lines are varied in width to represent the quantity of flow. Therefore, if there is a very wide line showing traffic on one California roadway and a very thin line showing traffic on another, the road with the wider line is generally the one that contains more traffic.

Because the movement of goods and people are usually shown lines, most flow maps are created with vector, instead of raster, based data so that they can show movement continuously over the Earth's surface. In vector-based flow maps, the vectors are points or lines that hold information about the direction and magnitude of item that is moving. The points and lines can then be overlaid onto a map to show the movement throughout a given area.

Vectors can be symbolized in a flow map with different orientations, point size, and line length or width to show direction and magnitude. For example, flow maps showing global wind patterns often have lines with arrows on them. The point of the arrow shows the direction of movement (straight, circular, curved, etc.), while the width of the line shows the wind's intensity. Although most flow maps use vector data, Arc GIS has recently introduced a tool for distributive flow maps that uses raster data. The Distributive Flow Lines (DFLT) is a spatial analyst tool in Arc GIS that generates distributive flow lines from one source to many different destination points. The DFLT is completely raster based until the end when it creates a vector-based flow line feature class to be used on flow maps. This raster-based tool is ideal because it allows for more control over the flow lines and it decreases processing time.

Another important thing to note about flow maps is that they can use and display both qualitative and quantitative data. For qualitative data the maps usually display symbols of uniform width that just show movement with arrows. This data is a connection of some sort and it is not based on magnitude. Quantitative flow mapping uses lines and symbols of different widths and sizes to show changes in magnitude between areas.

Types of Flow Maps

When looking at and creating flow maps it is important to note that there are three basic categories for the maps. These are (i) radial, (ii) network and (iii) distributive. Radial flow maps show relationships between one source and many destinations and use separate lines radiating out from a starting point to show movement. Network flow maps show the quantity of flow over an existing network. These types of flow maps most frequently show transportation and communication networks. Distributive flow maps are maps that show relationships between a single source and many destinations like a radial flow map. These maps are different however, because they often have a large, single line produced from one source and those forks into many smaller lines once they reach their destination.

What Makes a Good Flow Map?

Whether radial, network or distributive all good flow maps should have the following characteristics and components.

- Intelligent Distortion: Some flow maps feature distortion to show the movement of goods. Therefore, it is important that any intended distortion not change the meaning of the map.
- Merging of Edges that Share Destinations: If there are many lines going to the same destination it is important that their edges be combined to reduce map clutter.
- Intelligent Edge Routing: In some cases, branches or lines on flow maps will route themselves through the center of the map. This can obscure the other lines so they can be routed to the edge of the map so that all of the data can be easily seen.
- Layering and Branching Structure: Some flow maps have a common set of nodes. In these cases, layering of their lines works well to reduce map clutter.
- Linear or Logarithmic Display Widths: Flow maps can use both linear and logarithmic display widths. It is important to choose the correct one to best show the data.

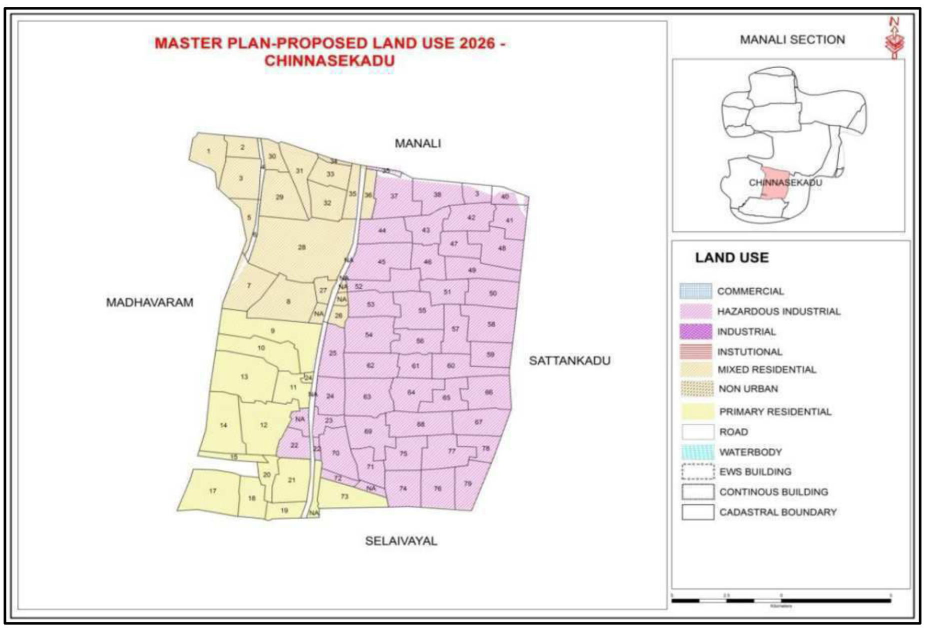
Because flow maps can use a wide variety of data there are also many different projects in a plethora of fields that can use this mapping technique. Business geographers can for example, use flow mapping to examine the amount of coal exports from a specific country. Hydrologists can monitor stream flow for a particular state or region. City planners and transportation geographers can use flow mapping to examine traffic patterns and the volume of cars on specific roadways to determine the best places for new businesses and/or residential developments.

Cadastral map

Cadastral surveying is the sub-field of cadastre and surveying that specializes in the establishment and re-establishment of real property boundaries. It is an important component of the legal creation of properties. A cadastral surveyor must apply both the spatial-measurement principles of general surveying and legal principles such as respect of neighboring titles. Cadastral surveys are specially designed large scale surveys, generally on 1:4000 scale which are linked to land ownership and property. In case of urban cadastral surveys, the scales may be as large as 1:500 to 1:4000. This paper is, however, emphasizing the rural and village properties. The urban cadastre, although very vital needs a separate and detailed discussion.

In practical proportion of the importance, the surveys and mapping oriented activities form only 10% of the total cadastral related work. The remaining 90% really fall in the realm of generating appropriate land records. The importance of these land records is, of course, very high because it is only through the cadastral maps and land records that the owner gets legally linked to his property. This property may be a cultivated field, house or a fishing pond. The fact of the matter is that lack of updating the maps and the land records have given rise to the innumerable court cases. The property related court cases are thriving because of the reduced importance of the cadastral surveys.

Figure 12.6 Cadastral Map with property ownership details



Revenue surveys were initiated by East India Company towards the end of 18th Century primarily to establish the 'domain of their influence' through the collection of revenue from the estates. These estates were rather scattered so only village boundaries were established by the traverse method of surveying. The inside details of properties were left to local surveys. Survey of India as a Department of Government of India, established in 1767, was fully involved in the process till 1904.Following the recommendation of the 1904 Committee of Government of India; the cadastral surveys were delegated to the States.

12.4 SUMMARY

In this Unit, you have learned the following:

1. Definition of Thematic maps and its purpose.
2. Basics of generating an isopleth map.
3. Different interpolation strategies used in map making.
4. The basics of flow maps and its types and purposes.
5. The concepts of cadastral map.

12.5 GLOSSARY

- Contours- These are imaginary lines that join points of equal elevation on the surface of the land above or below a reference point. Mean sea level is the most common reference point.
- Isoline- A line connecting points of equal value on a map. Isolines fall into two classes: those in which the values actually exist at points, such as temperature or elevation values, and those in which the values are ratios that exist over areas, such as population per square kilometer or crop yield per acre. The first type of isoline is specifically called an isometric line or isarithm; the second type is called an isopleth.
- Choropleth map- Thematic map in which areas are colored, shaded, dotted, or hatched to create darker or lighter areas in proportion to the density of distribution of the theme subject.
- Cadastral map- Cadastral maps show the boundaries of subdivisions of land, often with the bearings and lengths thereof and the areas of individual tracts, for purposes of describing and recording ownership. They may also show culture, drainage, and other features relating to land use and value.
- Isotherm- A line on a map connecting points of equal temperature.
- Flow map- A map that uses line symbols of variable thickness to show the proportion of traffic or flow within a network.
- Interpolation- The estimation of surface values at unsampled points based on known surface values of surrounding points. Interpolation can be used to estimate elevation, rainfall, temperature, chemical dispersion, or other spatially-based phenomena. Interpolation is commonly a raster operation, but it can also be done in a vector environment using a TIN surface model. There are several well-known interpolation techniques, including spline and kriging.

12.6 ANSWER TO CHECK YOUR PROGRESS

1. What are the purposes of thematic maps?
2. What is Interpolation and list the types of Interpolation.
3. List the different interpolation methods used in isopleth maps.
4. What are the different types of flow maps?
5. What is the usual scale used in cadastral mapping?

12.7 REFERENCES

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- http://en.wikipedia.org/wiki/Flow_map

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- Fig. 11.1 (Pg. No - 2) https://www.e-education.psu.edu/meteo3/l1_p10.html
- Fig. 11.2 (Pg. No - 5) http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst toolbox/understanding-interpolation-analysis.htm
- Fig. 11.3 (Pg. No - 5) http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst toolbox/understanding-interpolation-analysis.htm
- Fig. 11.4 (Pg. No - 6) http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analysttoolbox/understanding-interpolation-analysis.htm
- Fig. 14.5 (Pg. No - 7)https://en.wikipedia.org/wiki/List_of_the_largest_trading_partners_of_theUnited_States#/media/File:US_trade_final-01.svg
- Fig.11. 6 (Pg. No - 6) http://shodhganga.inflibnet.ac.in/bitstream/10603/181076/12/12_chapter%206.pdf

12.8TERMINAL QUESTIONS

1. What is an arithmic map?
2. Explain Isopleth maps and its types.
3. Explain the different interpolation methods used in mapping.
4. What are all the characteristics of a good flow map?
5. How the cadastral map is different from other maps?

UNIT 13 - DEMOGRAPHIC AND STATISTICAL MAPPING, SEQUENTIAL MAPS

13.1 OBJECTIVES

By the end of this unit you will be able to understand the:

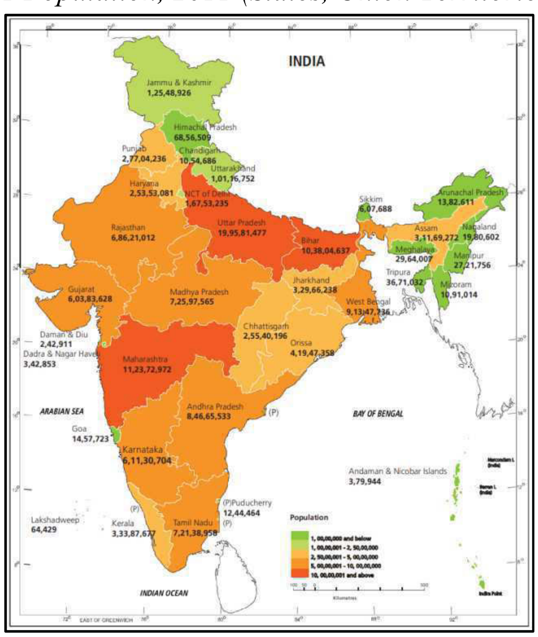
- Basics of demography.
- Fundamentals of demographic maps
- Different color schemes used on maps
- Basics on statistical / thematic maps
- Map types used to represent statistical data on maps

13.2 INTRODUCTION

Demographics—statistics about the population of a particular geography such as your town/city, state, or nation—profoundly affect how important decisions are made. Not only do demographics give information that is needed to plan future investments and services, data from sources such as the Census also help determine who gets central government aid, where assistance programs are targeted, etc. In fact, demographic data impact nearly everything you do: how far you travel to the store, how much you pay in property taxes, and how much support your child's school receives from local and state government.

Demographics comprise an array of socioeconomic information, including the breakdown of a population by gender, age, ethnicity, income, employment status, home ownership, etc. The Census of India, updated every 10 years, furnishes the most comprehensive population (Fig. 13.1). The Census houses a vast source of information on local, state, and national population characteristics. While there are certainly other data sources, most draw from the Census of India.

Figure 13.1 Population, 2011 (States, Union Territories')



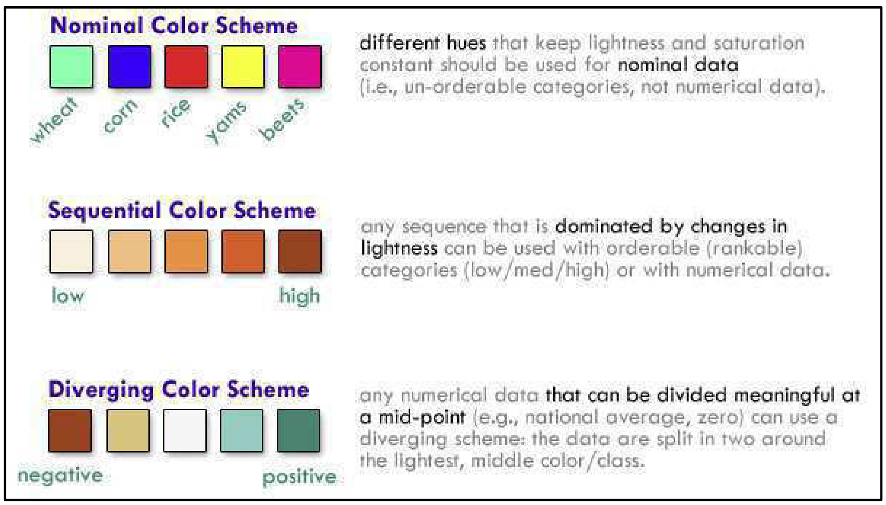
Source: Google

Using Colors on Maps

Color can be a challenging design element to perfect. It takes experience and a designer's eye to produce pleasing and effective color schemes, but there are also some guidelines to follow. Choosing colors carefully based on the nature of the data you're mapping will ensure that the map's message is made clear.

Nominal data are categories that are inherently UN orderable (like soils or land use) and should only be mapped with nominal color schemes. If you have orderable categories (such as low/med/high) or if you have numerical data, a sequential color scheme is what you need. Sequential color schemes can be single or multi-hue, but they are dominated and ordered by differences in lightness/saturation. Diverging schemes should only be used when your data has a natural mid-point such as a zero (e.g., positive and negative change/growth) or if you want to compare places to something like the national average (e.g., county data showing places that are above and below the national average for a variable like per capita income)

Figure13. 2 Different color schemes used in mapping



A statistical map is also called a thematic map or a special-purpose or a single-topic map. A thematic map focuses on the spatial variability of a specific distribution or theme (such as population density or average annual income), whereas a reference map focuses on the location and names of features. Thematic maps normally include some locational or reference information, such as place names or major water bodies, to help map readers familiarize themselves with the geographic area covered on the map. All thematic maps are composed of two important elements: a base map and statistical data. Normally, the two are available as digital files, such as a cartographic boundary file and census data. Desk-top geographic information systems or computer-mapping packages are typically used to generate thematic maps.

Two common thematic maps commonly produced are dot maps and choropleth1 maps. The ecumene concept is generally used for dot and choropleth maps, to ensure that the spatial representation of census data is limited to inhabited land. To ensure confidentiality, all census data are subject to random rounding and/or data suppression. Thematic maps can be used for exploratory spatial data analysis, confirming hypotheses, synthesizing spatial data by revealing patterns and relationships, and data presentation.

13.3 DEMOGRAPHIC AND STATISTICAL MAPPING, SEQUENTIAL MAPS

Maps have proved to be indispensable products in conducting population censuses since they will ensure completeness of the coverage throughout the country and eliminate the possibility of double coverage of the population. Maps will also: a) Assist to delineate the country into small manageable counting units or Enumeration Areas (Eas); b) Facilitate in assigning areas of counting to enumerators during the census; c) Enable the enumerators to plan their movement within the EA and identify households earmarked for call-backs especially in the urban areas; d) Enable effective supervision; e) Help in determining the personnel, materials and logistical requirements (budgeting); f) Help in presenting the results of a census software. Digital mapping is also becoming ever more closely integrated in standard computer applications, such as spreadsheets, graphics and business management software.

People have used maps for centuries to represent their environment. Maps are used to show locations, distances, directions and the size of areas. Maps also display geographic relationships, differences, clusters and patterns. Maps are used for navigation, exploration, illustration and communication in the public and private sectors. Nearly every area of scientific enquiry uses maps in some form or another. Maps, in short, are indispensable tools for many aspects of professional and academic work.

Mapping has been an integral part of census-taking for a long time. Traditionally, the role of maps in the census process has been to support enumeration and to present aggregate census results in cartographic form. Very few enumerations during the last several census rounds were executed without the help of detailed maps.

In general terms, mapping serves several purposes in the census process, as follows:

(a) Maps ensure coverage and facilitate census operations (pre-enumeration). The census office needs to ensure that every household and person in the country is counted and that no households or individuals are counted twice. For this purpose, census geographers partition the national territory into small data-collection units. Maps showing enumeration areas thus provide an essential control device that guarantees coverage of the census;

(b) Maps support data collection and can help monitor census activities (during enumeration). During the census, maps ensure that enumerators can easily identify their assigned geographic areas, in which they will enumerate households. Maps are also issued to the census supervisors assigned to enumerators to support planning and control tasks. Maps can thus also play a role in monitoring the progress of census operations. This allows supervisors to strategically plan, make assignments, identify problem areas and implement remedial action quickly;

(c) Maps make it easier to present, analyze and disseminate census results (post-enumeration). The cartographic presentation of census results provides a powerful means for visualizing the results of a census. This supports the identification of local patterns of important demographic and social indicators. Maps are thus an integral part of policy analysis in the public and private sectors.

From maps to geographic databases

Today, maps are but one form of information display subsumed under the broader term geographic information, and the form this geographic information most often takes is the geographically referenced database (or geo data base). Cartography was influenced by the information revolution somewhat later than other fields. Early computers were good at storing numbers and text. Maps, in contrast, are very complex, and digital mapping requires large data-storage capacity and fast computing resources. Furthermore, mapping is fundamentally a graphical application and early computers had limited graphical output capabilities. The earliest computer-mapping applications implemented on computers in the 1960s did not therefore find wide application beyond a few government and academic projects. It was not until the 1980s that commercial geographic information systems reached a level of capability which led to their rapid adoption in local and regional government, urban planning, environmental agencies, mineral exploration, the utility sectors and commercial marketing and real estate firms. This had an impact of the initial use of mapping technologies by National Statistical Commission (NSC).

New information sources also shorten the time from project planning to the creation of an operational database. The most important recent developments have been in navigation, remote sensing, image analysis, data manipulation and Internet mapping. GPS has revolutionized field data collection in areas ranging from surveying to environmental monitoring and transportation management. A new generation of commercial, high-resolution satellites can deliver pictures of nearly any part of the Earth's surface with enough detail to support numerous mapping applications, including those for censuses. The cost of precision digital mapping has fallen significantly due to the close integration of GPS techniques and remote data capture.

GIS has benefited greatly from developments in various fields of computing. Better database software allows the management of vast amounts of information that is referenced to digital maps. Census users develop data models for the storage, retrieval and display of geographic objects. Advanced visualization techniques allow us to create increasingly sophisticated representations of our environment. GIS data display functions go far beyond static two-dimensional displays and provide animation and three-dimensional modeling capabilities. Just as the input of textual information is facilitated by optical character recognition, fast, high-resolution scanning and sophisticated software speed up map data-conversion that previously relied exclusively on manual digitizing. This enabling technology has permitted data producers to move from a paper map base to a digital base, updating existing information. Intelligence is still needed, however, to add value to the subsequent products and services made possible by the technology adoption.

Similar advances are occurring in the areas of geographic data dissemination. All major GIS vendors now provide the tools to make geospatial or geographical databases accessible via the Internet. Government agencies at all levels are embracing this technology to provide access to vast amounts of spatial information to the public cheaply and quickly. The Internet is replacing printed maps and digital media as the most important means of data distribution. Correspondingly, maps themselves are no longer static objects but dynamic snapshots of a changing geographic database.

Internet mapping applications are one indication that the tools to utilize digital spatial information are constantly becoming cheaper and easier to use. While high-end GIS packages still require considerable training to be used effectively, desktop mapping packages are no more complicated to use than standard business software. Digital mapping is also becoming ever more closely integrated in standard computer applications, such as spreadsheets, graphics and business management software.

Some statistical offices were early adopters of GIS. Population, social and economic statistics are the foundation of public planning and management. The spatial distribution of socioeconomic indicators guides policy decisions on regional development, service provision and many other areas. Digital techniques allow better management, faster retrieval and improved presentation of such data. There has therefore always been a close linkage between geography and statistics — as reflected, for instance, by the fact that in many Latin American countries the national statistical and mapping agencies are housed under the same roof. This close integration of GIS in statistical applications yields large benefits to national statistical offices as it reduces the cost and time required to collect, compile and distribute information. GIS allows the statistical office to produce a greater number of services, thereby considerably increasing the return on investment in data collection.

Cartographic automation, GIS and other geospatial tools have enabled more efficient production of both enumerator maps and thematic maps of census results. In addition, advances in technology and new tasks for GIS using new data sources, such as remote sensing and GPS-enabled locational recording, have expanded the power of geographic representation within the NSO. Nevertheless, new technology should be used judiciously based on strategic goals that are determined by the leadership of the census organization. It is not a magic bullet that can solve all organizational problems but must be planned carefully.

Increasing demand for mapping statistical data

The benefits of geographic data automation in statistics are shared by the users of census and survey data. The data integration functions provided by geographic information systems, which allow the linking of information from many different subject areas, have led to a much wider use of statistical information. This in turn has increased the pressure on statistical offices to produce high-quality spatially referenced information for small geographic units. If carefully planned — that is, if the NSO can collect the information in small units and then aggregate it appropriately — then it should be able to satisfy the needs of many new data customers. Some examples of applications for such data include:

(a) Emergency planning and humanitarian response. Agencies can prepare for the eventuality of natural disasters by identifying highly populated areas that can be difficult to evacuate in case of fires, earthquakes, volcano eruptions or tsunamis. Following a major natural disaster, some of the early questions asked include the following. Which villages are affected? What is the size of their population? How many people were killed, injured and made homeless? What is the status of infrastructure, particularly roads and bridges, health centers, schools, water supply systems and government buildings, etc.? If digital maps of population distribution and housing characteristics could be overlaid with elevation and slope data, transportation networks and other geographic information of the affected area by the disaster, it is possible to generate reliable estimates of the number of people affected, their needs in terms of medical aid, food and shelter and above all their location. Standard "P-Codes" for populated places eases the difficulty of locating affected areas in need of assistance.

(b) Flood plain modeling. Major flooding is an increasing risk in many of the world's watersheds. Digital elevation and hydrological data, in combination with small-area census statistics, allows planners to make detailed assessments to reduce the risk for populations in flood-prone areas and for emergency management planning. Insurance companies in some countries use the same tools to assess risk levels of home owners, which lead to a fairer assessment of premiums.

(c) Planning of social and educational services. A main task of local and regional government is to ensure that all parts of the country have equal access to government services such as health care and education. Small area census data on age and social characteristics allow planners to forecast demand for various services. In combination with GIS data on trans port infrastructure, this information allows better distribution of resources among existing service centers and more rational decisions concerning the location of new facilities.

(d) Poverty analysis. In countries where income or consumption data are not collected during a census, household characteristics are an important indicator of the welfare of various population groups. Small area census data in combination with spatially referenced information on infrastructure and agro-ecological conditions can be used to estimate poverty incidence and the location of poor communities. This information improves targeting of poverty alleviation schemes by channeling resources to areas of greatest need while avoiding leakage of subsidies to non-poor communities.

(e) Utility service planning. Private and public water, gas, electricity and telecommunications utilities not only use GIS to manage their physical infra structure but also use spatial analysis of demographic data to assess current and future demand for services. Digital census data — together with digital terrain models — have been a key component in the design of location-based services around the world.

(f) Labour force analysis. Whether it is a private company looking for a suitable site to locate a factory or a government agency attempting to match labour supply and demand, small area census data are an important element in employment-related analysis. Journey-to-work analysis, in which the location of jobs and the residence of employees are compared, is critical for transportation planning.

(g) Marketing analysis. Companies use small area census data to plan the location of new stores and warehouses, to manage customer service information and to target advertising. An entire branch of GIS — termed variously business geographic or geo-demographics — has flourished. In fact, the strong demand for these types of analysis has been a major driving force for the development of inexpensive, easy-to-use desktop mapping packages.

(h) Epidemiological analysis. Small area census data, in combination with health incidence and biophysical data, allow health officials to estimate the population at risk of certain infectious and vector-borne diseases. Knowing how many people in the country are potentially affected by malaria or bilharzia, for instance, allows planners to estimate the resources required for eradication measures. Identifying where these risk groups are located supports prioritization and implementation of intervention activities.

(i) Agriculture. Geographic information on agro-ecological conditions, together with production data and small area data on the demand for food products, facilitate the analysis of food security issues. Famine early warning systems have been set up in many countries characterized by fragile ecosystems to prevent major food crises.

Planning the census process using geospatial tools

This section deals with preliminary organizational tasks in a census mapping project and with critical design issues that determine the nature of the resulting databases and thus the range of applications that it will support. The success of the actual data conversion process depends on a well-designed institutional environment and a well-planned operational strategy. The planning steps are divided here into institutional issues, such as the organizational structure for geographic support (including staffing and cooperation with other agencies), the explicit delineation of census geography and the design of the geospatial database.

User needs assessment

One of the first steps in a census-mapping project is a detailed needs assessment, followed by an investigation of feasible geographic options. The census mapping agency must then reconcile user expectations with what is feasible given available resources, working backward from final products and services to requirements.

A successful census-planning process requires extensive consultations with the main users of the information that will be produced in the census. This process should include consultation on geographic content, that is, geographic structures, including administrative hierarchies or summary levels, and also on geographic base products that support the analysis of census data.

The census office must consult with three main groups in the planning stages:

(a) Persons and institutions participating in census operations. In order to obtain full information about resources and potential bottlenecks, the NSO must carry out an intensive survey of available human resources in the country, available equipment that can be used, existing digital and analogue map products, and ongoing or planned relevant activities by other public and private entities. Avoiding duplication of efforts is key to reducing the cost of census geographic operations and to timely delivery of census products;

(b) Census geographic data-product users. These will mainly come from other government departments, the academic research community and the private sector;

(c) The general public. With access to computers and Internet information display options, private users are also an important user group. Citizens may, for example, want to obtain statistical information about their own neighborhood or a neighborhood they intend to move to. With the current rapid changes in technology, the census office must plan carefully to anticipate demand for its data.

User needs will determine the range of output products that need to be completed at the end of the census-mapping cycle. Products created by the NSO, which are discussed in more detail in chapter VI, should always include proper documentation, including coding and metadata, to make them most useful to users. Examples include:

- A set of digital enumeration area maps or derived dissemination units, which are designed to enable the production of all output products that will be disseminated to government departments and the general public.
- Geographic boundary files in a digital format for all statistical reporting units for which census indicators will be tabulated.
- Listings of all statistical and administrative reporting units, including towns and villages, their variant names and geographic coordinates.
- Geographic equivalency files that indicate how current reporting units relate to those used in previous censuses or how one set of reporting units relates to another set.
- Vector layers containing feature data, such as landmarks, roads, schools, hospitals and clinics, which can be used when analyzing population data spatially.
- Street index listings for all major urban areas.
- Centroid files that provide a representative geographic point reference for each reporting unit.
- Gazetteers that provide geographic coordinates for all population settlement sand other important geographic features in the country.

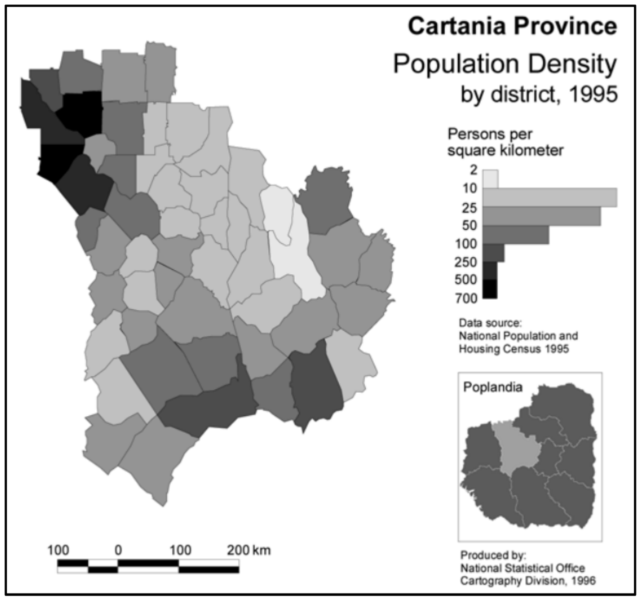
Census data as a thematic map

More relevant to the mapping of census results are “thematic maps”. These display the geographic distribution of physical or cultural phenomena that cannot easily be observed directly on the ground. Thematic maps can be based on qualitative or quantitative information. An example of the former is a map showing the distribution of people by mother tongue or religion. Quantitative thematic maps, sometimes called statistical maps, by contrast, provide some information about the relative size of the features that are mapped. An example is a map in which the symbols representing the cities in a country are scaled according to the size of each city. Another example is a map in which reporting areas, such as districts, are shaded according to their population density

Mapping discrete features - Census data compiled for public release consist of numbers aggregated for a reporting unit, such as a district or enumeration area. Such data are best represented cartographically, using choropleth maps. The term “choropleth” is derived from the Greek words for “choros” (place) and “pleth” (value). Choropleth maps show datafor discrete reporting units, which are often established independently from the actual spatial distribution of the data (e.g., administrative boundaries). The symbol—i.e., colour or pattern—used to shade each reporting unit is determined by the value. Choropleth maps are different from so-called “area-class maps” where the reporting units are determined by the data. For example, on a map showing forest cover, the reporting units will be determined by the boundary between forest and non-forest areas.

An example of a choropleth map has already been shown in fig.13.3.Choropleth maps are constructed by first dividing the complete range of data values for the reporting units into a set of categories. Each category is then assigned a colour or shade pattern. Since enumeration data have a natural ordering, there is usually some logic in the choice of colours or tones, such as from light to dark colour shades or from course to dense patterns. The goal is to give the user an intuitive sense of the magnitude of the value in each reporting unit.

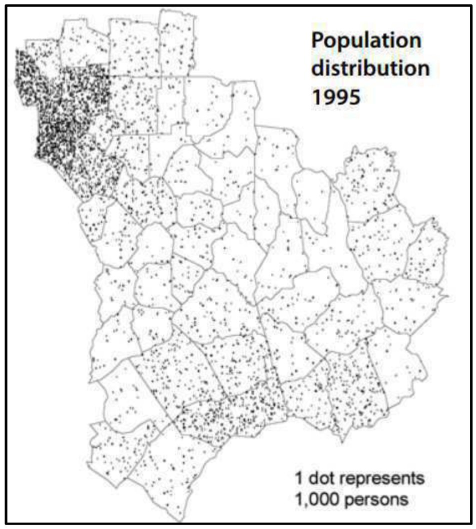
Figure 13.3 Example of a thematic map of population density



Choropleth maps are good at showing the overall distribution of data values on a map and for comparing the distributions across different maps. It is usually not possible to obtain the exact value for each reporting unit since the colours or shades only represent ranges of similar values. The values used for producing choropleth maps are almost always ratios, proportions or densities. These can be geographic ratios, where a data value such as population is divided by area to compute population density. Or they can be general ratios, where the denominator is a value other than area, such as the crude birth rate as the number of births per 1,000 persons. Most often when we map socio economic variables, the size of reporting units is not constant. For example, districts or provinces often vary drastically in size and population.

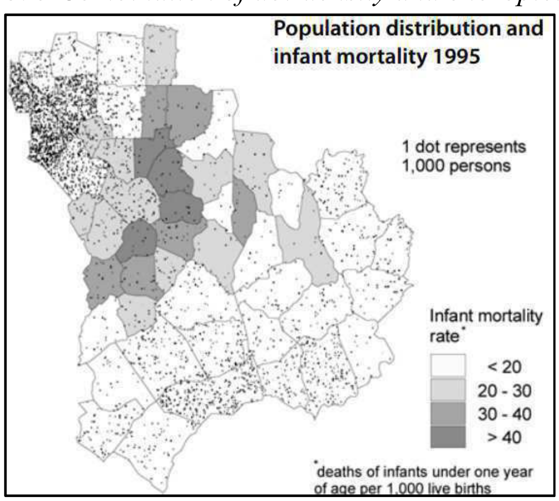
An alternative method for displaying count data are "dot maps". On dot maps, a point symbol is used to represent one or more units of a variable that is mapped. For example, each dot might represent 1,000 people or households. The magnitude of the variable is then represented by the varying density of dots in the reporting unit. Fig. 13.4 presents a typical dot map, showing population distribution.

Figure 13.4 Dot-density map



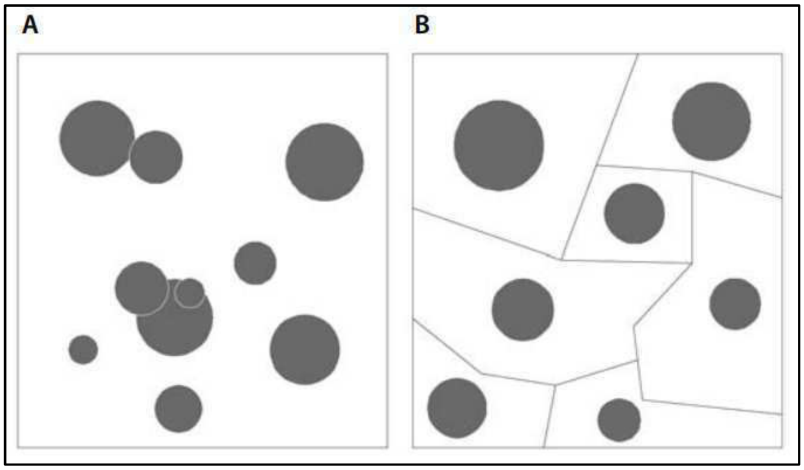
Dot-density maps can also be used in combination with choropleth maps to show two variables at the same time—for example, the map in Fig.13.5 shows that there is no relationship between high-population densities and high rates of infant mortality. In this case, the density of dots should not be very high so that the colours or shades for the underlying districts can be easily determined.

Figure13. 5 Combination of dot-density and choropleth maps



Proportional point symbols can also be used to map a quantity at a specific location. One popular type of census map, for instance, shows the location and size of major cities using circles or squares that are scaled according to each features numeric values. Such maps are called proportional or graduated symbol maps. Graduated symbol maps are suitable to show the absolute value of a variable. They are less appropriate for a relative value, such as a density or ratio.

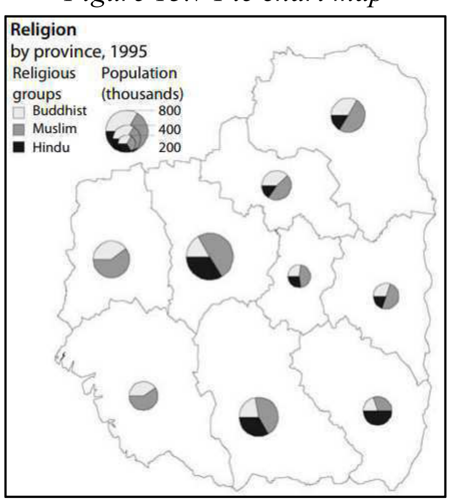
Figure 13.6 Proportional symbols for point and area features



There are two types of graduated symbol maps. In one instance, the data refer to a point feature, such as a city or household. In this case, the symbol location corresponds to the feature's location (Fig. 13.6.A). In the second instance, symbols are used to represent values of area features, such as districts. In this case a representative location within each reporting unit must be chosen (Fig. 13.6.B)

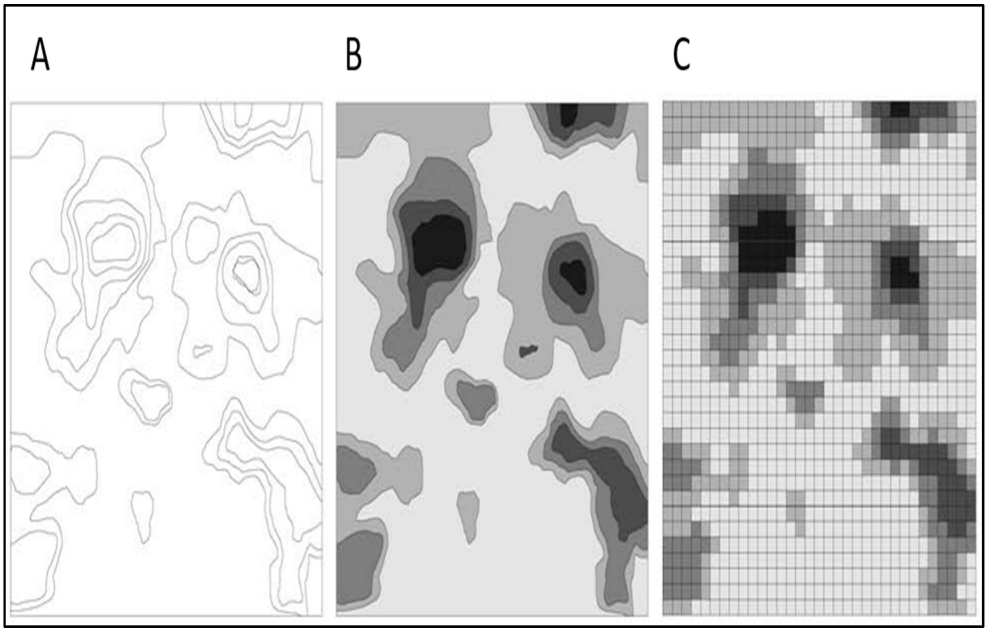
Chart or diagram maps show statistical information in a chart or diagram for each geographical observation have become very popular thanks to their availability in commercial desktop-mapping and GIS packages. The most common types of diagram maps use pie, bar or column charts. The charts are usually scaled so that the size of each pie chart, for example, reflects the magnitude of the denominator. For example, fig.13.7 shows the geographic distribution of the proportion of major religious groups. The pies are scaled according to total population. We therefore need to show two types of information in the legend: the colour that refers to each religious group and the population totals that correspond to a given pie size.

Figure 13.7 Pie chart map



Mapping continuous phenomena - The map types above are appropriate for data that are referenced for discrete geographic features, such as point locations or areas. Some geographic phenomena, however, are continuous. Temperature or elevation, for example, vary smoothly across space. However, it is also possible to view population distribution as a more orless continuously varying variable. The most common way of representing continuous data is by means of isolines or regular raster grids. Isolines— "iso" means equal—are lines of constant value and are also called contours (Fig.13.8.A).

Figure13. 8 Alternative cartographic methods for displaying continuous data

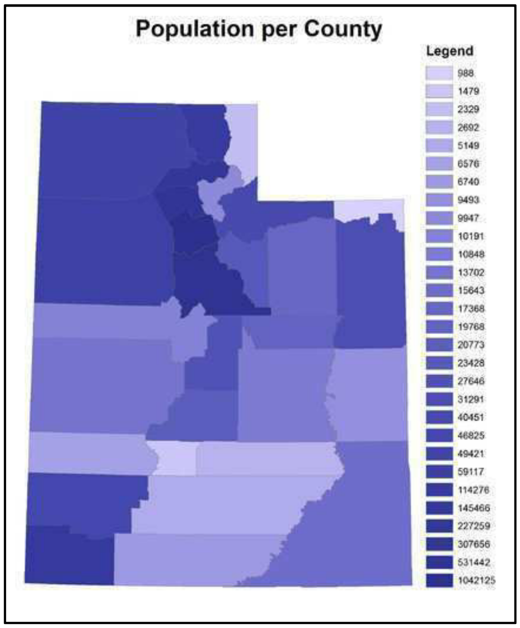


They are used on topographic maps that show elevation. Contour maps can also be shaded which causes them to look more like choropleth maps (Fig.13.8.B). Colours represent values in the data range between two contour intervals. Dot maps can also be used to provide a more continuous view of the distribution of population or a similar variable. For modelling and analysis in a GIS, continuous data are typically stored as regular raster grids (Fig.13.8.C). The grid cell size is chosen to preserve the variability in the data set, although a very fine grid leads to very large file sizes.

Color scheme for census mapping

A Color scheme is a collection of multiple colors chosen to be used together on a graphical work, such as a map. In Cartographic design, strategically chosen color schemes can achieve a number of goals, including harmony, contrast, conveying information, and showing the relationships between features on the map.

Figure 13.9 Sequential color schemes



The term is most commonly used for statistical thematic maps, in which color is used to represent quantitative and qualitative attribute values. A sequential color scheme is logically arranged from high to low and is often used in creating a map with sequential lightness steps. These data do not usually contain a critical midpoint value, but contain a range of values. For example (Fig. 13.9), lower data polygons can be represented by lighter colors while the higher value polygons are represented by dark colors.

13.4 SUMMARY

In this Unit, you have learned the following:

1. Definition for demography, the various data that constitutes the demography of an administrative unit.
2. The rules behind the use of standard colors on maps and data type specific colour schemes.
3. The importance of using GIS in census and demographic data collection and dissipation in the form of maps and other outputs.
4. The importance and growing demand of mapping statistical data.
5. The various steps involved in the planning of the census process using geospatial tools.
6. To map demographic data and to represent both discrete and continuous data in the map using different map type.
7. The common colour scheme used for census mapping.

13.5 GLOSSARY

- Administrative unit-A geographic area that serves administrative and governmental functions. It is usually defined and established by legal action.
- Annotation- Text that is used to label features on a map. Annotation can be stored in a GIS and drawn onto maps for display or printing.
- Attribute- A characteristic of a geographic feature. For example, a numeric or text field that is stored in a relational database table which can be linked to the geographic objects in a GIS.
- Boundary- A line which defines the extent of an aerial unit or the locations where two areas meet. A boundary is represented in a GIS as a line feature which may define a side of a polygon.
- Choropleth map- A statistical map in which values recorded for reporting units are first assigned to a number of discrete class ranges or categories
- Discrete geographical features- Individual entities that can be easily distinguished, such as houses or roads—as opposed to continuous geographical phenomena
- Enumeration area (EA)- Usually the smallest geographic unit for which census information is aggregated, compiled and disseminated

13.6 ANSWER TO CHECK YOUR PROGRESS

1. What is demographic map?
2. Name the organization which prepares the demographic data of India.
3. What is the common color schemas used in a map?
4. What type of data can be used to make chloropleth map?
5. What is Ecumene concept in mapping?

13.7 REFERENCES

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Image Credits

- Fig. 13.1 (Pg. No - 2) http://censusindia.gov.in/2011
- Fig. 13.2 (Pg. No - 3) https://www.axismaps.com/guide/general/using-colors-on-maps/
- Fig.13.3(Pg.No12)https://unstats.un.org/unsd/demographic/standmeth/handbooks/series_f103en.pdf
- Fig.13.4(Pg.No13)https://unstats.un.org/unsd/demographic/standmeth/handbooks/series_f103en.pdf
- Fig. 13.5 (Pg. No - 13) https://unstats.un.org/unsd/demographic/standmeth/handbooks/series_f103en.pdf
- Fig. 13.6 (Pg. No - 14) https://unstats.un.org/unsd/demographic/standmeth/handbooks/series_f103en.pdf
- Fig. 13.7 (Pg. No - 15) https://unstats.un.org/unsd/demographic/standmeth/handbooks/series_f103en.pdf
- Fig. 13.8 (Pg. No - 15) https://unstats.un.org/unsd/demographic/standmeth/handbooks/series_f103en.pdf
- Fig. 13.9 (Pg. No - 16) http://wiki.gis.com/wiki/index.php/Color_scheme

13.8 TERMINAL QUESTIONS

1. What are the advantages of mapping the census?
2. How discrete demographic parameters are gets mapped?
3. Explain how a continuous phenomenon such as temperature or elevation is being mapped.
4. Explain how Census data can be represented as a thematic map.
5. What is the most commonly used color scheme for census mapping?

UNIT 14 - MAP PRODUCTION, MAP PRINTING, COLORS AND VISUALIZATION, MAP REPRODUCTION, PRINTING SOFT COPIES AND STANDARDS

14.1 OBJECTIVES

By the end of this unit you will be able to understand the:

- Different map elements
- Different color schemes used in mapping
- Various cartography design standards
- Different techniques to print maps
- Various design principles in map making

14 .2 INTRODUCTION

Maps can influence people's conception of space; this is partly because of convention and partly because of the general characteristics of the graphic cues used, either on paper or on the monitor screen. Convention especially plays a role in topographic mapping: most of the symbols used on topographic maps have come down to us in a form conditioned by eighteenth-century examples and we have stuck to them ever since. Among these conventions are the rendering of water by a blue color, forests by a dark green and built-up areas by a red, grey or pink color. Association may have been at the root of this usage, but may not be valid any more, and so it has changed into convention. The Convention of using specific symbols on topographic maps originated in the example provided by French Topographic mapping practice in the eighteenth century. This Convention has been strengthened by the fact that in the nineteenth century all topographic maps were produced with the same objective, i.e. infantry warfare.

There is an ever-increasing proportion of maps, however, that have nothing to do with descriptions of the terrain and its fixed assets, and instead have other objectives: the thematic maps and the ever changing aspects of reality that are visualized, one is not governed by convention but is able to improve information transfer by using the innate characteristics of the variation in graphic characteristics (e.g. shape, color, size, texture) of the symbols we use. When we study map symbols as such, i.e. not as a representation of the Earth's surface but as a set of dots, dashes and patches, we find that it is this variation in graphical aspects which conveys meaning to the map reader, like a sense of varying magnitude or differences in nature. So, the differences in symbol and its size are an important characteristic, conveying to the map reader the sensation of differences in number, quantity and quality.

Color provides supporting information to well-made maps and layouts. Certainly, if those Google Maps were made with garish colors they would not be as popular as they are. The purpose of color on a map is to help a map viewer decipher the symbols in order to make meaningful inferences. Color is not, by itself, the purpose of a geographic information system (GIS) map. Even when color is used to display a variable, it is still only offering a means toward the visualization of that variable. For example, a map of watersheds could show some watersheds in green and some in black depending on the amount of intact forestland in each. Even though color is important in a map like this, as it serves more than a purely decorative purpose, the meaning of the map is still centered on how much forest cover is in each watershed, not around the nice colors. Because color is supporting information, we can conclude that poor color choice does not always affect the map in terrible ways. That of us who haven't an ounce of color theory in our background or a firm knowledge of color connotations may still produce a map that somewhat conveys its point, albeit perhaps in an ugly way. So, we may produce a map that effectively communicates but is not necessarily aesthetic. However, the chances that the color palette doesn't impede the map reader's understanding are slim and it's not a chance you want to take. A professional, compelling, and communicative map nails the analytical component while also standing on its artistic legs.

14.3 MAP PRODUCTION, MAP PRINTING, COLORS AND VISUALIZATION, MAP REPRODUCTION, PRINTING SOFT COPIES AND STANDARDS

Cartographers apply many design principles when compiling their maps and constructing page layouts. Five of the main design principles are legibility, visual contrast, figure-ground, hierarchical organization, and balance. Together these form a system for seeing and understanding the relative importance of the content in the map and on the page. Without these, map-based communication will fail. Together visual contrast and legibility provide the basis for seeing the contents on the map. Figure-ground, hierarchical organization and balance lead the map reader through the contents to determine the importance of things and ultimately find patterns. Here, we introduce these five principles and explain their importance in cartography. It's worth noting that these principles are not applied in isolation but instead are complementary to each other. Collectively they help cartographers create maps that successfully communicate geographic information.

1. Visual contrast which relates to how map features and page elements contrast with each other and their background. To understand this principle at work, consider your inability to see well in a dark environment. Your eyes are not receiving much reflected light so there is little visual contrast between features and you cannot easily distinguish objects from one another or from their surroundings. Add more light and you are now able to contrast features from the background. This concept of visual contrast also applies in cartography (Fig. 14.1).

Figure 14.1 Visual Contrast

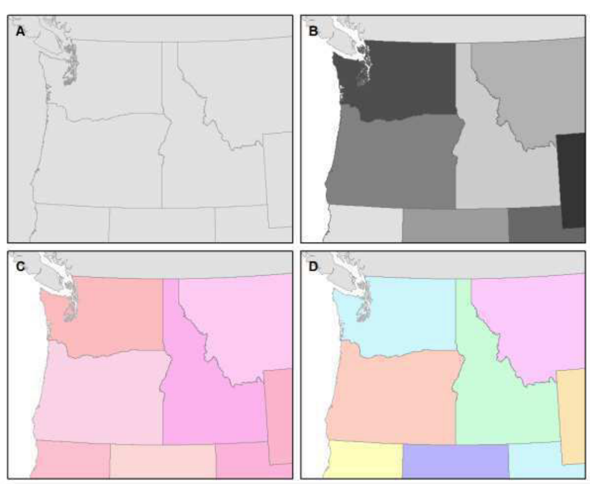


Figure 14.1When there is no variation in visual contrast (A), the map reader has a hard time distinguishing features from the background. For quantitative distributions (B), there must be enough contrast between tones for the reader to distinguish unique classes. For qualitative distributions (C), using variations of a single color hue (e.g., red) does not provide as much contrast as using a variety of hues (e.g., red, green, blue, etc.).

A well-designed map with a high degree of visual contrast can result in a crisp, clean, sharp-looking map. The higher the contrast between features, the more something will stand out, usually the feature that is darker or brighter. Conversely, a map that has low visual contrast can be used to promote a more subtle impression. Features that have less contrast will appear to belong together.

2. Legibility is "the ability to be seen and understood". Many people work to make their map contents and page elements easily seen, but it is also important that they can be understood. Legibility depends on good decision-making for selecting symbols that are familiar and choosing appropriate sizes so that the results are effortlessly seen and easily understood (Fig.14.2). Geometric symbols are easier to read at smaller sizes; more complex symbols require larger amounts of space to be legible. Visual contrast and legibility are the basis for seeing. In addition to being able to distinguish features from one another and the background, the features need to be large enough to be seen and to be understood in order for your mind to decipher what you eyes are detecting. Visual contrast and legibility can also be used to promote the other design principles: figure-ground, hierarchical organization, and balance.

Figure 14.2

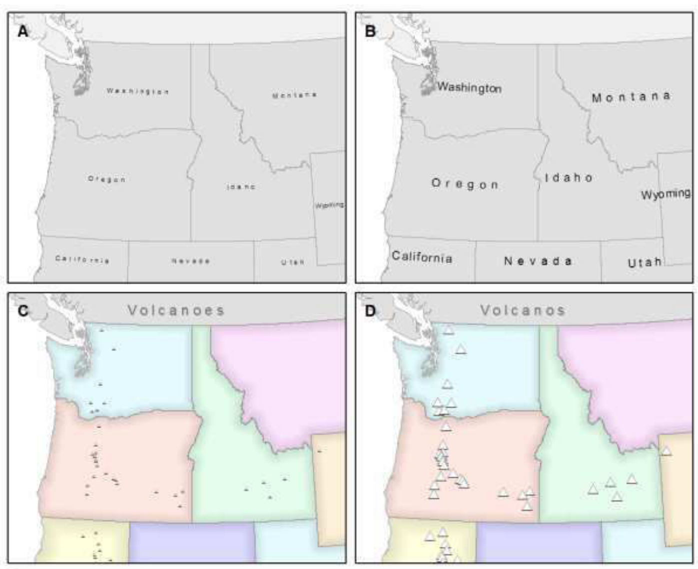
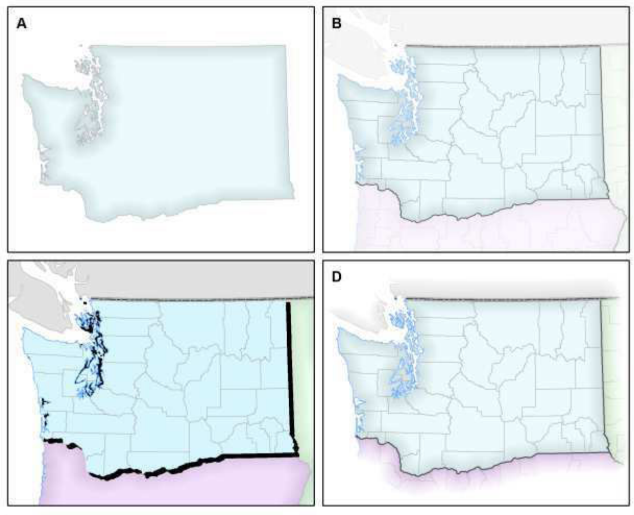


Figure 14.2: Text and symbols (A and C) that are too small cannot be seen. Once able to be seen (B and D), they must also be understood.

3. Figure-ground organization is the spontaneous separation of the figure in the foreground from an "amorphous" background. Cartographers use this design principle to help their map readers find the area of the map or page to focus on (Fig. 14.3). There are many to promote

figure-ground organization, such as adding detail to the map or using a white wash, a drop shadow, or feathering.

Figure 14.3: Using closed forms (A), a white wash (B), a drop shadow (C), or feathering (D) will promote figure-ground organization on your map.



4. Hierarchical Organization - One of the major objectives in map making is to "separate meaningful characteristics and to portray likenesses, differences, and interrelationships". The internal graphic structuring of the map (and the page layout more generally) is fundamental to helping people read your map. You can think of a hierarchy as the visual separation of your map into layers of information. Some types of features will be seen as more important than other kinds of features, and some features will seem more important than other features of the same type. Some page elements (e.g., the map) will seem more important than others (e.g., the title or legend). This visual layering of information within the map and on the page helps readers focus on what is important and enables them to identify patterns.

Hierarchical organization on reference maps (those that show the location of a variety of physical and cultural features, such as terrain, roads, boundaries, and settlements) works differently than on thematic maps (maps that concentrate on the distribution of a single attribute or the relationship among several attributes). For reference maps, many of the features should be no more important than one another and so, visually, they should lie on essentially the same visual plane. In reference maps, hierarchy is usually more subtle and the map reader brings elements to the forefront by focusing attention on them. For thematic maps, the theme is more important than the base that provides geographic context.

5. Balance involves the organization of the map and other elements on the page. A well-balanced map page results in an impression of equilibrium and harmony (Fig. 14.4). We can also use balance in different ways to promote "edginess" or "tension" or create an impression that is more "organic". Balance results from two primary factors, visual weight and visual direction. If you imagine that the center of your map page is balancing on a fulcrum, the

factors that will “tip” the map in a particular direction include the relative location, shape, size, and subject matter of elements on the page.

Figure 14.4

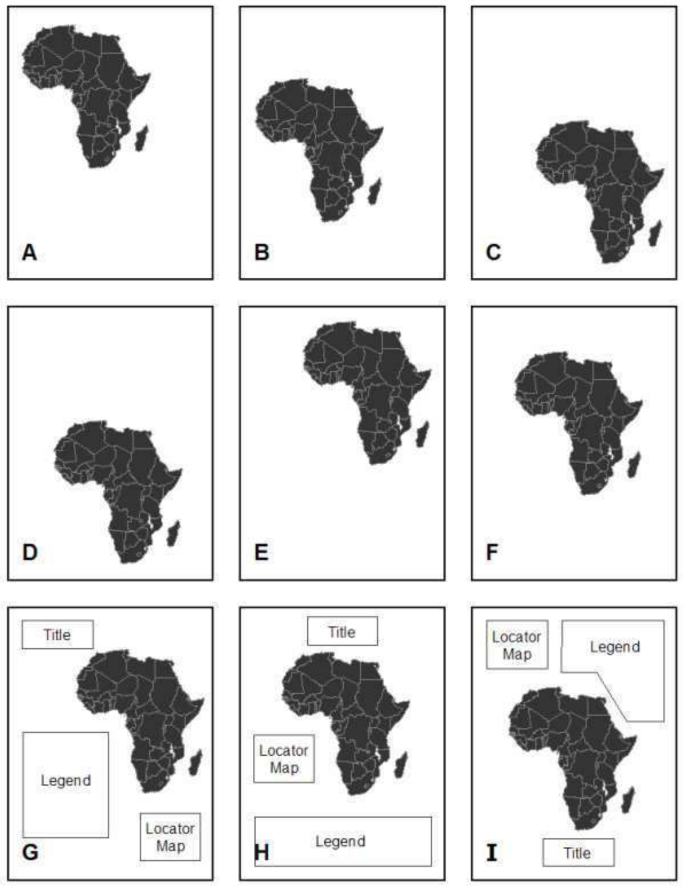


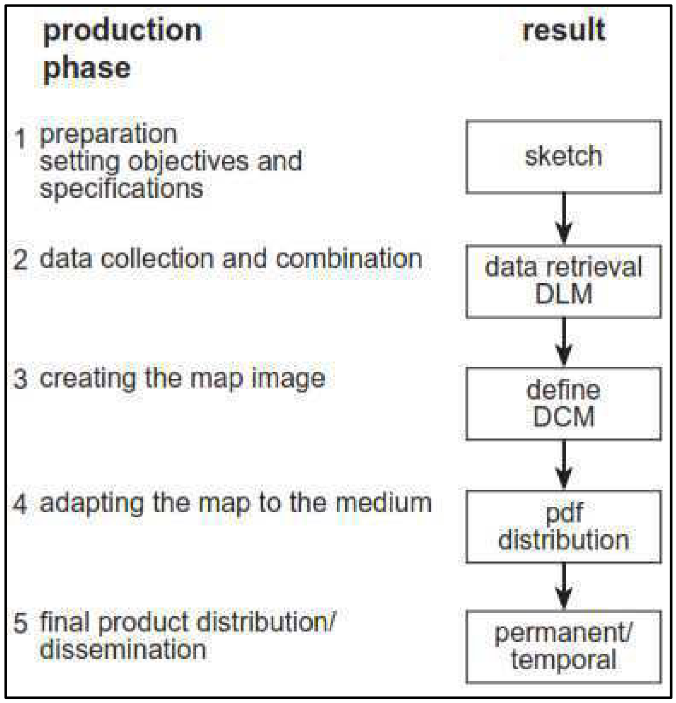
Figure 14.4 which of the top six maps seem most balanced? It should appear that (F) has visual equilibrium, usually achieved by placing the central figure slightly above center on the page. However, the addition of page elements, such as the title and legend, will modify the visual impression, so all content on the page should be evaluated together to judge balance.

Together these five design principles have a significant impact on your map. How they are used will either draw the attention of your map readers or potentially repel them. Giving careful thought to the design of your maps using these principles will help you to assure that your maps are ones people will want to look at.

Map Production Process

The map production process into five distinct phases (Fig. 15.5).The first phase is setting the map objectives: what area and map theme should it visualize, and for which year, and what should the map convey to the reader? The map type, aggregation level and resolution have to be defined, as well as the audience the map is intended for. In a traditional mapping environment, a sketch map would have been produced, to help this decision-making process. Map design specific actions have to be set as well: will the in colour or black and white, and which font is to be used for lettering the map?

Figure 15.5 Phases of map production



In the second phase the data will have to be selected from one or more (edited) digital landscape models and statistical files. The selection will include topographic base data and thematic content representing the results of spatial analysis. This selection will have to be processed: the topographic base data might be needed in a different projection, only a specific part of the mapped area might be needed, and it might have to be generalized and updated. The thematic attribute data will have to be processed as well, in order to have it answer the requirements set in phase 1. Ratios might have to be computed, r densities, or trends might have to be assessed. And the topographic and attribute data would have to be linked as well. According to the map design specific actions set in phase 1, the result of the data collected and combined in phase 2 will then take for min phase 3. This phase consists of the definition of the digital cartographic model, which will contain all graphical attributes (such as line colour, shading patterns and text fonts) of the geographic objects to be represented in the map.

The maps can be either a digital or a hardcopy print map. The on-screen (web) map could even be the final product. Maps produced in a GIS environment can be viewed in that GIS application or exported (as a JPG for instance).In the first case they would have additional capabilities: not only could their production be effectuated interactively but, more importantly, it is possible to keep a link with the GIS database. The map can be queried and so more in-depth or additional information can be obtained by the viewer from the map .Another option to create on-screen maps in, for instance, a web browser, is through use of a geo service. As a result of a request the map is sent to a webpage. If additional information, such as route data, is required a WPS (Web Processing Service) is called to calculate the route. The result is sent to the web browser via a WMS (Web Map Service).

The choice will depend on the type of output needed, but in most cases Adobe Illustrator wills is the intermediary to define the task of the printers or plotters. Software used to design maps will normally translate its drawing commands into a special language. The most common of these languages is PDF, developed by Adobe. With current technology the home/office use hardcopy devices are less suitable to produce many copies of the same map at reasonable prices. For this type of duplication, for instance to print topographic maps, one still relies on a printing press. The last phase is that of distribution or dissemination of the map, so that it reaches the intended audience, in the hope it will be read and stored as a temporal map and used for decision support.

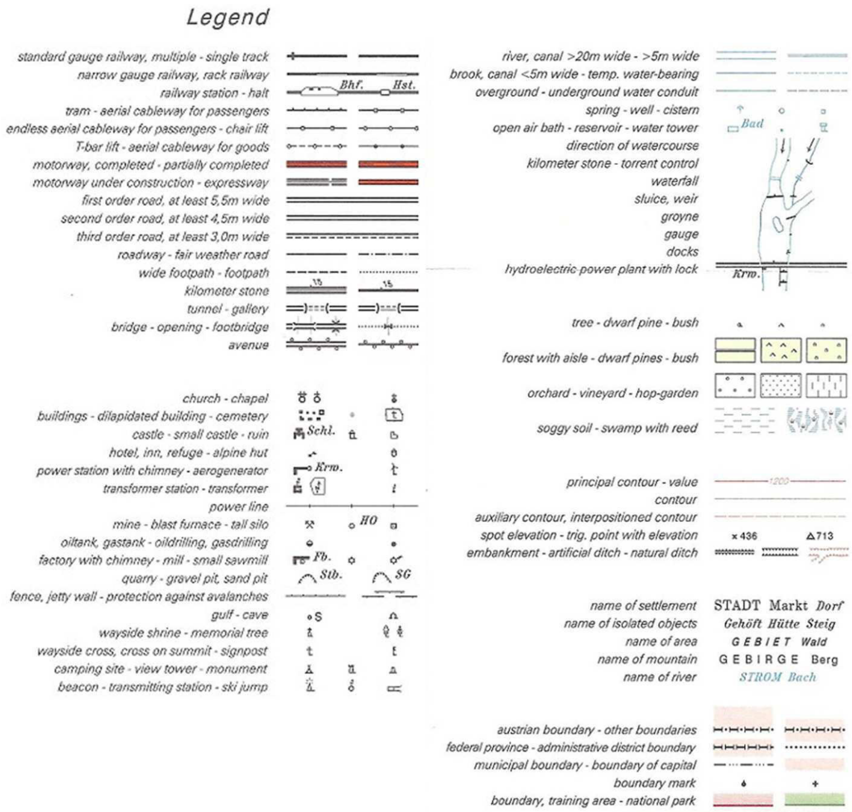
Printing Maps

Although we discuss the traditional mapping on paper here, the web and mobile mapping have the same principles. Let us first consider how to print a topographic map assuming you have a geographic database where the data are organized in layers such as:

- Administrative borders
- Communications
- Waters (lakes and rivers)
- Buildings
- Land use and land cover
- Elevation
- Geographical names

When printing it is best to start with the waters, and land cover and land use. That forms the background of the map. After that you can print the other layers and finish with the geographical names, which are the foreground of the map. The legend describes the content of the map. Setting up the legend is a time-consuming work. It is better to look at a map and see how a cartographer has solved the problem (Fig. 14.6).

Fig: 14.6 The legend for the Austrian topographic map at the scale of 1:50 000



Colour

As it is seen in the legend there are colours in a topographic map, but there are more maps like thematic maps and atlases that also have a lot of colour. The sunlight gives no colour but all colours can be seen in the rainbow, where the sunlight is reflected in the raindrops. When we are handling colour on a computer we use only three basic colours: red, green, and blue (RGB). Yellow is a mixture of green and red. This system is called additive and is shown in Fig. 14.7.

Figure 14.7

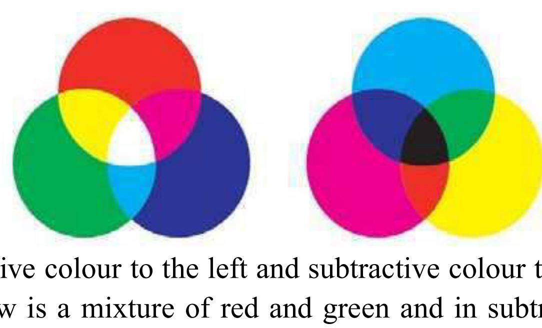


Figure 14.7 shows additive colour to the left and subtractive colour to the right. Observe that in additive colour yellow is a mixture of red and green and in subtractive colour green is a mixture of blue and yellow.

In a simple computerized colour system you may mark each basic colour with eight (0--7) different values which gives 256 different colours at the computer screen. In most computer

systems each basic colour is marked with24 (0-23) intensities which gives 13,824 different colours. That is many, but far from all colours in nature. When we are looking at colour on a paper plane we must use another system. When we add all colours we get a black colour instead of no colour as is shown in Fig. 14.7. In the colour system for printing we talk about the basic colours cyan, magenta and yellow. In the printing industry these colours are called process colours. The intensity is given by percentages. Each combination can also be whiter and darker. In a professional printing system one film is produced for each process colour but also one film for black. Since the process colours are given in percentages each film will be given a raster in order to let the required percentages of light pass the film.
All these films are then mounted in a printer for printing in what we call a 4-color system CMYK where C stands for cyan, M for magenta, Y for yellow, and K for key colour (black). The same system is used in ink colour printers for private use. A good colour handling is important for producing good maps. That is more important when printing thematic maps. The colours are very important for understanding the message the map is giving. The things you want to emphasize should be given with strong colours.

<u>Describing colours</u>

A simple way to describe colour is to use the colour circle. Fig. 14.8 shows such a circle. Orange consists of 50 % yellow and 50 % red. However, the figure shows just some colours.

Figure 14.8

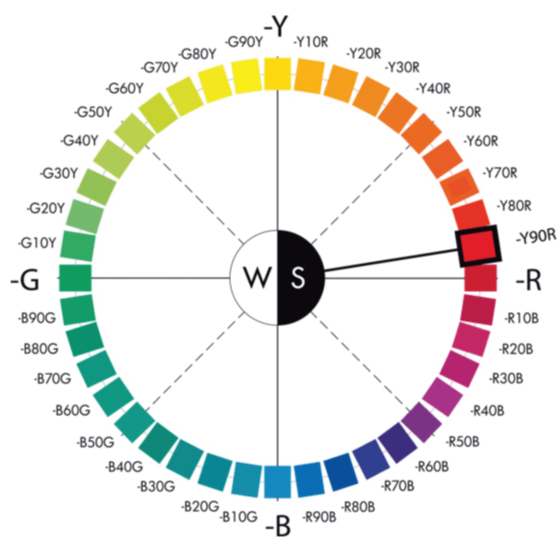


Figure 14.8: A colour circle and how the basic colours are mixed into other colours.
There are several systems for describing colours in more detail. One is the Natural Colour System (NCS) developed by the Scandinavian Colour Institute, Stockholm, Sweden. NCS also includes how to include whiteness and darkness of the colours. Let the six colours green, yellow, red, blue, white and black be placed in a cube with the white in the origin and black in the diagonal direction for the RGB, and vice versa for CMYK. The right angle from the diagonal will give the hue (colour tone), saturation (colour shade) and value (intensity for

colour brightness). This system is called HSV and it describes in a natural way how we understand colours.

Map Resolution

The thinnest line on a map might be 0.2 millimetres and in order to see a colour of an object we need a size of 1 square millimetre, which means 0.25 hectare at the scale of 1:50,000. Many objects on a map are of smaller size. Such objects may be enlarged or depicted by point symbols in order to make the map readable.

The density for images when printing books is 133 lines per inch (lpi). When we go to the computer we must count in dots per inch (dpi) and must double the line density to 266 dots per inch in order to get the same resolution. That explains why we shall need 300 dpi when scanning printed maps and images. 300 dpi is also close to the resolution we can detect without magnifying equipment.

When a map has been produced in the computer with colours selected in a fashionable way you also want to get the same colours in the printed map. That is not so simple. The International Colour Consortium is where big companies like Adobe, Agfa, Kodak, Microsoft etc., cooperate in establishing colour profiles for different printers. The aim is to incorporate handling of tint as standard into administrative systems. However, the main problem is to transform tints from the RGB system in the computer to the CMYK system in the films for printing. The method for that transformation is called ripping after raster image processing. That process is also used in your ink-jet plotter. In order to test that the right colours are obtained you may transform a part of the computer map to a document in PDF and print that. With a densitometer you can also measure the saturation and compare the result with measuring the same tint in an already printed map.

Paper Quality

Most paper is produced from wood cellulose. The cellulose fibres are obtained from the pulps either by chemical or mechanical processes. When producing a paper the fibres are organized in one direction. It is important to know the direction of the fibres since it is easier to bend a paper along the direction than across the direction. That is important if the map shall be folded. The weight of the paper is given in gram per square meter. The most common weight for ordinary writing paper is 80 grams (per square metre, which is not included in the daily talk). For printing maps, a paper of100 -- 150 grams is recommended. The surface of the paper is also important. There are many ways to coat the paper to get it smoother than the raw paper. That is needed for getting the small details of the map visible. If a good result is needed ask a printing office for advice.

Printing on waterproof paper is also possible to get maps that can be used in rain and while canoeing. Plastic material is available. For some orienteering events waterproof maps are printed. Such maps are not destroyed by water, but when roughly used they may be heavily wrinkled, and some details of the map content may be obliterated.

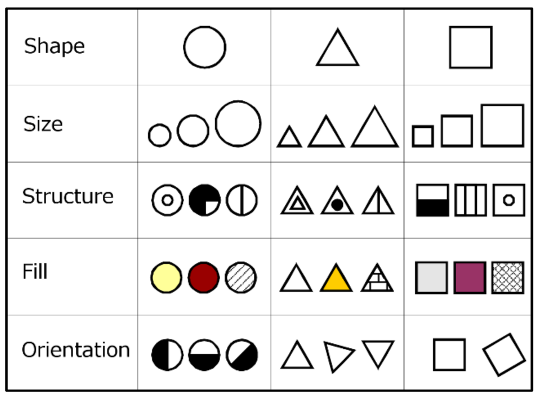
Notations

The overall description of the map should be given by the person who has designed the map. The map image is almost meaningless without a clear indication of the map's contents, and that indication should be given in the map title. Preferably, in the map title there is an indication of the topic covered, the area depicted and the year for which the data are valid (for instance: "Population density India in2011").

Map symbols and cartographic methods

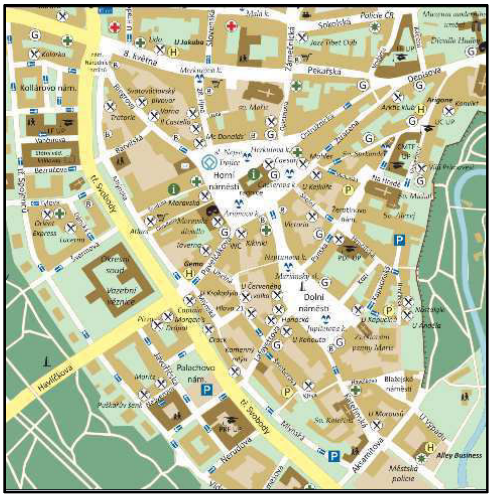
There are a number of methods for map visualization of map contents. The selection of methods is determined by the nature of the displayed features (which can either be related to points, lines or areas) and the objective of the map. Point map symbols—a simple geometric, figurative or alphanumeric picture—allow for the expression of feature characteristics at a particular location. Using the shape, size, structure, fill and orientation, both qualitative and quantitative characteristics can be expressed (Fig. 14.9).

Figure 14.9 Shape, size, structure, fill and orientation—graphic variables of point map symbols.



Qualitative feature characteristics are mostly expressed by the shape of the point symbol. The size of the map symbol is used mainly for expressing amounts, importance or super ordination of the features. The size of a symbol is proportional to the quantity of the feature and is related to the measurable parameter of the symbol—mostly the radius of a circle, the side of square, the height of a column or picture. The structure (internal graphical breakdown) of the symbol is used to express the internal feature structure, such as the ethnic structure of the population or the sectorial structure of manufacturing. The fill of the symbol by colours or by hatching is used mostly to express the qualitative feature characteristics. The orientation of the symbol (rotation around its centre point) is most commonly used to express the direction of movement, such as wind direction, migration of animals or sight line.

Figure 14.10 Maps with point map symbols



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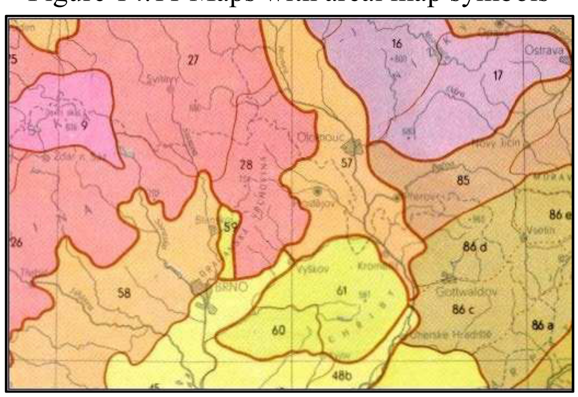
Line map symbols—various forms of lines—express both qualitative and quantitative characteristics of linear features by thickness, structure, colour and orientation (Fig.14.6). Simple lines (solid, dotted, dashed, dash-and-dot) and complex lines (with various supporting map symbols—crosses, "teeth," ripples, images) are used to express the quality of linear features. The thickness of the line symbol is determined by the relationship to the quantity of the feature (e.g., traffic volume) or importance or super-ordination (e.g., state, provincial, municipal borders). The qualitative characteristics of linear features are mostly expressed through colour (another feature = other colour). The longitudinal orientation of the symbol expresses the direction "forward/backward" such as animal migration or the movement of troops, and the transverse orientation expresses the fact that boundaries separate areas with different characteristics. Printed map symbols express both qualitative and quantitative characteristics of large-scale features by fill (colours or hatching) and outline. The fill is used more frequently, although outline provides the structure, thickness, colour and orientation (Fig. 14.11).

Figure 14.11 Maps with areal map symbols



National Map Policy for Sales/ Data Dissemination

The Central Government announced the National Map Policy (NMP) on 19th May2005. The NMP document authorizes Survey of India (SOI) to issue detailed guidelines on the implementation of the NMP.

Sales/ Data Dissemination:

(a) Analogue/Paper Maps: of all scales shall be made available from Survey of India (SOI) offices and Map Sales Counters on payment at prices as may be fixed by SOI from time to time. The list of such outlets, their addresses with telephone numbers shall be made available in the websitewww.surveyofindia.gov.in. These maps can also be sold by any retailer. Digitization of SOI analogue/paper maps is strictly forbidden.

(b) Map Transaction Registry (MTR): As stipulated in the National Map Policy, Survey of India will establish an on-line MTR for recording of all transactions relating to digital maps. Each user will be allotted a unique user ID and each transaction with a unique transaction ID. For all future correspondence, this user ID and Transaction ID should be referred.

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14.4 SUMMARY

In this Unit, you have learned the following:

1. A topographical map is the three-dimensional representation of surface features of the Earth.
2. Topographic maps are prepared on large and small scales and thus classified into various types according to their scale.
3. In India, Survey of India is the nodal agency for preparing and publishing the topographical maps of India at various scales.
4. The topographical maps of India are prepared at 1:1,000,000 (million map), 1:250,000 (degree map), 1:50,000 (quarter map) and 1:25,000 (special map) scale providing

latitudinal and longitudinal coverage of 4° × 4°, 1° × 1°, 15' × 15' and 7' 30" × 7' 30", respectively.

5. Interpretation of topographical map requires a thorough understanding of conventional signs, symbols, colors and key given in the map showing various features.
6. Map design fundamentals include Scale, Map Projection, Map Generalization, Map Design, Map Construction and Production.
7. To determine the area of a tract of land either directly from field measurements, or indirectly, from a plan or map.

14.5 GLOSSARY

- Cartography- It is art or science of making and study of maps.
- Topographic Map- A map of a small area drawn on a large scale depicting detailed surface features both natural and manmade. Relief in this map is shown by contours
- Contours- These are imaginary lines that join points of equal elevation on the surface of the land above or below a reference point. Mean sea level is the most common reference point.
- Geodesy- It is the discipline that deals with the measurement and representation of the earth, its gravity field and geodynamic phenomena (polar motion, earth tides, and crustal motion) in three-dimensional time varying space.
- Geoid- It is a three-dimensional shape approximated by mean sea level, on which the gravity force is constant and equal to its strength at mean sea level.
- Map design- This involves the planning of graphic elements (symbols, style of font, colors, legend) of maps.
- Map Projection- It is a systematic transformation that allows the orderly representation of earth's spherical graticules on a flat map.
- Scale- It is the relationship between the map distance and the corresponding ground distance in units of length.

14.6 ANSWER TO CHECK YOUR PROGRESS

1. What is scale in a map?
2. Name the organization which prepares the topographical maps of India.
3. What are the common symbols and signs used in a map?
4. Explain the concept of color theory.
5. List common labeling standards to be used in mapping.

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14.8 TERMINAL QUESTIONS

1. What are the different map design fundamentals?
2. Explain the various techniques to estimate area in map.
3. Explain what is meant by 'map interpretation' and what procedure is followed for its interpretation.
4. Draw the conventional signs and symbols for the following features
   - International Boundary
   - Villages
   - Metaled Road
   - Places of Worship
   - Railway line
5. How will you measure the area of an irregular tract of land using geometric shapes?