NATIONAL OPEN UNIVERSITY OF NIGERIA

ESM 291:
MAP ANALYSIS

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Study Units

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MODULE 1

INTRODUCTION TO MAPS AND MAP ANALYSIS

Module 1

Unit 1: What is a map?

1. Introduction

Maps are one of the world's oldest types of document and means of communication. Maps are common objects. We see them every day, we use them when we travel, and we refer to them often, but what is a map? This is the question this Unit will attempt to address.

2. Objectives

1. To understand the meaning of maps.
2. To briefly discuss the evolution of maps over time.

3. Main Body

3.1 What is a Map?

The question "What is a map?" is a deceptively simple question. Not until you are asked to provide an answer to that question – you may not realize that it is far more difficult to define a map than you think. Yet we encounter maps on a daily basis; map is rather a household term.

It is really difficult to define the word map. Consequently, there are several definitions of map. There is no universally accepted definition of map. In this Unit we will only present some definitions of or views on the subject of map.

On a general note, the term "map" is often used in mathematics to convey the notion of transferring information from one form to another. Hence, cartographers (map makers) map or transfer information from the surface of the Earth to a sheet of paper.

The term "map" is used loosely to refer to any visual display of information, particularly if it is abstract, generalized or schematic. A map could be understood to mean a flat drawing of a place or part of the world. A map can also be defined as a representation, usually on a flat surface, of a whole or part of an area. A map is a way of representing on a two-dimensional surface, (a paper, a computer monitor, etc.) any real-world location or object.

A map is a graphic representation or scale model of spatial concepts. It is a means for conveying geographic information. Maps are a universal medium for communication, easily understood and appreciated by most people, regardless of language or culture. (James S. Aber)

Norman Thrower, an authority on the history of cartography, defines a map as, "A representation, usually on a plane surface, of all or part of the earth or some other body showing a group of features in terms of their relative size and position." This seemingly straightforward statement represents a conventional view of maps. From this perspective, a map can be seen as a mirror of reality.

“A map is simply a drawing or picture (in 2-D) of a landscape or area of a country (in 3-D). It could be anything from a sketch map for a visitor to find your school to a detailed map of a town centre or mountain range” (Ordinance Survey).

A map is a picture or representation of the Earth's surface. However, maps show more than the Earth's surface; they show how things are related to each other by distance, direction, and size. Maps are a way of showing many things about a portion of the earth's surface on a flat piece of paper that can be carried and transported easily. A map is not a photograph of the Earth's surface. It can show many things that a picture cannot show, and as a result, a map looks different in many ways from a photograph of the Earth's surface.

No map can show all physical, biological, and cultural features for even the smallest area. A map can display only a few selected features, which are portrayed usually in highly symbolic styles according to some kind of classification scheme. In these ways, all maps are estimations, generalizations, and interpretations of true geographic conditions. (James Aber)

David Stephens, reflecting on the work of John Pickles notes that a map is text. John Pickles, a geographer with interests in social power and maps, suggests: maps have the character of being textual in that they have words associated with them, that they employ a system of symbols within their own syntax (grammar), that they function as a form of writing (inscription), and that they are discursively embedded within broader contexts of social action and power.

In other words, maps are a form of symbolization, governed by a set of conventions that aim to communicate a sense of place. Maps, even modern maps, are historic. They represent a particular place at a particular point in time. This definition of a map (although, like the mirror image idea, is also problematic) suggests that maps can afford the viewer a great opportunity to gain insights into the nature of places.

According to the *Multi-lingual Dictionary of Cartography* by the International Cartographic Association, a map is “a graphic representation, normally to scale, and on a flat medium of a selection of material or abstract features on or in relation to the surface of the earth or of a celestial body.” This is perhaps the most authoritative definition of a map. From this definition and others, we can learn certain things about map such as (see also Unit 2 below):

- A map is basically a drawing.
- It represents geographical features – both abstract (invisible) ones e.g. temperature, pressure, wind, etc., and material (visible) ones e.g. houses, rivers, hills, etc..
- It is usually drawn to scale; hence it is a reduced version of reality.
- It is commonly drawn on a flat surface such as paper.

A map represents geographic features or other spatial phenomena by graphically conveying information about locations and attributes. The locational information in a map describes the position of particular geographic features on the Earth's surface, as well as the spatial relationship between features. Attribute information describes characteristics of the geographic features represented, such as the feature type, its name or number and quantitative information such as its area or length.

Based on the foregoing, therefore, we can say that a map portrays 3 kinds of information about geographic features:

1. The ***location and extent*** of a feature is identified explicitly by reference to a coordinate system representing the earth's surface. This is ***where*** a feature is.
2. The ***attributes*** of a feature describe or characterize the feature. This is ***what*** the feature is.
3. The ***relationship*** of a feature to other features is implied from the location and attributes of all features. Part of the job of a map is to describe spatial relationships of specific features that the map aims to represent. Relationships can be defined explicitly, e.g. roads connecting towns, regions adjacent to one another, or implicitly, e.g. close to, far from, similar to, etc. Implicit relationships are interpreted according to the knowledge that we have about the natural world. Relationships are described as ***how*** or ***why*** a feature is.

There are many different types of maps that attempt to represent specific things. Maps can display political boundaries, population, physical features, natural resources, roads, climates, elevation (topography), and economic activities. (The various types of map are discussed in Unit 3 of this Module).

Maps are produced by ***cartographers***. Cartography refers to both the study of maps and the process of map-making.

3.2 Evolution of Maps

Maps have changed in many ways since maps were first used. The earliest maps that have withstood the test of time were made on clay tablets. Maps were produced on leather, stone, and wood. The most common medium for producing maps on is, of course, paper. Map has evolved from basic drawings of maps to the use of computers and other technologies to assist in making and mass producing maps. Today, maps are commonly produced on computers, using software such as GIS (Geographic Information Systems).

The way maps are made has also changed. Originally, maps were produced using land surveying, triangulation, and observation. As technology advanced, maps were made using remote sensing techniques such as aerial photography and satellite imaging, which is the process widely used today. In addition, the GPS (Global Positioning System), which is used in obtaining accurate locational information about objects or features, is equally used today in the production of maps.

With the aid of modern technological innovations, maps are now produced quicker and cheaper. More so, a greater variety of maps are now produced than before; for instance, we now have digital maps. The appearance of maps has evolved along with their accuracy. Maps have changed from basic expressions of locations, to works of art and extremely accurate scientific tool.

The range of map users also keeps increasing; there are more users of map today than ever before. Judging by modern man’s increasing crave for and reliance on maps, there seems to be little or nothing the world can do without maps.

4. Conclusion

Maps are important means of communication, which have been with man since time immemorial. They are used to graphically display and disseminate geographical information. The map is widely regarded as the geographer's shorthand since a very large volume of geographical data can be easily summarized and presented with a single map. Owing to their unique nature as powerful and effective means of visual communication, maps will always play vital roles in human affairs.

5. Summary

A map is a work of art, science and technology, which graphically represents the entire Earth's surface or a portion of it. Maps show us where things are located, the spatial pattern of distribution of features, as well as the relationship between various features. Maps and map-making have undergone some notable evolutionary trend. Over the years the surfaces on which maps were drawn, the methods of map-making as well as the appearance of maps have all witnessed notable changes. The uses as well as the users of maps have also diversified. Maps are increasingly playing major roles in various aspects of human endeavour.

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Unit 2: Characteristics and components of maps

1. Introduction

This Unit is about the distinguishing characteristics or attributes of a typical map. A map is a system made up of several sub-systems or parts. Hence, this Unit also presents the various component parts or elements of a map. Our understanding of the peculiar characteristics as well as components of map is crucial to effective and efficient map analysis.

2. Objectives

1. To discuss the unique characteristics of maps.
2. To identify the general components or elements that made up a typical map.

3. Main Body

3.1 Characteristics of Map

A typical map has the following characteristics:

- It is represented to scale. Every map is a reduced version of some aspect(s) of reality (i.e. things that actually exist on Earth). Hence, every good map must have a scale which shows by how much reality has been reduced. (The concept of scale is discussed in Unit 3 of Module 2).
- It is symbolized. Graphic symbols are used to draw a map; each symbol represents a particular category of geographical feature. (The concept of map symbols is discussed in Unit 2 of Module 2).
- It is projected. Map projection is the mathematical transformation of the spherical Earth unto a flat medium. Every map is, therefore, based on one form of projection or the other. (The concept of map projection is discussed in Unit 4 of Module 2).
- It is a two-dimensional representation of three-dimensional features.
- It is a model of reality. A map is a replica or representation of certain things that exist in real life.
- It is a selective representation. No map can show everything that exists in the area shown on the map. Hence, only things relevant to the purpose of a map are selected and represented on the map.
- It is a generalized representation. It is not practically possible to show every bit of detail about any feature represented on a map. Hence only those details about each feature which are considered to be important are given on the map. Moreover, one symbol is normally used to generally represent all features which are considered to be in the same class or group, irrespective of the individual differences that may exist among the features grouped together.
- It is a communication system. The map is used to graphically store, display and disseminate information.
- It shows only a static situation - one slice in time. A map only gives us information about the situation of things as at the time it was produced. In a sense, therefore, it could be said that map is usually out of date.

3.2 Components of maps

Maps may contain a variety of elements or components. However, all maps have some common components, which are explained below.

Title—A map must have a title. The title of a map should tell the reader "*what*," "*where*," and possibly "*when*" about the map. What is the map all about? Where on Earth does the map relate to? What time period does the map cover?—e.g. 2006 population of Nigeria.

Orientation—By convention, cartographers (map makers) place North at the top of maps. If there is a deviation from that practice, the map should have a compass rose or some other symbol to help orient the user.

Scale—The map scale should be shown so that the reader can make judgments about distances. Graphic scales are an absolute must when dealing with maps as computer images or printing images from digital sources. Ratio and written scales are virtually meaningless in this medium. (The concept of scale is further discussed in Unit 3 of Module 2).

Legend—There must be a legend or key that explains the symbols used by the cartographer. The map legend shows the symbols on a map and gives their meaning. To visualize reality the map reader needs to be able to convert various shapes, colors, and textures into the phenomena they represent.

Grid—The map needs to have a coordinate system, in the form of parallels of latitude and meridians of longitude, so that the area can be placed in its proper geographical location on the globe. (See Unit 5, Module 3 for discussions on coordinate systems).

Author / Publisher—The author/publisher of a map should be indicated. Knowing who created the map may offer hints as to the map's bias or biases. Does this person or organization have a vested interest in how the map is perceived by the map reader? For example, "town plats," maps created by western promoters, were aimed at attracting prospective settlers. Often they were purely propaganda.

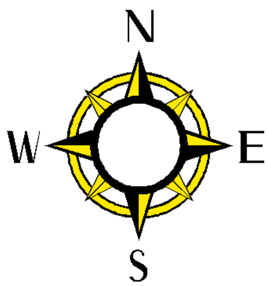
Place of Publication—The country or city where the map was published should be indicated.

Date—The date when the map was produced/published should be indicated. Knowing when the map was constructed helps to place the map in its chronological context. Does the map reflect true facts? For instance, post-1990 maps of Europe should show one Germany, not two.

Source—Indicate the source of the map.

Compass rose—A compass rose tells the directions (which way) on a map using the cardinal points of North, South, East, West, and so on.
  * North is at the top of a map.
  * South is at the bottom of a map.

* West is on the left side of a map.
* East is on the right side of a map.



4. Conclusion

The characteristics and components of maps are critical to map analysis. Unless one understands each of the various unique attributes as well as elements of a map it will difficult for one to properly read and interpret any map.

5. Summary

A map is a unique powerful means of storing, displaying and communicating geographical information. Basically, the map derives its peculiarity from its different characteristics or attributes. The map is essentially a graphic means of visual communication. The various components have to be seen and understood before one can derive meaning from the map.

The map is a model of reality; it represents something that exists in real life. However, the map is a reduced version of reality. Consequently, the map is usually drawn to scale – a scale that is significantly smaller than the real life situation. More so, a map uses symbols to represent the aspects of reality it portrays. The symbols need to be interpreted to understand what exactly they represent. Since it is not practically possible for a map to show everything about the reality it represents, there is usually the need to summarize or generalize the information about reality which a map shows. The map also has various elements or components, all of which add up to make the map what it is. Furthermore, each map component contributes to the reading and understanding of the map.

6. References/Further Reading

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Unit 3: Types/classes of map

1. Introduction

Maps are of different types. There are general maps and specialized maps. Each map type serves certain purpose(s). This Unit presents different classes and types of map as well as their main information contents.

2. Objectives

1. To identify the various types of map
2. To indicate the major information content of each type of map.

3. Main Body

3.1 Classes of Map

There are many different types of maps. In practice we normally think of two classes of map:

- Topographic map - a reference tool, showing the outlines of selected natural and man-made features of the Earth; often acts as a frame for other information. "Topography" refers to the shape of the Earth’s surface, represented by contours and/or shading, but topographic maps also show roads and other prominent features
- Thematic map - a tool to communicate geographical concepts such as the distribution of population densities, climate, movement of goods, land use etc.

3.2 Types of map

Topographic Map

A topographic map (Fig. 1) represents small areas of a place, also portraying the terrain features. In the topographic map the vertical and the horizontal lines of the terrain features are present which can be measured. The contour lines of the map basically show the shape and the elevation of the area. *For example:* The lines in the map which close together represent a steep terrain and those lines which are placed far apart are the indication of a flat terrain. Topographic maps show a 3 dimensional world in 2 dimensions by using contour lines to represent relief or landforms. Many people have trouble reading these maps, because they have mountains and valleys represented with concentric circles and lines.

Geologic Maps

A geologic map is a map of the different types of rocks that are on the surface of the Earth. By mapping different rock types, geologists can determine the relationships between different rock formations which can then be used to find mineral resources, oil, and gravel deposits. Also, you want to know what type of rock you are building on or else you might have a leaning building or a pile of rubble resulting from a collapsed building.

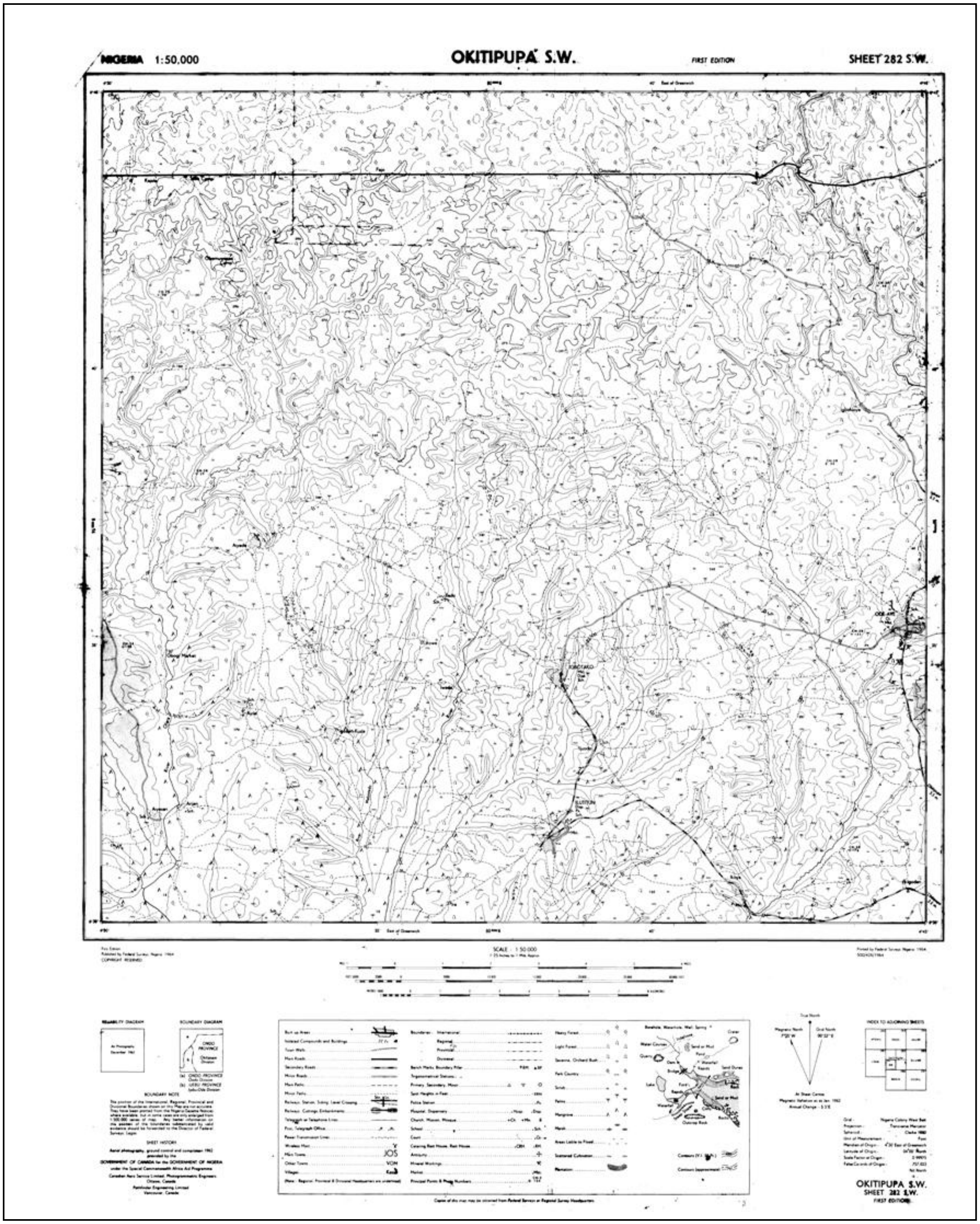

Fig. 1 A typical 1:50,000 Nigeria topographic map

Globe:

A globe is a map. Globes are some of the most accurate maps that exist. This is because the earth is a three-dimensional object that is close to spherical. A globe is an accurate representation of the spherical shape of the world.

Mental Maps:

The term *mental map* refers to the maps that aren't actually produced and just exist in our minds. These maps are what allow us to remember the routes that we take to get somewhere. They exist because people think in terms of spatial relationships and vary from person to person because they are based on one's own perception of the world.

Biogeographic Maps

Scientists involved in the study of animals, plants, and other living organisms use maps to illustrate where these groups live or migrate. It is important to many zoologists to know where the organisms that they study live and where they move to. People who monitor endangered species need to know if the ranges of migration have become larger or smaller through time.

Environmental Maps

These types of maps include maps that look at human's activity in urban and metropolitan areas and the environment in which we all live. Maps that illustrate physiographic features such as forests, grassland, woodland, tundra, grazing land, ocean floors, and ocean sediments could be included in this large grouping.

Resource Map

A resource map which is also called an economic map shows and represents the natural resources and the economic activity of different regions of an area.

Climate Maps

The climate maps give information about the climate of an area or a region. A climate map can be of a country, showing climates at different cities, of a continent or the world showing climate of different countries

Meteorological maps

Meteorological maps that show climate, weather and wind are types of environmental maps. Meteorologists, oceanographers, geographers, city planners, and many other professionals depend greatly on these maps to record and forecast their specific field.

Physical Map

A physical map is a map that represents the physical features of an area such as: vegetation, mountains, rivers, sea and lakes.

Road Maps

Road maps are of cities and towns which show all the routes of the cities and demonstrate the important roads and locations. Road maps show the location of important hospitals, airport and buildings of the city. Road maps are very important and helpful maps, especially for the tourists visiting a city.

Political Maps

Political maps are simple basic maps which tell about the national boundaries, capital, states, LGAs and other administrative units of a country.

4. Conclusion

There are different classes and types of map. Each map type conveys certain information. No single map can bear information about everything at the same time. Knowing the different types of map and particular kind of information they can display is helpful in selecting the map the use for some given project.

5. Summary

Maps can be grouped into various classes/types. We have basic or general maps; we also have derived or thematic maps. Basic maps contain information on different kinds of natural as well as cultural (man-made) features. Hence, they (basic maps) are considered general-purpose maps, since any of such maps can be used for different purposes. For instance, a topographic map, which is a basic or general-purpose map, shows natural features like rivers, vegetation, and relief as well as cultural features like settlements, roads, markets, and so on. Thus in map analysis, a topographic map can be used for numerous purposes. On the other hand, thematic or one-theme maps only give us details about the spatial distribution of one feature at a time. They are therefore referred to single-purpose maps; such a map can only be used to study the distribution of the one variable it deals with. For instance, a thematic map showing rainfall distribution in a place can only be used to study rainfall in the area, and nothing more.

We can map virtually everything that exists. Hence, we have geological maps, tourist maps, vegetation maps, climatic maps, soil maps, population maps, disease maps, poverty maps, road maps, political maps, economic maps, solid minerals map, agricultural maps, environmental degradation maps, language maps, religious maps, and so on.

6. References/Further Reading

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Types of Maps
http://msnucleus.org/membership/html/jh/earth/mapstype/lesson1/mapstypes01d.html

Unit 4: Functions/Uses of maps

1. Introduction

Maps have been an integral part of the human story for a long time. From cave/wall paintings, ancient maps of Babylon and Greek philosophers, through the Age of Exploration, and on into the 21st century, people have created and used maps as the essential tools to help them define, explain and navigate their way through the world.

Maps are used extensively throughout society. Road maps provide information such as street names and landmarks. Some maps are used for forecasting the weather, while others are used to plot the population in an area. Learning to recognize what a map has to offer is an important skill.

2. Objectives

1. To highlight the importance of maps.
2. To identify some of the uses or functions of maps.

3. Main Body

3.1 Functions of maps

The importance of maps cannot be overemphasized. We really cannot do without maps. Everybody uses maps, one way or the other. As Jessica Carpilo (2010) has rightly observed, “Maps are valuable, timeless objects that we would be lost without. Literally.” Some of the various uses of maps are listed below.

- The media uses maps to pinpoint the locations of important news items e.g. the latest international crisis.
- Many textbooks include them as illustrations.
- Traditionally, maps are used as aids to navigation; we consult maps to help us navigate from place to place. In other words, maps help us find our way from one place to another.
- Maps are used as reference documents,
- Maps are also used as wall decorations
- A map shows where things or places are located.
- Maps can be used to show how far one place is from another.
- Maps can be an important source of primary information for historical investigation. To the student of history, the idea of a map as a mirror image makes maps appear to be ideal tools for understanding the reality of places at different points in time.
- Today maps are used by people to find places they have not seen. Let’s say you are interested in finding the nearest shopping centre from your home. You can easily do this by consulting a map that shows the spatial distribution of shopping centres in your neighbourhood.

- The scale on the map can help you determine the distance between two places.
- The direction in which you should walk can also be determined.
- Many tourists (hikers) use topographic maps, especially in areas where there are no roads with signs.
- Geologists depend on topographical and geological maps to record the types of rocks and detect possible locations of solid minerals.
- Town Planners and Engineers use topographic maps when they are planning roads, buildings, or other human–made structures. Imagine designing a city without considering where hills and valleys are located!
- Using a map you can visualize in your mind what the place looks like that you are going to, and you can see what landmarks and features you will pass on the way to your destination. Maps mean you know what to expect, and they help you to know you are going in the right direction to arrive at your destination safely and quickly. (Ordinance Survey).
- Maps can be great fun – and they can lead you to all sorts of discoveries. They can help you get to know an area really well, because they pinpoint interesting places that are often hidden away, which you might otherwise never find. They can also help you find different routes to places you already know. Maps can also help you in your geography, history, environmental science or citizenship classes.
- Maps are used in the planning and execution of military operations. They are also used in training military personnel.
- Maps are important research tools.

We can conveniently group the roles maps play today into four broad categories:

- ***Data display*** : maps provide useful ways of displaying information in a meaningful way.
- ***Data stores***: as a means of storing data, maps can be very efficient, high density stores.
- ***Spatial indexes***: a map can show the boundaries of areas (e.g. land use zones, soil or rock types) and identify each area with a label. A separate manual with corresponding entries may provide greater detail about each area.
- ***Data analysis tool***: maps are used in data analysis to make or test hypotheses, such as the identification of cancer clusters; examine the relationship between two distributions using simple transparent overlays; identify suitable sites for a proposed project; and so on.

4. Conclusion

Maps have always been, and will always be, a very useful companion to man. The map helps man to better understand his immediate environment and the larger world around him. Maps play vitally important roles in the daily activities of man, such as navigation, governance, economic activity, and so on. Because of their power and usefulness, there is little or nothing man can really do without maps. The map actually helps in pointing the right way forward.

5. Summary

Maps are used for various purposes. Basically, we use maps to store, display and communicate geographically referenced information. We also use maps for education, research and training. Maps are equally useful as navigational aids. Without maps it will be difficult for us to properly plan and develop our physical environment in an orderly and economical manner. Maps are useful in resource planning and allocation. The map is a useful aid in analyzing and proferring workable solution to any given geographical problem. With maps we can effectively study the past, understand the present, and predict the future.

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Unit 5: What is map analysis?

1. Introduction

To fully understand a map we need to know how to decode its message and place it within its proper spatial, chronological, and cultural contexts. Decoding the message involves getting the actual contextual meaning of each of the symbols used to draw the map. This in turn demands reading and interpreting the map symbols. Unless one has a good understanding of what map analysis is all about it will be difficult for one to undertake proper analysis of any given map. Consequently, in this Unit we will attempt to explain what map analysis is all about and also to highlight the major tasks involved in map analysis.

2. Objectives

1. To define map analysis
2. To identify the various tasks involved in map analysis.
3. To discuss the procedures involved in accomplishing each of the tasks of map analysis.

3. Main Body

3.1 What is Map Analysis?

Map analysis involves the reading and interpretation of the content of a map. This entails decoding the map symbols to derive their meanings and also understand the message or information those symbols convey to the map user. Or as stated by Ajayi (2003), map reading is "the ability to recognize the conventional signs and symbols as used on maps and their descriptions in words of the area mapped with the aid of signs and symbol". In addition, map analysis is whereby a study is made regarding map types i.e. political maps, military maps, contour lines etc., and the unique physical qualities or elements of a map i.e. scale, title, legend etc.

In map analysis we can use the information displayed on the map to make some logical inferences or conclusions about some other facts not expressly shown on the map. In this sense, therefore, we can infer that map analysis ranges from an understanding of the fundamental nature of mapped data through a series of procedures used in deriving, analyzing and applying spatial information.

True, a map is an image of a place at a particular point in time, but that place has been intentionally reduced in size, and its contents have been selectively distilled to focus on one or two particular items. The results of this reduction and distillation are then encoded into a symbolic representation of the place. Finally, this encoded, symbolic image of a place has to be decoded and understood by a map reader who may live in a different time period and culture. When we are embarking on map analysis we are simply trying to reverse what the map maker did. In making a map we work or transfer information from reality (ground or Earth's surface) to paper. However, in map analysis we do the opposite, that is working from paper back to reality (ground).

To be sure you are not missing anything important you need to know about map components such as symbols, scale, legend, etc. as well as parameters like direction, distance, and relationships on maps. Knowing about these will help you unlock the secrets of maps.

3.2 Map analysis tasks

Usually map analysis is accomplished by executing a number of tasks. Basically there are four (4) broad tasks involved in map analysis. They are:

- Classification
- Delineation
- Enumeration, and
- Measurement.

Usually, the first two tasks mentioned above (i.e. classification and delineation) are first carried out in that logical order before any of the remaining last two (i.e. enumeration and measurement). Each of the tasks is discussed below.

3.2.1 Classification

This involves assigning objects, features, or areas to classes based on certain criterion. There are about three levels of confidence or precision that can be achieved in classification. These are: (i) *detection*, which is the determination of the presence or absence of a feature on a map. (ii) *recognition*, which involves assigning a feature to a general class. For instance, we can generally classify a feature as a road. (iii) *identification*, which means we have enough details about the identity of an object or feature that we are confident enough to place it in a very specific class. For instance, based on available details we can confidently say a particular road is a secondary (Trunk B) road instead of just classifying it generally as a road.

High level or more precise classification of features enables us to do more accurate and precise map analysis. In other words, the higher the level of classification, the more detailed and more accurate will be the level of map analysis we can do.

3.2.2 Delineation

This refers to outlining or placing boundaries round regions or areal units observed on the map. A typical example is the delineation of separate classes of land use or vegetation (see Fig. 2).

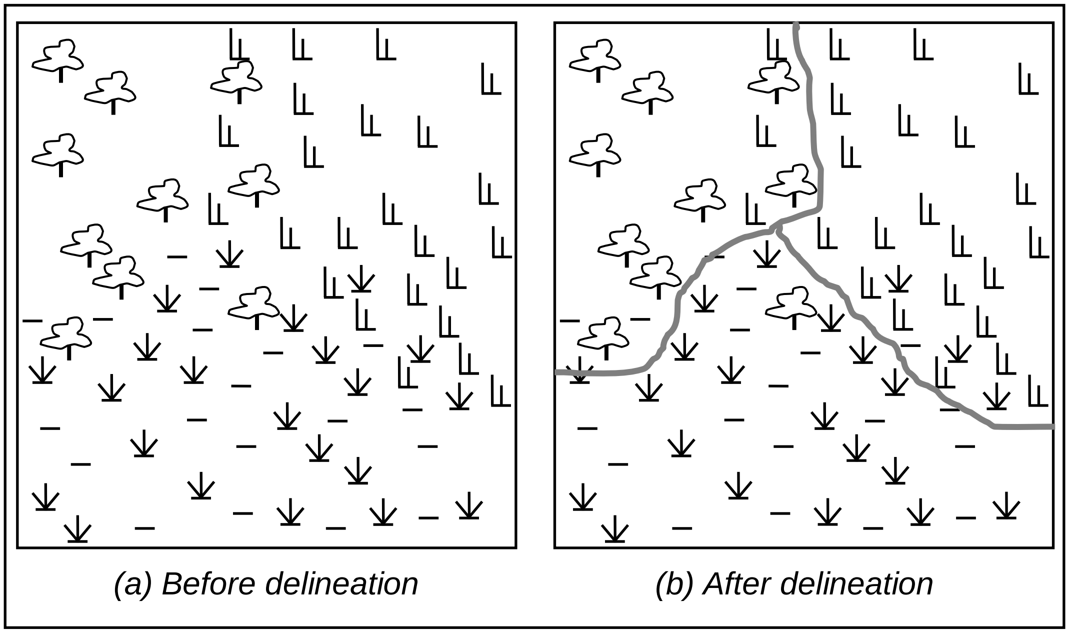

Fig. 2 Delineation of vegetation types on a map

3.2.3 Enumeration

This refers to listing or counting of discrete items visible on a map. For example, on a large scale map showing a portion of a city we can count or take a census of the number of individual houses, boreholes, bus stops, or petrol stations in the area.

3.2.4 Measurement

This refers to the physical quantitative measurement of certain variables such as length (distance), height, volume, perimeter and area. For instance, on a topographic map, we can measure and calculate the distance between two places, the height of the peak of a hill or mountain, or the area of a lake.

4. Conclusion

Unless maps are analyzed one will not be able to derive the information they contain. Map analysis entails having basic understanding of the concepts, procedures and considerations in analyzing mapped data. Some measure of technical skill is required to properly analyze a map and extract useful information from it. Before embarking on the analysis of any map, one must sure of what information one is looking for and that such information could be obtained from the map.

5. Summary

A map contains some information about certain geographical features. Map analysis involves studying and extracting information from a map. This demands reading and interpreting the signs and symbols on the map. Map analysis could be simple or complex. The information could be obtained "by eye", that is through direct observation, by merely looking at the map. On the other hand, the information on a map could be extracted by taking some scientific measurements and doing certain mathematical calculations. By and large, a map analysis exercise may require undertaking a number of tasks such as classification of features, delineation of polygonal features, feature enumeration, and measurement of some parameters of a feature(s).

6. References/Further Reading

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MODULE 2

BASIC CONCEPTS AND ELEMENTS OF MAP ANALYSIS

Module 2

Unit 1: The Concept of Geographical features/data

1. Introduction

Basically, map analysis involves a critical examination of the data/information presented on a map. The map data represent geographical features. Hence, it is important that the map analyst understands the concept of geographical features and geographical data. Also important is knowledge of the possible sources of data for map making. In this Unit, therefore, we will look at map or geographical features/data as well as the sources of such data.

2. Objectives

1. To identify the different types of geographical features and data.
2. To identify the various sources of data for map making.

3. Main Body

3.1 Types of Geographical Features/Data

Maps are produced using geographical or spatial data. The data give us locational and other useful information about the geographical features represented on the map. With respect to their geometric dimensions, geographical features are generally categorized as point, line, or area (polygon). Similarly, geographical data could be point, line or polygon. These geometric descriptions are the basic data elements of a map. Each of the geographical feature/data type is discussed below.

3.1.1. Points:

They are represented as a single ‘dot’ on the map (Fig. 3).

- Points are used to indicate discrete locations.
- They have no length or area at the given scale.
- They usually have a single X, Y coordinate.
- Used to represent a feature that is too small to be displayed as a line or area.

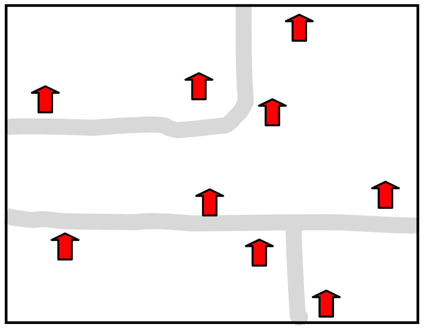

Fig. 3 An example of Point features

3.1.2. Arcs / Lines:

Arcs are ordered sets of Points that have the look of a straight line or a curved arc depending upon the feature it describes (Fig. 4).

- They are considered to have a length but no width.
- They are accompanied by a set of coordinates.
- They are used to represent a geographical feature that is too narrow to have area, such as a stream or a road.

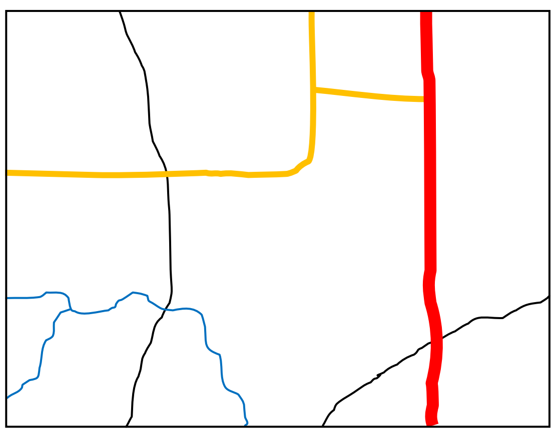

Fig. 4 An example of Lines

3.1.2. Polygons/Areas

They are closed features whose boundary encloses a homogenous area (Fig. 5).

- They have an area that is given by the arcs/lines that make the boundary.
- They are used to represent features that have area (e.g. lakes, large cities and islands)

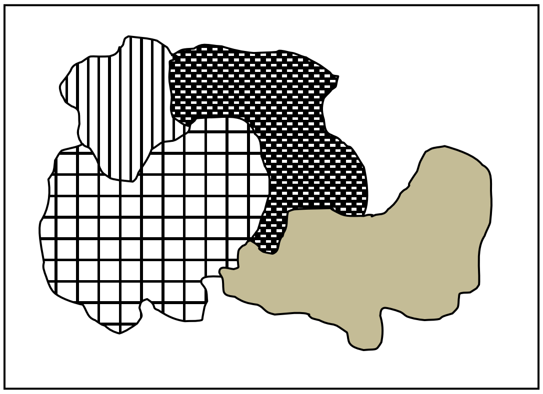

Fig. 5 An example of Polygons

3.2 Sources of Data for Map Making

There are various sources of data for map making. The sources, however could be grouped into two broad categories namely *primary sources* (hence primary data), and *secondary sources* (hence secondary data). Primary data are original data collected and used for the first time by the person using the data. On the other hand, secondary data is already existing data which was collected and used previously.

The major primary and secondary sources of data for map making include:

- Traveller's Note (e.g. data collected during a field trip or excursion).
- Existing maps
- Aerial photographs
- Satellite images
- Land survey
- Questionnaire survey
- Official Statistical records
- Field observation
- Global Positioning System (GPS)
- Digital environmental information files

4. Conclusion

Proper categorization of geographical features/data is very crucial to effective and efficient map analysis. As we will see later, there are variations in the way point, line and polygonal features represented on maps and analyzed. In the same vein, there are different sources from which we can get our data for map making. Knowing the source of data used in making a map helps us to assess the level of integrity and reliability of that map.

5. Summary

There are various types of geographical features which can be mapped. For convenience sake, however, the features are classified as point, line, or area (polygon). Data relating to geographical features are usually used to represent them on a map. In line with the classes of geographical features we have point data, line data, and polygonal (area) data. The data can be collected from primary or secondary sources. Primary data is data originally collected by the user and which has never been used before. On the other hand, secondary data is an already existing data, which has been used before for one purpose or the other. The idea of categorizing geographical data into point, line or area, as well as having knowledge of data sources, are all important to our understanding and analyzing of maps.

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Unit 2: The Concept of Map symbols

1. Introduction

Maps are usually drawn using graphic or visual symbols. In other words, when we draw a map we are simply symbolizing the various geographical phenomena shown on the map. When we engage in map reading and analysis we are only trying to decode the symbols in order to understand their meanings and, hence, the information they bear and convey. There are different kinds of map symbols. It is important that we know the symbols and how they are used on maps. Understanding map symbols and their meanings helps us to properly interpret maps and derive the information being communicated through the maps.

2. Objectives

1. To understand the meaning of map symbols
2. To identify the various types of map symbol

3. Main Body

3.1 What is map symbol?

Every map is drawn using a set of symbols. A map symbol is any graphic or visual sign or mark used on a map to represent and communicate information about a geographical feature. The symbols are used to code or set data and present it in form of a diagram or illustration. Symbols are part of the sign language of the map. The symbols used on a map are usually defined in the map's legend or key.

3.2 Types of Map symbol

There are different types of symbols that can be used to produce a map. However, using dimension as a parameter we can conveniently group the different symbols into three broad categories namely point symbols, line symbols and area symbols. Notice that this grouping is also in line with our grouping of geographical features into point features, line features and area features in Unit 1 above. Nonetheless, we also have conventional symbols, pictorial symbols, and literal or textual symbols.

3.2.1 Point symbols

Point symbols are used to map point or zero-dimensional features. On the map point symbols are shown as individual discrete dots existing at single spots or locations. The dots, however, are not always circular. In other words, point symbols could be of various shapes and sizes too (Fig. 6(a)). More so, a point symbol can be used to represent a qualitative value or a quantitative value. As shown in Fig. 6(a), when used as a qualitative symbol, a point symbol simply shows us where individual features are located. For example, a symbol showing a building, settlement, petrol station, trigonometric station, spot height or benchmark. On the other hand, if used as a quantitative symbol it indicates the quantity or amount of the feature it represents. For instance, as illustrated in Fig. 6(b), one dot can be used to represent 5000 people in a dot map showing the distribution of human population in a region(s).

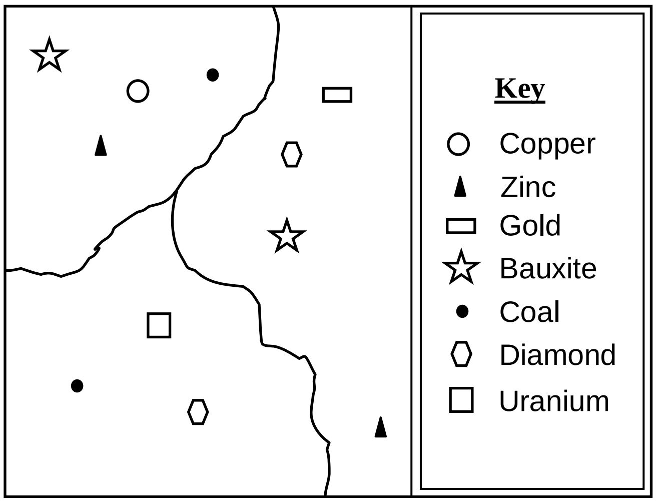
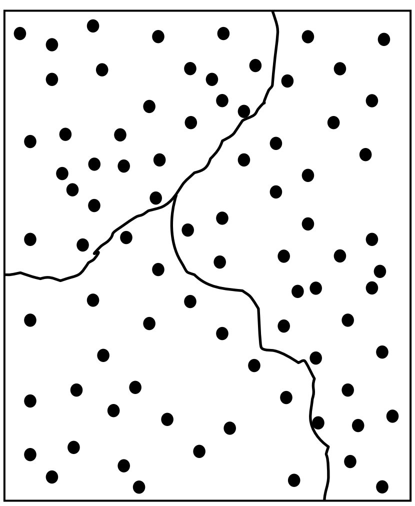


Fig. 6(a) Point symbols (qualitative)



1 dot represents 5000 people

Fig. 6(b) Point symbol (quantitative)

3.2.2 Line Symbols

Line symbols are used to represent one-dimensional or linear features such as roads, rivers, railways, pipelines, and power or telecommunication cables. Like point symbols, some line symbols (e.g. ones showing rivers or roads) are used to show qualitative values (Fig. 7(a)), while some (e.g. contour lines) are used to show quantitative values (Fig. 7(b)). Line symbols (e.g. flow maps) can also be used to show the movement or flow of people, goods, energy, animals etc. from one location to another. Line symbols that show movement can indicate both the direction of the movement and the quantity involved in the movement (Fig. 7(c)). There are different patterns of line symbols.

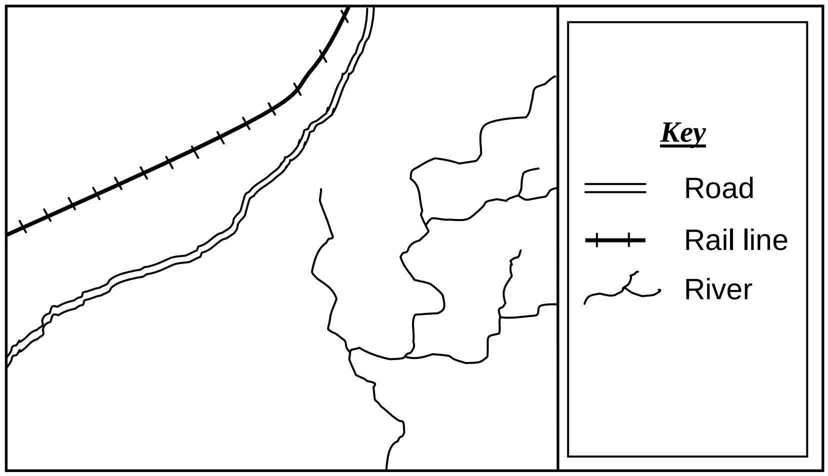


Fig. 7(a) Line symbols showing different types of linear features

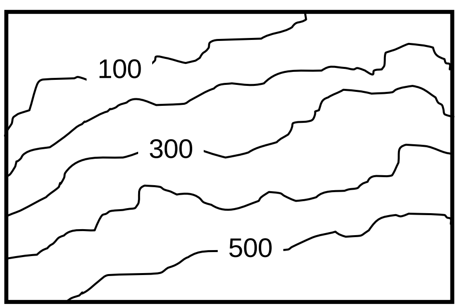


Fig. 7(b) Quantitative line symbol (contour lines)

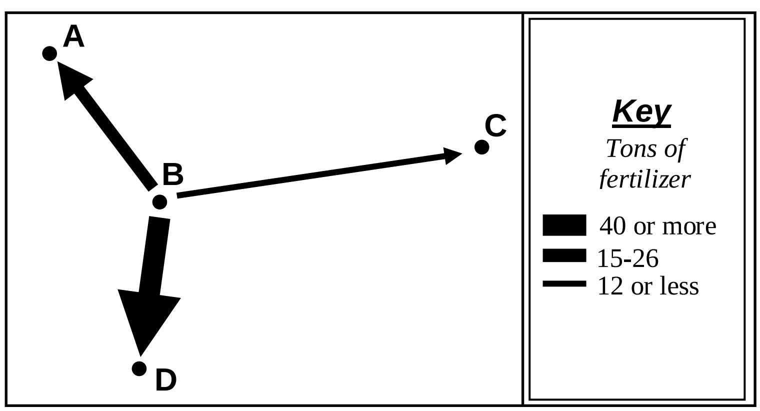


Fig. 7(c) Line symbol (flowline) showing the direction and volume of fertilizer moved from one place to another

3.2.3 Area Symbols

Area (or areal) symbols are used to map two-dimensional or polygonal features; that is, features that significantly cover a wide area of land. Examples of areal features include lakes, lagoons, farmlands, school compounds, state, country, and so on. There are qualitative area symbols as well as quantitative area symbols. Fig. 8(a) shows different land use types in a place; the area symbols used here are qualitative. On the other hand, Fig. 8(b) is composed of quantitative area symbols showing the distribution of population density. The area symbol can also be in form of a colour or pattern.

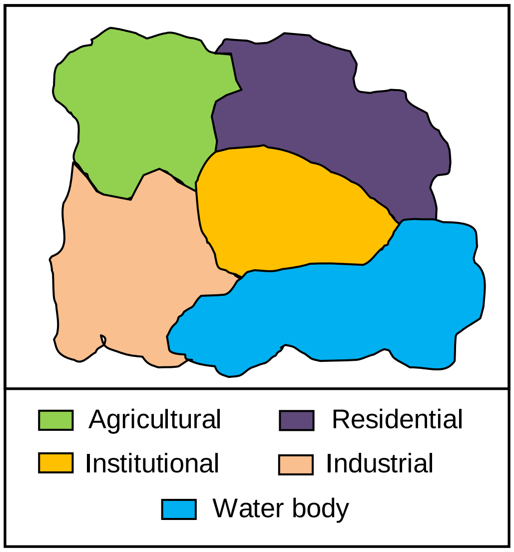


Fig. 8(a) Qualitative Area symbols showing land use types

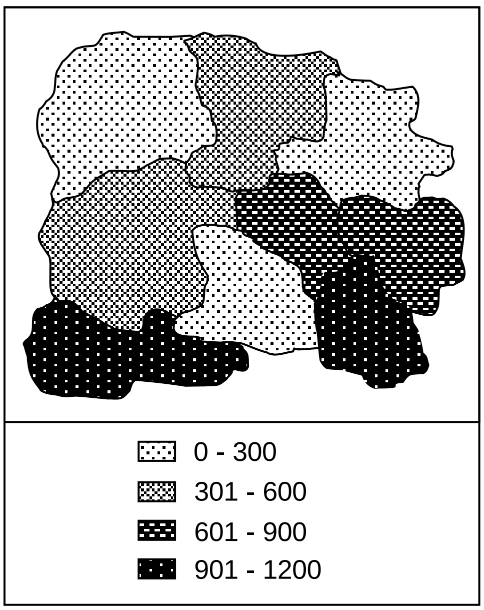


Fig. 8(b) Quantitative Area symbols showing distribution of population density

3.2.4 Conventional Symbols

These are commonly recognized and used map symbols. Some examples are shown in Fig. 9.

3.2.5 Literal or Textual Symbols

These are symbols that are derived from the abbreviation of some words; hence they are in form of texts or letters. They are used to indicate the locations of the features they represent. Some examples are (see also Fig. 9):

Sch = School
Mkt = Market
Ch = Church
RH = Rest House
PO = Post Office
Hosp = Hospital

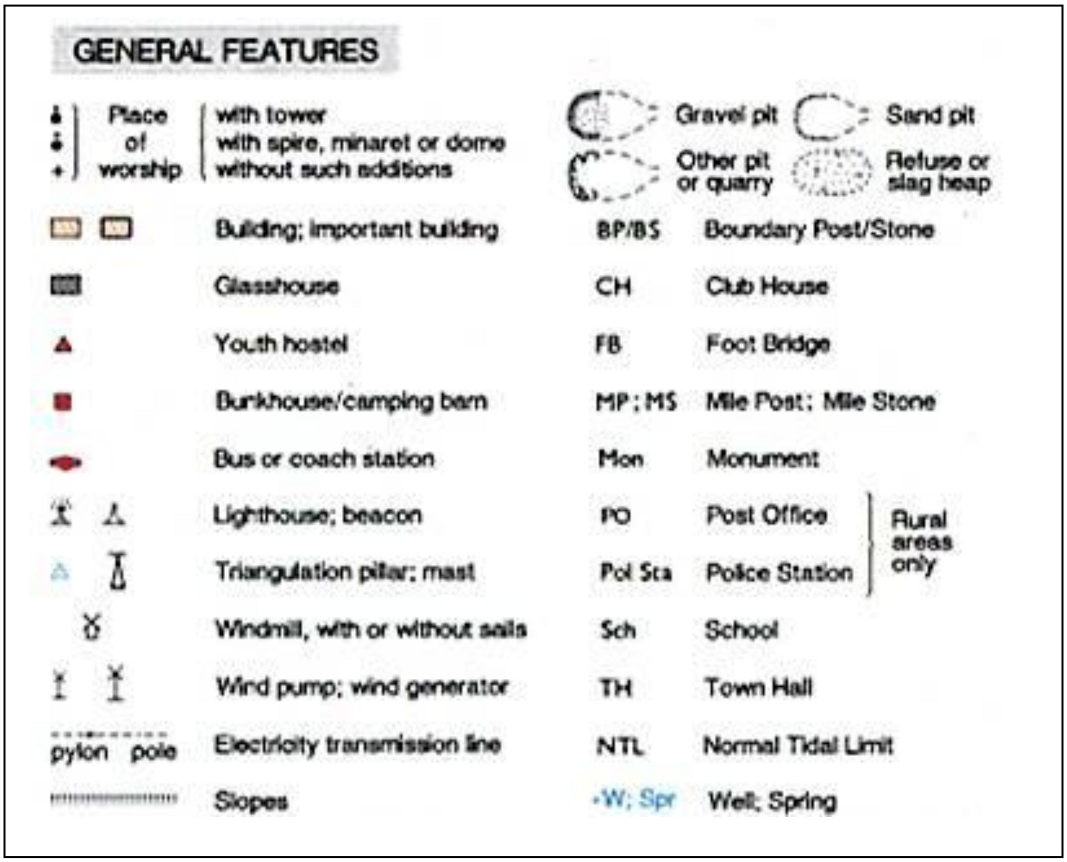


Fig. 9 Some conventional and literal map symbols

3.2.6 Pictorial Symbols

These are symbols that look very similar to what they represent; they are like a picture or diagrammatic illustration of the feature they stand for (Fig. 10). Such symbols are very easy to understand even without the aid of a legend or key. Hence, pictorial symbols are mostly used in producing maps for children and non-literate adults.

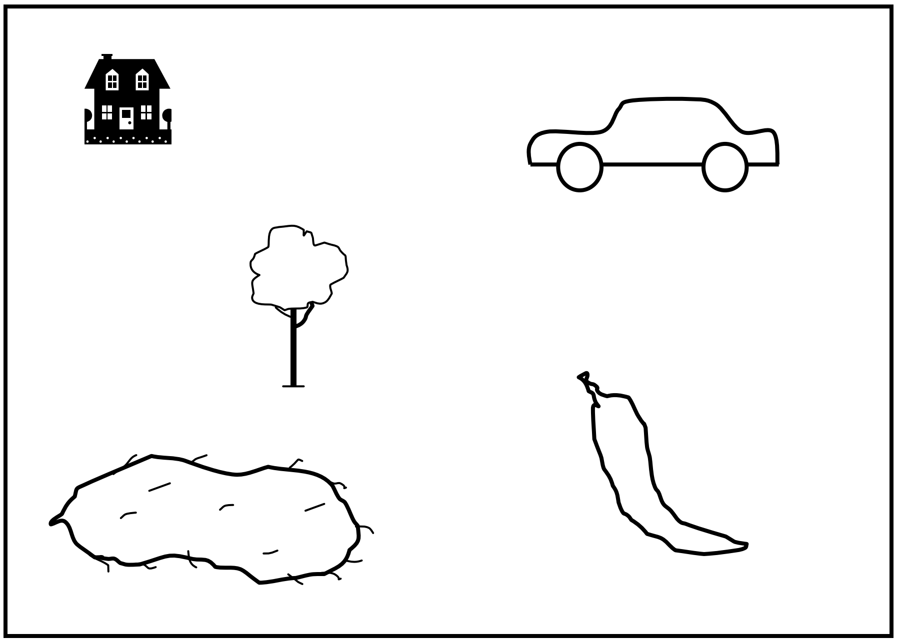


Fig. 10 Some Pictorial Symbols

4. Conclusion

Every map is symbolized. Symbols are the language of the map maker. Hence, to properly read or analyze a map requires learning and understanding the symbols used to make the map. There are various types of map symbol. Some of the symbols are used to represent and communicate qualitative values while some are used to convey quantitative information.

5. Summary

Map symbols are used to encode and communicate geographical information. There are different kinds of symbols at the disposal of the map maker. We have point symbols, which are used to represent point features; line symbols for portraying linear features; and area symbols for mapping areal features. We also have conventional symbols, pictorial symbols and textual or literal symbols. A map may be produced using a combination of different categories of symbols. It is always good to provide a legend or key that explains what each symbol on a map represents.

6. References/Further Reading

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Unit 3: The Concept of Scale

1. Introduction

Scale is one of the most important elements of a map. Any map without a scale is incomplete. The scale controls not only how features are shown, but what features are shown on a map. In this lesson we will learn about the meaning, types and sizes of map scale as well as how to convert from one scale type to another.

2. Objectives

1. To understand the meaning of scale.
2. To identify the different types of map scale.
3. To recognize the different sizes of scale.
4. To learn how to convert from one form of scale to another.

3. Main Body

3.1 What is scale?

The scale of a map is the ratio between distances on the map and corresponding distances in the real world. In other words, map scale tells the relationship between a distance measured between two points on the map and the actual distance between them on the ground. The scale of a map shows how much how much the given area has been reduced to paper size, and hence how much you would have to enlarge your map to get the actual size of the piece of land shown on the map. For instance, if a map has a scale of 1:50,000, then 1 cm on the map equals 50,000 cm or 0.5 km on the Earth's surface.

The Map Scale tells the user how the map relates to the real world features it represents. To show a portion of the Earth's surface on a map, the scale must be sufficiently adjusted to cover the objective. The extent of reduction is expressed as a ratio. The unit on the left indicates distance on the map and the number on the right indicates distance on the ground.

Maps are made at different scales for different purposes. The scale controls not only how features are shown, but what features are shown on a map. For instance, a 1:2,500 map will show individual houses and lamp posts while a 1:100,000, which is a much smaller scale will not show such features.

3.2 Types of Map Scale

A map scale can be expressed in three different ways namely representative fraction (RF), statement, and linear. Each of them is discussed below.

(i) A **ratio or representative fraction (RF)** indicates how many units on the earth's surface are equal to one unit on the map. It can be expressed as 1/100,000 or 1:100,000. In this example, one centimeter on the map equals 100,000 centimeters (1 kilometer) on the earth. It also means that one inch on the map is equal to 100,000 inches on the land. Other common RFs include 1:63,360 (1 inch to 1 mile) and 1:1,000,000 (1 cm to 10 km). The numerator of a Representative Fraction is always 1. More so, it should be noted that in RF the number on the left hand side (i.e. 1) is the distance or length on map while the figure on the right hand (e.g. 50,000, which is also the denominator) is the corresponding or equivalent length or distance on ground. So the RF 1:10,000 means 1 centimetre on the map represents 10,000 centimetres on the ground (or 1in on the map represents 10,000 inches on the ground).

(ii) A **word statement** gives a written description of scale, such as "One centimeter equals one kilometer" or "One centimeter equals ten kilometers." Here, the first map would show much more detail than the second because one centimeter on the first map covers a much smaller area than on the second map.

It shouls be noted that the two methods mentioned above for indicating scale would be ineffective if the map is reproduced by a method such as photocopying and the size of the map is modified. If this occurs, and one attempts to measure one centimetre on the modified map, it won't be the same as one centimetre on the original map. This can, however, be taken care of by using a linear or graphic scale.

(iii) **Linear scale** (also known as graphic scale or bar scale – Fig. 11) would be able to solve this problem as it is simply a line marked with distance on the ground which the map user can use along with a ruler to determine scale on the map. As long as the size of the graphic scale is changed along with the map, it will be accurate.
As shown in Fig. 11 a linear scale is often made up of two component parts namely the *primary subdivisions* and the *secondary subdivisions*. The 'primaries' are on the right hand side of the zero while the 'secondaries' are on the left hand side. While the primaries are subdivided into kilometers (or miles), the secondaries are subdivided into smaller units such as metres (or furlongs).

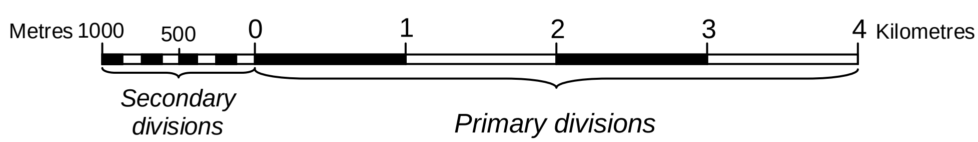

Fig. 11 Linear scale

3.3 Sizes of scale

There are three broad categories into which map scales can be grouped. These are small scale, medium scale, and large scale. As a general rule, the higher the denominator the smaller the scale and vice versa.

(a) ***Small-Scale*** maps have scales of about 1:1,000,000 and smaller such as 1:2,000,000;

1:6,000,000; 1:30,000,000 and are used for maps of wide areas. Such maps are used when much detail is not required.

(b) ***Medium-Scale*** maps have scales of 1:50,000; 1: 75,000; 1:100,000 to 1 : 1,000,000 and are used for maps of medium sized areas.

(c) ***Large-Scale*** maps have scales larger than 1:50,000 e.g. 1:1000; 1:2,500; 1:5000; 1:10,000 and are used when we want to represent higher levels of detail.

It should be noted that a large scale map shows small features and great detail. On the other hand, a small scale map shows only large features. Simply put, a 'large-scale' map gives a larger and more detailed representation of a feature than does a 'small-scale' map. In other words, the smaller the scale the greater is the area which can be shown on a map of given size, but on the other hand we are able to show less and less details. A large-scale map covers a small area but shows more details while a small-scale map covers a large geographical area but gives less detail.

3.4 Conversion from one scale type to another

In map reading, one can convert from one scale type to another. For instance, we can convert from statement scale to Representative Fraction (R.F.) and vice versa or from linear scale to statement or RF, and so on.

Examples:

i) *Conversion from R.F. to statement scale*

Examples:

Convert the following R.F. scales to statement scale: (a) 1:1000; (b) 1:20,000; (c) 1:150,000

Solutions:

NB: 100cm =1m; 100,000cm = 1km

(a) 1:1000

The R.F. means 1cm represents 1000cm.

1000cm is equal to 10 metres, that is $\frac{1000}{100}$ *or* 0.01km that is $\frac{1000}{100000}$

Therefore, the statement scale is 1cm represents 10 metres or 0.01km.

(b) 1:20,000

The R.F. means 1cm represents 20,000cm.

20,000cm = $^1/_5$ or 0.2km, that is $\frac{20,000}{100,000}$

Therefore, the statement scale is 1cm represents 0.2km or 5cm represent 1km.

(c) 1:150,000

The R.F. means 1cm represents 150,000cm.

150,000 = 1.5km, that is $\frac{150,000}{100,000}$

Therefore, the statement scale is 1cm represents 1.5km or 2cm represents 3km.

ii) *Conversion from statement scale to R.F.*

Examples:

Convert the following statement scales to Representative Fraction:

(a) 1cm to ½ km (b) 4cm to 1km

Solutions:

(a) 1cm to ½ km

The statement scale means 1cm represents ½ or 0.5km.

Convert to the same unit of measurement.

1km = 100,000cm

½km = $\frac{100,000}{2}$ = 50,000cm

Therefore, the R.F. is $\frac{1}{50,000}$ or 1:50,000

(b) 4cm to 1km

Convert to the same unit of measurement.

1km = 100,000cm

The statement scale means 4cm represent 100,000cm

If 4cm represent 100,000cm,

1cm will represent $\frac{100,000}{4}$ = 25,000cm

Therefore the R.F. is $\frac{1}{25000}$ *or* 1:25,000

iii) *Conversion from Linear scale to statement scale*

Example:

Convert the linear scale in Fig 12a to statement scale

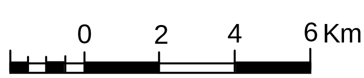

Fig. 12a Linear scale

Solution:

Using your ruler, carefully measure the length of a line segment in the primary divisions of the linear scale, for example from 0 to 1 in Fig. LINa. In this example the line segment measures 1cm. (Note: in some other cases, it could be less than 1cm or, as in the example below, more than 1cm). This measurement represents the distance on the map. Since the distance on the map from 0 to 1 in Fig. LINa is 1cm, which represents 2km on the ground as indicated in the figure, hence the statement scale is 1cm to 2km.

iv) Conversion from Linear scale to R.F.

Example:
Convert the linear scale in Fig. 12b to R.F.

Fig. 12b Linear scale

Solution:

Using your ruler, carefully measure the length of a line segment in the primary divisions of the linear scale, for example from 0 to 1 in Fig. LINb. The line segment in this example measures 2cm. This measurement represents the distance on the map. Since the distance on the map from 0 to 1 in Fig. LINb is 2cm, which represent 1km on the ground as indicated in the figure, therefore the R.F. scale is worked out as follows:

2cm = 1km or 100,000cm

Therefore 1cm = $\frac{100{,}000}{2} = 50{,}000$

The R.F. is 1:50,000.

4. Conclusion

Scale is an important component of any map. Without a scale a map could be considered to be a mere sketch. The scale enables us to relate map distance to the equivalent distance on ground. The scale gives us an idea of by how much reality has been reduced to paper (map) size and, hence, by how much we need to enlarge the map to get back to the original size of the reality represented on the map. In analyzing a map we need to make use of the map scale whenever necessary. In fact, without the scale it will be impossible to accurately measure and determine the actual value of certain parameters such as distances, dimensions and quantitative magnitudes of features on the map.

5. Summary

Every good map has a scale. The scale of a map could be indicated in about three ways namely Representative Fraction (RF), Word of Statement, or Graphical (also Bar or Linear) scale. On a map, it is often better to express the scale in all the three ways, or at least two. This makes for easy understanding of the scale. But where the scale is indicated using only one of the three methods, it is still possible to convert it to any of the other two methods. For instance, we can convert from RF to Statement or Bar scale, from Bar scale to RF or Statement, from Statement to Bar scale or RF, and so on.

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Unit 4: The Concept of Map Projection

1. Introduction

Maps are actually projections of a part of or the entire Earth. For quite some time it was thought that our planet was flat, and during those days, a map simply was a miniature representation of a part of the world. Now that we know that the Earth's surface is curved in a specific way, we know that a map is in fact a flattened representation of some part of the planet. The field of map projections concerns itself with the ways of translating the curved surface of the Earth into a flat map.

2. Objectives

1. To examine the concept of map projection.
2. To identify the elements and classes of map projection

3. Main Body

3.1 What is map projection?

The Earth's surface is curved but as it must be shown on a flat sheet. A projection is a method by which the curved surface of the earth is represented on a flat surface. It involves the use of mathematical transformations between the location of places on the earth and their projected locations on the plane (flat surface e.g. paper). A ***map projection*** is a mathematically described technique of how to represent the Earth's curved surface on a flat map. In other words, it is the mathematical process of transforming the spherical earth into a flat earth (Fig. 13). It is also the representation of parts of the surface of the Earth on a flat paper map or on a computer screen. Every map we see on paper has been projected; it is the projected version of the spherical earth.

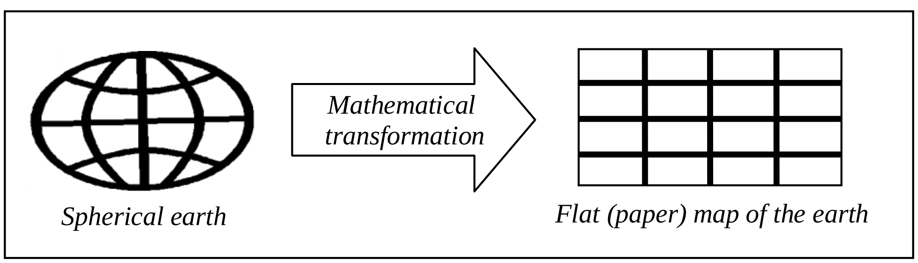

Fig. 13 Map projection

3.2 Classification of map projections

There are several types of map projections, as well as several methods used to achieve these projections. Basically, however, there are three classes of map projections; they are ***cylindrical***, ***conical*** and ***azimuthal*** (Fig. 14**).** The Earth's reference surface projected on a map wrapped around the globe as a cylinder produces a cylindrical map projection. Projected on a map formed into a cone gives a conical map projection. When projected directly onto the mapping plane it produces an azimuthal (or **zenithal** or planar) map projection. Fig. 14 below shows the surfaces involved in these three classes of projections.

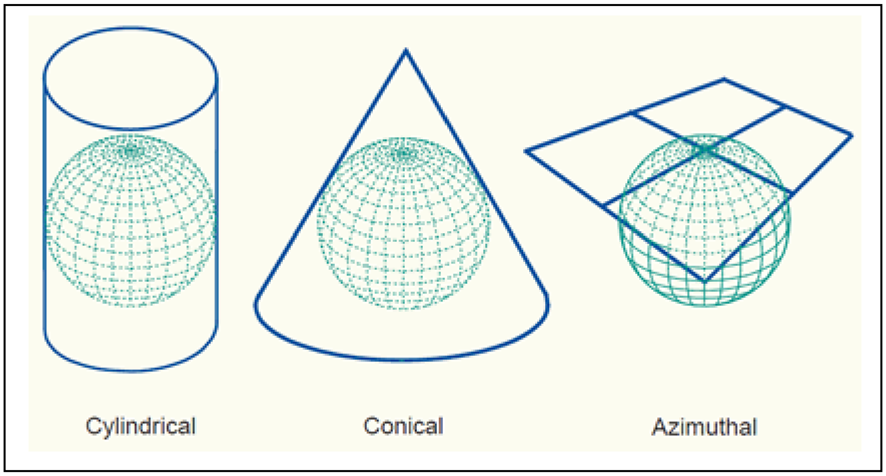

Fig. 14 The three classes of map projections: cylindrical, conical and azimuthal. The projection planes are respectively a cylinder, cone and plane. (kartoweb.itc.nl).

Distortions

A map projection without distortions would correctly represent shapes, angles, areas, distances and directions, everywhere on the map. Unfortunately, any map projection is associated with scale distortions. There is simply no way to flatten out a piece of ellipsoidal or spherical surface without stretching some parts of the surface more than others. The amount and which kind of distortions a map will have depends largely - next to size of the area being mapped - on the type of the map projection that has been selected.

Projections can be identified by the distortions which they avoid - in general a projection can belong to only one of these classes:

- ***Equal area or Equivalent projections*** preserve the area of features by assigning them an area on the map which is proportional to their area on the earth - these are useful for applications which require measuring area.
- ***Conformal projections*** preserve the shape of small features, and show directions (bearings) correctly - they are useful for navigation.
- ***Equidistant projections*** preserve distances to places from one or two points.

There are several types of map projections, as well as several methods used to achieve these projections. Each projection is most accurate at its center point and becomes more distorted the further away from the center that it gets. The projections are generally named after either the person who first used it, the method used to produce it, or a combination of the two. Some common types of map projections include:

- Mercator
- Transverse Mercator
- Robinson
- Lambert Azimuthal Equal Area
- Miller Cylindrical
- Sinusoidal Equal Area
- Orthographic
- Stereographic
- Gnomonic
- Albers Equal Area Conic

4. Conclusion

Basically, map projection is a mathematical process used to transform the curved surface of the Earth into a flat surface. Every map is based on a particular projection.

5. Summary

Map projection has to do with showing the curved surface of the Earth on a plane or flat sheet. It involves using mathematical transformations between the locations of places on the Earth and their projected locations on the flat map. This transformation from one shape (spherical) to another (plane) always leads to some form of distortions. Generally, the distortion is usually least when the map shows just a small area, and greatest when a map shows the entire surface of the Earth. There are three properties of the Earth's surface that can be distorted during the process of projection. These are area, shape and distance (length). A map projection can only preserve one or two of these properties but not all three. Hence, projections are identified by the particular property they preserve (that is the one they did not distort). We therefore have equal area projections (which preserve the area features); conformal projections (which preserve shape of small features and also show directions or bearings correctly); and equidistant projections (which preserve distances to places from one or more points). In terms of methods or techniques used in producing them and hence their physical appearances, map projections can be classified into three namely cylindrical, conical and azimuthal. Several map projections have been invented, but none of them is yet considered to be the best. The choice of which projection to adopt in making a map depends on the main objective of the map.

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Unit 5: Coordinates, Directions and Bearings

1. Introduction

Maps are usually produced based on certain coordinate systems that enable us to accurately determine the locations of features. Maps can also give us information on the directions or angular bearing of features relative to any other features. Therefore, coordinates are important items on maps. In this Unit we will look at the various coordinate systems and also how to determine directions and bearings of features on a map.

2. Objectives

1. To understand the meaning of geographical coordinate systems.
2. To know the importance of coordinates.
3. To identify various coordinate systems.
4. To discuss compass directions.
5. To discuss bearings.

3. Main Body

3.1 Coordinate Systems

Locations and directions on maps are accurately determined using a coordinate system. The two types of coordinate systems commonly used are the ***geographical coordinate system*** and the ***rectangular or plane coordinate system***.

3.1.1 Geographical coordinates

We can identify locations as precise points on the Earth's surface by using a grid system of **latitude** and **longitude**. The method of giving a north and south direction (latitude) and an east and west direction (longitude) is used through the world. Latitude and longitude uses a coordinate system of intersecting lines that measures distances in degrees. This system helps us in measuring distances and finding directions or bearings between and among places on the Earth's surface. The starting point is the prime meridian, which represents 0º longitude. The exact opposite position at 180º is called the International Date Line, which is where the date actually changes.

Latitude

Latitude lines are parallel; they run east and west around the earth's surface and measure distances north and south from the Equator (Fig. 15). The parallels of latitude become increasingly shorter closer to the poles. On the globe the 60th parallel is only one half of that at the equator.

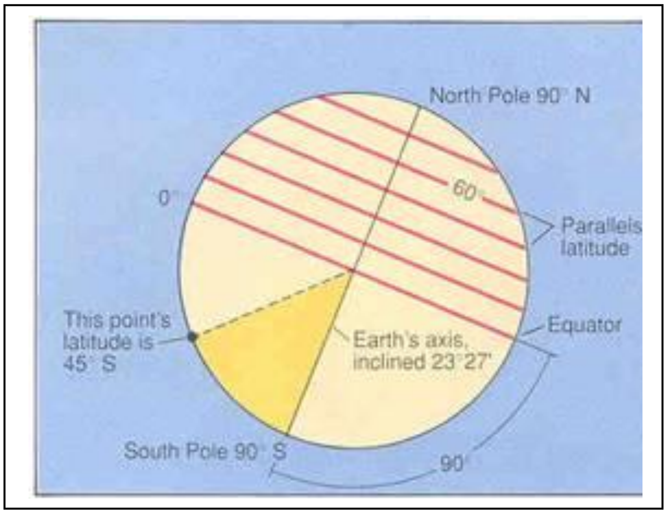

Fig. 15 Lines of latitude

Longitude

Longitude lines (Fig. 16) run north and south around the earth's surface; they intersect at the poles, and measure distance east and west from the Prime Meridian. Meridians of longitude are arbitrary but conventional lines and together with the parallels based upon the naturally given equator, constitute the globe grid. Since the meridians converge at the poles, the difference between the degrees of longitude becomes shorter as one moves away from the equator.

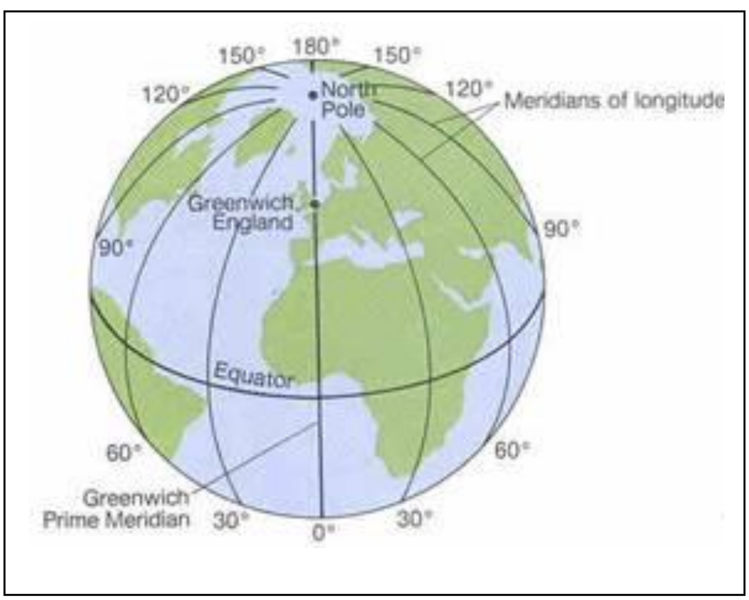

Fig. 16 Lines of longitude

3.1.2 Rectangular coordinates

The rectangular or plane coordinate system (also known as the grid reference system) is made up of square grids that are numbered (see Fig. 17). The grid lines help us to pinpoint an exact location anywhere on the map by giving a unique number known as a grid reference. In other words, the grid references help us to find the accurate positions or locations of places on a map. The vertical lines are called ***eastings***, since they increase in value as you travel east on the map. The horizontal lines are called ***northings***, since they increase in value as you travel north on the map.

We have the four-figure grid reference (e.g. 1326), six-figure grid reference (e.g. 137264), and so on. Grid references are easy to use in identifying the location of any place if you can remember that you always have to go along the corridor before you go up the stairs. In other words, to find the grid reference number of a place first use the eastings to go along the corridor until you come to the bottom left-hand corner of the square you want. Write this two-figure number down. Then use the northing to go up the stairs until you find the same corner. Put this two-figure number after your first one and you now have the four-figure grid reference. The easting is usually read before the northing. For instance, in Fig. 17 the grid number for location A is 1126; that of location B is 125270, location C is 135295 while location D is 142297.

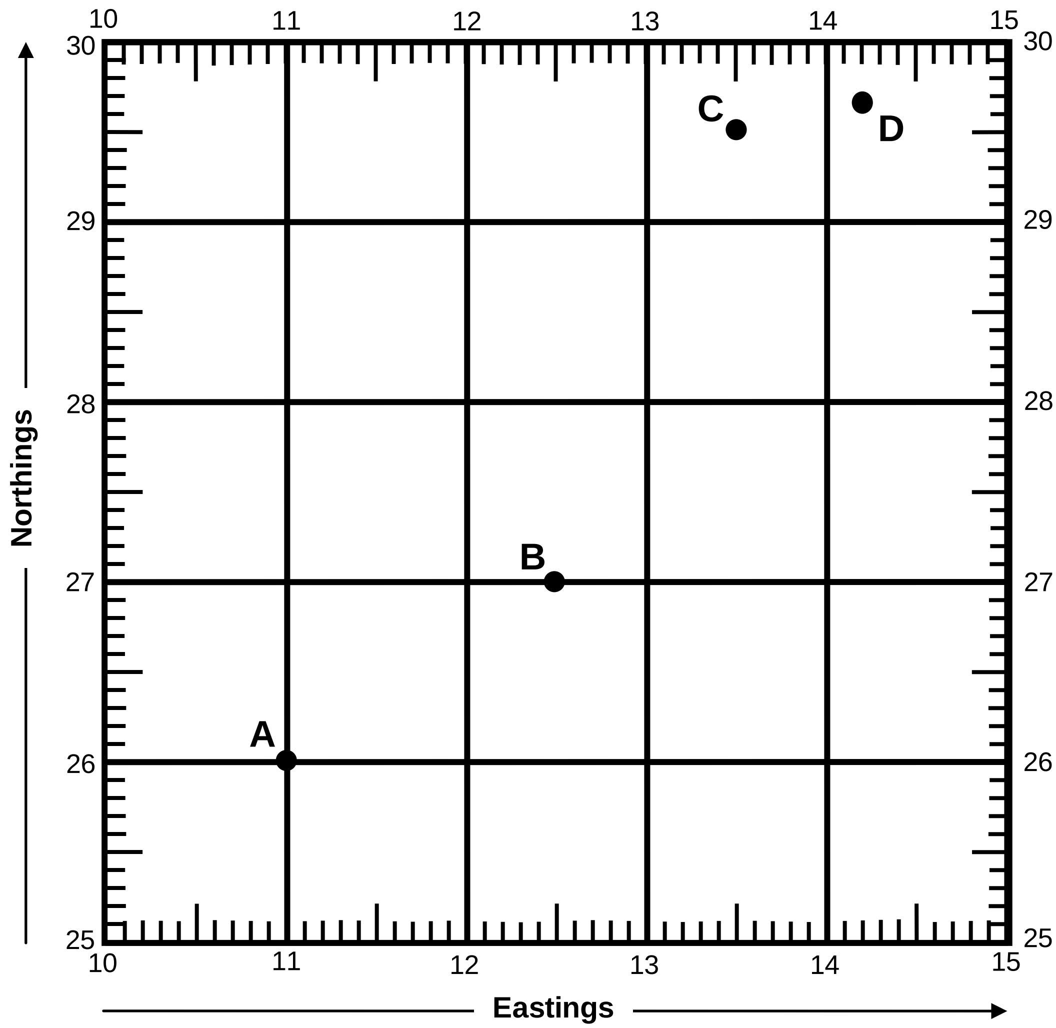

Fig. 17 The grid reference system

3.2 Directions

Directions are determined using the compass rose. As shown in Fig. 18, the compass is usually marked with cardinal points. The four major cardinal points are North, South, East and West. Intermediate points or subdivisions can be derived from these major cardinal points. For instance, we have North-East, South-East, South-West and North-West. These subdivisions can further be divided to obtain tertiary divisions such as North-North-East, East-North-East, East-South-East, and so on. In all, we have sixteen cardinal points or compass directions (Fig. 18).

Using the compass it is possible to tell the direction of a place or location from another place. As illustrated in Fig. 19 the direction of location A from location B is north-west. In other words, A is located north-west of B.

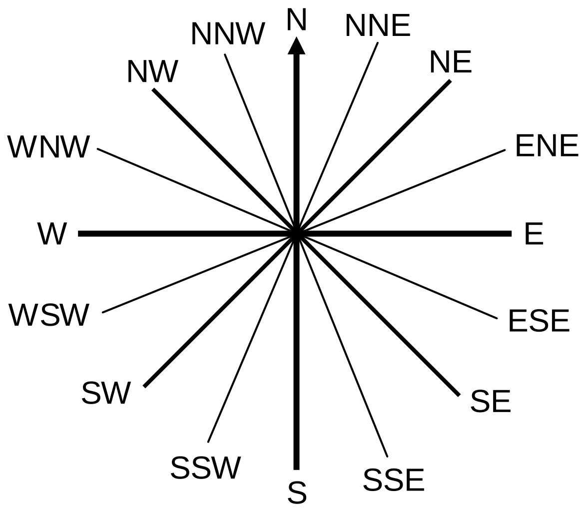

Fig. 18 Compass directions

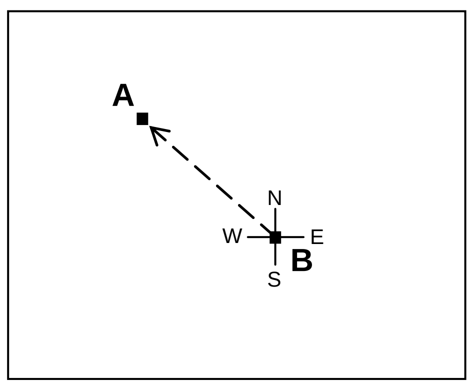

Fig. 19 Measurement of direction

3.3 Bearings

Bearings are directions measured in angles. They are very useful in more accurately determining the relative locations of places. Bearings are usually measured in degrees (0^o – 360^o) in a clockwise direction from the true north (see Fig. 20).

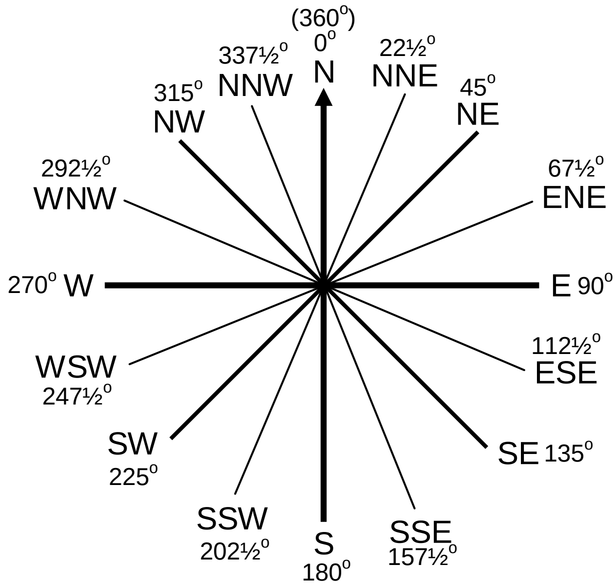

Fig. 20 Cardinal points and their bearings

On a map the angular bearing or direction of a place from another place can be measured using a protractor. The following steps can be taken to measure the bearing of a place ***from*** another place:

a) Identify the two places on the map.
b) Draw four-cardinal points on the location (point of observation) ***from*** which you are looking for the bearing of the other location.
c) Draw a straight line to join the centres of the two locations.
d) Measure the angular bearing using the protractor. To do this, place the centre of the protractor at the point where the north-south and east-west lines of the cardinal points intersect each other. Reading from 0^o in a clockwise direction, the degree which directly falls on the line joining the two places is the bearing of the location of the place we wish to determine its bearing from the other location.

Example:
Determine the bearing of location B ***from*** location A (Fig. 21). As shown in Fig. 21 the bearing of B from A is 157^o.

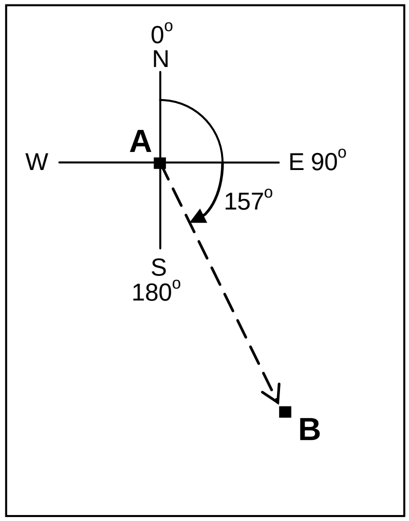

Fig. 21 Measuring bearing

4. Conclusion

Latitudes and longitudes as well as other geographical referencing systems are very useful in fixing the positions of features on a map. Without a coordinate system it will be difficult to establish the actual position of a feature. In the same vein, the cardinal points expressed using the compass rose guide us in establishing the geographical direction and angular bearings of features on the map. Thus without the coordinate system and the compass we will not be able to know our positions on the Earth's surface and we will get loss, not knowing our direction.

5. Summary

Coordinate systems such as geographical coordinates and rectangular coordinates are very useful in determining the accurate locations of features on the map. The coordinates are used to geographically reference the positions of features on the surface of the Earth. In other words, in map analysis coordinates are used to relate the position of a feature appearing on a map to its equivalent position on the Earth's surface.

Similarly, the direction or angular bearing of a feature relative to another feature can be established. The compass rose, which is one of the important components of a map, helps us in determining the direction or bearing of features with reference to other features.

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MODULE 3

MAP ANALYSIS AND INTERPRETATION

Module 3

Unit 1: Analysis of Settlements

1.0 Introduction

Human settlements are common features of topographical and some other basic maps. They are usually of different origin, shapes, sizes and functions. Settlement studies are important for planning, development and management purposes.

2.0 Objectives

1. To identify and classify different types of settlement.
2. To analyze settlement patterns.

3.0 Main Body

3.1 Types of Settlement

Settlement could be broadly classified as rural or urban.

Rural settlements

Rural settlements are usually smaller in size than urban settlements. More so, rural settlements are inhabited by relatively few people who are socially, culturally and linguistically homogenous. Such settlements could be dispersed, nucleated or linear in arrangement. Homesteads, hamlets and villages are examples of rural settlement types. Rural settlements are hardly planned; people build their houses wherever they pleased (Fig. 22).

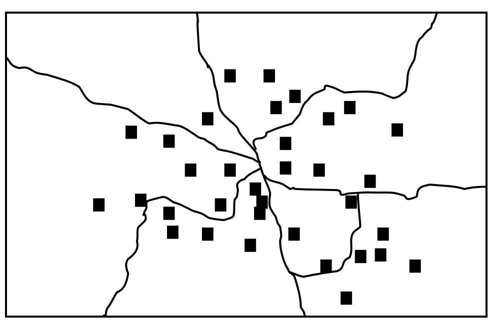

Fig. 22 A rural settlement

Urban settlements

Urban settlements are usually larger than rural settlements. They are known to be densely populated and are inhabited by people from different social, cultural and linguistic backgrounds. Most urban centres are the product of conscious planning; hence the roads, buildings and other infrastructure are often well laid out (Fig. 23). The settlement pattern of urban centres is commonly nucleated or linear. Examples of urban settlements are towns, cities, conurbations, metropolis, megalopolis, and megacities.

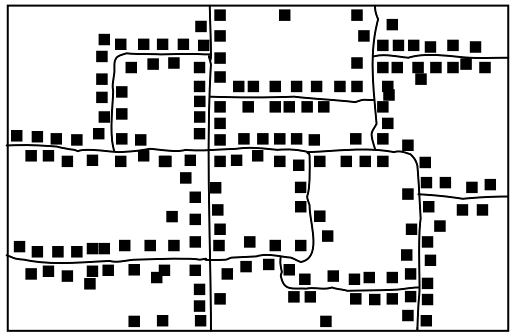

Fig. 23 A planned urban settlement

3.2 Settlement Patterns

Settlements could be of various patterns or shapes. Settlement pattern refers to the arrangement or layout of buildings in a settlement. There are four major settlement patterns namely dispersed, nucleated, linear, and homestead (or isolated).

Dispersed settlement pattern

The main characteristic of this settlement pattern is that the buildings are scattered and could be far from one another (Fig. 24).

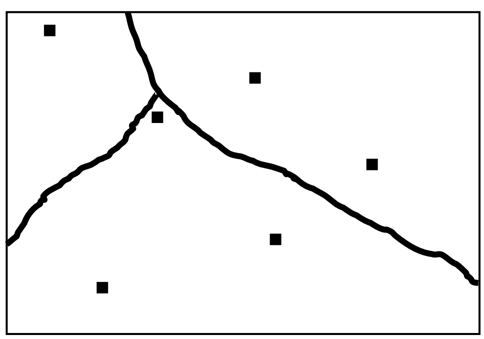

Fig. 24 Dispersed settlement pattern

Nucleated settlement pattern

This is more or less the opposite of dispersed settlement. In a nucleated settlement the buildings are clustered; hence they are very close to one another as shown in Fig. 25.

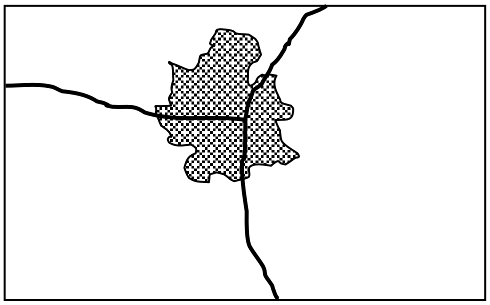

Fig. 25 Nucleated settlement pattern

Linear settlement pattern

In a linear settlement layout the buildings are located along transportation or communication routes such as roads, railways, and rivers (Fig. 26).

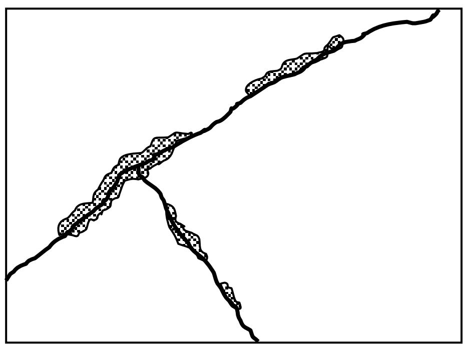

Fig. 26 Linear settlement pattern

Homestead

A homestead is an isolated one family residence. Each building is usually far from others. It could be a farmstead, mining camp, fishing hut, or lumbering camp (Fig. 27).

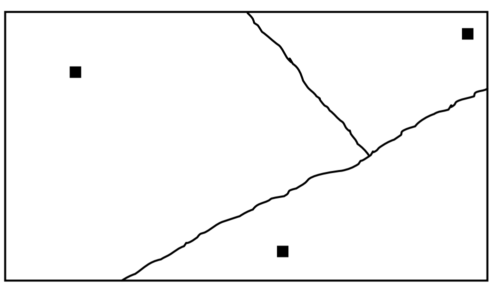

Fig. 27 A homestead settlement

4.0 Conclusion

Settlements are among the important cultural features commonly shown on maps, especially topographical maps, township maps and other basic maps. Map-based settlement analysis helps us to understand various aspects of settlements such as their types, size, spatial distribution, pattern of organization, shape, as well as historical development over time. The study of settlements is relevant for a number of reasons such as effective physical planning, resource allocation, economic development, security, provision of infrastructural facilities and social amenities, and so on.

5.0 Summary

There are different types of settlements. Some settlements are small while some are big. We have rural settlements as well as urban settlements. Rural settlements include homesteads, hamlets and villages. On the other hand, urban settlements include towns/cities, metropolis, megalopolis, megacities, and so on. In terms of their spatial distribution, settlements can be nucleated or dispersed. Nucleated settlements are mostly found in urban centres while dispersed centres are more common in rural areas. Settlements can also develop in an elongated or linear manner along line features such as roads, coastlines, or railways.

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Unit 2: Analysis of Point Features

1. Introduction

So many features appear on maps as dots. In this Unit we will focus attention on both qualitative and quantitative analyses of point features.

2. Objectives

1. To identify the various ways point features can be analyzed.
2. To illustrate, with examples, how point features are analyzed.

3. Main Body

3.1 Enumeration

Enumeration involves nominal counting of the number of individual or discrete point features on a map. Such discrete point features could be settlements, boreholes, wells, buildings, trees, animals in a wildlife park, and so on. Fig. 28 is a hypothetical map showing the distribution of boreholes and electricity transformers in four Wards of a Local Government Area (LGA). As the map shows Ward A has a total of six boreholes and three transformers; Ward B has four boreholes and three transformers, and so on.

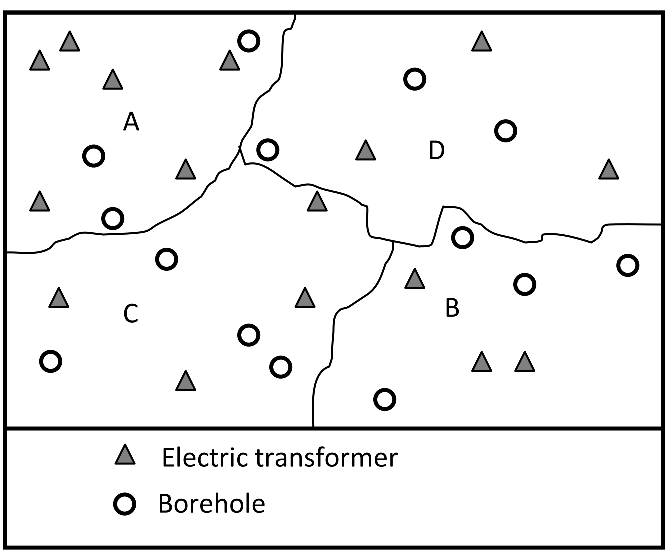

Fig. 28 Examples of point features

3.2 Calculating the density of a point feature distribution

Density is a measure of the level of compactness of a particular point feature distributed over a geographical space. In other words, density is a measure of the number or population of a feature per square kilometre. Therefore, density (D) is measured by the formula:

$$\mathbf{D} = \frac{\mathbf{P}}{\mathbf{A}}$$

Where:

D	=	Density
P	=	Population
A	=	Area

To measure the density of a point feature distributed over a given geographical space shown on a map, the steps to follow are:

1. Enumerate or count the number of the feature to obtain the population (P).
2. Using the scale of the map, calculate the area of the geographical space or region under consideration (Note: the answer should be in square kilometre (km^2)).
3. Apply the formula above to determine the density of the distribution.

Example:

Fig. 28 shows the distribution of churches in a locality. We can calculate the density of the churches by relating the number or population of the churches to the area or land mass of the locality. As can be easily ascertained from the map, there are twenty-seven (27) churches in the locality. Assuming the area of occupied by the locality is determined to be $3.68km^2$, we can calculate the density of the churches thus:

$$D = \frac{27}{3.68}$$

$$= \mathbf{7.34}$$

The density (D) is 7.34. What this means is that there are 7.34 churches within every one square kilometre in the locality.

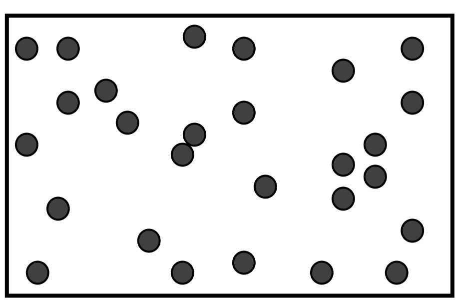

Fig. 28 Distribution of churches in a locality

3.3 Measurement of degree of clustering

The degree or level of clustering (or dispersion) of a point feature distribution can be determined. This can be achieved using either the Quadrat Analysis technique or the Nearest Neighbour Analysis technique. The nature of a point distribution can be described as aggregated, random or uniform. We will briefly consider the Nearest Neighbour Technique here.

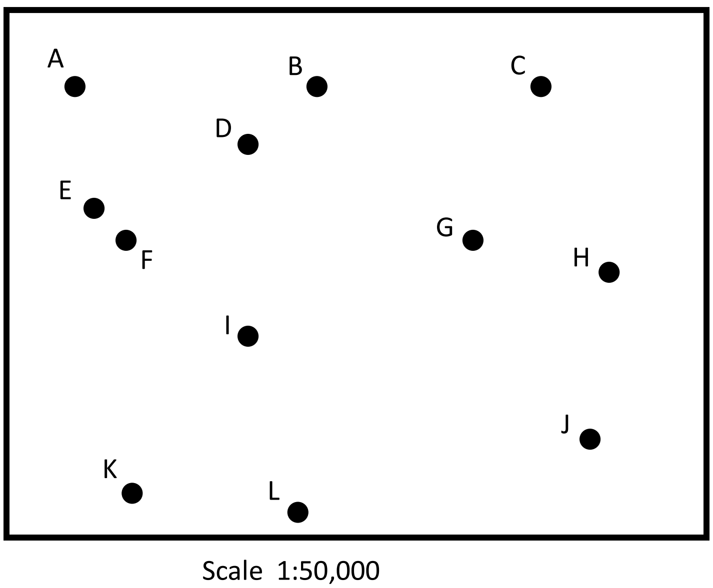

Fig. 29 Distribution of Senior Secondary schools in a locality

Consider the distribution of Senior Secondary schools in a locality as shown in Fig. 29. We can measure the degree of clustering of the schools using the Nearest Neighbour technique. The following steps are used:

1. On a straight line, measure the distance between a point (a school in this our example) and its nearest neighbour on the map. For instance, in Fig. 29 the nearest neighbour to point A is point E. (Note that in some cases two points within an area are located closer to one another than they are to any other point, in which case the same distance is measured twice. For instance in Fig. 29 points E and F are closer to each other than they are to any other point. Hence we will measure the distance EF and also the distance FE). The measurements are recorded in a table as shown in Table 1.
2. The distance measurements on map are usually in centimetres; they need to be converted to kilometres (or metres) using the map scale, to find the ground equivalent of each measurement. For instance, the distance from point A to its nearest neighbour E is 2cm.

Given the map scale of 1:50,000, the distance in kilometres between A and E will be (2 x 50,000)/100000, which gives us 1km. (See Table 1).

3. Find the area of the place within which the points are located. Again you have to measure the dimensions of the place on map and convert to square kilometres using the map scale. If the place is rectangular in shape (as in the present example), the formula for finding the area of a rectangle is used. On the other hand, if the place has an irregular shape, then any of the methods for calculating the area of an irregular shape can be used. (Please see Unit 4 below for a discussion on each of the methods for calculating the area of an irregular areal shape).
4. Having measured the distances between the points and also the area of the place, proceed to calculate the Nearest Neighbour index by using the following formula:

$$R = \frac{rA}{rE}$$

Where R = Near neighbour index (NB: this index ranges in value from 0 (aggregation) through 1 (random) to 2.15 (uniform)).

rA = observed mean distance.

rE = expected mean distance in a random distribution. $rE = \frac{1}{2}(p^{(-\frac{1}{2})})$, where p = the observed density of points in the place under consideration (i.e. density is number of points divided by area).

Table 1 Nearest neighbour distance measures

Distance	Length (cm)	Length (km)
AB	2.0	1.0
BD	1.2	0.6
CG	3.0	1.5
DB	1.2	0.6
EF	0.6	0.3
FE	0.6	0.3
GH	2.6	1.3
HG	2.6	1.3
IF	2.8	1.4
JH	3.0	1.5
KL	2.8	1.4
LK	2.8	1.4
	Total	**12.6**

Total number of points (schools) in the place is 12.

Area covered by the place on map is 9.1cm x 7cm. On ground this will be 4.55km x 3.5km, which is equal to 15.93km^2.

Observed mean distance (rA) = 12.6/12 = 1.05km.

Density of points (p) = 12/15.93 = 0.7533.

Expected mean distance (rE) $= \frac{1}{2}(0.7533^{-0.5})$
$= 0.5(1.1523)$
$= 0.5762$

Near Neighbour index (R) = rA/rE
= 1.05/0.5762
= 1.82.

Interpretation: the result (1.82) indicates that the distribution of schools in the place under consideration tends towards uniform.

4. Conclusion

Point features can be qualitatively or quantitatively analyzed. Whatever form of the analysis, however, the essence is to understand certain spatial aspects or dimensions of the point distribution.

5. Summary

A point feature is any recognizable individual feature that exists at a spot or single location. On maps, especially small scale maps, the locations of point features are indicated with dot symbols. Point features can be analyzed by counting how many they are within a given geographical area. For instance, we can count the number of boreholes in a community. We can equally calculate the density of a point distribution, whereby we determine the average number of such a feature per square unit of an area (e.g. number per square kilometre). Similarly we can also measure the level of clustering of a point distribution, that is, whether it is dispersed, aggregated, or uniformly distributed.

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Unit 3: Analysis of Linear Features

1. Introduction

Characteristically, line (or linear) features are generally considered to one-dimensional in nature; they are said to have length and no width or height (or depth). Line features have many properties that can be analyzed with aid of a map. In this Unit we will learn some of the ways line features are analyzed.

2. Objectives

1. To understand the different shapes of linear features.
2. To identify and measure some inherent parameters of linear features.
3. To analyze certain relationships that exist among similar linear features.

3. Main Body

- Measuring the length of a linear feature (distance measure)
- Determining the length ratio
- Bifurcation ratio
- Index of connectivity

3.1 Measuring the length or distance of a linear feature

As shown in Fig. 30, the shape of a linear feature could be regular or irregular. The shape of the features determines how it is measured.

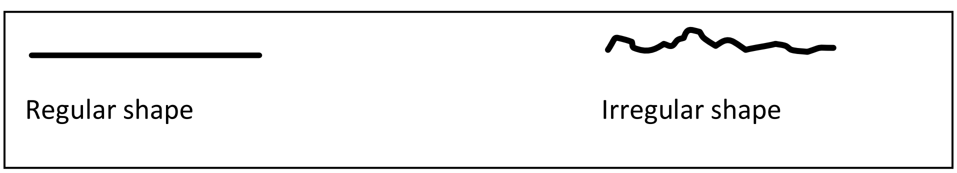

Fig. 30 Regular and irregular line shapes

It is easier to measure a regular shape than an irregular shape. If a linear feature has a regular shape, that is it is a straight line, a ruler can be used to directly measure its length on the map. On the other hand, if a linear feature has an irregular shape, that is, it is curvy or zigzag in nature, either the edge of a piece of paper or a white thread (the type used by tailors), is used to measure the length of the feature, carefully following the curves. Mark the beginning and the end of the feature on the material you are using to do the measurement. After tracing or measuring the length of the feature on the map using the thread or paper, stretch out the material used over a ruler and read off and record the total length (usually in centimetres, or inches, as the case may be). Next, use the scale of the map to calculate the equivalent distance on ground.

Thus, the logical steps involved in calculating the length or distance of a linear feature are:

(i) Measure the length of the feature on paper (map). This can be achieved in a couple of ways. If the line is a straight line (as the crow flies) you can use a ruler to measure it, or alternatively you can use a string to measure it and stretch the string on a ruler to read off the length in centimetres. On the other hand, if the line is winding, bend the string to follow the exact shape until you reach the second or end point. Then place the string against a ruler or the scale bar on the map to measure the distance on your string.

(ii) Now that you have a distance in centimeters, using the map scale, calculate the ground equivalent of the distance on paper using the following formula:

$$L_g = \frac{MD \times MS}{100{,}000}$$

Where:

L_g	=	Length of a linear feature on ground. (This is usually in kilometres, or miles).
MD	=	Map distance (length of the feature as measured on the map. This distance is usually measured in centimetres, or inches)
MS	=	Map Scale (the denominator of the map scale)
100,000	=	a constant used to convert from centimetres to kilometres (NB: 100,000 cm is equal to 1km).

Example:

Problem:

If a portion of a road measures 6.3cm on a map at a scale of 1:50000, what is the length of the road portion on ground?

Solution:

MD = 6.3cm
MS = 50000

Therefore,

$$L_g = \frac{MD \times MS}{100{,}000}$$

$$= \frac{6.3 \times 50000}{100000}$$

= <u>3.15km</u> (NB: Always indicate the correct unit of measurement of your answer).

3.2 Analyzing Road Network Connectivity

Roads connect different settlements in any given geographical area. For planning and development purposes, it is possible and often necessary to determine the level of connectivity in an area. The level connectivity in a place also indicates the degree of accessibility or ease of movement from one location to another in that place. Poor road connectivity in, say a city, means people will find it difficult moving around in that city. The desirable ideal situation, therefore, is to have full or one hundred percent connectivity. However, in reality full connectivity is hardly attained. By calculating the present level of road connectivity, planners and decision makers are able to know the number of additional road networks that might be needed to achieve full connectivity or at least significantly improve on the situation on ground.

A typical road network is made up of two important elements namely *nodes* and *links* (Fig. 31). Nodes represent settlements while links (also known as arcs) represent road segments connecting the settlements.

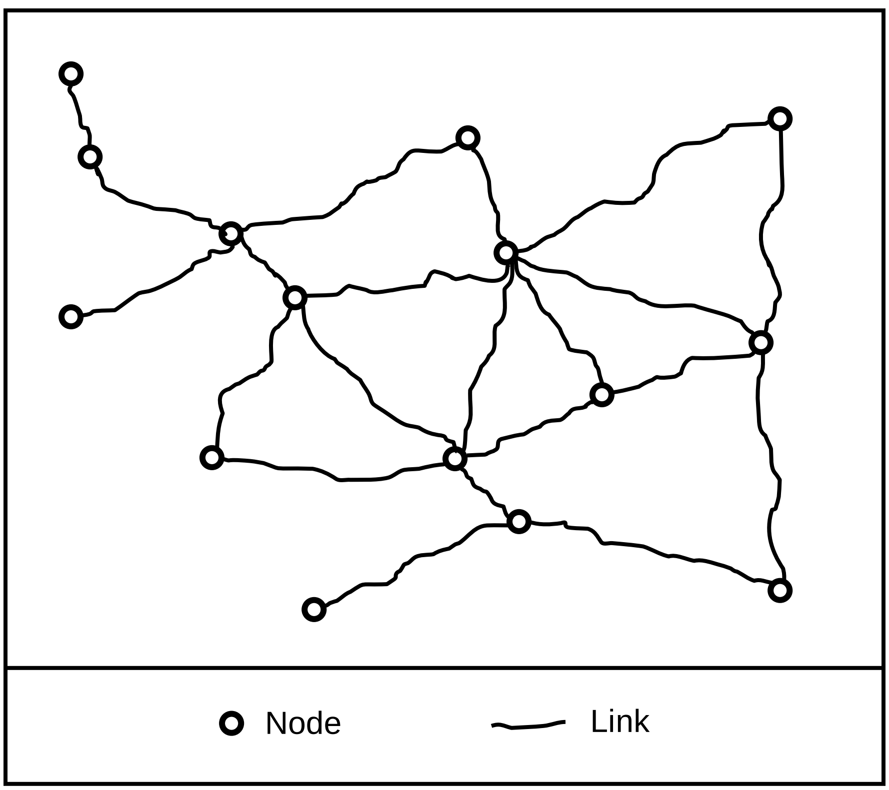

Fig. 31 Road network in a city

To calculate the percentage connectivity of road network in a city such as the one shown in Fig. 4.2, the following steps are taken:

1. On a map showing the road network, count the number of nodes.
2. Count the number of links.
3. Apply the formula given below to determine the percentage connectivity.
4. If what you have is not full connectivity, then determine the number of additional links (roads) that would be needed to achieve full connectivity in the area.

Percentage Connectivity (% Connectivity) is determined by the formula:

$$\%\ \text{Connectivity} = \frac{\textbf{A}\text{ctual (Existing) links}}{\textbf{P}\text{ossible (Maximum) links}} \times \frac{100}{1}$$

OR

$$\%\ \text{Connectivity} = \frac{\mathbf{A}}{\mathbf{P}} \times \frac{100}{1}$$

Where P = n(n-1)/2, n = number of nodes

Using Fig. 31 as an example, we can determine the level of road network connectivity in that city thus:

Number of nodes (n) = 15
Number of existing links = 21
Possible links (P) = 15(15-1)/2, = 105

$$\%\ \text{Connectivity} = \frac{21}{105} \times \frac{100}{1}$$

$$= 20\%$$

From the result above it is obvious that with a connectivity of only 20% the city has a poor road network. Whereas the existing number of roads (links) in the city is 21 while the total number required to achieve full connectivity in the area is 105, it then means that additional 84 roads (105 – 21) will be needed to achieve complete or 100% connectivity in the city.

3.3 Drainage Analysis

Drainage here refers to streams and rivers. The drainage resources existing in a place are usually shown on topographic, physical geography, or hydrological maps. Drainage analysis is important for a number of purposes including water resources management, irrigation and other agricultural activities, hydropower supply, and so on.

We normally deal with two kinds of drainage analysis namely qualitative analysis and quantitative analysis. Qualitative analysis basically has to do with description of the physical distribution and patterns of streams/rivers in a given place. On the other hand, quantitative drainage analysis is concerned with issues such as number of streams, bifurcation ration, length of stream, area of stream (or river) basin, stream density, stream frequency, and stream intensity.

3.3.1 Types of Drainage Pattern

There are different types of drainage pattern which can be shown on a map. Some of the major drainage patterns are identified and illustrated below.

(a) *Trellis drainage pattern*: In a trellis pattern (Fig. 32) the distributaries of a stream run almost parallel to each other; hence they join the main stream at almost right angle.

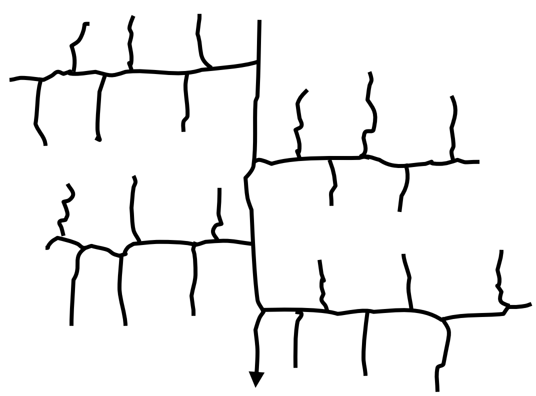

Fig. 32 Trellis drainage pattern

(b) Dendritic drainage pattern: As shown in Fig. 33 this drainage pattern is similar to the branches of trees; it is characterized by irregular branching of the tributaries of a stream in different directions.

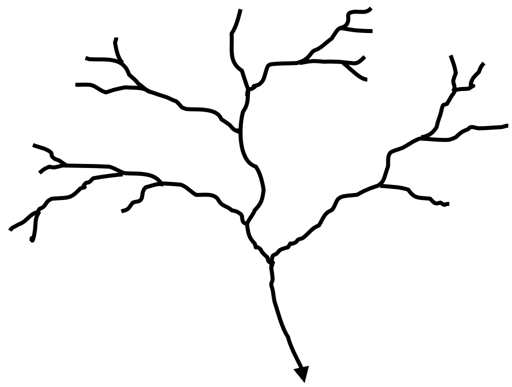

Fig. 33 Dendritic drainage pattern

(c) *Centripetal drainage pattern*: This pattern is characterized by many streams or rivers converging or flowing into a lake from different directions as shown in Fig. 34.

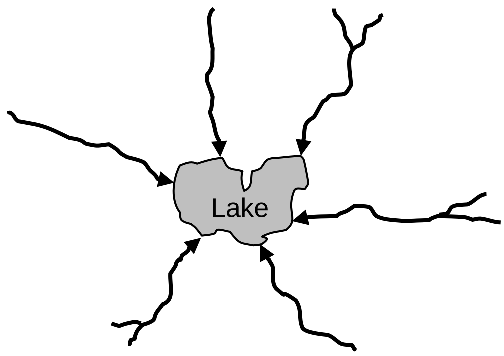

Fig. 34 Centripetal drainage pattern

(d) *Radial drainage pattern*: In a radial drainage pattern several streams or rivers flow from a central highland (hill or mountain) to different directions away from each other (Fig. 35).

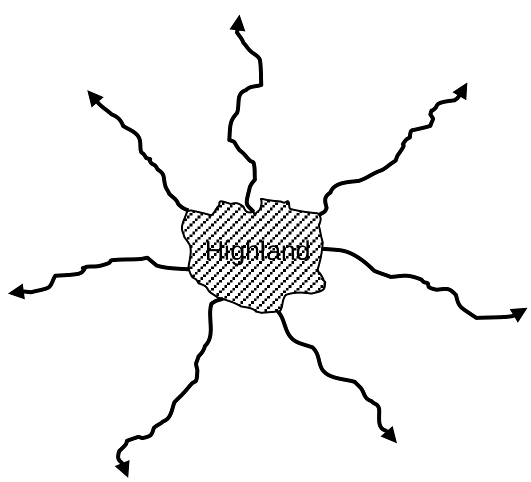

Fig. 35 Radial drainage pattern

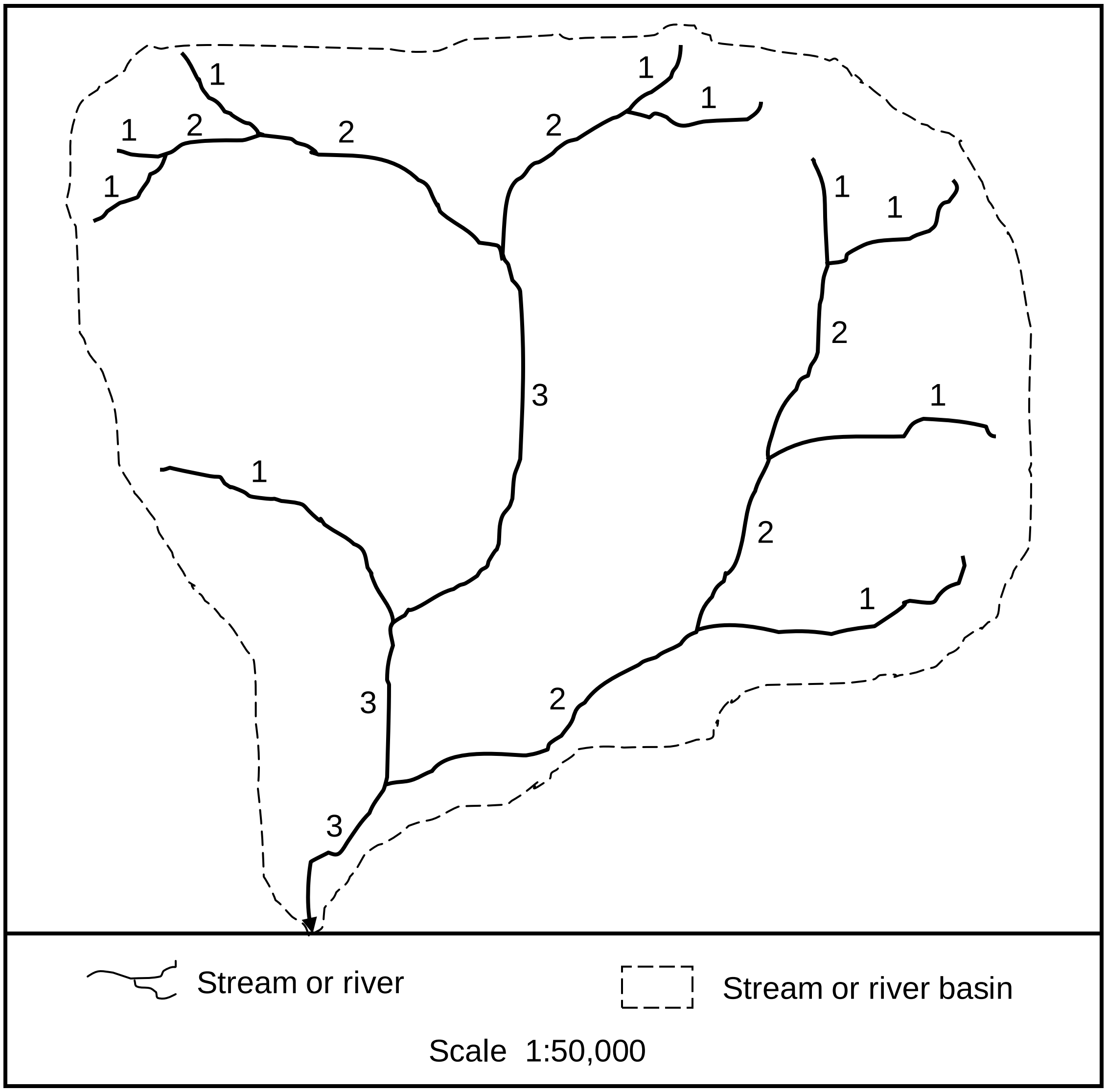

Fig 36 A stream network

3.3.1 Stream Ordering

Having identified and delineated a particular drainage system for analysis, the first thing to do is to carry out a systematic ordering or ranking of the various stream segments making up that drainage system. There are several methods of ranking stream segments. However, for the purpose of this course we will adopt a modified version of the method devised by Strahler. In this method stream segments are ranked as 1st order, 2nd order, 3rd order, and so on. As shown in Fig. 36 a first order stream is any stream segment that does not have any other stream flowing into it. When two first order streams meet they form a 2nd order stream. Similarly, when two 2nd order streams meet they form a 3rd order stream, and so on. It should also be noted that as indicated in Fig. 36, when a lower order stream joins a higher order stream the resulting stream segment will still be that higher order stream. For instance, if a 1st order stream flows into a 2nd order stream, the stream segment produced will still be ranked 2nd order. In the same vein, if a 2nd order stream joins a 3rd order to produce a new stream segment, this new segment will be ranked 3rd order. It is only when two (or more) stream segments of the same order meet at a common confluence to form another segment that a higher order stream is produced.

Stream ordering helps us to identify and know the number of segments in each order or category, and hence, the total number of segments in the drainage system under consideration. It is, therefore, customary to create a stream order table after ordering the streams in a drainage basin. Table 2 has been generated based on the stream ordering in Fig. 36; the Table shows the number of segments in each stream order.

Table 2 Stream Orders

Stream Order	**Number of segments**
n => 1st order	10
n+1 => 2nd order	6
n+2 => 3rd order	3
Total	19

3.3.2 Bifurcation Ratio

Bifurcation ratio (Br) is used to compare the relationship between a stream order and the next higher stream order. In other words, it is used to determine the proportion of a stream order say the n^{th} order (i.e. 1st order) in relation to the $(n+1)^{th}$ order (i.e. 2nd order). The formula for calculating the Bifurcation ratio is:

$$\mathbf{Br} = \frac{\mathbf{Sn}}{\mathbf{S(n+1)}} = \frac{\textbf{Number of stream segments in the } \mathbf{n^{th}} \textbf{ order}}{\textbf{Number of stream segments in the } \mathbf{(n+1)^{th}} \textbf{ order}}$$

Examples:

Using the information contained in Table 2 the Bifurcation ratio between the first order stream segment and the second order segment is calculated thus:

$$Br = \frac{10}{6}$$

$$= 1 : 1.7$$

Similarly, the Br between the 2nd order streams and the 3rd order streams is:

$$Br = \frac{6}{3}$$

$$= 1 : 2$$

Interpretation:
The above Br (1 : 1.7) result between the 1st and 2nd order streams indicates that for every single 2nd order stream there are 1.7 1st order streams. In other words, the first order stream segments in the drainage network are 1.7 times greater than the second order streams. In the same way, the Br of 1 : 2 between the 2nd and 3rd order streams shows that the 2nd order streams are twice larger in number than the 3rd order streams.

3.3.3 Drainage density (Dd)

This refers to the average or mean length of streams in a drainage basin. To determine this index, the total length of all stream segments in the basin is measured and divided by the area of the basin. This gives us an idea of the average length of stream per unit area; e.g. 3.2km of stream per square kilometre. The stream density is determined by the formula:

$$\mathbf{Dd} = \frac{\sum \boldsymbol{l}}{\mathbf{A}} = \frac{\textbf{Total length of streams}}{\textbf{Area of stream basin}}$$

3.3.4 Stream frequency (Sf)

This is the mean number of stream segments in a drainage basin per unit area of the basin. To obtain this index, simply count the number of stream segments in the basin and divide it by the area of the basin. This will give us an idea of the average number of segments per unit area.

$$\mathbf{Sf} = \frac{\sum \boldsymbol{Ns}}{\mathbf{A}} = \frac{\textbf{Total number of stream segments}}{\textbf{Area of stream basin}}$$

3.3.5 Length Ratio (L_R)

This index measures the relationship or ratio between the average length of all the stream segments belonging to a particular stream order and the average length of all the stream segments in the next higher stream order.

$$L_R = \frac{\sum ln/Sn}{(\sum ln + 1) / Sn+1}$$

$$= \frac{\text{Total length of 1}^{st}\text{ order streams / number of segments in 1}^{st}\text{ order}}{\text{Total length of 2}^{nd}\text{ order streams / number of segments in 2}^{nd}\text{ order}}$$

3.3.6 Drainage intensity (Di)

This is a product of the drainage density and stream frequency. The formula for calculating drainage intensity is:

$$Di = \frac{\sum l \sum ns}{A^2} = DdSf$$

Where: Dd = Drainage density
Sf = Stream frequency

4. Conclusion

Line patterns are common features on maps. Topographical maps, road maps, utility maps and hydrological maps are used to show different types of line features existing in a place. The line network can be analyzed in various ways and for various purposes. Line network analysis is quite useful for project planning and implementation purposes. For instance, we can use road network analysis to improve the provision of roads and accessibility. Similarly, drainage analysis can be used for planning water supply schemes, water resources management, irrigation and other agricultural purposes, hydroelectricity supply, watershed management, planning and management of inland water transportation, and so on.

5. Summary

Line or network analysis involves studying various aspects of a line pattern. Line patterns include road network, telecommunication network, power supply network, drainage network and so on. Usually, the particular network to be analyzed is first delineated on the map. We can then undertake several other tasks such as percentage connectivity and drainage analysis which involves stream ordering, calculating the bifurcation ratio between a stream order and the next higher order, calculation of the area of the river or stream basin, measuring drainage density, length ratio, stream frequency, and so on.

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Unit 4: Analysis of Areal Features

1. Introduction

Area (or areal) features, which are also known as polygonal features, are basically two-dimensional in nature; they have considerable length and width. In map analysis there are various characteristics of areal features that can be examined. This Unit, therefore, is expressly dedicated to discussions on the analysis of areal features on maps.

2. Objectives

- Measuring the perimeter of an areal feature (i.e. distance around the feature)
- Determining the area of a polygon (areal feature)

3. Main Body

3.1 Calculating area

Like linear features, areal features can also have regular or irregular geometric shapes (Fig. 37). Regular geometric shapes include circle, square, triangle, and rectangle. It is easier to find the area of a regularly shaped feature than that of an irregularly shaped feature. To calculate the area of a feature with regular shape, the appropriate formula for that shape is used. For instance, the area of a square figure is found by multiplying the length by the width (that is, L x W); the area of a triangle is found by multiplying one-half of the base by the height (i.e. ½b x h), and so on.

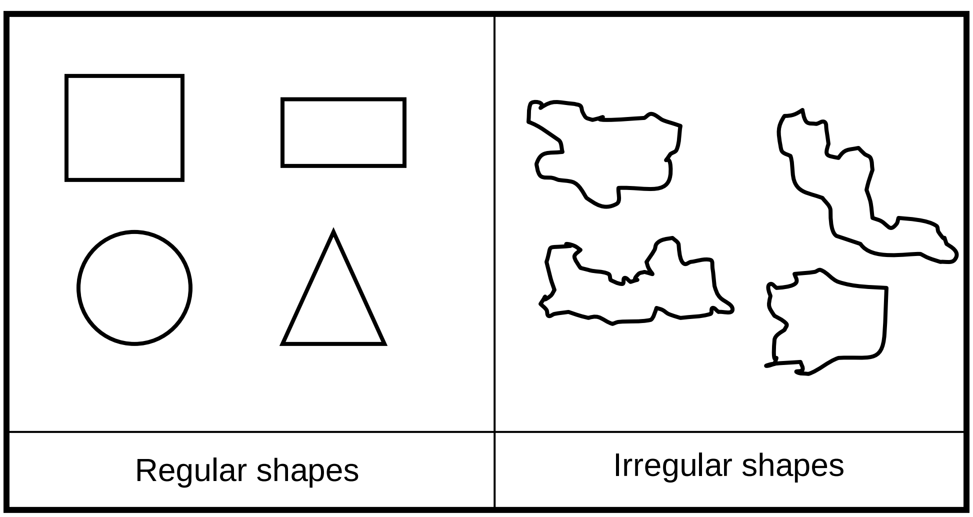

Fig. 37 Regular and irregular shapes of areal features

In reality most of the areal features we deal with have irregular shape. Examples of such features are lakes, farmland, school compound, Local Government area, state, country, etc. There are a number of ways by which the area of an areal feature could be calculated manually. Here we will discuss only three of such methods namely:

- Square grid method.
- Strip or rectangular method, and
- Triangular method.

Each of the above methods actually involves imposing a series of smaller regular shape on the irregularly-shaped figure whose area is to be determined. The area of each of the regular-shaped figure smaller figures is calculated; then the areas of all the regularly-shaped figures into which the irregularly-shaped figure was divided are summed up to finally get the approximate area of the irregular figure.

The following general steps are involved in calculating the area of an irregularly-shaped figure:

1. Trace or copy out the outline of the figure on a piece of plain paper or gridded (graph) paper.
2. Depending on the method you prefer to use, impose a series (grids or cells) of the appropriate regular shape on the figure (See Fig. 38).
3. Count the number of cells covering the entire figure. (Note: a single square, rectangle or triangle is a grid unit or cell).
4. Using the map scale, calculate the area of each unit or cell.
5. Sum up the area of all the individual cells to obtain the area of the feature.

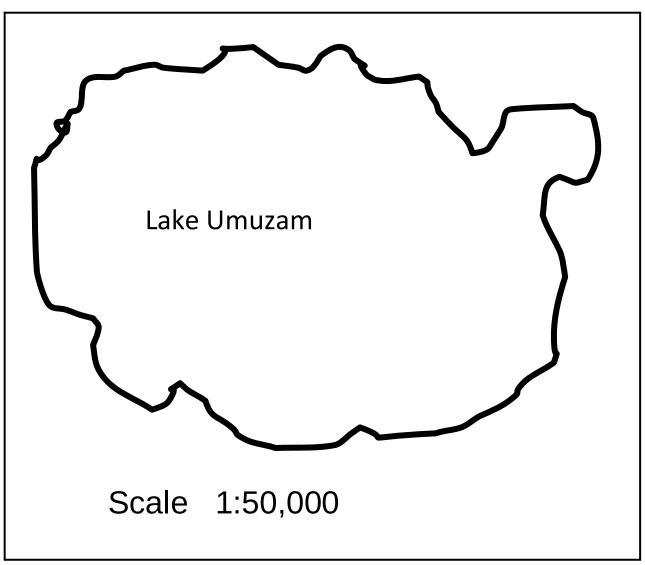

Fig. 38 A lake: an example of an areal feature with irregular shape

Example (i):
Using the square grid method calculate the area of the lake in Fig. 39.

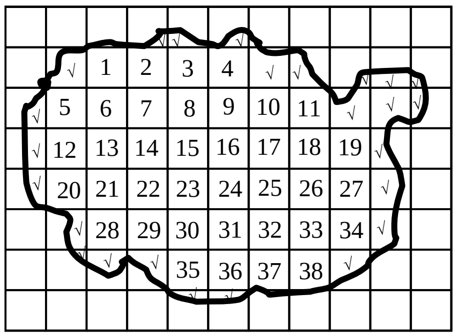

Fig. 39 Square grid method

Solution:

1. Impose a square grid on the outline of the lake. Note: the squares should be of the same size; in this example each square is assumed to be 1cm x 1cm.
2. Count the number of complete squares (which is 38 in Fig. 39).
3. Count the number of incomplete squares (which is 25 in Fig. 39). Divide this number by 2 and add the result (12.5 $\simeq$ 13) to the number of complete squares obtained in step 2 above (i.e. 38 + 13 = 51).
4. Record the total number of complete squares, which in this case is 51.
5. Find the area of one square using the map scale. On paper (that is on the map) each square measures 1cm x 1cm. Since the map scale is 1:50000, and the area of a square is L x W (1cm x 1cm), one square will be:

$$\frac{1 \times 50000}{100000} \times \frac{1 \times 50000}{100000}$$
$$= 0.5 \times 0.5$$
$$= 0.25km^2$$

6. Calculate the area of the lake (which should be in square kilometre) by multiplying the area of the one square by the number of total complete squares:

$$= 0.25 \times 51$$
$$= 12.75km^2$$

Thus the area of the lake using the square grid method is $12.75km^2$.

Example (ii):
Using the triangular method calculate the area of the lake in Fig. 40.

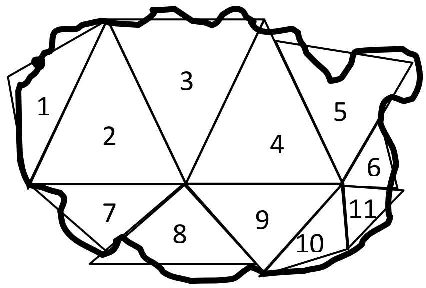

Fig. 40 Triangular method

Solution:

1. As shown in Fig. 40, impose a series of triangles on the outline of the lake and number them. The triangles may not necessarily be of the same size.
2. Measure the height and base of each triangle, and using the map scale, convert the values to the ground equivalent, that is in kilometre (km).
3. Calculate the area of each triangle using the formula ½base x height.
4. Add up the areas of all the triangles to obtain the overall area of the lake.

Example (iii):

Using the rectangular method calculate the area of the lake in Fig. 41.

Solution:

1. Draw a series of rectangular on the outline of the lake as shown in Fig. REC. (Note: the rectangles may not be of the same width, although it is more convenient to make all the rectangles of equal width as in this example). Number the rectangles consecutively.
2. Measure the length of each rectangle and sum up the length of all the rectangles (nine of them in this example – see Fig. 41).
3. Using the map scale (1:50,000) find the ground equivalent of the width of the rectangles (assuming they have the same width, say 1cm, as in this example); similarly calculate the total length of the rectangles (the answers should be in kilometre). For is instance, if the total length of all the rectangles on paper is 197.4cm; its ground equivalent will be:

   $$\frac{197.4 \text{ x } 50000}{100000}$$

   $= 98.7\text{km}$

   Also the width (1cm) will be:

   $$\frac{1 \text{ x } 50000}{100000}$$

   $= 0.5\text{km}$

4. Multiply the total length of the rectangles with the width to obtain the overall area of the lake thus:

$98.7 \times 0.5 = 49.35km^2$

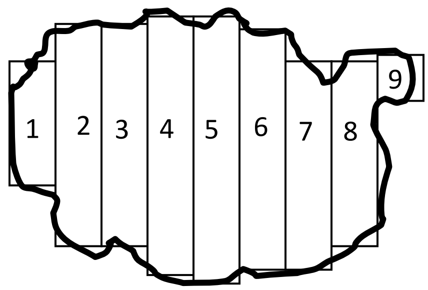

Fig. 41 Rectangular method

4. Conclusion

Polygonal features usually cover a considerable amount of space. We can subject such features to various kinds of analysis. However, in map reading, we are often concerned with the calculation of the area and perimeter of any polygonal features of interest on the map. Knowing the areal extent of a feature gives us an idea of how big or small the feature is in real life.

5. Summary

The geometric shape of an areal feature could be regular or irregular. Regular geometric figures include circles, squares, rectangles, triangles, hexagons, and so on. The calculation of the area of a regular shape is simple and straightforward. The area of a polygonal figure with a regular shape can be calculated using the appropriate formula that pertains to that particular shape. On the other hand, the calculation of the area of a polygon with an irregular shape is somewhat more complicated. In this case, the irregular shape of the polygonal feature is first converted to any regular shape, especially square, triangle or rectangular. Then the appropriate formula is applied to find the area of the figure.

Apart from calculating the amount of land space occupied by an areal feature, we can also calculate the perimeter of the feature. Perimeter is the linear distance round the edge or boundary of an areal feature.

6. References/Further Reading

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Unit 5: Analysis of Relief Features

1. Introduction

Relief is the difference in elevation between the high and low points of a land surface, usually measured as relative relief. The relief features of a land surface are shown on a map by means of various techniques such as contour lines, hachure, hill shading, spot heights, bench marks and trigonometric stations. Contours in particular show the shape of the earth's surface in a particular region. Contours also give the elevation of places above a datum level, at regular height intervals. Different relief or topographical features shown a map using contour lines include lowlands, valleys, highlands, slopes, aspect, watershed, floodplain, and so on.

2. Objectives

1. To identify different types of landforms.
2. To study how various relief types are represented on maps.
3. To discuss slopes, cross-sections and intervisibility.
4. To understand how to calculate average gradient.

3. Main Body

3.1 Methods of representing relief on maps

There are different methods of showing relief on maps. The methods include contour lines, hachuring, hill shading or layer colouring, spot heights and trigonometric stations.

Contours

The relief features of a place are usually shown on topographical maps using contour lines. A contour is a line joining points of equal height value (Fig. 42).

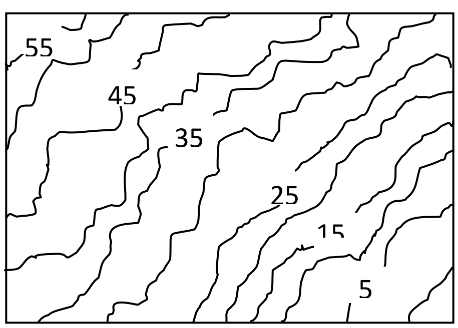


Fig. 42 Contour lines

Hachuring

Hachures are short lines drawn to show the shape of the land. As shown in Fig. 43 the lines are usually drawn following the direction of the slope or gradient.

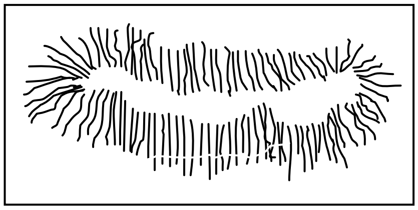


Fig. 43 Hachures

Contour layering and colouring

This method of relief representation involves dividing an area into height zones with each zone representing a range of heights. For example, if the height of an area ranges from 0 to 500m, the land can be divided into any convenient height zones such as 0 – 100m, 100 – 200m, 200 – 300m, 300 – 400m, 400 – 500m. Then different shades of colour are used to represent each height zone or contour layer (Fig. 44). Conventionally, blue is used to represent water bodies, green for lowlands, yellow for middle grounds, brown for highlands and white for snow capped hill or mountain tops.

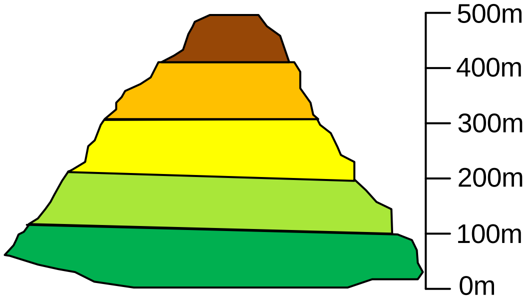


Fig. 44 Contour layering

Spot Heights

A spot height is a point whose height above mean sea level has been accurately determined through land surveying techniques. On a map a spot height is indicated with a dot and the actual height value written beside the dot e.g. ● 1500.

Trigonometrical stations

These are points on the ground indicating where the angles of triangulation have been measured when mapping an area using land survey methods. On the map the location of a trigonometrical station is shown by an equilateral triangle with a dot inside it and the height of that location written beside the triangle e.g. △ 1125. There are three types of trigonometrical stations namely:

- △ Primary Trigonometrical Station
- ▽ Secondary Trigonometrical Station
- ⊙ Minor Trigonometrical Station

Bench Marks

A Bench Mark (BM) is a permanent land survey mark inscribed on an object such as wall, building, roadside, or bridge to indicate the exact height above sea level of that spot. On a map they are shown by the symbol ↑BM or BM↑. The height is usually written beside it e.g.

↑BM 350 or BM↑ 520

3.2 Landforms on Contour Maps

There are different types of landform. One of the tasks of relief analysis is to identify the various relief features on a map. The commonest means of representing landforms or relief features on maps is by the use of contour lines. Some of the common landforms that can be represented on a contour map are shown below.

Hill or Mountain

This is a piece of land which rises above the surrounding environment (Fig. 45).

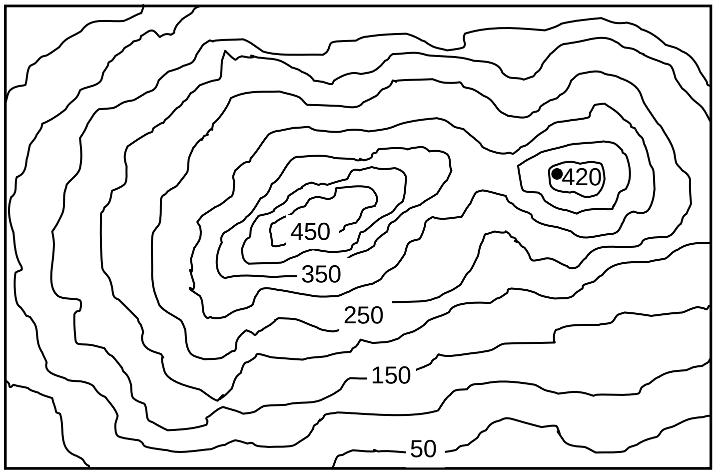


Fig. 45 Contours of two hills

Valleys and Spurs

A valley is a long, narrow depression in-between two highlands. If a valley has water flowing through it, it is known as a river valley, while the one without water is called a dry valley. As indicated in Fig. 46, on contour maps valleys are represented by V-shaped contour lines with the V being inverted hence the apex pointing upwards. On the other hand, a spur is a piece of upland stretching out from a hill and having a length that is greater than its width. Like valleys, spurs are indicated on contour maps with V-shaped contour lines. However, unlike in the case of valleys, the apex of the V-shaped contours of spurs point downwards towards the lowland (Fig. 46). Hence, spurs can be said to be the opposite of valleys.

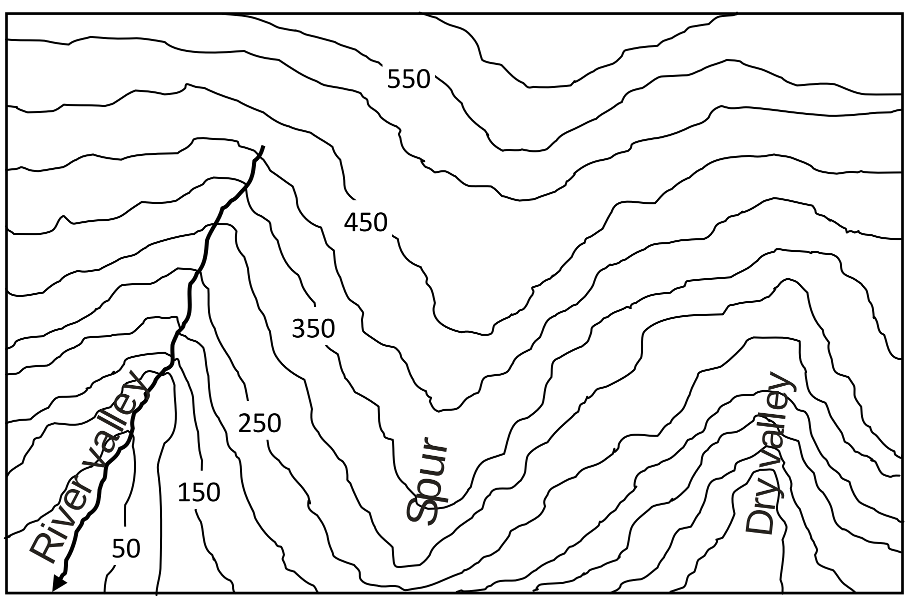


Fig. 46 Valleys and spurs

Escarpment

This is a long stretch of highland or ridge with a very steep (scarp) slope on one side and a very gentle (dip) slope on the other side (Fig. 47).

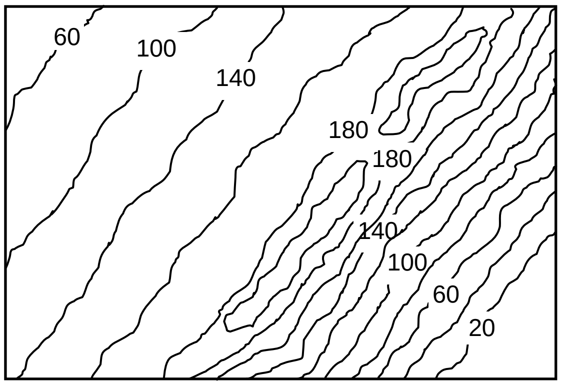


Fig. 47 An escarpment

Ridge

A ridge is a narrow long chain or range of highlands (Fig. 48). The highlands are usually separated from one another by openings known as col (saddle) or pass (gap).

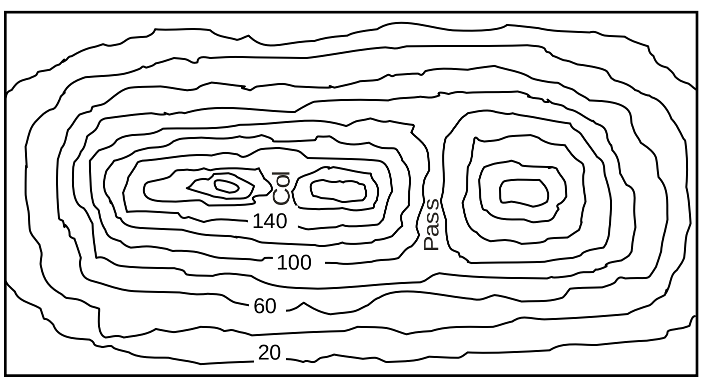


Fig. 48 A ridge with a col and a pass

Col or Saddle

As shown in Fig. 48, a col or saddle is a low land separating two highlands. The major difference between a col and a saddle is that a saddle is usually wider than a col.

Pass or Gap

Like a col, a pass or gap is also a lowland that separates two highlands (see Fig. 48); it is a way through a mountain range. However, whereas a col appears at a high altitude, a pass occurs at lower altitudes. Consequently, a pass is usually deeper with the land on both sides being very much higher than what obtains in the case of a col or saddle.

Plateau

A plateau is large area of highland with an almost flat or table top (Fig. 49).

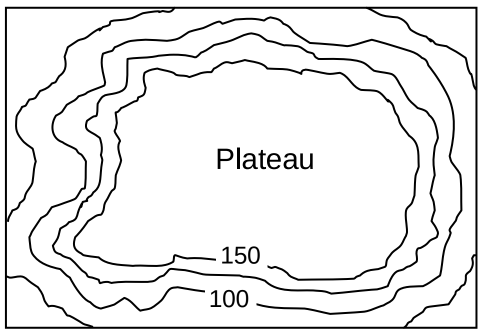


Fig. 49 A plateau

3.3 Slopes, Cross-sections and Intervisibility

3.3.1 Slope

Slope refers to the angle or inclination of any side of a highland (hill or mountain). There are different types of slope. For instance, a slope can be gentle or steep. It can also be a combination of both gentleness and steepness, in which case it can be described as being either a concave or a convex slope, depending on the arrangement of gentle and steep portions of the slope.

On a contour map a gentle slope is shown with widely spaced contour lines (see Fig. 50a). On the other hand, the contour lines of a steep slope are close to one another (Fig. 50b). A concave slope when the slope of a hillside is steep at the upper level and gentle at the lower level (Fig. 50c). Conversely, if the slope of a hillside is gentle at the upper level but steep at the lower level, this results into a convex slope (Fig. 50d).

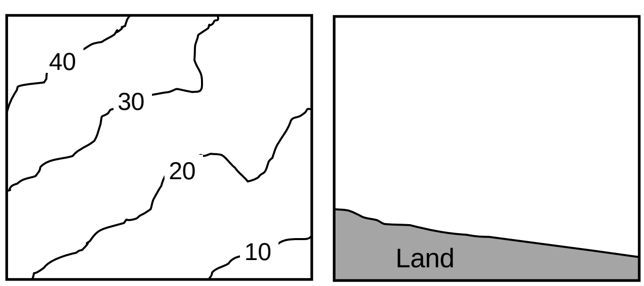


Fig. 50a Contours and shape of a gentle slope

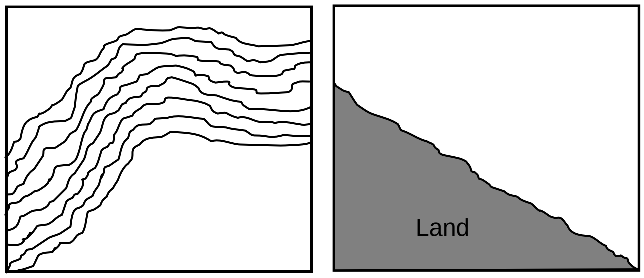


Fig. 50b Contours and shape of a steep slope

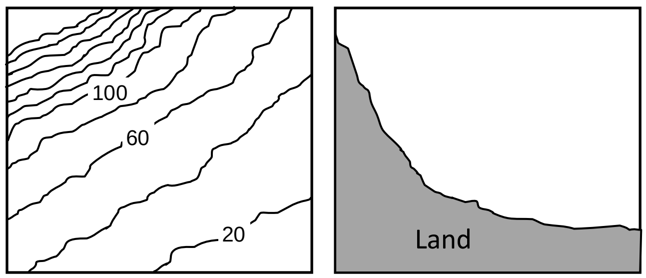


Fig. 50c Contours and shape of a concave slope

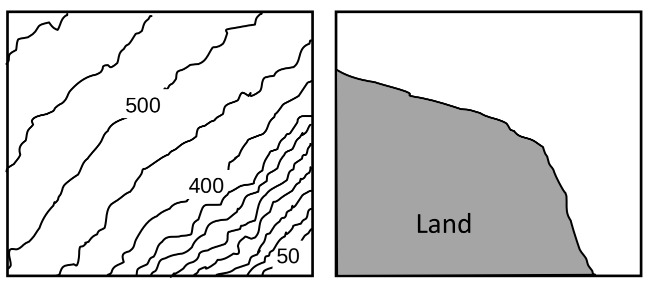


Fig. 50d Contours and shape of a convex slope

3.3.2 Cross-sections

A cross-section is usually drawn to show the shape of the ground represented by a series of contour lines on a map. In other words, cross-sections give us a general idea of the topography or nature of slopes in various places.

A cross-section is usually drawn between two places of interest on a map. Consider the contour map of a hypothetical island shown in Fig. 51. We can draw a cross-section showing the topography between points A and B.

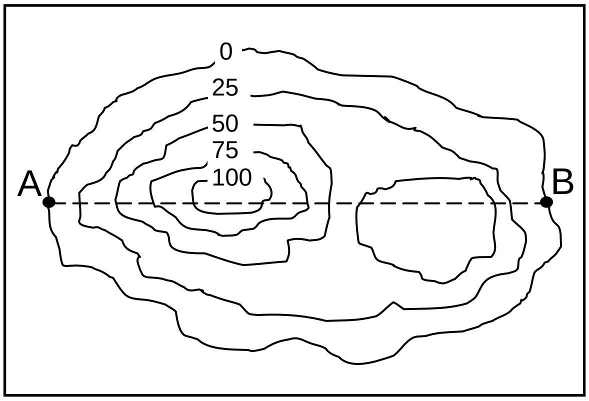


Fig. 51 An island

To drawn a cross-section between two locations such as A and B (Fig. 51), the following procedure should be followed:

1. Get a piece of paper that is longer than the two locations of interest; the paper should have a straight edge.
2. Place the straight edge of the paper along the line connecting the two places (e.g. the dotted line AB in Fig. 51).
3. Carefully mark on a paper the locations of A and B.
4. While still firmly holding the paper along line AB, mark the spots where the contour lines crossed line AB. Record the value of the contour at each crossing.
5. Choose a convenient vertical scale for drawing the grids e.g. say 5cm : 125m (which is 1cm equals 25m). In choosing the vertical scale you must take into consideration the lowest and highest contour values crossed by the line between the two points of interest. In the example we are using the lowest contour value is 0m while the highest value is 100m. Based on the contour interval on the map, the vertical grid should be drawn such that it will be a step higher than the highest contour value. Hence in our present example since the highest contour value is 100m we are going a step higher to 125m (NB: the contour interval in Fig. 51 is 25m). Subdivide the line of the vertical scale according to correspond with the contour values. The vertical scale for drawing a cross-section between points A and B in Fig. 51 is shown in Fig. 53.
6. As shown in Fig. 52, place the piece of marked paper on the base of the vertical scale and mark each contour point on the baseline.
7. Using a pencil and ruler draw a faint but visible vertical dashed line at each contour point extending it to correspond with its actual value on the vertical scale as shown in Fig. 54.
8. Using a thick continuous curvy line join the tops of the vertical dash lines (see also Fig. 54).

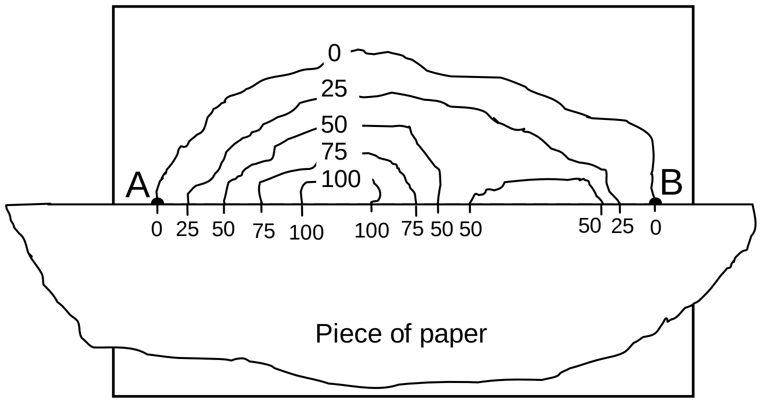


Fig. 52 Marking the contour points on a piece of paper

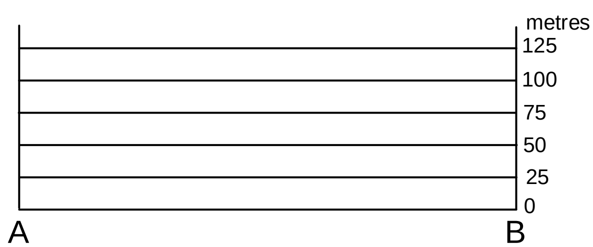


Fig. 53 A vertical scale

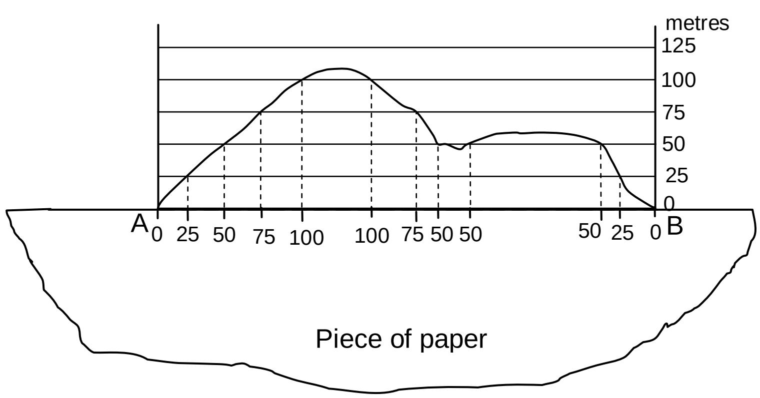


Fig. 54 Transfer of contour point values from paper to vertical scale

3.3.3 Vertical Exaggeration

In drawing a relief profile or cross-section as discussed above, we make use of a vertical scale as well as a horizontal scale (which is the scale of the map). However, the vertical scale is usually exaggerated or enlarged more than the horizontal scale. This is deliberately done to improve on the rendition of the cross-section. Vertical exaggeration actually refers to the number of times the vertical scale is enlarged over and above the horizontal scale. To calculate the vertical exaggeration the following steps should be followed:

1. Write or convert both the vertical scale and the horizontal scale as a ratio or representative fraction (RF).
2. Divide the horizontal scale by the vertical scale of the cross-section to obtain the vertical exaggeration.

For instance, if as in the example above the vertical scale is 1cm to 25m (or 1:2500. NB: 1m = 100cm; hence 25m = 2500), and the horizontal scale is 1:50,000, the vertical exaggeration will be 50,000 ÷ 2500 = 20. This means the vertical scale was enlarged or exaggerated 20 times more than the horizontal scale. As noted earlier, exaggerating the vertical scale enables us to have a better view or mental perception of the relief profile.

3.3.4 Intervisibility

In map analysis *intervisibility* is a measure that is used to determine if one location on a contour map can be physically seen from another location given clear weather conditions. Determining the intervisibility of two places on a map requires drawing a cross-section between the two places. (The procedures for drawing a cross-section have already been discussed above). After drawing the cross-section, a straight line is drawn between the two places; this is known as line of sight. If the line of sight cuts across a high-rise physical obstruction such as a hill, trees, tall buildings and so on, then the two points are not intervisible from each other. But if there is no such obstruction it then means that the two points are intervisible. As shown in Fig. 55 points A and B are not intervisible while points C and D are intervisible.

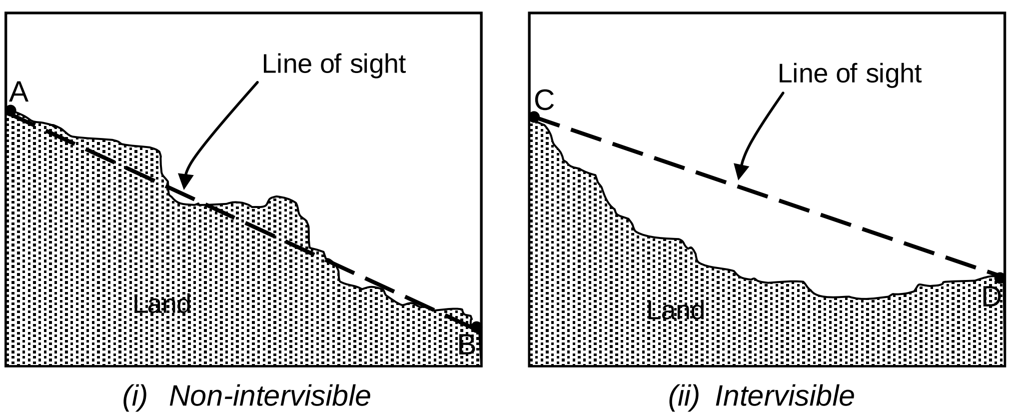


Fig. 55 Intervisible and non-intervisible places

3.4 Calculating Average Gradient

Gradient refers to the amount of slope. It is usually expressed as the ratio between the *height* and *length* of the ground between two places on a contour map. In reality slope between two places is hardly even or smooth; it is usually undulating and, hence, of different steepness. For this reason we normally talk about the average slope or gradient between two places.

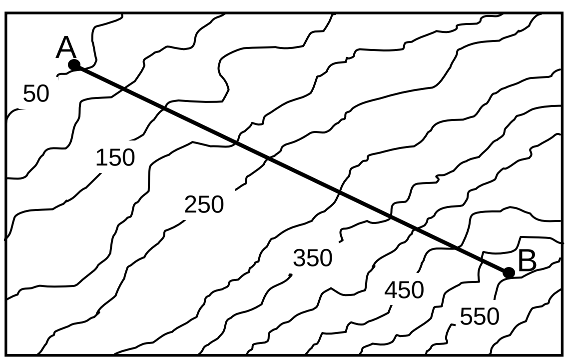
The following procedures are followed in calculating average gradient:

1. On the map identify the two points you want to determine the average gradient between them.
2. Identify and record the height of each of the places.
3. Determine the difference in height between the two places by subtracting the value of the lower height from that of the higher height; this gives you the vertical interval (V.I.).
4. Measure the horizontal distance between the two places on the map. (This measurement will be in centimeters). However you will need to convert the paper measurement (that is measurement on the map) to its ground or horizontal equivalent (H.E.) using the map scale.
5. Calculate the gradient using the following formula:

$$\text{Gradient} = \frac{\text{Difference in height (metres)}}{\text{Horizontal distance (metres)}}$$

$$\text{Or} \quad \frac{\text{Vertical Interval}}{\text{Horizontal Equivalent}} \quad \text{or} \quad \frac{\text{V.I.}}{\text{H.E.}}$$

Example:
Assuming the horizontal distance between points A and B in Fig. 56 is 10cm, what is the average gradient between the two locations?



Scale 1:50000

Fig. 56

Solution:

(i) V.I. = B-A = 550m-50m =500m.

(ii) H.E. = 10cm (distance on map). To find the ground equivalent we have to relate the map distance to the map scale thus:

$$\frac{10 \times 50000}{100000}$$

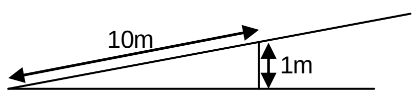
= 5km or 5000m (NB: 1000m = 1km. Also note that the unit of measurement of the H.E. should be the same as that of the V.I. It is preferable to have both in metres).

(iii) Average Gradient = $\frac{V.I.}{H.E.}$

$= \frac{500}{5000}$

$= \frac{1}{10}$ or 1 in 10 or 1:10

The average gradient between points A and B is 1 in 10. What this means is that for every 10 metres one walks horizontally from A towards B, one correspondingly rises 1 metre vertically. This can be illustrated thus:



It should be noted that in calculating average gradient, the smaller the denominator, the steeper the slope. For instance, a gradient of 1 in 20 is steeper than a gradient of 1 in 40.

4. Conclusion

Relief features are prominent components of the Earth's surface. There are different types of relief features. The features are represented on topographical maps and other physical maps using various means such as contour lines, hachures, and so on. Relief features can analyzed qualitatively or quantitatively to derive some important information about them. Moreover, the features can be studied on their own, or in relation to other features such as settlements, vegetation, water bodies, and so on.

5. Summary

In this Unit we've been able to identify different types of landforms or relief features. We also considered how various relief types are represented on maps. Other aspects of relief studied include slopes, cross-sections and intervisibility of two places on a map. Similarly, we looked at how to calculate average gradient.

6. References

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