B.Sc. GEOGRAPHY LAB MANUAL

2nd Semester

Prepared By
Pure & Applied Science Dept.
Geography

MIDNAPORE CITY COLLEGE

MIDNAPORE CITY COLLEGE

Department of Pure and Applied Sciences
Laboratory Manual for Bachelor of Science (Honours)
Major in Geography
(CCFUP), 2023 & NEP, 2020
Semester – II

PREFACE TO THE FIRST EDITION

This is the first edition of Lab Manual for BSc Honours in Geography (Second Semester). Hope this edition will help you during practical. This edition mainly tried to cover the whole syllabus. Some hard topics are not present here that will be guided by responsive teachers at the time of practical.

ACKNOWLEDGEMENT

We are really thankful to our students, teachers, and non-teaching staffs to make this effort little bit complete. Mainly thanks to Director and Principal Sir to motivate for making this lab manual.

Course Type: Major-2

Course Code: GEOHMJ102

Course Title: P: Cartographic Techniques (Practical)

MJ-2: Cartographic Techniques (Practical)

Course Objective:

1. Create professional and aesthetically pleasing maps through thoughtful application of cartographic conventions;

2. Develop an understanding of the concepts regarding scale, map projections to suit map purposes;

3. Better understand the techniques of ground surveying and apply them in real situations

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. Read and prepare maps.

2. Comprehend locational and spatial aspects of the earth surface.

3. Use and importance of maps for regional development and decision making.

Course contents:

1. Maps: Classification and types. Components of a map.

2. Concept and Construction of scales: Linear, comparative, diagonal and vernier

3. Map projections: Classification of map projection.

4. Construction, properties and uses of projections: Cylindrical Equal area, Polar Zenithal Stereographic, Simple conical with one standard parallel, Polyconic projection, Bonne's, and Mercator's. Concept and significance of UTM projection.

5. Basic concepts and principles of surveying. Survey with equipment: Prismatic Compass, Dumpy level, Theodolite, Abney level, Clinometer.

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1. Maps: Classification and types. Components of a map.

The map is considered as a symbiotic relationship between elements such as objects, reins and also themes. Many maps are usually static and also fixed to paper or some medium. Maps represent space that could be real or may be fictional. The space which is mapped could be two dimensional such as the surface of the earth and also three dimensional.

What are Maps?

A symbolic representation with selected characteristics of the place, which are usually drawn on a flat surface, is known as a map. These maps represent all the information about this world in a very simple and lucid manner. Via these different maps, we get to know about the world by showing the sizes and shapes of different countries and continents. The map also marks the locations of features, and distances between these places.

In our map study requirement, we come across different types of maps among which generally there are 2 basic maps:

- Topographic and General Maps – which summarizes the actual landscape.
- Other Maps, especially the Thematic Maps – that comment on specific feature types of a place.

Description on 10 Different Types of Maps

Maps are of varied types which attempt to show different classifications. These maps are placed in two groups:

- Reference Maps
- Thematic Maps.

Reference Maps: show the location of the geographic areas which the data has been tabulated. The maps also display the boundaries, names and also many geographic areas and also all the physical features. The physical features include roads, rail, coastlines, rivers, lakes and mountains.

Thematic Maps: A thematic map shows the spatial distribution of one or more specific data themes for selected geographic areas. The map may be qualitative (e.g., predominant farm types) or quantitative (e.g., percentage population change).

Now, We Will Study Some Commonly Used Maps Which Are as Follows:

Political Boundary Maps

Political Maps are those maps that show boundaries between the countries, states, and other political units. A commonly used political map in the US shows almost 50 states.

Election Result Maps

They are considered some type of political map which shows election results by the geographic subdivision or by voting district. In the US, for the presidential election, the red-state/blue-state maps are in use.

Physical Maps

This map shows the topographic land structure. There are different color gradient reliefs. Like for example, Dark greens are used for sea-level elevations, green grades to tan, and brown for elevation increase. While the highest elevation is the shades of gray.

Digital Road, Street, and Highway Maps

Google Maps has special tools which enable the feature for us to search the “nearby” restaurants, hotels, bars and pubs, museums, bike shops, pizza hub, schools, etc. If Google Maps is allowed to use our current location, then we can easily reach our destination following the google direction.

Topographic Map

This type of map shows the earth’s topography by using brown-colored contour lines. Roads, place names, streams, and other features are shown on this map distinctively.

Time Zone Maps

In this type of map, the world's 24-hour time zones are displayed in different color bands. By following the numbers on the top and bottom of the map, we can determine the time interval between these two locations.

Geologic Map

In the geological map, the road and the street colors are faintly displayed with color. These geological maps are important first tools to conduct an earthquake hazard.

Zip Code Maps

Zip Code Maps show zip codes in various states. They are the maps that show the approximate boundary of the zip code areas that are used by the United States of Postal Service. They are plotted over a base map which shows the zip code coverage area.

Weather Maps

Weather Maps show higher temperatures that are being projected in a country. This map is prepared by the National Weather Service operating in all the nations.

Species Distribution Maps

These maps show specific plants and animals which are to be found in that place.

Other Types of Maps Which Further Help in Their Way Are as Follows:

- Income Maps
- Resource Maps
- Earthquake Maps
- Plate Tectonic Maps
- The Map is Drawn on a Clay Tablet

Types of Maps and Charts Available

As the range of maps and charts which are now available in many of the countries is so extensive that if we make a complete listing of that, it will be impractical enough. The list would primarily include aeronautical (that is the worldwide and national), congressional or political districts, population distribution, geologic (with various scales), highways (that have national and secondary political units), historical, hydrographic (with coastal areas, inland waters, foreign waters), national forests, other forest types, public land survey plats, soil, and topographic (that are mainly national and foreign).

Components of a map

A map should include the following components namely, the title, scale, direction, grid system, projection, legend, conventional signs and symbols.

(A) Title

It indicates the purpose or theme of the map. Example: India – Physical, World – Political, Tamil Nadu – Transport.

(B) Scale

Scale makes it possible to reduce the size of the whole earth to show it on a piece of paper. A scale is a ratio between the actual distance on the map to the actual distance on the ground. Scales can be represented in three methods. They are the Statement, Representative Fraction (R.F) and Linear or Graphical scale methods.

Statement scale

The statement scale describes the relationship of map distance to ground distance in words, such as one centimetre to ten kilometres. It is expressed as 1cm = 10 km.

The Representative Fraction (R.F)

It describes the proportion or ratio of the map distance to ground distance. It is usually abbreviated as R.F. It is stated as 1/100000 (or) 1:100000. This means that one unit on the map represents 100,000 of the same unit on the ground. This unit may be an inch or a centimetre or any other linear measurement unit. Thus,

Representative Fraction (R.F.) = Distance on the map / Distance on the ground

For example: To find the RF when the scale is 1 cm to 1km. Here, 1 cm =1 km

According to the formula, R. F. = 1 cm / 1 km

Convert the km to cm. Therefore, 1km =100000 cm. So, RF. is 1:100000.

Find the R.F. when the scale is 1 centimetre to 2 kilometres.

Linear (or) Graphical scale

In a map, a linear scale is represented by a straight line divided into equal parts (Primary and secondary) to show what these markings represent on the actual ground. This scale helps in the direct measurement of distance on the map.

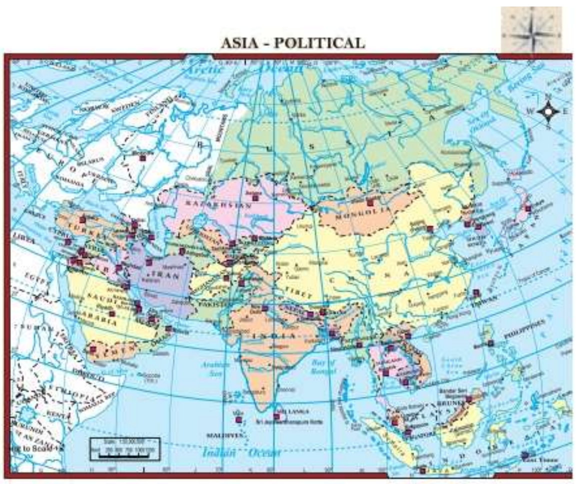
Linear scale model

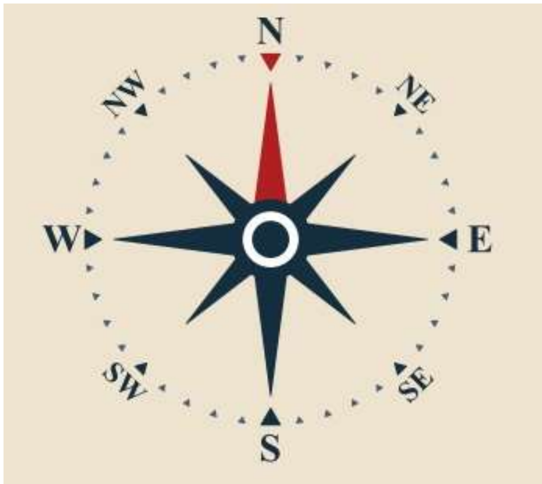
(Graphic Scale)

1/50,000 (fractional scale)
1:50,000 (ratio)
1 unit on the map represents 50,000 units in the real world.

(C) Direction

Maps are drawn normally with north orientation. North direction in a map is always towards the North Pole of the earth. If you position yourself looking at the North Pole, on your right will be the east; your left will be the west; at your back will be south. These four main directions are called the cardinal directions. Direction is usually indicated on a map by a North-South line, with the North direction represented by an arrow head.

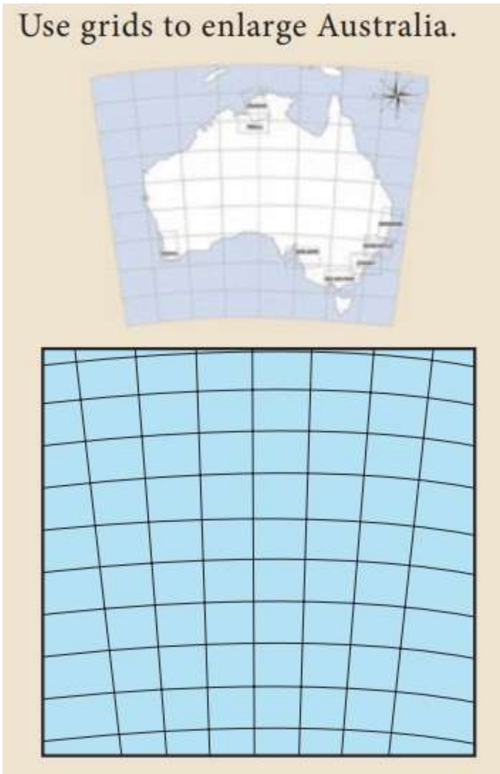




(D) Grid System

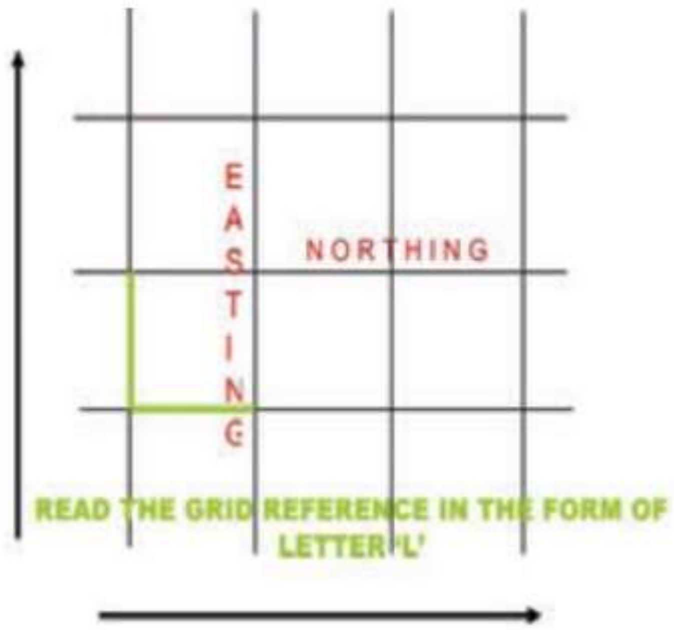
The location of a place can be simply defined by its latitude and longitude. In normal practice, latitude is stated first and then comes the longitude. The latitude and longitude of a place can be expressed in units of degree, minutes and seconds.

A grid is a set of lines with alphanumeric codes for defining a location on a map in many topographical sheets. The lines that run horizontally from left to right of the map are known as northings, whereas, the lines that run vertically from the top to the bottom of the map are called eastings. The points at which the vertical and horizontal lines of the grid intersect are called coordinates which are identified by numbers or letters.



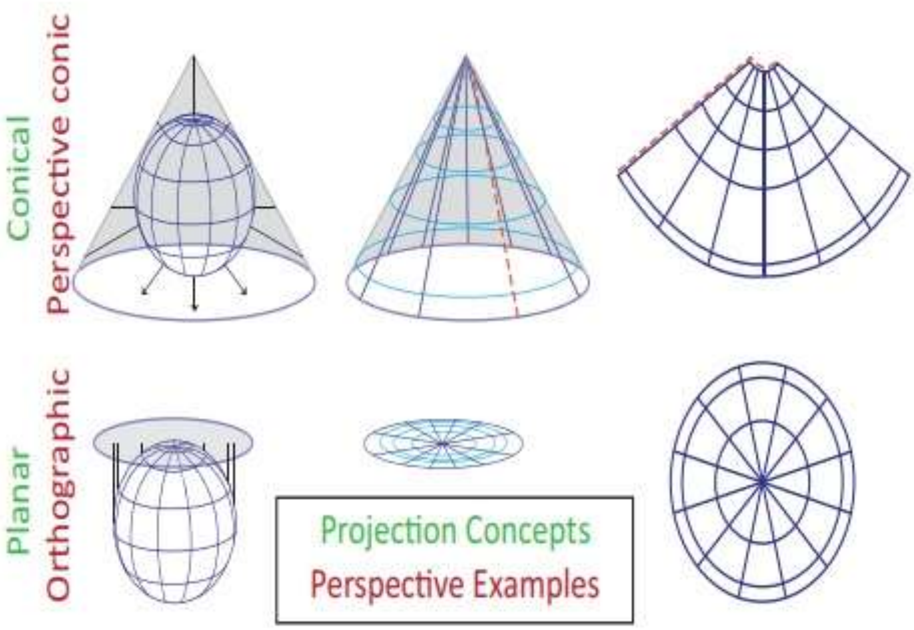
(E) Projection

A map projection is a way of showing the spherical shaped earth on a flat piece of paper. Where does the word 'projection' come from? Imagine a clear globe with latitude and longitude lines and the outlines of the landmasses on it. Suppose there was a light bulb inside the globe. If you wrapped a piece of paper around the globe and turned on the light bulb, the outlines of the grid and landmasses would be projected onto the paper. Map projection is defined as the transformation of spherical network of latitudes and longitudes on a plane surface. Projections are drawn to maintain the shape, area and directions.



The three methods in widest use are as follows:

- Projection on the surface of a cylinder
- Projection on to the surface of a cone
- Projection directly onto a flat plane, called planar or zenithal or azimuthal projection



(F) Legend

The legend of a map helps to understand the map details which are placed at the left or right corner at the bottom of the map.

(G) Conventional signs and symbols

A map is a global language and it needs to be drawn according to the international standards. Conventional signs and symbols are standard symbols used on a map and explained in the legend to convey a definite meaning. The topographic map contains a variety of information about physical and cultural features. These are shown by using signs and symbols in various colours so that the clarity of the map is maintained.

There are three types of map symbols

1. Point Symbols - buildings, dipping tanks, trigonometrical beacons
2. Line Symbols - railways, roads, power lines, telephone lines
3. Area Symbols - Cultivated lands, ponds, orchards and vineyards

The following colour codes are used with map symbols:

1. Brown: land or earth features - contour lines, eroded areas, prominent rock outcrops, sand areas and dunes, secondary or gravel roads.

2. Light Blue: water features - canals, coastlines, dams, lakes, marshes, swamps and levees, ponds, rivers and water towers.

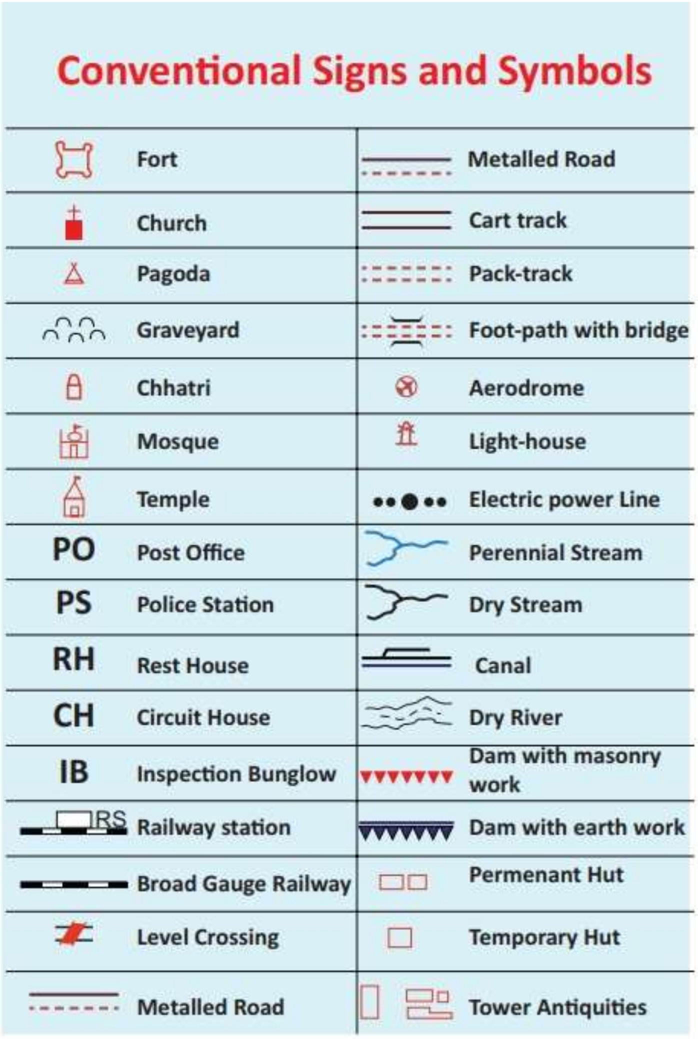
3. Dark Blue: national waterways.

4. Green: vegetation features - cultivated fields, golf courses, nature and game reserve boundaries, orchards and vineyards, recreation grounds, woodland.

5. Black: construction features - roads, tracks, railways, buildings, bridges, cemeteries, communication towers, dam walls, excavations and mine dumps, telephone lines, power lines, windpumps, boundaries.

6. Red: construction features - national, arterial and main roads, lighthouses and marine lights.

7. Pink: international boundaries.



Conventional Signs and Symbols

	Fort		Metalled Road
	Church		Cart track
	Pagoda		Pack-track
	Graveyard		Foot-path with bridge
	Chhatri		Aerodrome
	Mosque		Light-house
	Temple		Electric power Line
PO	Post Office		Perennial Stream
PS	Police Station		Dry Stream
RH	Rest House		Canal
CH	Circuit House		Dry River
IB	Inspection Bunglow		Dam with masonry work
RS	Railway station		Dam with earth work
	Broad Gauge Railway		Permenant Hut
	Level Crossing		Temporary Hut
	Metalled Road		Tower Antiquities

2. Concept and Construction of scales: Linear, comparative, diagonal and vernier.

Scale, a fundamental concept of geography, has many different types each of which tells an aspect of the story about how Earth's systems work.

Map or Cartographic Scale

Map or cartographic scale is the ratio of a distance on Earth compared to the same distance on a map. There are three types of scales commonly used on maps: written or verbal scale, a graphic scale, or a fractional scale. A written or verbal scale uses words to describe the relationship between the map and the landscape it depicts such as one inch represents one mile. A map reader would use a ruler to measure the distances between places. A graphic scale is a bar marked off like a ruler with labels outlining the distances the segments represent. Just as you would with a written or verbal scale to measure distance with this type of scale you would use a ruler. Finally, a fractional scale, typically represented as a ratio (1/50,000 or 1:50,000), indicates that one unit (inch, centimeter, football field or pitch, etc.) on the map represents the second number of that same unit on Earth. So if the ratio was 1:50,000 one centimeter on the map would represent 50,000 centimeters (500 meters) in real life. The whole map, at this ratio, would encompass a typical county in the United States.

Somewhat counterintuitively we describe detailed maps of smaller areas as large-scale maps and global maps as small scale. This is best illustrated with the fractional scale system. A large-scale map has a smaller ratio (1:10,000 or 1:25,000) and would have more details such as streets and building footprints. Whereas a small-scale map has a larger ratio (1:500,000 or 1:1,000,000) and illustrates an entire state, province, or country with just the larger cities or towns and major highways. Maps are not complete without a scale. It is key to making an accurate and understandable map.

Spatial Scale

There are three more general ways to describe scale as well: local, regional, and global. Local-scale is a specific place with unique physical features such as climate, topography, and vegetation.

Regions, however, vary considerably in size. They are generally larger than one place, such as a town or city, and may include several towns or multiple states or provinces. There are three types of regions: formal, functional, and vernacular. The easiest to identify is a formal region as it has recognized boundaries or borders and often governments. An example would be the German state of Bavaria or the Sahara Desert. A functional, or nodal, region is characterized by a common point or trait and is frequently used to describe economic areas such as the metropolitan area around Washington, D.C. in the United States. Finally, a vernacular or perceptual region is one that has characteristics that are perceived to be different from that of the surrounding areas. An example would be the Appalachian

Mountains in the United States. Certain economic activities and cultural characteristics are attributed to an area that encompasses nine U.S. states that the mountain range covers.

Global-scale, of course, covers all of Earth. Studying patterns at this scale is critical due to globalization. As the world becomes more interconnected information, goods, and ideas are traded at faster and faster rates changing the way we communicate and live. While most feel globalization has not destroyed the uniqueness of specific places, forces promoting globalization often come into conflict with those focused on preserving local traditions. Additionally, in some cases, globalization has increased the wealth gap between wealthy and poorer nations.

Examining patterns in different scales is critical to understanding the problem and its effects, which often vary by location. In the study of climate change, choices made at the local level, such as burning fossil fuels for power, can have larger impacts at the regional level (e.g., acid rain) or the global level where we see the increase in atmospheric carbon dioxide leading to rising temperatures. The results of the rising levels of carbon dioxide have different impacts on different localities. Coastal regions battle rising sea levels and the ground is shifting below Arctic communities as the permafrost melts. In order to appropriately understand and address complex issues like climate change, we need to examine it and devise solutions at multiple scales.

Graphical Construction of Scale

1. Simple or Plain Scale or Linear Scale

They read or measure up to **two** units or a unit and its sub-division, for example centimetres (cm) and millimetres (mm). When measurements are required up to first decimal, for example 2.3 m or 4.6 cm etc. It consists of a line divided into number of equal main parts and the first main part is sub-divided into smaller parts. Mark zero (O) at the end of the first main part. From zero-mark numbers to the main parts or units towards right and give numbers to the sub-divisions or smaller parts towards left. Give the names of the units and sub-units below clearly. Indicate below the name of the scale and its R.F clearly.

Example:

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

Solution:

Before initiating the construction, we have to perform the following calculation to derive the length of the scale.

The given R. F. of the map is 1:250,000 as we want to develop a scale in Kilometre, the given R. F. can be expressed as: one cm. represents 250,000 cm.

If we draw a line of 12 cm, it will represent the number of kms in following way: 1 cm. represents 250,000 cm or if we express it in km. 1 cm = 2.5 km (1, 00,000/250,000)

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

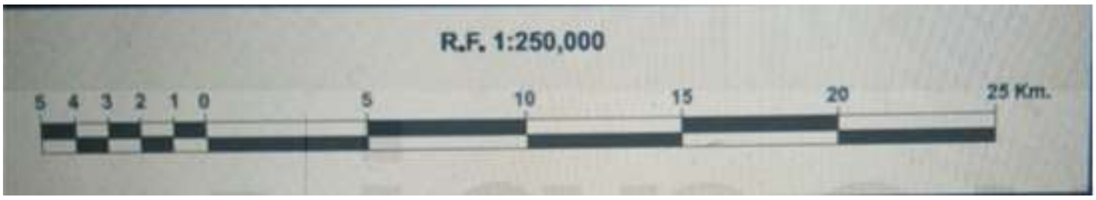
Steps Involved in the Construction

1. Based on the above calculation, we have to read upto 1 km. in this linear scale for 30 km. Therefore, we will divide this scale into six primary divisions. Thus, each primary division will read 5 km.

2. As discussed earlier in this section, the extreme left primary division of the scale will be divided into five equal divisions. Each secondary division will represent a minimum distance of one km.

3. While numbering the scale, zero should be marked after one interval from the left, so that the left-hand end of the line can be numbered 5 and the primary divisions to the right of zero can have numbers 5, 10, 15, 20 and 25.

This method of numbering enables us to read off directly the whole numbers as well as the fraction from the scale.



Plain Scale Depicting Primary and Secondary Divisions

2. Comparative Scale

In simpler terms, a comparative scale may be expressed as a pair of scales having a common R.F. but graduated to read different units. Some of the examples of comparative scales are (i) different units; (ii) time scale; (iii) pace scale; and (iv) revolution scale. Let us discuss each of them and their construction with an example each.

Different Units

As the name suggests, this type of scale depicts reading in two different units. An example of a comparative scale of two different units may be showing distances in meters and yards having common zero point. Let us solve the below given example for more clarity.

Example:

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

Calculation:

The given R.F. is 1:100,000

As we want to develop a scale in miles, the given R. F. can be expressed as: For mile 1 inch represents 100,000 inch 6" will represent 100000x6 Miles = 625 Miles = 9.46 miles 63360 66

For our convenience, let us convert it into a round figure of 10 miles. In this case, we have to recalculate the length of the scale.

Therefore, the length of the scale will be as follows: 625 Miles are shown by a line of 6" 66 1 mile will be shown by a line of 6 x 66" 625 10 miles will be shown by 6 x 66 x 10" = 6.3". 625 Miles for km 1 cm. represents 100,000 cm or 1 km. Then 15 cm. will represent 1 km. × 15 = 15 km.

Steps Involved in the Construction

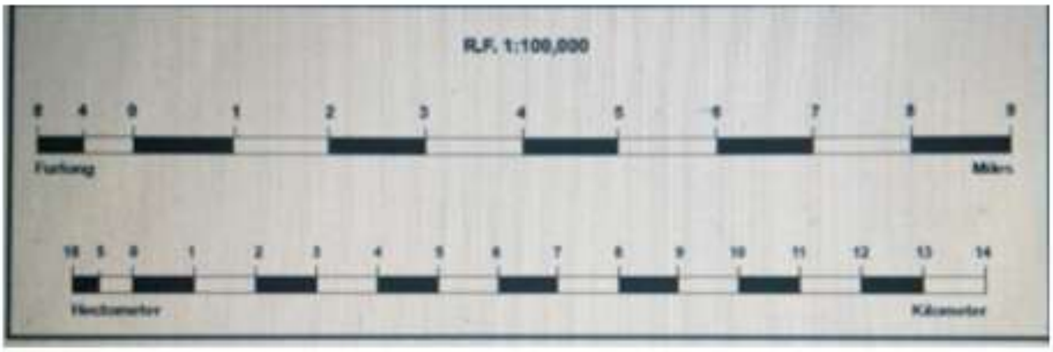
The following steps are followed while constructing comparative scale for depicting two different units. We have already calculated the length of the scale.

1. We will start the construction of comparative scale by drawing two straight lines. The length of the line representing mile is 6.3" whereas the second line representing kilometre is 15 cm.

2. Divide 6.3" line into 10 equal parts to show the primary division of one mile distance. Similarly, divide the line of 15 cm. into 15 equal parts to show the primary division of 1 km.

3. The first primary division in the extreme left will be divided into two equal parts. Thus, one secondary division will represent 4 furlongs. Similarly, to measure distance in hectometre, divide left primary division into two equal parts. Thus, one secondary division will measure the distance of 5 hectometre.

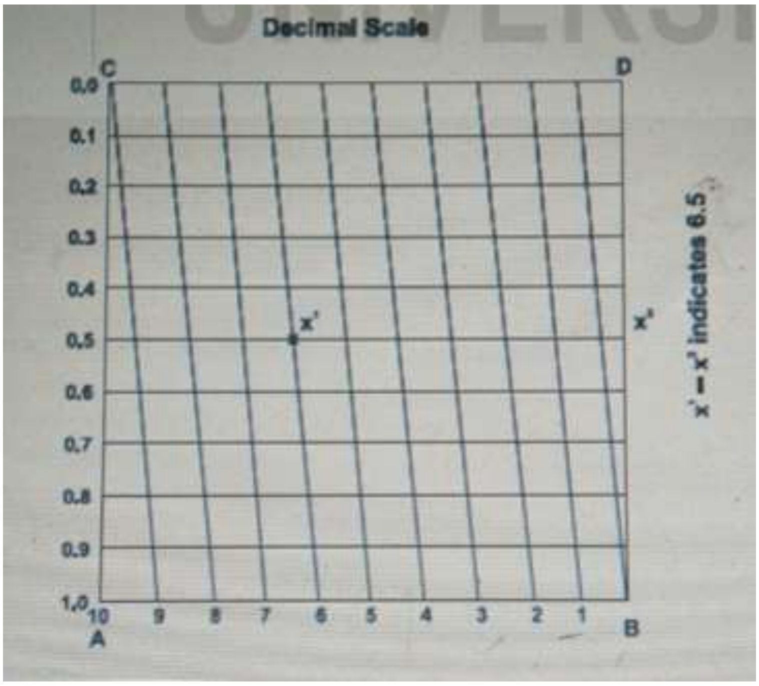
4. Now draw the comparative scale where the zero of both the scales should coincide with each other.



Comparative Scale Depicting Two Different Scales

3. <u>Diagonal Scale</u>

Diagonal scales are drawn for greater precision or higher degree of accuracy. Can you imagine how is this precision achieved? Yes, you're right. We achieve this precision because this scale is specifically used to measure up to three units. For example, in a metric system you can measure kilometres (km), meters (m) and centimetres (cm). Similarly, in British system of measurement you can measure miles, furlongs and yards etc. If you observe closely the previous two scales, they are best suited for measuring up to two units. This scale is used when very small distances such as 0.1 mm are to be accurately measured or when measurements are required up to second decimal. The below given figure depicts micro-distance in a diagonal scale.



Reading of Micro-Distance in a Diagonal Scale

<u>Example 1:</u>

To read the distance of one hundredth part of a mile, draw a diagonal scale on R.F. 1:63,360 and also show the distance of 1.56 mile on the scale.

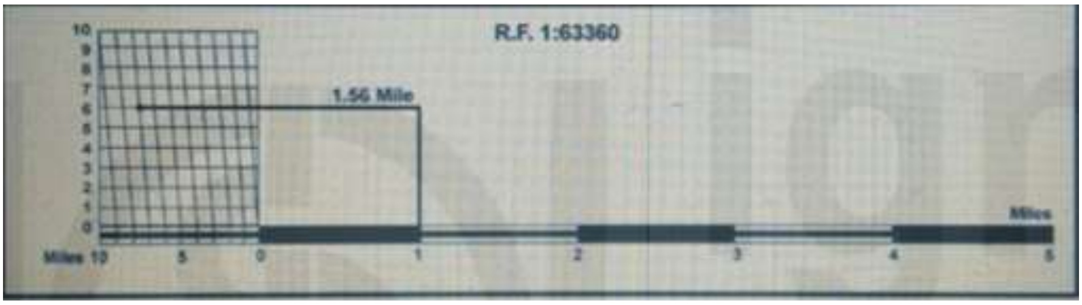
Solution:

Steps involved in the Construction

1. As per the given exercise, 1" represents 1 mile, as 1 mile is equal to 63,360". Draw a line of 6", and divide it into 6 primary divisions. Thus, one primary division will represent one mile.

2. Divide the first primary division of the left side into ten secondary divisions. Thus, the one secondary division will represent 0.1-mile distance.

3. To read the distance of 0.01 mile draw 10 parallel lines to the main scale. On the left side of primary division mark 10 points of equal distances on the upper most line of the scale. Join these 10 small distances with the diagonals.



Diagonal Scale Showing the Distance of 1.56 Mile

Example 2:

Draw a diagonal scale to read 3.47 inches. R. F= 1:1.

Calculation: Reading to be shown: 3.47 inches

= (3.00 + 0.40 + 0.07) inches

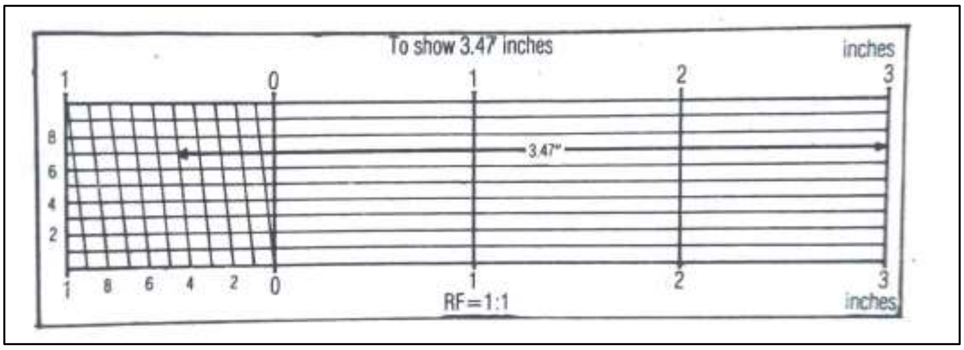
= (3 x 1.00 + 4 x 0.10 + 7 x 0.01)) inches

Therefore, a primary division is to be divided into 10 equal parts (1 inch/ 0.1 inch) and a secondary division also in 10 equal parts (0.1 inch/ 0.01 inch) with the following readings:

Division

Primary		Secondary		Tertiary	
Value	No	Value	No	Value	No
1.00 inch	3	0.10 inch	4	0.01 inch	7

Since the R.F is 1:1 the length of a primary division will be 1 inch.



Diagonal scale

4. <u>Vernier Scale</u>

Do you know why this scale is named so? This scale is named after its inventor Pierre Vernier, a French Mathematician in 1631. Vernier scales are drawn to achieve greater accuracy in the form of fraction of a division in both linear and angular measurements. This scale consists of a small moving scale. This small moving scale has the graduated edge which slides along the graduated edge of a larger sale. The larger scale is known as primary scale and as mentioned above the small graduated scale is known as Vernier scale.

<u>Example:</u>

Draw a vernier scale to read 65°39' when the value of one division of vernier scale and vernier constant are 5'24'' and 0.6' respectively.

<u>Solution</u>

<u>Step 1</u>

Least count of Main Scale (d)

= (VC + Length of one small vernier scale division)

$= (0.6' \text{ or } 0'36'' + 5'24'') = 6'' \qquad * \{0.6' = 0.6' \times 60'' = 0'36''\}$

$$\text{No. of Vernier Scale Division (n)} = \frac{d}{vc} = \frac{6'}{0'36''} = 10$$

$$\text{Vernier Constant (V.C.)} = 0.6' \text{ or } \{0.6' = 0.6' \times 60'' = 0'36''\}$$

Step 2

Total Scale Reading (T.S.R.) = 65°39'

Main Scale Reading (M.S.R.) = 65°36'

Vernier Scale Reading (V.S.R.) = (T.S.R. – M.S.R.) = (65°39' - 65°36') = 3'

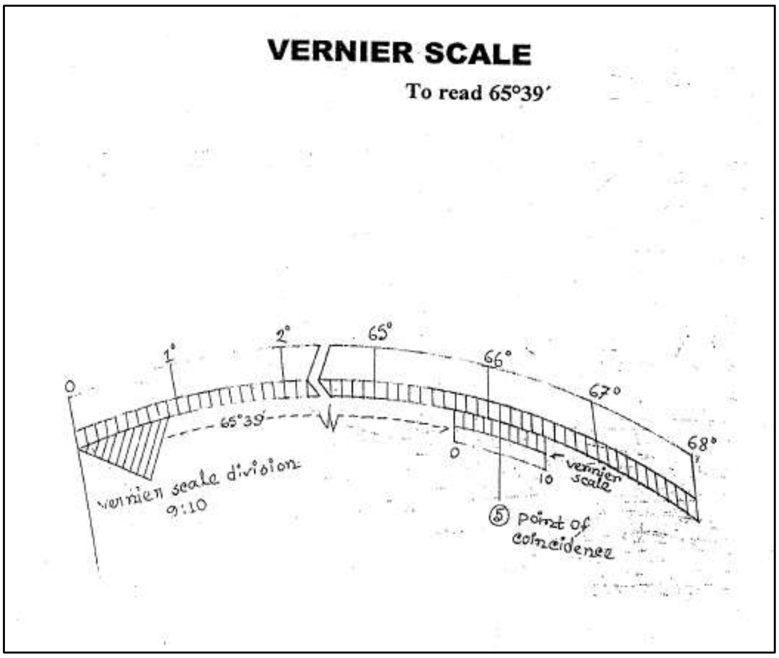
Step 3

Coincident point of Vernier Scale Division with the any foreword division of main scale

$$= \frac{\text{Total Scale Reading} - \text{Main Scale Reading}}{\text{Vernier Constant}}$$

$$= \frac{65°39' - 65°36'}{36''}$$

$$= 5 \text{ th Division}$$



3. Map projections: Classification of map projection.

Classification of Map Projections

Map projections are classified on the following criteria:

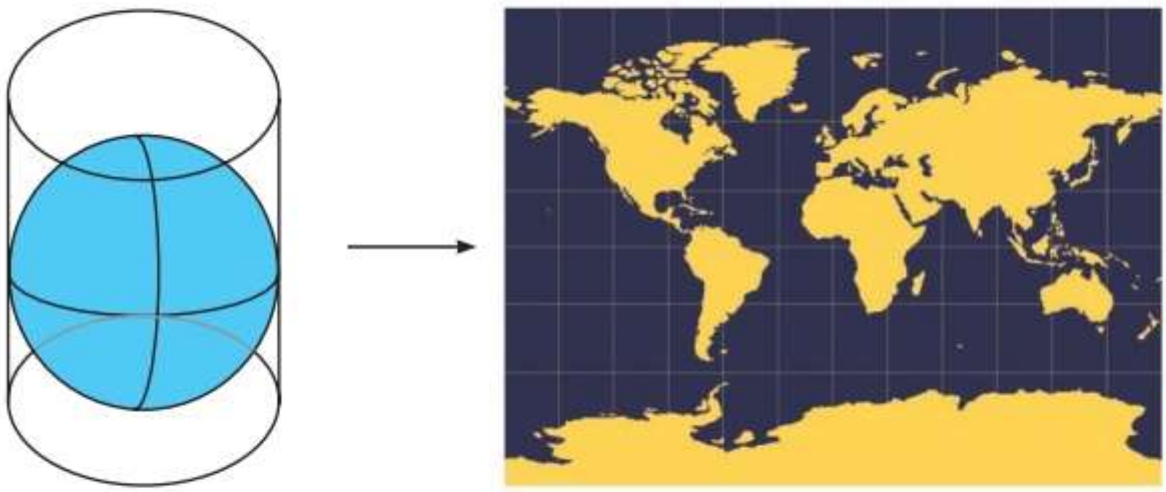
- Method of construction
- Development surface used
- Projection properties
- Position of light source

Classification based on Methods of Construction

Given below are the projections that are based on the method of construction:

a). Perspective Projections: These projections are made with the help of shadow cast from an illuminated globe on to a developable surface.

b). Non-Perspective Projections: A developable surface is only assumed to be covering the globe and the construction of projections is done using mathematical calculations.



Cylindrical Projection

Classification based on Developable Surface used

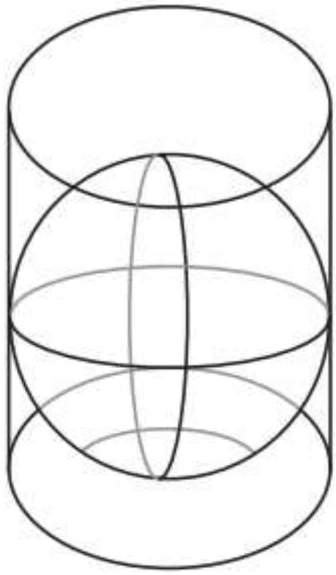
The three basic projections are based on the types of developable surface. They are:

1. Cylindrical Projection

- It can be visualized as a cylinder wrapped around the globe.
- The longitudes (meridians) and latitudes (parallels) appear as straight lines.

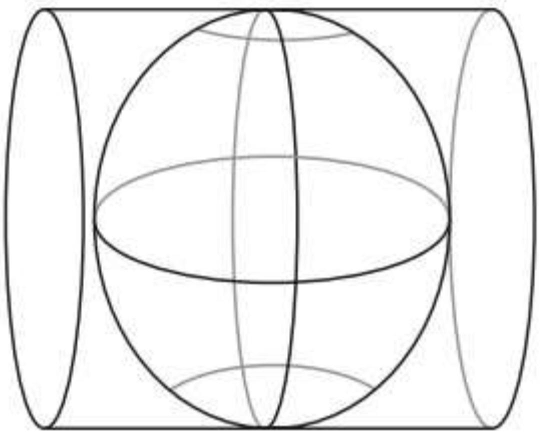
- Length of equator on the cylinder is equal to the length of the equator, therefore, it is suitable for showing equatorial regions.

Normal: when a cylinder has line of tangency to the equator. It includes Equirectangular Projection, the Mercator projection, Lambert's Cylindrical Equal Area, Gall's Stereographic Cylindrical, and Miller cylindrical projection.



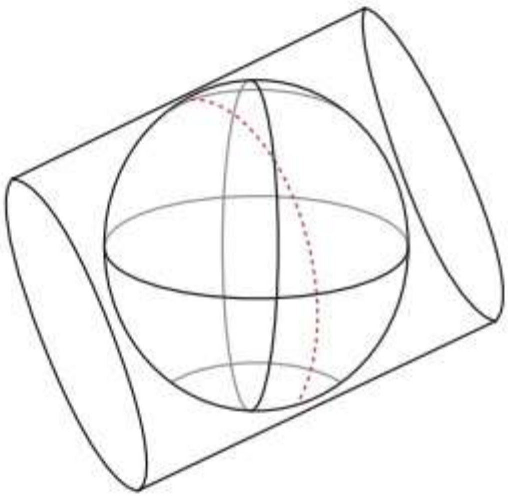
(a) Normal

Transverse: when cylinder has line of tangency to the meridian. It includes the Cassini Projection, Transverse Mercator, Transverse cylindrical Equal Area Projection, and Modified Transverse Mercator.



b) Transverse

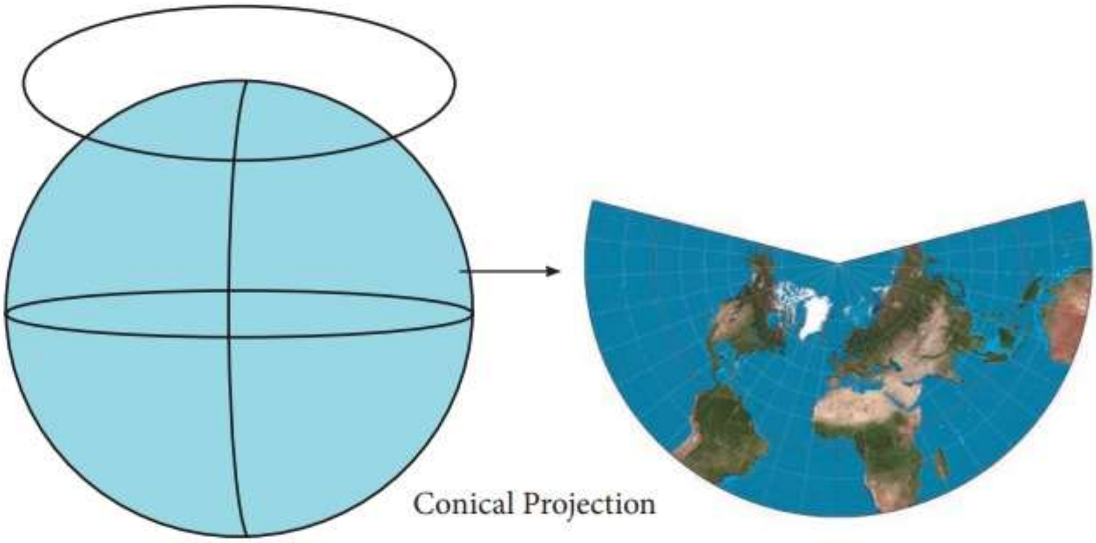
Oblique: when cylinder has line of tangency to another point on the globe. It only consists of the Oblique Mercator projection.



(c) Oblique

2. Conical Projection

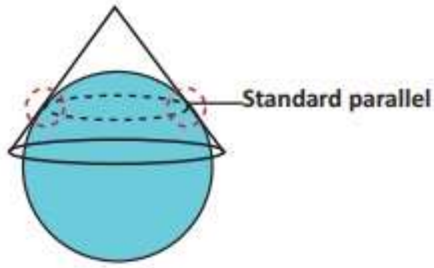
- It can be visualized as a cone placed on the globe, tangent to it at some parallel.
- After projecting the graticule on to the cone, the cone is cut along one of the meridian and unfolded. Parallels appear as arcs with a pole and meridians as straight lines that converge to the same point.
- It can represent only one hemisphere, at a time, northern or southern hemisphere.
- It is suitable for representing middle latitudes.



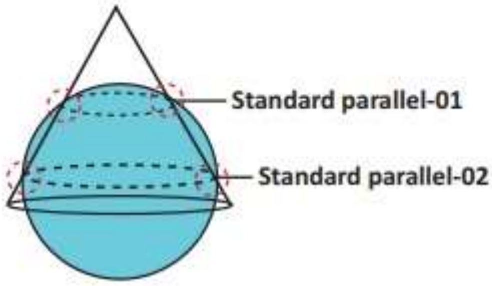
Conical Projection

Conical projection is divided into two. They are

Tangent: when the cone is tangent to only one of the parallel.

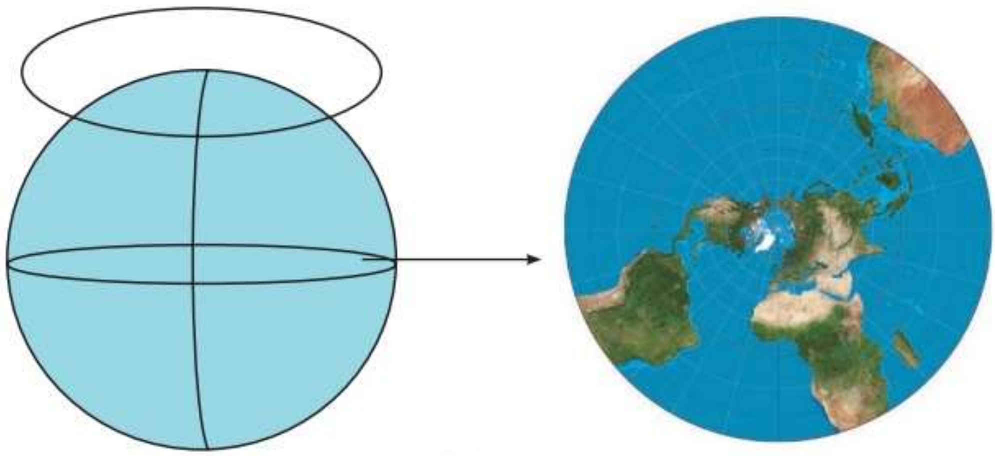


Secant: when the cone is not big enough to cover the curvature of earth, it intersects the earth twice at two parallels.



3. Azimuthal /Zenithal Projection

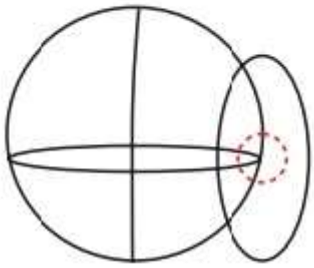
- It can be visualized as a flat sheet of paper tangent to any point on the globe
- The sheet will have the tangent point as the centre of the circular map, where meridians passing through the centre are straight line and the parallels are seen as concentric circle.
- Suitable for showing polar areas



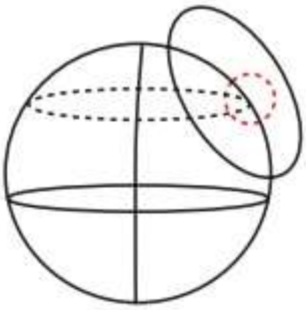
Zenithal Projections

Aspects of zenithal projection:

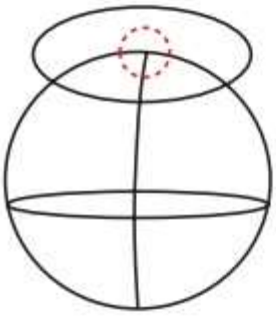
Equatorial zenithal: When the plane is tangent to a point on the equator.



Oblique zenithal: when the plane is tangent to a point between a pole and the equator.



Polar zenithal: when the plane is tangent to one of the poles.



According to properties, map projections can be classified as:

Equal area projection: It is also known as homolographic projections. The areas of different parts of earth are correctly represented by such projections.

True shape projection: It is also known as orthomorphic projections. The shapes of different parts of earth are correctly represented on these projections.

True scale or equidistant projections: Projections that maintain correct scale are called true scale projections. However, no projection can maintain the correct scale throughout. Correct scale can only be maintained along some parallels or meridians.

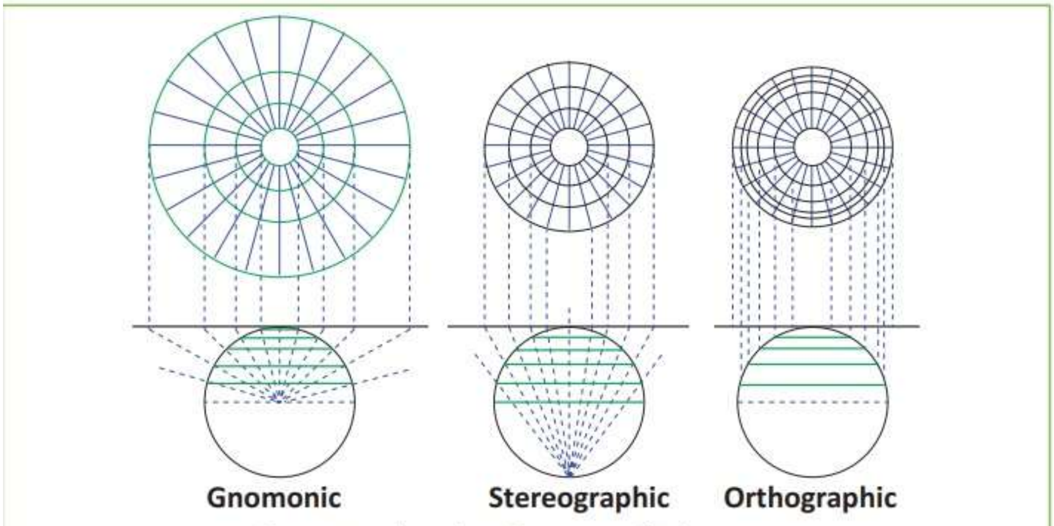
Classification based on Position of light source

Placing light source illuminating the globe at different positions results in the development of different projections. These projections are

Gnomonic projection: when the source of light is placed at the centre of the globe

Stereographic Projection: when the source of light is placed at the periphery of the globe, diametrically opposite to the point at which developable surface touches the globe.

Orthographic Projection: when the source of light is placed at infinity from the globe opposite to the point at which developable surface touches the globe.



Projection based on Position of light source

Criteria	Parameter	Classes/ Subclasses			
Extrinsic	Datum Surface	Direct / Spheroidal	Double/ Spherical	Triple	
	Plane or surface of projection	Ist Order	2nd Order	3rd Order	
		I. Planar II. Conical III. Cylindrical	a. Tangent b. Secant c. Polysuperficial	i. Normal ii. Transverse iii. Oblique	
	Method of Projection	Perspective	Semi-perspective	Non-perspective	Conventional
Intrinsic	Properties	Azimuthal	Equidistant	Othomorphic	Homolographic
	Appearance of parallels and meridians	Both parallels and meridians straight Parallels straight, meridians curve Parallels curves, meridians straight Both parallels and meridians curves Parallels concentric circles , meridians radiating st. lines Parallels concentric circles, meridians curves			
	Geometric Shape	Rectangular	Circular	Elliptical	Parabolic

4. Construction, properties and uses of projections: Cylindrical Equal area, Polar Zenithal Stereographic, Simple conical with one standard parallel, Polyconic projection, Bonne's, and Mercator's. Concept and significance of UTM projection.

CONSTRUCTION OF MAP PROJECTION

A. Polar Zenithal Stereographic Projection

The projection which is obtained by projecting graticule of latitudes and longitudes on a plane tangent to the globe, it is called a zenithal projection.

Properties Common to Zenithal Projections

1. One important property of zenithal projection is that they have true bearings from the centre or we can say that directions of all points from the centre are correct. That is why they are also called azimuthal projections.
2. The projecting surface is tangent to the globe.
3. Shape is distorted away from the centre.

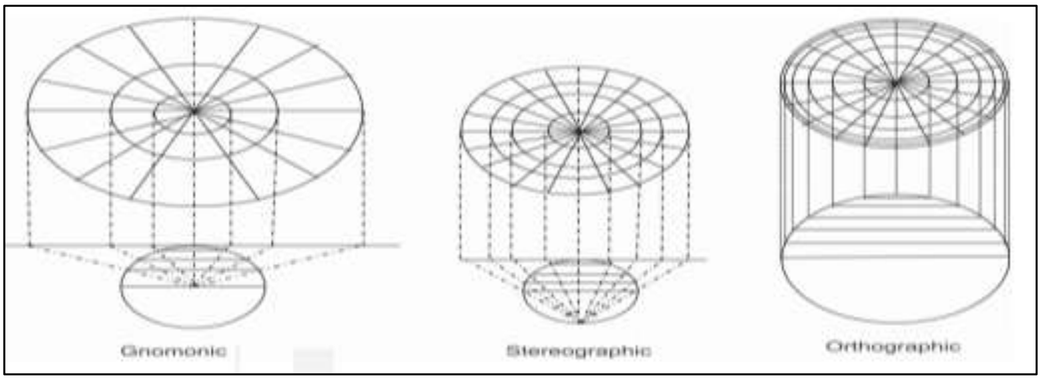
Types of Zenithal Projections

- Zenithal projections are divided into two broad types, that is, perspective and non-perspective projections.
    1. If light is used as a source for projecting the graticule of parallels and meridians, then it is called **perspective zenithal projection**.
    2. Those which do not involve the use of light for projecting the graticule of parallels and meridians are called **non-perspective zenithal projections**.

- Perspective zenithal projections are further divided into three types on the basis of position of this light source.
    1. If the source of light is placed at the centre of the projecting globe, it is called a **gnomonic zenithal projection**.

2. If the source of light is placed diametrically opposite to the point of contact of the tangential plane, it is called a **stereographic zenithal projection**.
3. Now when the light source is at infinity, so that the rays of light are parallel, the resultant projection is called an **orthographic zenithal projection**.

In the figure you can see the different position of light sources in the projecting globe (in gnomonic, stereographic and orthographic cases) in the lower portion and the respective projected graticule of parallels and meridians in the upper portion.



Example:

Draw the graticules of polar zenithal stereographic projection for the map of Northern Hemisphere at an interval of 15º on a scale of 1:225,000,000.

Step I: Radius of the generating globe (R): Actual radius of the earth / denominator of R.F.

Step II: parallels to be drawn: 0º, 15^0 N, 30^0 N, 45^0 N, 60^0 N, 75^0 N, 90^0N.

Step III: Radius of any parallel (r_θ) = 2R tan (90^0- θ / 2)

= 2 x 1.11 tan (90^0- θ / 2) inch

= 2.22 tan (90^0- θ / 2) inch

Computation table for r_φ

r_φ \ φ_N	0°	15°	30°	45°	60°	75°	90°
$2.22 \tan\left(\frac{90°-\varphi}{2}\right)$ inch	2.22	1.70	1.28	0.92	0.59	0.29	-

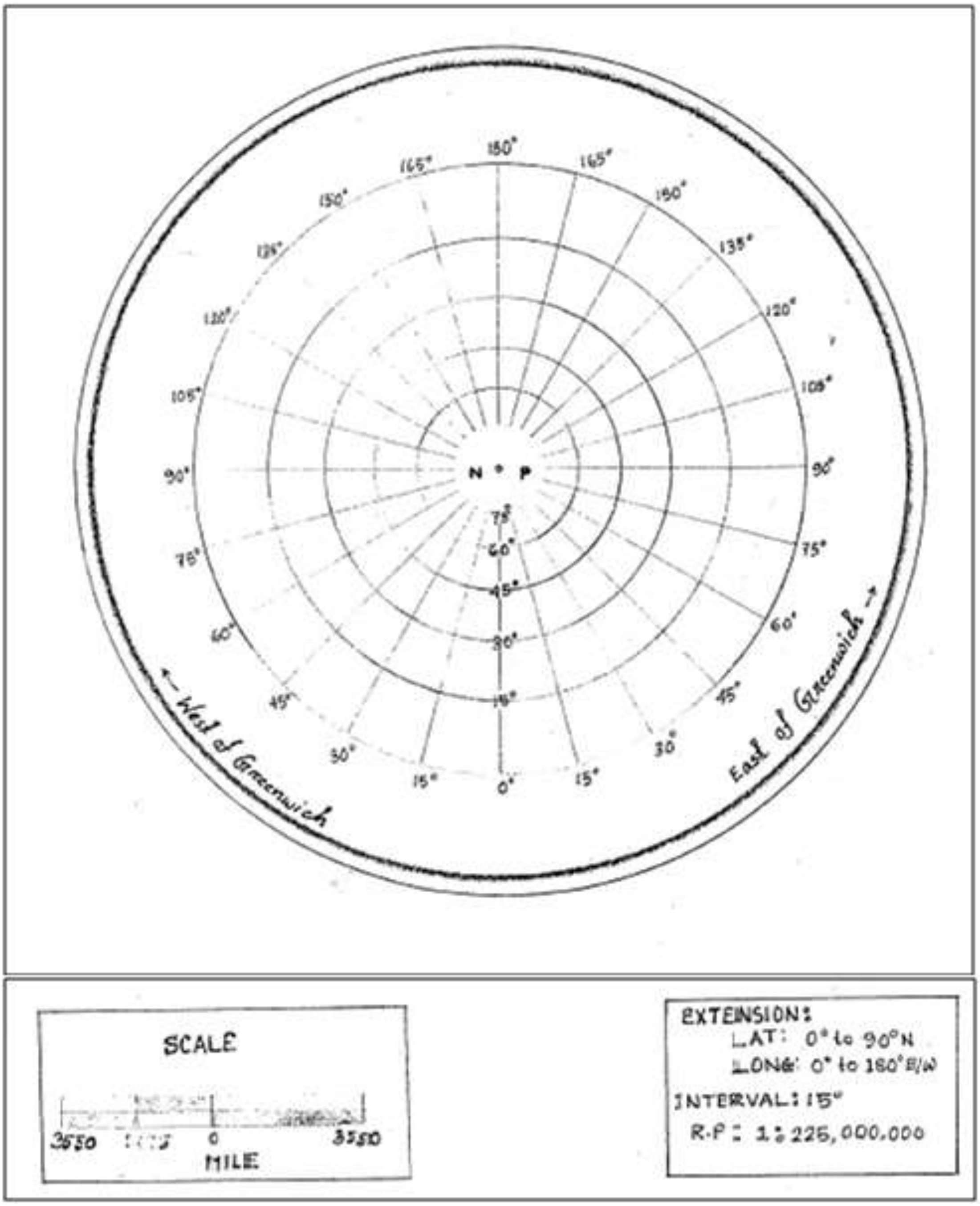
Step-IV: calculation for graphical scale

1 inch on the map distance represents 225,000,000 inch on the ground

1 inch on the map distance represents 225,000,000/63360 mile on the ground

= 3551.136364 mile

POLAR ZENITHAL STERIOGRAPHIC PROJECTION

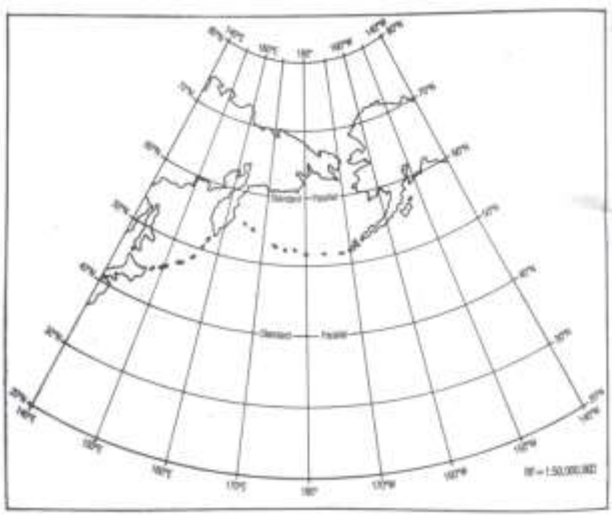


B. Simple Conic with Two Standard Parallels

In this projection, a simple right circular cone is taken as the projection plane. Two circles of the cone correspond to two different parallels on the generating globe and form an ordinary cone independent of the globe. These are the standard parallels which are so selected as to cover two-thirds of the latitudinal extent of the area to be mapped. The parallels appear as concentric arcs of circle while meridians appear as straight lines converging at the vertex of the cone.

Construction

1. A straight line is drawn vertically through the centre of the paper to represent the Central Meridian.
2. It is then divided by d for spacing the parallels.
3. An arc of circle of r_1 radius centred on the Central Meridian is drawn passing through the Φ_1, division-mark on the Central Meridian to represent the first Standard Parallel.
4. Similarly, with r_2 radius the Standard Parallel Φ_2 is drawn.
5. From the centre of the Standard Parallels, concentric arcs of circles are drawn through the remaining division-marks to represent the other parallels.
6. By d_1, the Standard Parallel, Φ_2 is divided for spacing the meridians.
7. Similarly by d_2, the Standard Parallel, Φ_2, is divided for spacing the meridians.
8. Straight lines are drawn through the corresponding division points on the Standard Parallels to represent the meridians.
9. The graticules are then accurately and properly labelled.



Simple Conical Projection (with Two Standard Parallel)

Properties

1. This is a non-perspective projection.
2. The parallels are concentric arcs of circles truly spaced on the Central Meridian.
3. The Pole is represented by an arc of circle.

4. Radial scale is true along the Central Meridian.
5. The parallels are equidistant from one another.
6. The meridians are straight lines truly spaced on the Standard Parallels.
7. The meridians converge at the vertex of the cone.
8. Tangential scale is true along the Standard Parallels.
9. Deformation is negative within the inter-standard parallel area while it is positive beyond the Standard Parallels.
10. It is the most suitable projection for mid-latitude countries with latitudinal extent relatively smaller than the longitudinal extent.

Example

Draw graticules of Simple Conical Projection with Two Standard Parallels for extension, 20°N to 80°N and 140°E to 140°W at 10° interval. Scale is 1 : 50 X 10^6.

Calculation

Step 1

Radius of the generating globe, R = Actual Radius of the Earth / Denominator of R.F.

Radius of the reduced earth is, $R = \frac{250{,}000{,}000 \text{ inches}}{50{,}000{,}000} = 5$ inches.

Step 2

The division along the Central Meridian for spacing the parallel at interval 10°,

$$d = \frac{\pi R}{180°} \times i° = 0.8727 \text{ inch}$$

Step 3

For 20°N to 80°N parallels at 10° interval, Standard Parallels chosen are:

$$\Phi_1 = 20°\text{N} + \frac{(80° - 20°)\text{N}}{3} = 20°\text{N} + 20°\text{N} = 40°\text{N}$$

And

$$\Phi_2 = 80°\text{N} - \frac{(80° - 20°)\text{N}}{3} = 80°\text{N} - 20°\text{N} = 60°\text{N}$$

Step 4

Parallels to be drawn – 20N, 30N, 40N, 50N, 60N, 70N and 80N

Meridians to be drawn – 140E, 150E, 160E, 170E, 180E, 170W, 150W, and 140W

Step 5

The radius of the Standard Parallel, Φ_1,

$$r_{\emptyset_1} = R(\emptyset_1 - \emptyset_2)^c \times \frac{\mathrm{Cos}_{\emptyset_1}}{\mathrm{Cos}_{\emptyset_1} - \mathrm{Cos}_{\emptyset_2}}$$

$$r_{40} = 5.(60° - 40°)^c \times \frac{\mathrm{Cos}40°}{\mathrm{Cos}40° - \mathrm{Cos}60°} = 5.0255 \text{ inches}$$

$$r_{60} = 5.(60° - 40°)^c \times \frac{\mathrm{Cos}60°}{\mathrm{Cos}40° - \mathrm{Cos}60°} = 3.2801 \text{ inches}$$

Step 6

The division on the Standard Parallel, Φ_1, for spacing the meridian at 10° interval,

$$d_1 = \frac{2\pi R\mathrm{Cos}\emptyset_1}{180°} \times i°$$

$$d_1 = \frac{2\pi R\mathrm{Cos}40°}{360°} \times 10° = 0.6685 \text{ inch}$$

$$d_2 = \frac{2\pi R\mathrm{Cos}60°}{360°} \times 10° = 0.4363 \text{ inch}$$

C. Cylindrical Equal Area

This projection is also known as Lambert's Cylindrical Projection in which the distance between latitude decreases towards the higher latitudes. In this projection, the pole is shown with the parallel equal to the equator; hence the shape of the area gets highly distorted at the higher latitudes. Therefore, the projection is non-orthomorphic. The parallels of latitude and the meridians of longitude intersect each other at the right angle. Area lying between 45° N and S latitudes can be suitably shown on this projection. The projection is also suitable to show the distribution of tropical crops such as coffee, rice, and rubber, etc.

Properties of Cylindrical Equal-Area Projection

Properties of cylindrical equal area projection are more or less similar to simple cylindrical projection. Following are the main properties of this projection:

Shape of Parallels and Meridians:

Parallels are represented by a set of parallel straight lines and are of same length as like that of the equator. Parallels are variably spaced on the meridians. Inter-parallel spacing decreases rapidly toward the pole. The tangential scale rapidly increases pole-ward and is infinity at the poles. Meridians are parallel straight lines truly spaced on the equator. Meridians are of same length equal to the diameter of the globe. The inter-meridian spacing is uniform on all the parallels. The pole is represented by a straight line equal to the length of $2\pi R$.

Intersection of Parallels and Meridians:

Like other cylindrical projections, the parallels and meridians intersect each other at right angles in all parts of the projection.

Scale along Parallels and Meridians:

The scale along the standard parallel i.e., the equator is true. Along other parallel and all meridians scale is not true. The amount of exaggeration in scales increases in both parallels and meridians as we move from the equator towards the pole. The exaggerations in scales are so much that it leads to distortion of shape in the political map of the countries located in the sub-polar and polar areas.

Uses and Limitations of Cylindrical Equal-Area Projection

1. This projection is most suitable for the area lying between 45º N and S latitudes.
2. It is most appropriate to show the distribution of tropical crops like rice, tea, coffee, rubber and sugarcane, etc.
3. Distortion increases as we move towards the pole.
4. The projection is non-orthomorphic.
5. Equality of area is maintained at the cost of distortion in shape.

Example:

Draw a neat graticules of Cylindrical Equal area projection for an area extending 40^0 N to 40^0 S & 20^0 W to $60^{\,0}$ E at an interval of 10^0 on a scale 1: 75000000.

Step I:

Radius of the generating globe (R): Actual radius of the earth / denominator of R.F.

= 250,000,000 inch/ 75,000,000

= 3.33 inch

Step II:

Divisions along the equator for spacing the meridians at i^0 interval (d) = $2\Pi R/360^0 \times 10^0$

= $2\ \Pi \times 3.33$ inch / $360^0 \times 10^0$

= 0.58 inch

Step III:

Parallels to be drawn: 40^0 N, 30^0 N, 20^0 N, 10^0 N, 0^0, 10^0 S, 20^0 S, 30^0 S, 40^0 S

Meridians to be drawn: 20^0 W, 10^0 W, 0^0, 10^0E, 20^0E, 30^0E, 40^0E, 50^0E, 60^0E

Step IV:

The height of any parallel above the equator ($y\theta$) = R Sin θ

= 3.33 sin θ (inch)

Computation table for y_φ

φ N/S / y_φ	10°	20°	30°	40°
3.33 sin φ (inch)	0.58	1.14	1.67	2.14

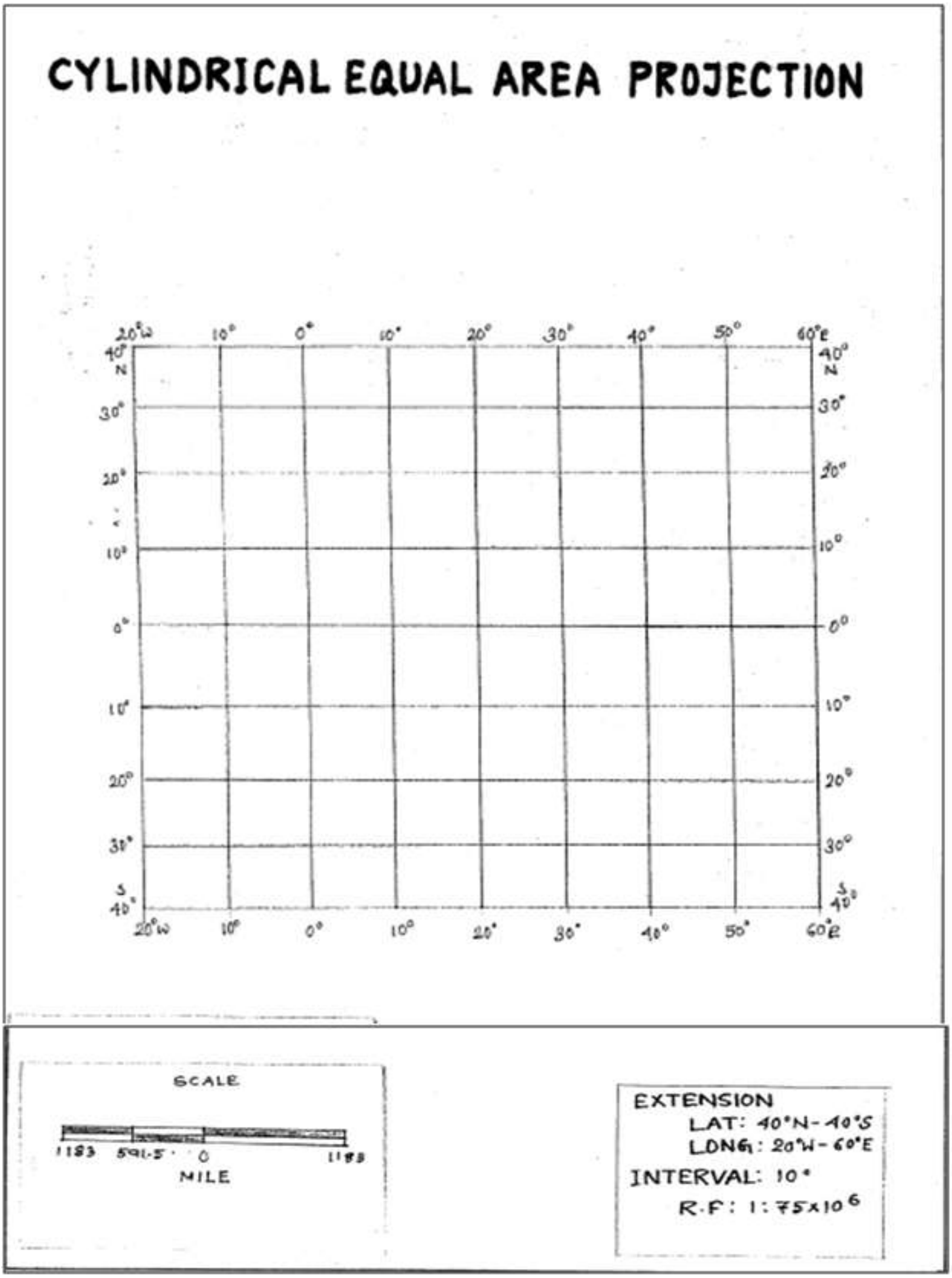
Step V:

Calculation for graphical scale

1 inch on the map distance represents 75,000,000 inches on the ground

1 inch on the map distance represents 75,000,000/63360 mile on the ground

= 1183.712121 mile



D. Bonne's Projection

It is a special case of conical projection named after a French cartographer Rigobert Bonne, who designed this projection. It is different from the former two projections because in this all the parallels are drawn true to scale. However, only one parallel is considered as standard parallel and hence its radius is determined. The curvature of other parallels depends on the standard parallel. For drawing the meridians, all the parallels are divided separately and truly and the points so obtained are joined by smooth curves.

Properties of Bonne's Projection

1. All parallels are concentric curves. However, their curvature depends on the curvature of the selected standard parallel for construction.
2. All meridians are smooth curves except the central meridian which is a straight line.
3. The scale is true along all the parallels as all of them are drawn true to scale.
4. The scale is correct along the central meridian only. This is the reason why shape gets distorted away from the central meridian.
5. This is an equal area projection as in this, the area of each quadrangle is made equal to the corresponding quadrangle on the globe. Both height and base are true to scale.
6. As this is an equal area projection, it is suitable for maps of Europe, North America, and Australia etc.

Use

It is used for maps of all continents except Africa. Sinusoidal projection is suitable for drawing maps of Africa, which is a special case of Conical projection, but you will study about sinusoidal projection at higher levels. Bonne's projection is also used for topographical maps of countries like Netherlands, Belgium, and Switzerland etc.

Example:

Draw a neat graticule of Bonne' s projection for the map of Europe extending from 35^0N to 75^0N & 10^0 W to 50^0 E at an interval of 10^0 on a scale of 1:60,000,000.

Step I

Radius of the generating globe (R): Actual radius of the earth / denominator of R.F.

= 250, 000000/ 60000000 = 4.17 inch

Step II

Parallels to be drawn: 35^0 N, 45^0 N, 55^0 N, 65^0 N, 75^0N (Standard parallel is 55^0N)

Meridians to be drawn: 10^0 W, 0^0, 10^0 E, 20^0 E, 30^0 E, 40^0 E, 50^0 E (central meridian is 20^0 E)

Step III

Division along the central meridian for spacing the parallels at i^0 interval (d)

$= \Pi R/180^0 \times i^0$

$= \Pi \times 4.17$ inch $/ 180^o \times 10^0$

$= 0.73$ inch

Step IV

Radius of the standard parallel ($r\,\theta$) $= R \cot\theta$

$= 4.17 \cot 55^0$ (inch)

$= 2.92$ inch

Step -V

The division on the parallel for spacing the Meridians at i^0 interval ($d\theta$)

$= 2\Pi R \cos\theta / 3600 \times i^0$

$= 2 \times \Pi \times 4.17$ inch $\times \cos\theta / 360^0 \times 10^0$

$= 0.73 \cos\theta$

Computation table for ($d\varphi$)

φ_N / $d\varphi$	35^o	45^o	55^o	65^o	75^o
$0.73 \cos\varphi$ (inch)	0.6	0.52	0.42	0.30	0.19

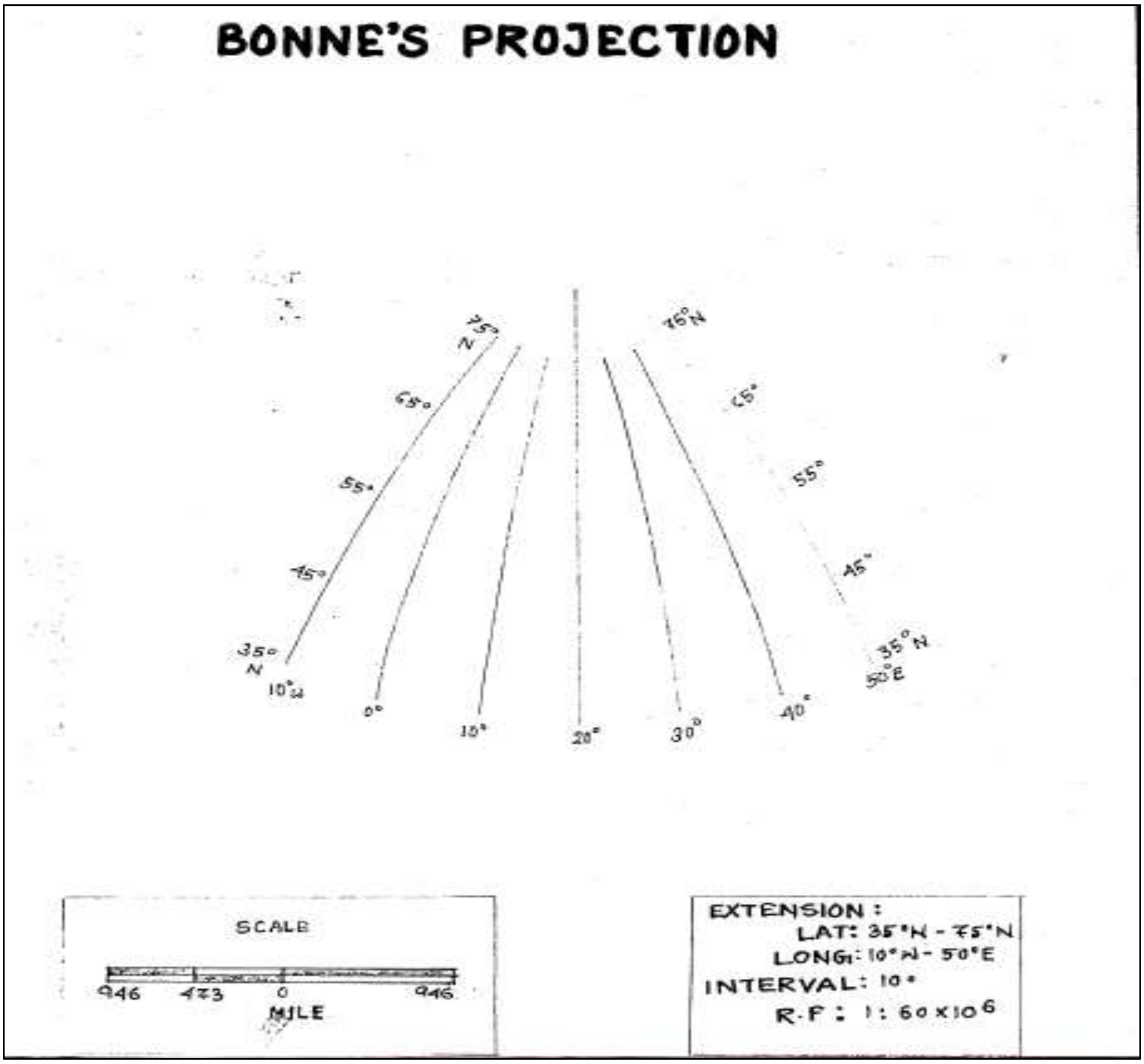
Step VI

Calculation for graphical scale

1 inch on the map distance represents 60,000,000 inches on the ground

1 inch on the map distance represents 60,000,000/63360 mile on the ground

= 946.969697mile

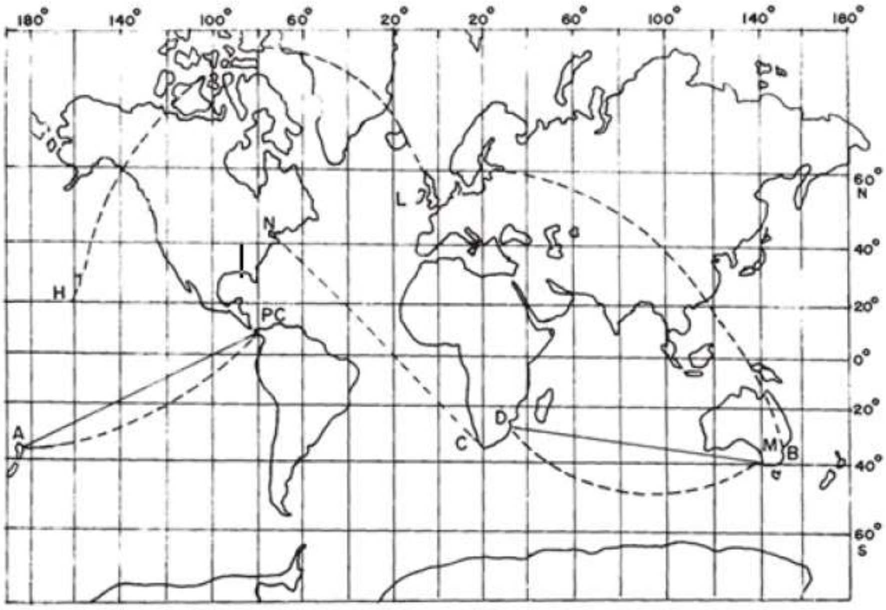


E. Mercator's Projection

This is a cylindrical orthomorphic projection designed by Flemish, Mercator and Wright. In this, a simple right circular cylinder touches the globe along the equator. All the parallels are of the same length equal to that of the equator and the meridians are equispaced on the parallels. Therefore, the tangential scale increases infinitely toward the pole. To maintain the property of orthomorphism, the radial scale is made equal to the tangential scale at any point. Hence parallels are variably spaced on the meridians and the poles can never be represented. The parallels and meridians are represented by sets of straight lines intersecting at right angles.

Construction

1. A straight line is drawn horizontally through the centre of the paper to represent the Equator.
2. It is then divided by d for spacing the meridians.
3. Through each of these division points, straight lines are drawn perpendicular to the Equator to represent the meridians.
4. On the Central Meridian, heights of different parallels (Y_{Φ}) from the Equator are marked.
5. Through each of these points straight lines are drawn perpendicular to the Central Meridian to represent the parallels.
6. The graticules are then accurately and properly labelled.



Straight lines are Laxodromes or Rhumb lines and

Dotted lines are great circles

Properties

1. All parallels and meridians are straight lines and they intersect each other at right angles.
2. All parallels have the same length which is equal to the length of equator.
3. All meridians have the same length and equal spacing.
4. Spacing between parallels increases towards the pole.
5. Scale along the equator is correct as it is equal to the length of the equator on the globe; For example, the 30º parallel is 1.154 times longer than the corresponding parallel on the globe.
6. Shape of the area is maintained, but at the higher latitude's distortion takes place.
7. The shape of small countries near the equator is truly preserved while it increases towards poles.
8. It is an azimuthal projection.

9. This is an orthomorphic projection as scale along the meridian is equal to the scale along the parallel.

Uses

1. More suitable for a world map and widely used in preparing atlas maps.
2. Very useful for navigation purposes showing sea routes and air routes.
3. Drainage pattern, ocean currents, temperature, winds and their directions, distribution of worldwide rainfall and other weather.

Example

Draw a Mercator's projection for the map of India with extension of 60°E to 100°E and 4°N to 40°N on the scale of 1:25 X 10^6 at 4° intervals.

Calculation

Step 1

Radius of the generating globe, R = Actual Radius of the Earth / Denominator of R.F.

Radius of the reduced earth is, $R = \frac{250{,}000{,}000 \text{ inches}}{250{,}000{,}00} = 10$ inches.

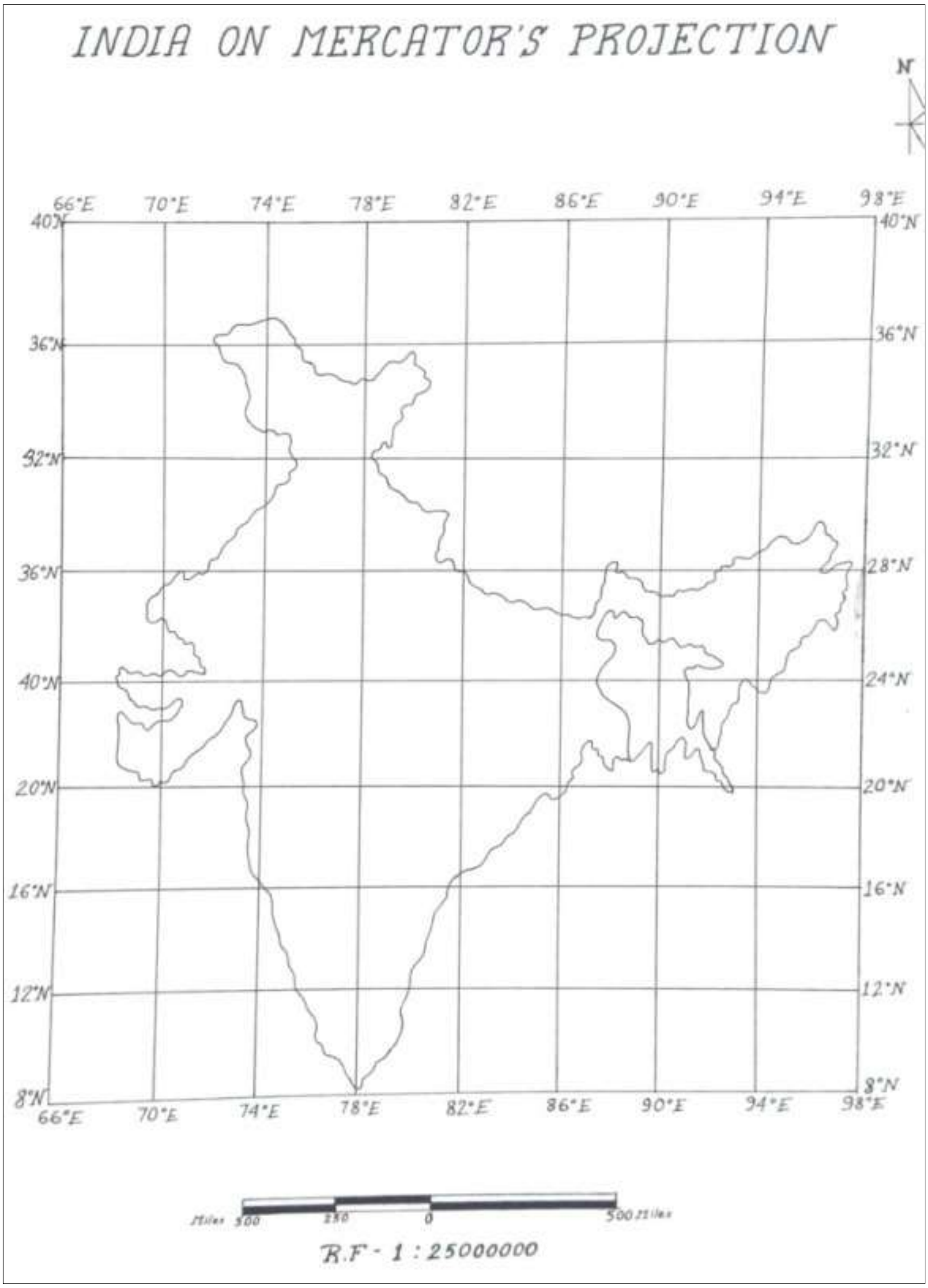
Step 2

Division along the equator for spacing the meridians at 4° interval, $d = \frac{2\pi R}{360°} \times 4° = 0.678$ inch.

Step 3

Height of any parallel above the equator, $Y_{\Phi} = 23.026\ R \log \tan \left(\frac{90° + \emptyset}{2}\right)$

Φ	4°N	8°N	12°N	16°N	20°N	24°N	28°N	32°N	36°N	40°N
$\left(\frac{90° + \emptyset}{2}\right)$	47°	49°	51°	53°	55°	57°	59°	61°	63°	65°
$Y\ \Phi$	0.70	1.40	2.11	2.33	3.56	4.32	5.09	5.90	6.74	7.63



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5. Basic concepts and principles of surveying. Survey with equipment: Prismatic Compass, Dumpy level, Theodolite, Abney level, Clinometer.

Traverse Survey Using Prismatic Compass

A prismatic compass is navigation and surveying instrument which is extensively used to find out the bearing of the traversing and included angles between them, waypoints (an endpoint of the lcourse) and direction. The compass calculates the bearings in whole circle bearing system which determines the angle which the survey line makes with the magnetic north in the clockwise direction. The whole circle bearing system also known as the azimuthal system varies from 0 degrees to 360 degrees in the clockwise direction. The included angles can be calculated by the formulas F-P ±180 in case of anti-clockwise traverse and P-F ±180 in case of clockwise traverse, where 'F' is the fore bearing of forward line in the direction of survey work and 'P' is the fore bearing of previous line.

Example

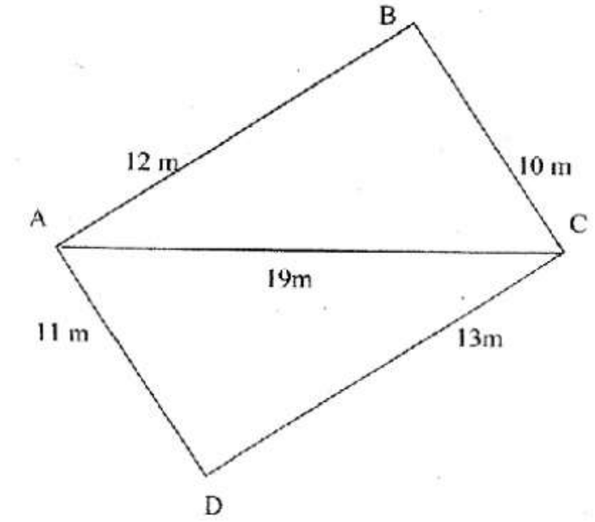
Make a closed traverse survey (ABCDA) with the help of Prismatic Compass.

1. Prepare a field hook and enter the data.
2. Complete the field book with necessary corrections.
3. Plot the traverse on a suitable scale with proper annotations.
4. Calculate the area of the traverse and represent by circle.

FIELD BOOK
CLOSED TRAVERSE SURVEY BY PRISMATIC COMPASS
CLOCKWISE CIRCUIT

Place:................................
Date:................................. Roll
No.:............................
Time:................................ Instrument
No.:.................

Station	Line	Length on Ground (M)	Observed Whole Circle Bearing		Remarks
			Fore	Back	
A	AB	12	70°15′	249°15′	All stations are affected by local attractions. Survey done clockwise direction. Diagonal Distance, AC = 19 m.
B	BC	10	130°00′	311°00′	
C	CD	13	240°30′	57°30′	
D	DA	11	314°00′	136°00′	



Rough sketch at field.

COMPUTATION TABLE

CLOSED TRAVERSE SURVEY BY PRISMATIC COMPASS

CLOCKWISE CIRCUIT

Place:.................................
Date:.................................. Roll
No.:............................
Time:................................. Instrument
No.:.................

Station	Line	Length on Ground (M)	Observed Whole Circle Bearing		Difference (d) FB - BB	Error (E) d - 180°	c = E/2	Corrected Whole Circle Bearing		Remarks
			Fore	Back				Fore	Back	
A	AB	12	70°15′	249°15′	179°	-1°	-30′	69°45′	249°45′	All stations are affected by local attractions. Survey done clockwise direction. Diagonal Distance, AC = 19 m.
B	BC	10	130°00′	311°00′	181°	+1°	+30′	130°30′	310°30′	
C	CD	13	240°30′	57°30′	183°	+3°	+1°30′	239°00′	59°00′	
D	DA	11	314°00′	136°00′	178°	-2°	-1°	315°00′	135°00′	

Calculation of Including Angle of the Traverse

Angle	FB of a line ~BB of the Preceding Line (Measured in the Direction of Survey)		Calculated Including Angle	Corrected Including Angle
A	CFB of AB ~CBB of DA	69°45′ ~135°00′	65°15′	65°15′
B	CFB of BC ~CBB of AB	130°30′ ~249°45′	119°15′	119°15′
C	CFB of CD ~CBB of BC	239°00′ ~310°30′	71°30′	71°30′
D	CFB of DA ~CBB of CD	315°00′ ~ (59°00′ + 360′)	104°00′	104°00′
			Σ360°00′	**Σ360°00′**

Checking Including Angle:
Σθ = (2n – 4) X 90° (n = Side of Traverse)
= (2 X 4 - 4) X 90°
= (8 – 4) X 90°
= 4 X 90°
=360°

Checks are applied and found satisfactory.

Note: CFB = Corrected Fore Bearing, CBB = Corrected Back Bearing

FORMULA

1. General Error Correction:

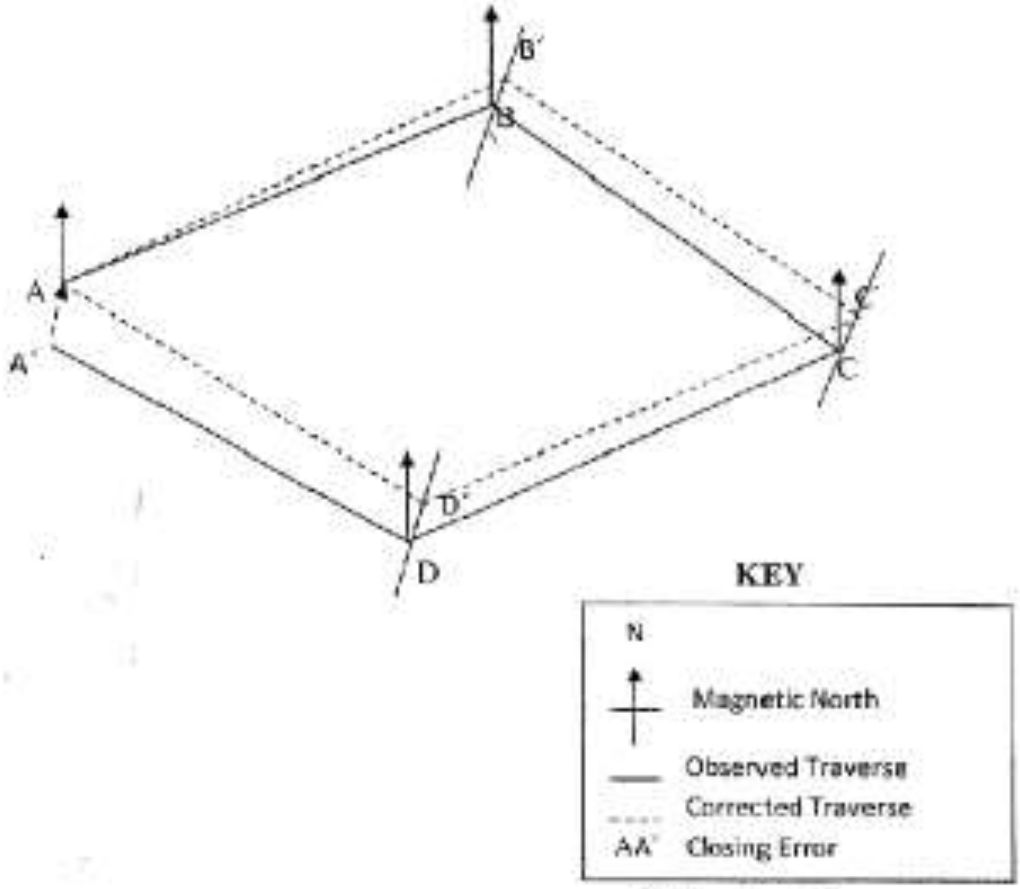
- If error is negative, deduct e/2 from the smaller readings and add e/2 to the larger one.
- If error is positive, deduct e/2 from the larger readings and add e/2 to the smaller one.

2. For Including Angle Correction:

- *ln case of clock wise survey if corrected BB is less than corrected FB then 360° added to corrected BB.
- In case of anti-clock wise survey if corrected FB is less than corrected BB then 360° added to corrected FB.

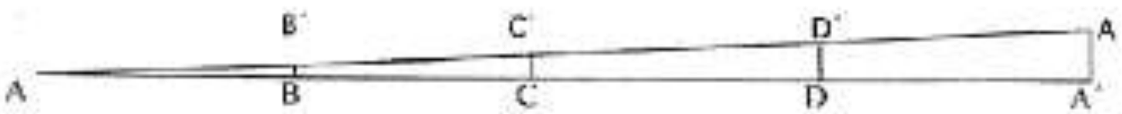
PLOTTING OF A CLOSED TRAVERSE (ABCDA)

Method: Parallel Meridian (Clockwise Circuit)



Scale: 1cm to 2m

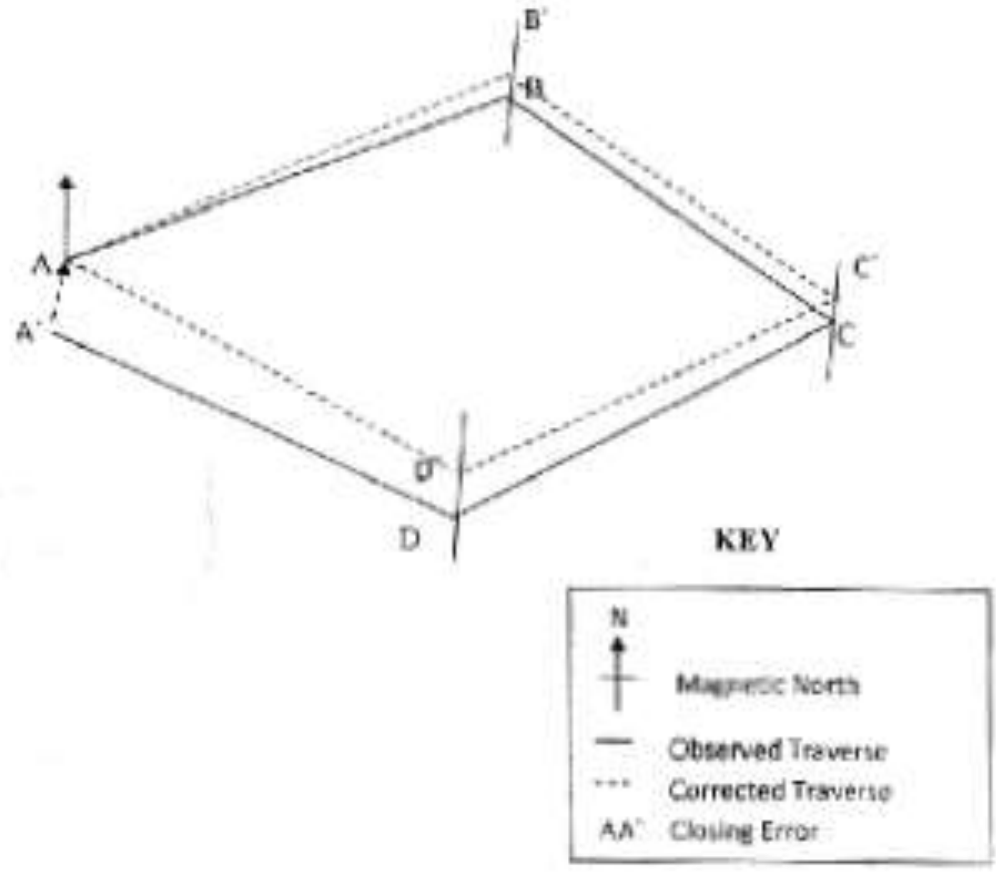
Distribution of closing error after Bowditch method



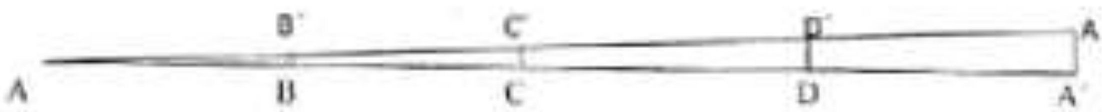
Scale: 1 cm to 4m

PLOTTING OF A CLOSED TRAVERSE (ABCDA)

Method: Including Angle (Clockwise Circuit)



Distribution of closing error after Bowditch method



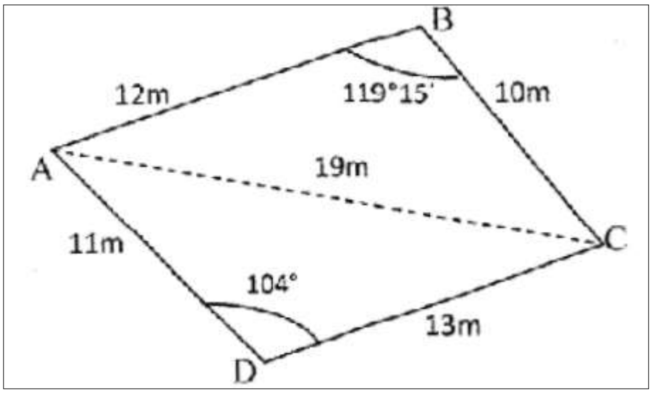
Scale: 1 cm to 4m

Determination of the ground area of the traverse:

Area of the traverse can he calculated by two methods.

1. On the basis of including angle.
2. On the basis of length.

1. <u>On the basis of including angle:</u>



The area of the traverse ABCDA = AABC + AADC

Area of the ΔABC = $\frac{1}{2} \times l_{AB} \times l_{BC}\ Sin\angle B$

$= \frac{1}{2} \times 12\text{m} \times 10\text{m} \times \text{Sin } 119°15'$

$= 52.35$ sq. m.

Area of the ΔADC = $\frac{1}{2} \times l_{AD} \times l_{CD}\ Sin\angle D$

$= \frac{1}{2} \times 11\text{m} \times 13\text{m} \times \text{Sin } 104°00'$

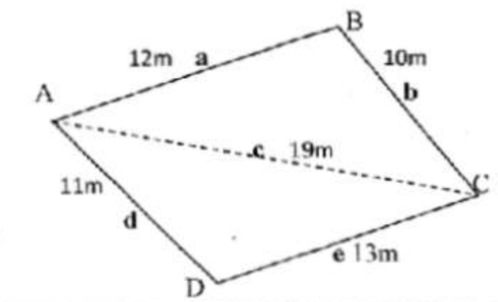
$= 69.38$ sq. m.

Therefore, the area of the traverse ABCDA = ΔABC + ΔADC

= 52.35 sq. m. + 69.38 sq. m.

= 121.73 sq. m.

2. <u>On the basis of length:</u>



TRIANGLE	LENGTH OF SIDE	REMARKS
ΔABC	AB(a) = 12m BC(b) = 10m AC(C) = 19m	Scalene Triangle
ΔADC	AD(d) = 11m DC(e) = 13m AC(C) = 19m	Scalene Triangle

The area of the traverse ABCDA = ΔABC + ΔADC

Area of the ΔABC = $\sqrt{\boldsymbol{S} \times (\boldsymbol{S}-\boldsymbol{a}) \times (\boldsymbol{S}-\boldsymbol{b}) \times (\boldsymbol{S}-\boldsymbol{c})}$

Where, a, b, c are the sides of the triangle and S is semiperemetre.

$$S = \frac{1}{2}(a+b+c)$$

$$S = \frac{1}{2}(1+10+19)m.$$

$$\mathrm{S} = 20.5 \text{ m.}$$

$$\Delta ABC = \sqrt{S \times (S-a) \times (S-b) \times (S-c)}$$

$$= \sqrt{20.5 \times (20.5-12) \times (20.5-10) \times (20.5-19)}$$

$$= 52.38 \text{ sq. m.}$$

Area of the ΔADC = $\sqrt{\boldsymbol{S} \times (\boldsymbol{S}-\boldsymbol{d}) \times (\boldsymbol{S}-\boldsymbol{e}) \times (\boldsymbol{S}-\boldsymbol{c})}$

Where, d, e, c are the sides of the triangle and S is semiperemetre.

$$\mathbf{S} = \frac{\mathbf{1}}{\mathbf{2}}(\mathbf{d}+\mathbf{e}+\mathbf{c})$$

$$S = \frac{1}{2}(11+13+19)m.$$

$$\mathrm{S} = 21.5 \text{ m.}$$

$$\Delta ADC = \sqrt{S \times (S-d) \times (S-e) \times (S-c)}$$

$$= \sqrt{20.5 \times (20.5-11) \times (20.5-13) \times (20.5-19)}$$

$$= 69.26 \text{ sq. m.}$$

Therefore, area of the traverse ABCDA

= 52.38 sq. m. + 69.26 sq. m.

=121.64 sq. m.

DETERMINATION OF AREA POF DIFFERENT TRAINGLE

1. EQUILATERAL TRAINGLE (LENGTH OF THE THREE SIDE ARE WQUAL

$$Area = \frac{\sqrt[3]{}}{4} \times Side^2$$

2. ISOSCELES TRAINGLE: (LENGTH OF TWO SIDES ARE EQUAL)

$$Area = \frac{b}{4} \times \sqrt{4a^2 - b^2}$$

Where, b = Ground, a = Length of any one of remaining same two sides.

3. SCALENE TRAINGLE: (LENGTH OF THREE SIDES ARE UNEQUAL)

$$Area = \sqrt{S \times (S-a) \times (S-b) \times (S-c)}$$

a, b, c are the triangle and S is semiperemetre.

$$S = \frac{1}{2}(a + b + c)$$

Diagrammatic Representation of Area:

1. Representation by square:

Computation of one side of square for the traverse ABCDA

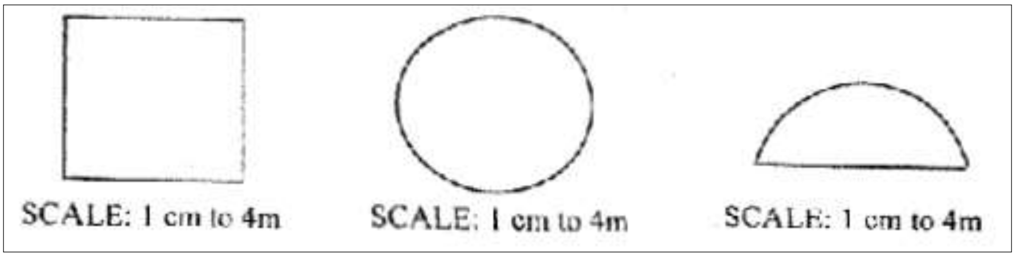
$$l = \sqrt{A} = \sqrt{121.64\, sq.m.} = 11.03\, m.$$

2. Representation by a circle:

$$r = \sqrt{\frac{A}{\pi}} = \sqrt{\frac{1211.64\, sq.m.}{\pi}} = 6.22\, m.$$

3. Representation by a semi-circle:

$$r = \sqrt{\frac{2A}{\pi}} = \sqrt{\frac{2 \times 121.64\, sq.m.}{\pi}} = 8.80\, m.$$

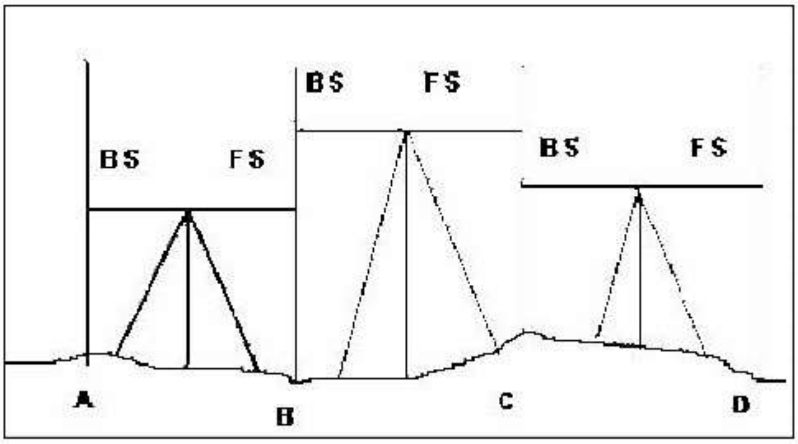


Levelling by Dumpy Level and Prismatic Compass Aim

To find the difference in elevation between two points.

Instruments

1. Dumpy level
2. Levelling staff



Procedure

1. Let A and B be the two given points whose difference is elevation is to be found.
2. Set the level at convenient point O1 carryout temporary adjustments and take B.S on A
3. Take FS on the Point C
4. Shift the instrument to point O2 and perform temporary adjustments.
5. Take B.S on C.
6. Take F.S. on D.
7. Shift the instrument to point O3 and perform temporary adjustments.
8. Take B.S on D
9. Take F.S on B.
10. Find the difference in elevation between A and B by both the methods.

Result: Difference in elevation between A and B = ……………

Page of Level-Book										
Name of work survey for:-									Page No:-	
Levelling from -----------------------------To------------------------										
Instrument No--							Conducted by:-			
Station	Distance In meters	Bearings		Staff Reading			Height of Instrument or		Reduced Level	Remarks
		FORE	BACK	Back (B.S)	Inter (I.S)	Fore (F.S)	Rise	Fall		

LEVELLING/ CONTOUR PLAN

A contour is an imaginary fine joining places with equal elevation above sea level. Technically, it is defined as the line of intersection of a level surface with the surface of the ground. The vertical distance between two consecutive contours is called contour interval while the horizontal distance between the two is known as horizontal equivalent. Normally, the nature of the ground, the purpose and extent of survey, the map scale and the amount of time and financial investment involved together determine the contour interval. The smaller the map scale, the larger is the contour interval and the smaller the interval, the larger is the amount of field and office works. The contour maps are useful both for the engineering, hydrological and geomorphological studies.

Methods

The preparation of a contour plan or map requires first, the surveying and plotting of a traverse plan, second, levelling operations to find the reduced levels of all the points on the traverse and finally, the interpolation of contours on the traverse plan.

- **Traverse Survey**

If the area to be contoured is not very extensive, a traverse may be so laid that it consists of a set of radial lines diverging from the apparently highest or lowest point of the area. The lengths and directions of each line may be fixed by the traverse surveying with either a prismatic compass or a theodolite. The points at a regular distance apart on each line are then marked on the ground by pegs.

In some cases, the area may be divided into rectangular or square grids; each corner of which is marked by a peg. The position of these points can be easily fixed by traversing.

- **Levelling Operations**

The equipment's for levelling consists of a level (commonly a dumpy level), a tripod, a levelling staff, a tape and a well laid and neatly drawn field book for recording the staff readings, distances and field notes.

Procedure

I. The instrument is first set up at a convenient height and at a place, from where maximum number of stations can be sighted.
II. With the help of the bubble tub (s), the instrument is then perfectly levelled by turning the foot screws right in and left out in positions when the telescope is: a) parallel to a line through two-foot screws and b) perpendicular to it. This operation is successively repeated taking other foot screws until the bubble remains stationary at the centre of the level tube for any position of the telescope.
III. The telescope is then directed towards the staff held vertically over the station (within or outside the traverse) with a known reduced level (Bench Mark). The eye piece and the object are focused properly and the staffs reading for the middle stadia is taken and the first reading is entered as a back sight reading (BS).
IV. Similarly, the staff readings for all the stations visible are taken successively. The last reading of the setup is entered as a fore sight reading (FS) while all others as intermediated sight readings (IS).
V. The instrument is then shifted to some other position(s) from where the readings of the remaining stations (not covered in the first set up) can be taken. After precise levelling of the instrument, the reading is to be taken on the staff held at the last station of the former set up; it is a back sight reading of course. This station is called a change point (cp).
VI. vi. Following the same procedure staff reading are then taken on the remaining stations.

Computation

The reduced levels of the stations can be calculated in either of the two common methods— the collimation method and the rise and fall method.

Example

1. Prepare a contour plan of an area traversed by 3 radial lines (OA, OB. OC) each being 9 m. long. Each radial line is divided into 3 equal parts.
2. Enter the readings oil a neatly drawn field book.
3. Find out the reduced level of the stations (when BM of the central station is 7.00 m). At least one CP is in line OB at 9 m distance from central station.
4. Draw at least 3 contours with equal interval.

FIELD BOOK

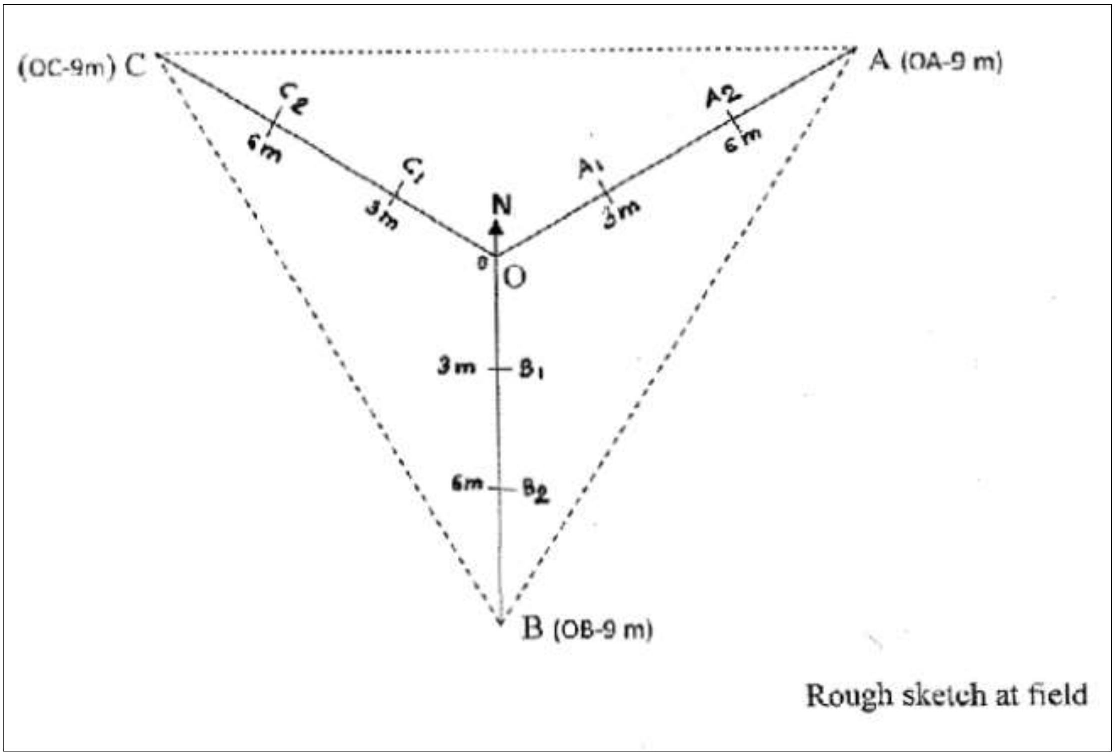
CONTOURING BY DUMPY LICVEL & PRISMATIC COMPASS

Place: Instrument No.:

Date: Surveyor's Name

Time: Roll No.:

Stations	Distance from O (m.)	Staff Reading (m.)			Remarks
		B.S.	I.S.	F.S.	
O	0	0.850			B.M.(7.00m) Mg Bg of OA = 60° Mg Bg of OB = 180°30' Mg Bg of OC = 300°
A_1	3		1.015		
A_2	6		1.200		
A	9		1.350		
B_1	3		1.105		
B_2	6		1:205		
B	9	1.115		1.360	C.P.
C_1	3		0.775		
C_2	6		0.960		
C	9		.	1.115	



FIELD BOOK

CONTOURING BY DUMPY LICVEL & PRISMATIC COMPASS

Place: Instrument No.:

Date: Surveyor's Name

Time: Roll No.:

Stations	Distance from O on ground (m.)	Distance from O on map (cm.)	Staff Reading (m.)			Collimation Level (m.)	Reduced Level (m.)	Remarks
			B.S.	I.S.	F.S.			
O	0	0	0.850			7.850	7.000	B.M.(7.00m)
A_1	3	2		1.015		7.850	6.835	Mg Bg of OA = 60°
A_2	6	4		1.200		7.850	6.650	Mg Bg of OB = 180°30'
A	9	6		1.350		7.850	6.500	Mg Bg of OC = 300°
B_1	3	2		1.105		7.850	6.745	
B_2	6	4		1.205		7.850.	6.600	
B	9	6	1.115		1.360	7.850 / 7.605	6.490	**C.P.**
C_1	3	2		0.775		7.605	6.830	
C_2	6	4		0.960		7.605	6.645	
C	9	6			1.115	7.605	6.490	**Collimation Method applied**
$\sum$			1.965		2.475			

Arithmetical Check:

ΣB.S ~ΣF.S = Last R.L. ~First R.L.

1.965 ~2.475 = 6.490 ~7.0

0.51 = 0.51 (Checks are applied and found satisfactory)

Note

1. Collimation method is applied, B.M. at first station.
2. R.L. is same at first station at B.M. at first station is 7.000 m
3. After that CL is calculated at first station. CL = RL of 1st station + Staff Reading of that station / 1st instrument. Here 7.000 + 0.850 = 7.850. It should be continue up to CP.
4. RL is calculated of these stations from given formula. RL = CL Staff Readings.
5. After CP same method is applied for calculating CL. CL = RL of CP + Staff Reading of that station/ 2nd instrument. Here 6.490 + 1.115 = 7.605
6. Same method is applied for calculating remaining RL.
7. Arithmetic check can be done.
8. At last select the contour.

Selection of Contour Value

Range = (Highest RL - Lowest RL) = (7.000 m. - 6.490 m.) = 0.510 m.

Interval of contour = $\frac{Range}{n+1}$ (n = Desired no. of contours. Here 3) = $\frac{0.510\ m.}{3+1} = \frac{0.510\ m.}{4} = 0.1275\ m.$

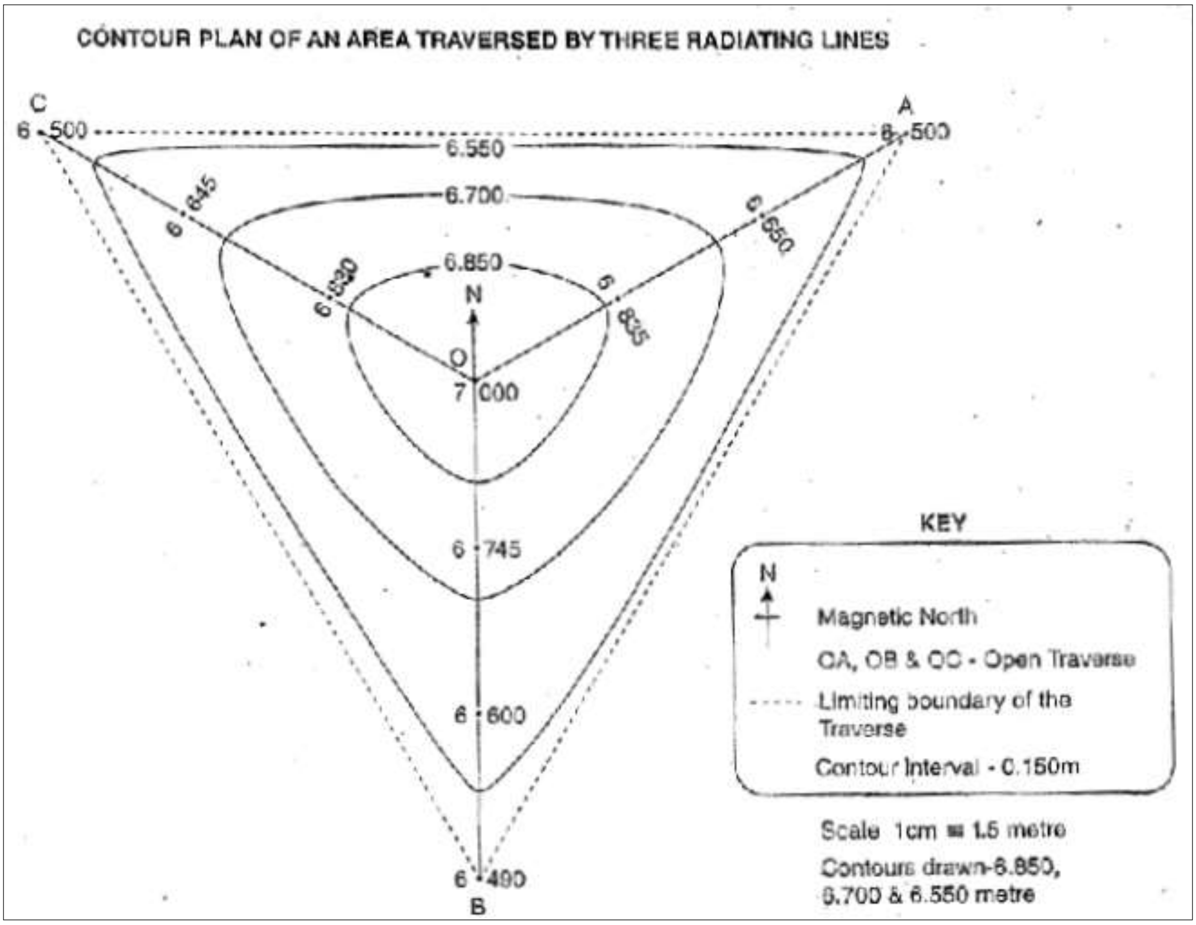
Selection of 1st Contour = Lowest RL + Interval of contour = 6.490 m. + 0.1275 m. = 6.6150 (**6.60 m. Approx**)

Selection of 2nd Contour – 1st Contour + Interval of contour = 6.60 + 0.1275 = 6. 7275 (**6.70 m. Approx**)

Selection of 3rd Contour = 2nd Contour + Interval of contour = 6.70 + 0.1275 = 6. 8275 (**6.80 m. Approx**)

Selection of contour value*2nd method = Selection of contour by arbitrary choice way

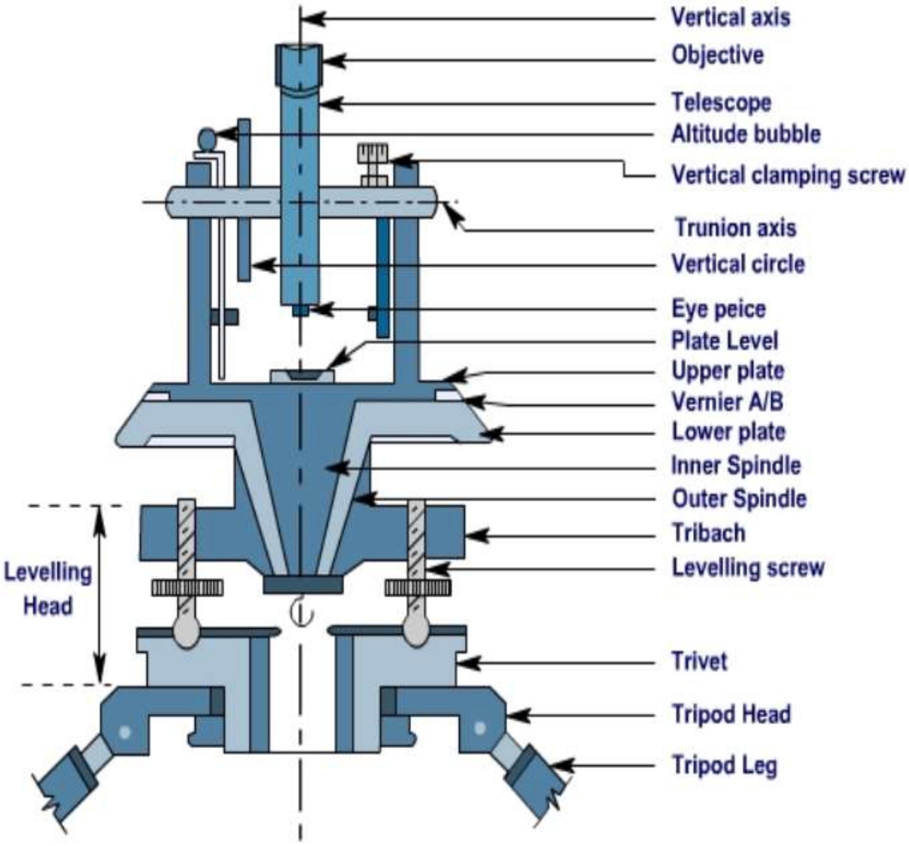
You can select the value of contour arbitrarily by showing highest & lowest value. But the intervals of contours are remaining same. Here 2nd method is followed. Contour values are 6.850 m.; 6.700 m.; & 6.550 m.



<u>Theodolite survey</u>

The system of surveying in which the angles are measured with the help of a theodolite, is called Theodolite surveying. The Theodolite is a most accurate surveying instrument mainly used for:

- Measuring horizontal and vertical angles.
- Locating points on a line.
- Prolonging survey lines.
- Finding difference of level.
- Setting out grades
- Ranging curves
- Tacheometric Survey



Transit theodolite

A transit theodolite allows for a full rotation of the telescope installed inside the instrument around its horizontal axis in a vertical plane.

Non-transit theodolite

The telescope in non-transit theodolite cannot rotate 360 degrees around its horizontal axis on a vertical plane. To a certain extent, it can be turned to take vertical angles.

Theodolite category

We can further classify theodolite into two categories based on the scale. The first category is the Vernier Theodolites utilised in routine surveying operations, which are installed on a Vernier scale. The second is the Micrometre Theodolite installed in a Micrometre scale.

Repetition method of measuring Horizontal angles

When it is required to measure horizontal angles with great accuracy as in the case of traverse, the method of repetition may be adopted. In this method the same angle is added several times by keeping the vernier to remain clamped each time at the end of each measurement instead of setting it back to zero when sighting at the previous station. The corrected horizontal angle is then obtained by dividing the final reading by the number of repetitions. Usually six reading, three with face left and three with face right, are taken the average horizontal angle is then calculated.

Procedure: -

1) Let LOM is the horizontal angle to be measured as shown in fig. O is the station point fixed on the ground by a peg. Set up the theodolite over the peg 'o' and level it accurately.

2) Set the horizontal graduated circle vernier A to read zero or 360° by upper clamp screw and slow-motion screw. Clamp the telescope to bisect the bottom shoe of the flag fixed at point 'L' and tighten the lower clamp. Exactly intersect the centre of the theodolite should be left and the telescope in normal position.

3) Check the reading of the vernier A to see that no slip has occurred. Also see that the plate levels are in the centre of their run. Read the vernier B also.

4) Release the upper clamp screw and turn the theodolite clockwise. Biset the flag bottom shoe fixed at point M by a telescope. Tighten the upper clamp screw and bisect the shoe exactly by means of upper slow-motion screw.

5) Note the reading on both the vernier to get the approximate value of the angle LOM.

6) Release the lower clamp screw and rotate the theodolite anticlockwise ai azimuth. Bisect again the bottom shoe of the flag at 'L' and tighten the lower clamp screw. By means of slow-motion screw bisect exactly the centre of the shoe.

7) Release now the upper clamp screw and rotate the theodolite clockwise. Bisect the bottom shoe of the flag fixed at M and tighten the upper clamp screw. By means of

slow motion screw bisects exactly the centre of the shoe. The vernier readings will bw now twice the of the angles.

8) Repeat the process until the angle is repeated the required number of times (usually

3). Add 360° for every complete revaluation to the final reading and divided the total angle by number of repetitions to get the value of angle LOM.

9) Change the face of the theodolite the telescope will now be inverted. Rrpeat the whole process exactly in the above manner and obtain value of angle LOM.

10)The average horizontal angle is then obtained by taking the average of the two angles obtained with face left and face right.

11)Usually three repetitions face left and three with face right should be taken and the mean angle should be calculated.

S.N.	Instrument Station	Shifted to	Face left readings			
		Venier A 0,I,II	Venier B 0,I,II	Total angle	No of Repetition	Mean horizontal angle 0,I,II
	o	L				
		M				
		L				
		M				
		L				
		M				

S.N.	Instrument Station	Shifted to	Face Right readings				
		Venier A 0,I,II	Venier B 0,I,II	Total angle 0,I,II	No of Repatition	Mean horizontal angle 0,I,II	Average horizontal angle 0,I,II
	o	L					
		M					
		L					
		M					
		L					
		M			3		

RESULT: Average horizontal angle is found to be ------------

Measurement of vertical Angles with Theodolite

Theodolite is an instrument designed for the measurement of horizontal and vertical angle. It is most precise method it is also used for laying of horizontal angles Locating points on line prolonging the survey line establishing the gradient, determination of difference in the elevation setting out curve. Theodolite are of two types transit and non-transit. Transit theodolite is commonly used now a days. In transit theodolite telescope can be revolved a complete revolution about its horizontal axis in a vertical plane. A transit theodolite consists of essential part tripod. The head comprises of two parts

a) A levelling foot screws for levelling the instrument i.e. for marking vertical axis truly vertical.

b) A movable head or centering arrangement for centering the vertical axis accurately over a station point.

Measurement of vertical angle

A vertical angle is the angle between the inclined line of sight to an object and the horizontal. It may be an angle of elevation or on angle of depression according as the instrument. To measure angle of elevation or depression LOM shown in fig. proceed as follows:

1) Set up the theodolite at station point O and level it accurately with reference to the altitude level.

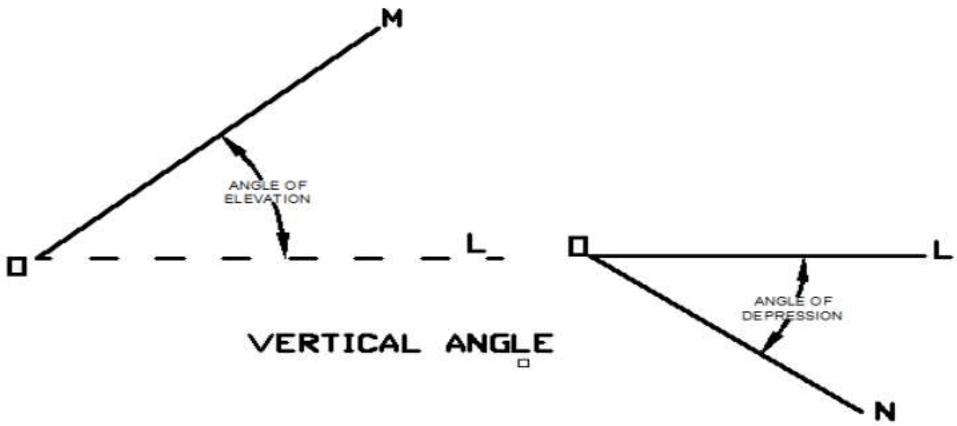
2) Set vertical verniers C and D exactly to zero by using the vertical circle clamp and tangent screw, while the altitude level should remain in the centre of its run. Also, the face of the theodolite should be left.

3) Release the vertical circle clamp screw and rotate the telescope in vertical plane so as to bisect the object M. tighten the vertical circle clamp and exactly bisect the object by slow motion screw.

4) Read both verniers C and D. the mean of the tow readings gives the value of the required angle.

5) Similar observation may be made with other face. The average of the tow values thus obtained gives the value of the required angle which is free from instrumental errors.

6) Similarly, the angle of depression can be measured following the above steps.



VERTICAL ANGLE

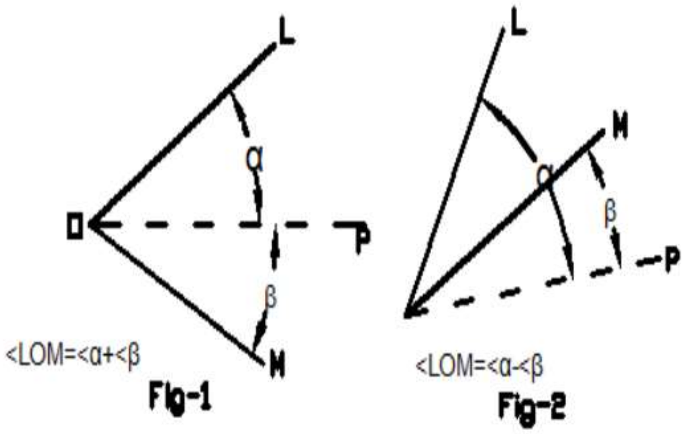
To measure the vertical angle between two points L and M

Sometimes it is required to measure vertical angle between two points L and M. There can be three possibilities.

(a) One point is above the line of sight and the other is below the line of sight then angle LOM as shown in fig will be equal to ($<\alpha + <\beta$)

(b) Both the points are above the line of sight. Then the angle LOM= $<\alpha - <\beta$ (Refer Fig 2)

(c) Both the points are below the line of sight, then the angle LOM= $<\alpha - <\beta$ (Refer Fig 3)



To measure the angle between two points L and M proceed as follows

1) Set the theodolite at station point O and accurately level it.

2) Bisect the flag at L as explained already and take the reading on the verniers C and D. Calculate the mean angle.

3) Bisect the flag at M as before and take the reading on the verniers C and D. Calculate the mean angle.

Observation table:-

S.N.	Instrument Station	Sighted to	Face left readings			
			Venier C 0,I,II	Venier D 0,I,II	Mean Angle	Vertical Angle
	o	P				
	(+ve)	L				
	(-ve)	M				

S.N.	Instrument Station	Sighted to	Face Right readings				Average Vertical Angle 0,I,II	Remarks
			Venier C 0,I,II	Venier D 0,I,II	Mean Angle 0,I,II	Vertical Angle 0,I,II		
	o	P						
	(+ve)	L						
	(-ve)	M						

Result: The average value of vertical is found to be--------------------.

Abney level survey

Abney level is a light compact bond instrument of low elevation. It is widely used for - Measuring the angle of elevation or depression.

1) Taking alone of the ground when chaining along the uneven ground.

2) Tracing a great contour or a alignment of a road.

Abney level consist of:

1) A square lighting tube fitted with an eye piece or small telescope at one end at the other end the mirror is placed at an angle of 450 inside the tube the wire is lanced across the tube behind the mirror by which object can be bisected.

2) A small bubble tube is attached to the mirror arm which can be rotated by means of worm wheel.

3) A semicircular quadrate arch is marked zero at the middle point. The graduation is made from 0°–6°.

Measurement of vertical angle

Direct the instrument towards the object & bisect it with cross wire & at the same times the middle wheel until the crass wire bisects the reflection of the required angle in the arc by means of the vernier it may be noted that the bubble tube is always horizontal & the vertical arm vertical, whatever may be the inclination of telescope.

The observer stands at one end of the slope & direct the instrument on to the mark all vane fixed on the ranging rod at the same height as the observer wheel until the reflected image of the bubble is brought to the centre of its run & intersected by the cross wire the bubble tube is now horizontal while the telescope is parallel to the slope of the ground. The angle read on the arc gives the slope of the ground.

To trace the grade contour: -

With the help of the vernier the rolling gradient can be obtained mark the height of the observer on the ranging rod. Direct the instrument towards the mark on the ranging rod held at the convenient distance ray 30-50 meter the ranging rod is then moved upward downward until the observer bisect the vane with cross hair & simultaneously over the bubbled centered is the instrument station to the point on which ranging rod is held parallel to this point & repeat the process to establish the next point the process is continued until the last point is established.

If the Abney level is not giving correct values of angle of inclination of there is difference of two observations, then adjust the instrument to the mean value. i.e. (T1+T2/2) light the object & centre the bubble by means of adjusting screw of the bubble tube.

Clinometer survey

The clinometers are light compact hand instruments commonly used for the measurement of slopes, tracing contours, setting grades, to determine the difference in elevation. They are adapted for rough and rapid work. The simplest form of clinometers consists of i) a semicircle graduated in degrees in both directions with zero placed at the middle of the arc, ii) a light plumb bob suspended from the centre. The various types of clinometers are: Abney clinometers or Abney level, Indian pattern clinometers or tangent clinometers, De lisle’s clinometer, Watkin’s mirror clinometers, foot rule clinometers.

Objective

To make a mathematical instrument ‘clinometer’ to measure the height of a distant object.

Prerequisite Knowledge

1. Concept of angle of elevation and depression.
2. Properties of right-angled triangle.

Materials Required

Small pipe or drinking straw, a wooden board, wooden strip, thread, weight, screw, geometry box, etc.

Procedure

1. Prepare a semi-circular protractor with the help of geometry box. Mark degrees in sexagesimal scale with 0° at the lowest and 10 to 90° proceeding both clockwise and anti-clockwise.
2. Fix a hollow pipe along the diameter of it fig. (i).
3. Punch a whole at the centre of a semicircle.
4. Suspend a weight (w) from a small nail fixed to the centre.
5. Ensure that the weight at the end of the string hangs below the protractor.

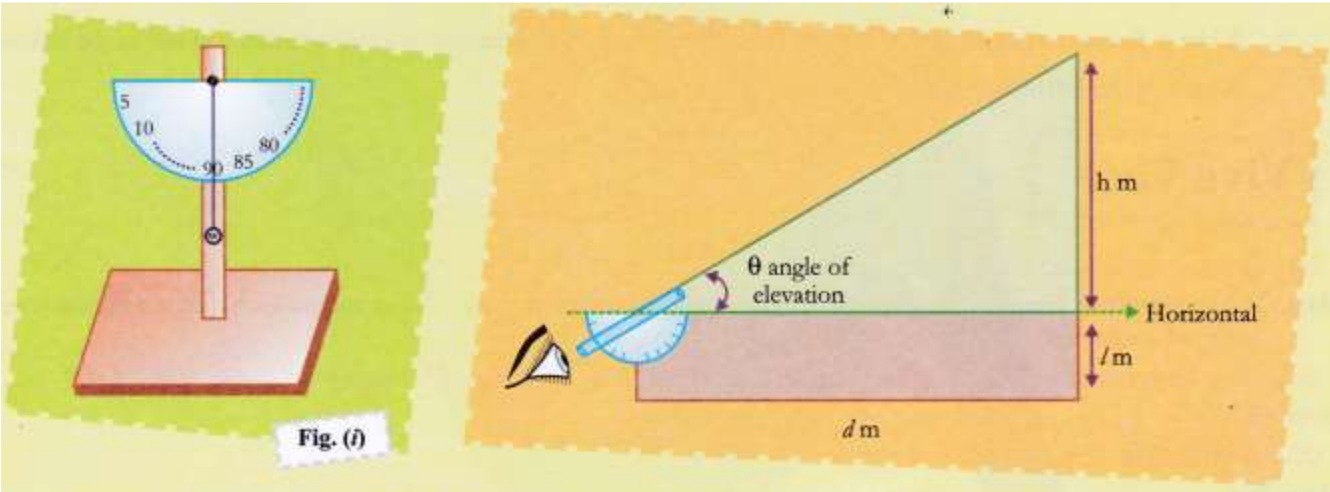


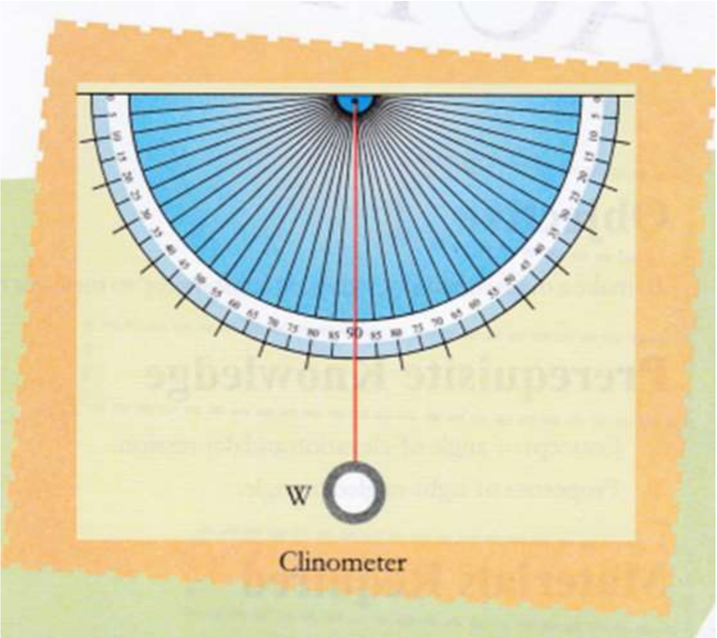
Fig. (i)

Determining the Height of an Object:

1. Measure the distance of the object from you. Let it is d.
2. Look through the hollow pipe straw at the top of the object by rotating it gradually. Make sure that you can clearly see the top of the object.
3. Hold the clinometer steady and record the angle which the string makes on the scale of the clinometer.
4. This angle is the required angle of elevation, let be θ.
5. Using trigonometric ratio: $\tan\theta = \frac{height}{distance} = \quad \frac{h}{d}$
   $h = d.\tan\theta$

Observation

1. angle of elevation 0.
2. distance between object and clinometer d.
3. height of clinometer/(let)
   Therefore height of object $= l + h = l + d\tan\theta$



Result

Angle of elevation can be found easily.

Suggested Readings:

1. Anson R. and Rowelling F. J., 1994: International Cartographic Association: Basic Cartographic Vol. Pegmen Press.

2. Gupta K.K. and Tyagi, V. C., 1992: Working with Map, Survey of India, DST, New Delhi.

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5. Rhind D. W. and Taylor D. R. F., (eds.), 1989: Cartography: Past, Present and Future, Elsevier, International Cartographic Association.

6. Robinson A. H., 2009: Elements of Cartography, John Wiley and Sons, New York.

7. Singh R. L. and Singh R. P. B., 1999: Elements of Practical Geography, Kalyani Publishers.

8. Sarkar, A. (2015) Practical Geography: A systematic approach. Orient Black Swan Private Ltd., New Delhi

Course Type: SEC - 2

Course Code: GEOSEC02

Course Title: P: Coastal Management (Practical)

SEC-1T: Coastal Management

1. Components of a coastal zone. Coastal morphodynamic variables and their role in evolution of coastal forms.

2. Environmental impacts and management of mining, oil exploration, salt manufacturing, land reclamation and tourism.

3. Coastal hazards and their management using structural and non-structural measures: Erosion, flood, sand encroachment, dune degeneration, estuarine sedimentation and pollution

4. Principles of Coastal Zone Management. Exclusive Economic Zone and ICZM.

5. Coastal Regulation Zones with reference to India (2018-2019).

Assessment:

1. Project Report to be submitted on any one of the topics based on the above syllabus.

2. Viva-voce.

1. Components of a coastal zone. Coastal morphodynamic variables and their role in evolution of coastal forms.

Components of a coastal zone

Coastal zone

The coastal zone refers to the area where land and sea meet, which includes beaches, coastal cliffs, estuaries, tidal flats, and nearshore waters. The coastal zone is a dynamic environment that is shaped by the interaction between physical, biological, and human processes. It is also an important area for economic and recreational activities, as well as a habitat for many plant and animal species. However, the coastal zone is also vulnerable to environmental threats such as erosion, sea level rise, pollution, and overfishing. To address these challenges, coastal zone management strategies are developed to balance human uses of the coastal zone with conservation goals and sustainability.

Coastal zone as a system unit

The coastal zone can be considered as a system unit, which is a collection of interconnected parts that work together to achieve a common function. In this case, the coastal zone is a complex system that includes both natural and human components, such as beaches, dunes, wetlands, estuaries, tidal currents, ocean currents, fish populations, and human settlements.

The natural components of the coastal zone interact with each other and with the physical forces of wind, waves, tides, and currents to form dynamic coastal ecosystems. These ecosystems provide important ecological services such as habitat for wildlife, nutrient cycling, water filtration, and erosion control.

The human components of the coastal zone include economic and recreational activities such as tourism, fisheries, shipping, and oil and gas exploration. These activities can have both positive and negative impacts on the natural systems of the coastal zone.

To understand the dynamics of the coastal zone as a system unit, it is important to consider the interactions between the natural and human components, as well as the feedback mechanisms that link them together. Effective coastal zone management requires a holistic approach that considers the entire system, taking into account the complex interconnections and trade-offs between different components.

Salient features of coastal zone

The coastal zone is a dynamic and complex environment with a number of salient features that distinguish it from other ecosystems. Some of the key features of the coastal zone include:

1. **Physical diversity:** The coastal zone includes a variety of physical environments such as beaches, cliffs, estuaries, mangroves, and coral reefs. These diverse environments create a wide range of habitats for a variety of plant and animal species.
2. **Productivity:** The coastal zone is one of the most productive ecosystems on the planet, with high levels of primary and secondary productivity. This productivity is driven by the interaction of physical, chemical, and biological processes.
3. **Vulnerability:** The coastal zone is particularly vulnerable to natural and human-induced changes. Sea level rise, erosion, storm surges, and pollution are just some of the threats that the coastal zone faces.
4. **Human influence:** The coastal zone has been heavily influenced by human activities, including land use change, development, overfishing, and pollution. These activities have had significant impacts on the natural systems of the coastal zone
5. **Economic importance:** The coastal zone is a critical economic resource, providing a range of goods and services, including fisheries, tourism, recreation, and energy resources.
6. **Biodiversity:** The coastal zone is home to a high level of biodiversity, including many endemic and endangered species. The interaction between the physical and biological components of the coastal zone creates a unique and valuable ecosystem.
7. **Connectivity:** The coastal zone is connected to a variety of other ecosystems, including Open Ocean, wetlands, and rivers. This connectivity creates important ecological linkages and allows for the exchange of nutrients and species.

Effective coastal zone management requires an understanding of these salient features, and a recognition of the need to balance the often competing demands of ecological conservation and human development.

Coastal zone of West Bengal

The coastal zone of West Bengal, India is a significant part of the state's geography and economy. It stretches along the Bay of Bengal for approximately 158 km and includes a number of important cities and towns such as Kolkata, Haldia, and Digha. The coastal zone of West Bengal is characterized by its extensive mangrove forests, sandy beaches, and estuaries.

The Sundarbans, which is a UNESCO World Heritage Site, is located in the coastal zone of West Bengal and is one of the largest mangrove forests in the world. The Sundarbans is home to a number of rare and endangered species, including the Bengal tiger, the Indian rhinoceros, and the saltwater crocodile.

The coastal zone of West Bengal is also an important economic resource for the state, with fishing and tourism being major industries. The region is home to a number of traditional fishing communities, who rely on the rich fisheries of the Bay of Bengal for their livelihoods. Tourism is also a significant industry, with a number of popular beaches and resorts located in the region.

Globally, coastal zones are important ecosystems that provide a wide range of ecological services, including carbon storage, erosion control, and habitat for a variety of plant and animal species. However, coastal zones are also under threat from a range of human activities, including overfishing, pollution, and habitat destruction. Effective coastal zone management is essential to ensure that these valuable ecosystems are protected and conserved for future generations.

Components of coastal zone

Physical components

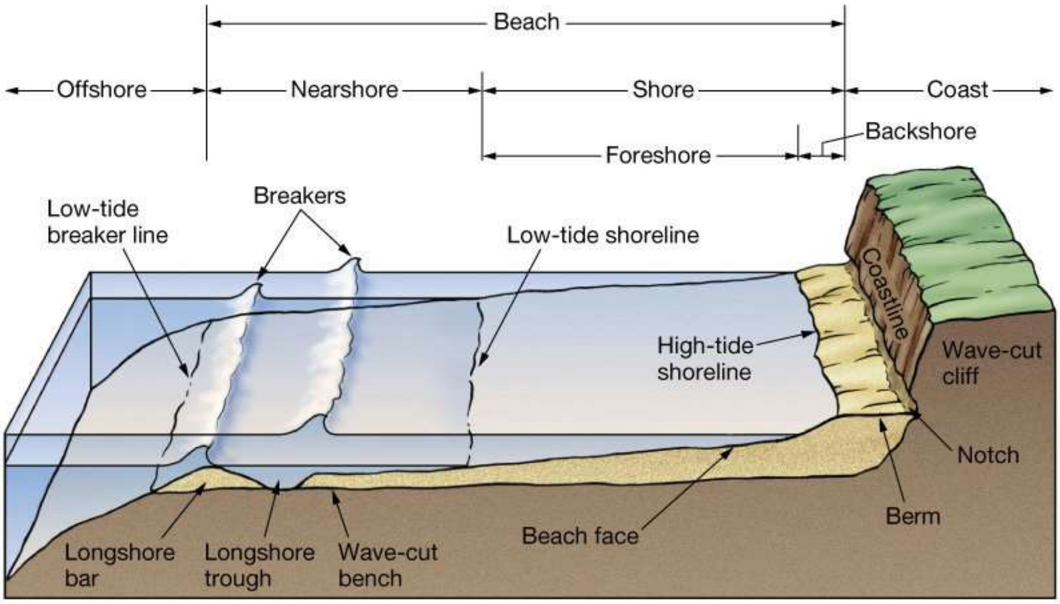
The physical components of the coastal zone are the natural features and processes that shape the coastal environment. These components can be broadly divided into three categories: the nearshore zone, the shoreline zone, and the coastal land zone.

1. **Nearshore zone:** This is the area closest to the shore, and includes the surf zone, the subtidal zone, and the benthic zone. The surf zone is the region where waves break, and it is characterized by strong wave action, high turbulence, and shifting sandbars. The subtidal zone is the area that lies below the low tide line, and it is characterized by soft sediments and a variety of benthic organisms such as clams, crabs, and worms. The benthic zone is the ocean floor, and it is home to a diverse range of organisms such as coral reefs, seagrasses, and kelp forests.
2. **Shoreline zone:** This is the area that is influenced by the tides, and includes the intertidal zone, the beach, and the dune system. The intertidal zone is the area between the high tide and low tide lines, and it is characterized by the presence of both marine and terrestrial organisms. The beach is the area where sand is deposited by waves, and

it is an important habitat for shorebirds, crabs, and other organisms. The dune system is a series of sand dunes that form along the beach, and they help to stabilize the shoreline and provide habitat for a range of plant and animal species.

3. **Coastal land zone:** This is the area that extends inland from the shoreline, and includes estuaries, wetlands, and other coastal ecosystems. Estuaries are areas where freshwater and saltwater mix, and they are important habitats for a variety of fish and bird species. Wetlands are areas where the land is saturated with water, and they are important for flood control, water filtration, and carbon sequestration.

Overall, the physical components of the coastal zone are dynamic and interconnected, and they play a critical role in shaping the coastal environment and providing habitat for a wide range of plant and animal species.



Mortphological components

The morphological components of the coastal zone refer to the physical characteristics of the landforms and features that make up the coastal environment. These components are shaped by natural processes such as erosion, sediment transport, and deposition, as well as human activities such as land use change and coastal engineering. Some of the key morphological components of the coastal zone include:

1. **Shoreline:** The shoreline is the interface between land and water, and it is shaped by the action of waves, currents, and tides. It can take many forms, including cliffs, beaches, and marshes.
2. **Beach:** The beach is the area of deposited sand and sediment that lies between the shoreline and the surf zone. Beaches are dynamic environments that are constantly changing in response to wave action and sediment transport.
3. **Dunes:** Dunes are mounds of sand that form along the beach and are shaped by wind and wave action. They provide important protection against coastal erosion and storm surge, as well as habitat for a range of plant and animal species.

4. **Estuaries:** Estuaries are areas where freshwater and saltwater mix, and they are shaped by the interaction of tides, currents, and sediment transport. They are important habitats for a variety of fish and bird species, as well as for commercial and recreational activities.
5. **Wetlands:** Wetlands are areas where the land is saturated with water, and they are shaped by the interaction of tidal and freshwater systems. They are important for flood control, water filtration, and carbon sequestration.
6. **Barrier islands:** Barrier islands are narrow strips of sand that form parallel to the coast and are separated from the mainland by a lagoon or bay. They provide important protection against coastal erosion and storm surge, as well as habitat for a range of plant and animal species.

Overall, the morphological components of the coastal zone are shaped by the dynamic interaction of natural processes and human activities, and they play a critical role in shaping the coastal environment and providing habitat for a wide range of plant and animal species.

Socio-economic components of coastal zone

The socio-economic components of the coastal zone refer to the human activities, structures, and institutions that are part of the coastal environment. These components are shaped by a range of factors, including economic development, land use patterns, cultural practices, and government policies. Some of the key socio-economic components of the coastal zone include:

1. **Fishing and aquaculture:** Fishing and aquaculture are important economic activities in many coastal areas. They provide employment and income for millions of people around the world, and they support local and global food systems.
2. **Tourism:** Tourism is a major economic driver in many coastal areas, and it can have both positive and negative impacts on the environment and local communities. Tourism infrastructure, such as hotels and resorts, can have significant impacts on coastal ecosystems, while tourism revenues can support conservation and sustainable development efforts.
3. **Ports and shipping:** Ports and shipping are critical components of the global economy, and they are often located in coastal areas. These activities can have significant impacts on the coastal environment, including pollution, habitat loss, and the introduction of invasive species.
4. **Coastal development:** Coastal development, including residential and commercial development, can have significant impacts on the coastal environment. It can lead to habitat loss, increased pollution, and coastal erosion, and it can also exacerbate the impacts of natural hazards such as storms and sea level rise.
5. **Traditional and cultural practices:** Traditional and cultural practices, such as fishing and farming, can play an important role in the socio-economic fabric of coastal communities. These practices can also support sustainable management of coastal resources and contribute to the conservation of cultural and natural heritage.

Overall, the socio-economic components of the coastal zone are critical for the well-being of coastal communities and the global economy. Effective management of these components requires a holistic approach that balances economic development with environmental protection and social equity.

Coastal morphodynamic variables

Coastal morphodynamics refers to the study of how coastal landscapes and seascapes change over time due to a variety of physical processes. These processes include waves, tides, currents, sediment transport, and erosion, and they can have significant impacts on the shape, size, and stability of coastal landforms such as beaches, dunes, cliffs, and tidal flats.

Coastal morphodynamics is an interdisciplinary field that combines elements of geology, geography, oceanography, and engineering. It involves the use of a range of methods and techniques, including field observations, remote sensing, computer modeling, and laboratory experiments, to understand and predict coastal changes and their impacts on natural and human systems.

Some of the key concepts and processes in coastal morphodynamics include:

1. **Sediment transport:** Coastal sediment transport refers to the movement of sand, gravel, and other materials along the shoreline and in the nearshore zone. This process is influenced by waves, tides, currents, and wind, and it plays a key role in shaping coastal landforms and maintaining coastal ecosystems.
2. **Erosion and deposition:** Erosion and deposition are the processes by which coastal landforms are formed and modified over time. These processes are influenced by a range of factors, including wave energy, sediment supply, and sea level changes.
3. **Shoreline dynamics:** Shoreline dynamics refer to the movement of the land-water interface along the coast over time. This process is influenced by a range of factors, including sea level changes, sediment supply, and coastal erosion and deposition.
4. **Coastal hazards:** Coastal hazards, such as storms, floods, and sea level rise, can have significant impacts on coastal landscapes and seascapes. Coastal morphodynamics plays an important role in understanding and mitigating the impacts of these hazards.
5. **Coastal management:** Coastal management involves the use of a range of tools and strategies to protect and enhance coastal ecosystems and human communities. Coastal morphodynamics provides important information for decision-makers and planners in designing effective management strategies.

Overall, coastal morphodynamics is a complex and dynamic field that is essential for understanding and managing coastal environments in a changing world. It plays a critical role in protecting and preserving the ecological, economic, and social values of coastal regions.

Components of coastal morphodynamics

Coastal morphodynamics is a complex field that involves the study of a range of physical processes that shape the coastal environment. The components of coastal morphodynamics can be broadly divided into the following categories:

1. **Waves:** Waves are the primary driver of coastal morphodynamics, and they play a critical role in shaping coastal landforms and ecosystems. Waves are created by wind and they transport sediment along the shoreline and in the nearshore zone.
2. **Tides:** Tides are another important driver of coastal morphodynamics. Tidal currents can transport sediment, and they can influence the shape and size of coastal landforms such as tidal flats, salt marshes, and estuaries.
3. **Sediment transport:** Sediment transport refers to the movement of sand, gravel, and other materials along the shoreline and in the nearshore zone. This process is influenced by waves, tides, currents, and wind, and it plays a key role in shaping coastal landforms and maintaining coastal ecosystems.
4. **Erosion and deposition:** Erosion and deposition are the processes by which coastal landforms are formed and modified over time. These processes are influenced by a range of factors, including wave energy, sediment supply, and sea level changes.
5. **Shoreline dynamics:** Shoreline dynamics refer to the movement of the land-water interface along the coast over time. This process is influenced by a range of factors, including sea level changes, sediment supply, and coastal erosion and deposition.
6. **Coastal hazards:** Coastal hazards, such as storms, floods, and sea level rise, can have significant impacts on coastal landscapes and seascapes. Coastal morphodynamics plays an important role in understanding and mitigating the impacts of these hazards.
7. **Human impacts:** Human activities, such as coastal development, navigation, and fishing, can have significant impacts on coastal morphodynamics. These impacts can alter sediment transport patterns, increase erosion and deposition rates, and exacerbate the impacts of coastal hazards.

Overall, understanding the components of coastal morphodynamics is critical for managing coastal environments and mitigating the impacts of human and natural processes. It requires an interdisciplinary approach that combines elements of geology, oceanography, engineering, and ecology.

Variables of coastal morphodynamics

Coastal morphodynamics is a complex field that involves the study of various variables that interact to shape the coastal environment. Some of the key variables that are studied in coastal morphodynamics include:

1. **Sediment grain size and composition:** The size and composition of sediment particles play a critical role in determining their transport and deposition patterns along the coast.
2. **Wave energy:** The energy and direction of ocean waves are important factors that influence coastal erosion and deposition rates, as well as the formation of coastal landforms such as beaches, dunes, and cliffs.
3. **Tidal range and currents:** Tides and tidal currents can transport sediment, and they can influence the shape and size of coastal landforms such as tidal flats, salt marshes, and estuaries.

4. **Sea level changes:** Changes in sea level, both short-term and long-term, can have significant impacts on coastal morphodynamics by altering sediment transport patterns, erosion and deposition rates, and the position of the land-water interface.
5. **Coastal topography and geology:** The topography and geology of the coastal zone can influence sediment transport patterns, erosion and deposition rates, and the formation and evolution of coastal landforms.
6. **Human activities:** Human activities, such as coastal development, navigation, and fishing, can have significant impacts on coastal morphodynamics by altering sediment transport patterns, increasing erosion and deposition rates, and exacerbating the impacts of coastal hazards.
7. **Climate variability:** Climate variability, such as El Niño events or long-term climate change, can have significant impacts on coastal morphodynamics by altering wave energy, sea level, and sediment transport patterns.

Overall, understanding the complex interactions between these variables is critical for managing coastal environments and mitigating the impacts of human and natural processes. It requires an interdisciplinary approach that combines elements of geology, oceanography, engineering, and ecology.

Coastal morphodynamics variables play a crucial role in the evolution of coastal landforms. Here are some examples:

1. Sediment grain size and composition: Sediment grain size and composition determine how sediment is transported along the coast, as well as how it is deposited. Coarser sediment is typically transported by stronger waves and currents and deposited in areas with higher energy levels, such as beaches or dunes. Finer sediment, on the other hand, is more easily transported and may be deposited in areas with lower energy levels, such as tidal flats or estuaries. Sediment grain size and composition play a critical role in the evolution of coastal landforms. Here are some examples:

- **Beach formation:** The size and composition of sediment particles determine how they are transported by waves and currents. Coarser sediment is typically transported by stronger waves and deposited in areas with higher energy levels, such as beaches. Finer sediment is more easily transported and may be deposited in areas with lower energy levels, such as tidal flats or estuaries. The size and shape of beaches, therefore, are influenced by the size and composition of sediment particles.
- **Barrier island formation:** Barrier islands are formed by the accumulation of sediment transported by waves and currents. The size and composition of sediment particles determine how easily they are transported and deposited, and therefore play a critical role in the formation and evolution of barrier islands.
- **Delta formation:** Deltas are formed by the deposition of sediment carried by rivers or other sources into a body of water, such as a lake or ocean. The size and composition of sediment particles influence the rate at which they settle out of the water and are deposited. Coarser sediment settles out more quickly and may form the primary

channel, while finer sediment may be deposited in areas with lower energy levels, such as the distributary channels.

- **Estuary formation:** Estuaries are typically formed in areas where rivers meet the ocean and are influenced by the size and composition of sediment particles carried by the river. The sediment may settle out and form tidal flats or salt marshes, or be transported downstream and deposited in the ocean.

Overall, the size and composition of sediment particles are important factors in the formation and evolution of coastal landforms. Understanding the sediment dynamics of a coastal system is crucial for managing coastal environments and mitigating the impacts of natural and human-induced processes.

2. Wave energy: Wave energy plays a critical role in shaping coastal landforms. Strong waves erode the shoreline and transport sediment offshore, while weaker waves deposit sediment onshore. The balance between erosion and deposition determines the shape and size of coastal landforms such as beaches, dunes, and cliffs. Wave energy plays a critical role in the evolution of coastal landforms. Here are some examples:

- **Beach formation:** Waves erode sediment from the shoreline and transport it offshore, while weaker waves deposit sediment onshore. The balance between erosion and deposition determines the shape and size of beaches. The energy of waves determines the degree of erosion and deposition. Stronger waves erode more sediment, leading to steeper beaches, while weaker waves deposit more sediment, leading to flatter beaches.
- **Coastal cliffs and headlands:** Wave energy also plays a significant role in the formation of coastal cliffs and headlands. Strong waves erode the base of cliffs and headlands, causing them to retreat inland over time. The shape and orientation of headlands also influence the direction of wave energy, leading to differential erosion and the formation of distinctive coastal features.
- **Barrier island formation:** Barrier islands are formed by the accumulation of sediment transported by waves and currents. Strong waves may erode sediment from the seaward side of a barrier island, while weaker waves deposit sediment on the landward side, leading to the formation of a new barrier island.
- **Dune formation:** Dunes are formed by the deposition of sediment by wind or waves. Wave energy is a key factor in the formation and maintenance of dunes. Stronger waves can transport sediment higher up the beach, leading to the formation of taller dunes.
- **Offshore features:** Waves also shape offshore features such as sandbars, reefs, and submerged shoals. Strong waves can transport sediment over longer distances, leading to the formation of offshore sandbars or submerged shoals. Reefs can be formed by the accumulation of marine organisms, which thrive in areas with high wave energy.

Overall, wave energy is a crucial factor in the evolution of coastal landforms. The strength and direction of waves influence erosion, deposition, and sediment transport, leading to the formation of distinctive coastal features over time. Understanding the wave dynamics of a coastal system is crucial for managing coastal environments and mitigating the impacts of natural and human-induced processes.

3. Tidal range and currents: Tidal range and currents can shape coastal landforms such as tidal flats and salt marshes by transporting sediment and determining the position of the land-water interface. High tidal ranges and strong tidal currents can create complex channels and estuaries, while lower tidal ranges can lead to the formation of barrier islands. Tidal range and currents play a significant role in the evolution of coastal landforms. Here are some examples:

- **Estuaries and tidal flats:** Estuaries are typically formed where rivers meet the ocean and are influenced by tidal currents. Tidal currents transport sediment and shape the morphology of the estuary and surrounding tidal flats. The direction and strength of tidal currents determine the patterns of sediment deposition and erosion, leading to the formation of tidal channels, mud flats, and salt marshes.
- **Barrier islands:** Tidal currents also play a role in the formation and maintenance of barrier islands. Tidal currents may transport sediment onto the island, leading to growth and maintenance of the island. Alternatively, tidal currents may erode sediment from the seaward side of the island, causing the island to migrate or erode over time.
- **Beaches and dunes:** Tidal currents can transport sediment along the shoreline, leading to the formation of beach ridges and dunes. The strength and direction of tidal currents influence the pattern of sediment deposition and erosion, leading to the formation of different types of beach and dune systems.
- **Coastal erosion:** Tidal currents can also play a role in coastal erosion. Strong tidal currents can erode sediment from the base of coastal cliffs or headlands, causing them to retreat over time.

Overall, tidal range and currents are important factors in the formation and evolution of coastal landforms. The strength and direction of tidal currents determine the patterns of sediment deposition and erosion, leading to the formation of distinctive coastal features over time. Understanding the tidal dynamics of a coastal system is crucial for managing coastal environments and mitigating the impacts of natural and human-induced processes.

4. Sea level changes: Changes in sea level can have a profound impact on coastal landforms. Rising sea levels can lead to erosion and the loss of coastal land, while falling sea levels can lead to the exposure of new landforms such as offshore reefs or sandbars. Sea level changes play a critical role in the evolution of coastal landforms. Here are some examples:

- **Sea level rise:** Rising sea levels can cause the coastline to retreat inland, leading to erosion of beaches, dunes, and bluffs. Coastal wetlands, estuaries, and salt marshes may also be inundated as the sea level rises. The degree of impact on a particular coastal system will depend on factors such as the rate of sea level rise, the elevation of the land, and the sediment supply.
- **Sea level fall:** Falling sea levels can cause the coastline to advance seaward, leading to the formation of new beaches, dunes, and other coastal landforms. This can also lead to the exposure of previously submerged land, such as coastal platforms, rock formations, and reef systems.

- **Subsidence:** Local subsidence can exacerbate the effects of sea level rise, leading to accelerated coastal erosion and inundation. Human activities such as groundwater withdrawal, oil and gas extraction, and urbanization can contribute to subsidence.
- **Coastal landforms:** The changes in sea level over geological time have played a significant role in the formation of many coastal landforms. For example, the retreat of the last ice age caused sea levels to rise rapidly, leading to the formation of new coastal features such as barrier islands, spits, and lagoons.

Overall, sea level changes have a profound impact on the evolution of coastal landforms. Natural and human-induced factors can influence sea level, leading to changes in the morphology of the coastline over time. Understanding the dynamics of sea level changes is crucial for managing coastal environments and mitigating the impacts of natural and human-induced processes.

5. Coastal topography and geology: The topography and geology of the coastal zone can also influence the evolution of coastal landforms. Coastal cliffs, for example, are often formed in areas where the rock is resistant to erosion, while softer sedimentary rock may be more prone to erosion and deposition. Coastal topography and geology play a crucial role in the evolution of coastal forms. The interplay between these factors can result in a diverse range of landforms, including beaches, cliffs, estuaries, deltas, and coral reefs.

Topography refers to the shape and relief of the land, including the elevation and slope of the coastal area. The topography of a coastline can determine the type of wave action that occurs, which can then impact the formation of coastal landforms. For example, if a coastline has a steep topography, it may experience higher wave energy, which can lead to the formation of cliffs or sea stacks. In contrast, a gentle topography may lead to the formation of sandy beaches or mudflats.

Geology refers to the type and structure of rock formations in the coastal area. The type of rock can affect the rate of erosion and the stability of the coastal landforms. For example, softer rock types, such as sandstone or shale, may erode more quickly than harder rock types like granite. This can lead to the formation of features like sea caves or arches. In addition, the structure of the rock can affect the way it weathers and erodes, leading to unique coastal formations like sea stacks or sea cliffs.

Other factors, such as tides, currents, and sediment supply, also play a role in the evolution of coastal forms. These factors can interact with topography and geology to shape the coastline over time. Understanding the interplay between these factors can help us predict how coastal landforms will evolve in response to natural and human-induced changes.

6. Human activities: Human activities can also have a significant impact on the evolution of coastal landforms. Coastal development, for example, can alter sediment transport patterns and increase erosion rates, while dredging and navigation can alter tidal currents and impact sediment deposition. Human activities can have a significant impact on the evolution of coastal forms. The alteration of natural processes by human activities can lead to changes in the coastline and the formation of new landforms. Some of the key ways that human activities can impact the coastal environment include:

- **Coastal development:** The construction of buildings, marinas, and other structures can alter the natural coastline and change sediment patterns. This can lead to erosion or accretion of the shoreline and the formation of new landforms.
- **Dredging and sand mining:** Dredging and sand mining can alter sediment patterns, leading to erosion in some areas and sediment accumulation in others. This can impact the formation and stability of coastal landforms.
- **Land reclamation:** Land reclamation involves filling in coastal areas to create new land for development. This can impact the natural processes that shape the coastline, leading to changes in the formation of coastal landforms.
- **Pollution and climate change:** Human activities such as pollution and climate change can impact the health of coastal ecosystems, leading to changes in the formation and stability of coastal landforms.
- **Coastal management practices:** The management of coastal areas can impact the formation and stability of coastal landforms. For example, the construction of seawalls or groins can alter sediment patterns and lead to changes in the coastline.

Overall, human activities can have both positive and negative impacts on the evolution of coastal forms. It is important to consider these impacts when making decisions about coastal management and development to ensure the long-term health and stability of coastal ecosystems.

Overall, the complex interactions between these variables determine the evolution of coastal landforms over time. Understanding these processes is critical for managing coastal environments and mitigating the impacts of human and natural processes.

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2. Environmental impacts and management of mining, oil exploration, salt manufacturing, land reclamation and tourism.

Environmental impacts mining in the coastal areas

Mining in coastal areas can have significant environmental impacts that can affect the health of coastal ecosystems and the communities that rely on them. Some of the key environmental impacts of mining in coastal areas include:

- **Habitat destruction:** Mining activities can destroy coastal habitats, such as mangroves, seagrass beds, and coral reefs, which provide critical habitats for a variety of marine species.
- **Erosion and sedimentation:** Mining activities can cause erosion and sedimentation, leading to changes in the shape and elevation of coastal landforms. This can impact the natural processes that shape the coastline, leading to changes in the formation and stability of coastal landforms.
- **Pollution:** Mining activities can release a range of pollutants, including heavy metals, chemicals, and sediment, into coastal waters. These pollutants can impact the health of marine organisms and the quality of coastal ecosystems, leading to a decline in biodiversity.
- **Acid mine drainage:** Acid mine drainage occurs when water and air come into contact with sulfide minerals in mining waste, creating sulfuric acid. This can release toxic metals and chemicals into the environment, leading to a range of environmental impacts, including the destruction of aquatic habitats and the loss of biodiversity.
- **Climate change:** Mining activities can contribute to climate change by releasing greenhouse gases, such as carbon dioxide and methane, into the atmosphere. This can impact coastal ecosystems by changing ocean temperatures and acidity levels, leading to the loss of coral reefs and other marine habitats.

Management

Effective management strategies can help to minimize the environmental impacts of mining in coastal areas. Some key management strategies include:

- **Environmental impact assessments (EIAs):** Conducting EIAs before mining activities begin can help to identify potential environmental impacts and risks. This can help to inform decision-making and ensure that appropriate mitigation measures are put in place.
- **Best practices and regulations:** Establishing and enforcing best practices and regulations for mining activities can help to minimize environmental impacts. This can include measures such as minimizing waste and pollution, managing water resources, and protecting critical habitats.

- **Monitoring and reporting:** Regular monitoring and reporting of mining activities can help to ensure that environmental impacts are minimized and that any issues are identified and addressed promptly.
- **Rehabilitation and restoration:** Rehabilitating and restoring mined areas can help to reduce the environmental impacts of mining and restore natural habitats. This can include measures such as re-vegetation, erosion control, and habitat restoration.
- **Community engagement and consultation:** Engaging with local communities and stakeholders can help to ensure that their concerns and needs are considered in decision-making and that the impacts of mining are minimized.

Overall, effective management strategies can help to minimize the environmental impacts of mining in coastal areas and ensure the long-term sustainability of coastal ecosystems and the communities that rely on them.

Overall, mining in coastal areas can have significant environmental impacts that can have long-lasting effects on coastal ecosystems and the communities that rely on them. It is important to carefully consider these impacts when making decisions about mining in coastal areas and to implement effective management and mitigation strategies to minimize these impacts.

Environmental impacts oil exploration in the coastal areas

Oil exploration in coastal areas can have significant environmental impacts on coastal ecosystems and the communities that depend on them. Some of the key environmental impacts of oil exploration in coastal areas include:

- **Oil spills:** Oil spills are a major risk associated with oil exploration in coastal areas. Spills can result in extensive environmental damage, including the loss of habitat and wildlife, and can have long-term impacts on the health of coastal ecosystems.
- **Habitat destruction:** Oil exploration activities can result in the destruction of coastal habitats, such as mangroves and seagrass beds, which provide critical habitats for a variety of marine species.

- **Pollution:** Oil exploration activities can result in pollution of coastal waters, including the release of toxic chemicals and heavy metals into the environment. This can have significant impacts on the health of marine organisms and the quality of coastal ecosystems.
- **Noise pollution:** Seismic testing and drilling activities associated with oil exploration can create high levels of underwater noise that can disrupt the behavior and communication of marine animals.
- **Climate change:** Oil exploration activities can contribute to climate change by releasing greenhouse gases, such as carbon dioxide and methane, into the atmosphere. This can impact coastal ecosystems by changing ocean temperatures and acidity levels, leading to the loss of coral reefs and other marine habitats.

Overall, oil exploration in coastal areas can have significant environmental impacts that can have long-lasting effects on coastal ecosystems and the communities that rely on them. It is important to carefully consider these impacts when making decisions about oil exploration and to implement effective management and mitigation strategies to minimize these impacts.

Management

Effective management strategies can help to minimize the environmental impacts of oil exploration in coastal areas. Some key management strategies include:

- **Environmental impact assessments (EIAs):** Conducting EIAs before oil exploration activities begin can help to identify potential environmental impacts and risks. This can help to inform decision-making and ensure that appropriate mitigation measures are put in place.
- **Best practices and regulations:** Establishing and enforcing best practices and regulations for oil exploration activities can help to minimize environmental impacts. This can include measures such as minimizing waste and pollution, managing water resources, and protecting critical habitats.
- **Spill prevention and response plans:** Developing and implementing spill prevention and response plans can help to minimize the risk of oil spills and ensure that appropriate measures are taken in the event of a spill.
- **Monitoring and reporting:** Regular monitoring and reporting of oil exploration activities can help to ensure that environmental impacts are minimized and that any issues are identified and addressed promptly.
- **Restoration and compensation:** Rehabilitating and restoring areas affected by oil exploration activities can help to reduce the environmental impacts of oil exploration and restore natural habitats. Additionally, providing compensation to affected communities and stakeholders can help to mitigate the social and economic impacts of oil exploration.
- **Community engagement and consultation:** Engaging with local communities and stakeholders can help to ensure that their concerns and needs are considered in decision-making and that the impacts of oil exploration are minimized.

Overall, effective management strategies can help to minimize the environmental impacts of oil exploration in coastal areas and ensure the long-term sustainability of coastal ecosystems and the communities that rely on them.

Environmental impacts salt manufacturing in the coastal areas

Salt manufacturing in coastal areas can have several environmental impacts on the coastal ecosystems and communities that depend on them. Some of the key environmental impacts of salt manufacturing in coastal areas include:

- **Habitat destruction:** Salt manufacturing often involves the clearing of coastal vegetation, such as mangroves and salt marshes, which provide critical habitats for a variety of marine and terrestrial species. This can result in the loss of biodiversity and the disruption of ecological processes.
- **Soil and water pollution:** Salt manufacturing involves the use of chemicals, such as hydrochloric acid, which can contaminate soil and water resources, affecting the quality of these resources for both humans and wildlife.
- **Water use:** Salt manufacturing can result in the excessive use of water resources, which can lead to the depletion of groundwater and the drying up of wetlands.
- **Energy consumption:** Salt manufacturing requires significant amounts of energy, which can result in greenhouse gas emissions and contribute to climate change.
- **Salinization:** The disposal of waste brine, a byproduct of salt manufacturing, can lead to the salinization of soils and groundwater, affecting the ability of plants and animals to survive in affected areas.

Overall, salt manufacturing in coastal areas can have significant environmental impacts on coastal ecosystems and the communities that depend on them. It is important to carefully consider these impacts when making decisions about salt manufacturing and to implement effective management and mitigation strategies to minimize these impacts.

Management

Effective management strategies can help to minimize the environmental impacts of salt manufacturing in coastal areas. Some key management strategies include:

- **Environmental impact assessments (EIAs):** Conducting EIAs before salt manufacturing activities begin can help to identify potential environmental impacts and risks. This can help to inform decision-making and ensure that appropriate mitigation measures are put in place.
- **Best practices and regulations:** Establishing and enforcing best practices and regulations for salt manufacturing activities can help to minimize environmental impacts. This can include measures such as minimizing waste and pollution, managing water resources, and protecting critical habitats.
- **Efficient water management:** Implementing efficient water management practices can help to reduce the amount of water used in salt manufacturing, minimizing the impact on water resources.
- **Waste management:** Developing and implementing effective waste management strategies can help to reduce the impact of salt manufacturing on the environment. This can include measures such as recycling and reuse of waste products, and responsible disposal of waste brine.
- **Restoration and rehabilitation:** Rehabilitating and restoring areas affected by salt manufacturing activities can help to reduce the environmental impacts of salt manufacturing and restore natural habitats.
- **Community engagement and consultation:** Engaging with local communities and stakeholders can help to ensure that their concerns and needs are considered in decision-making and that the impacts of salt manufacturing are minimized.

Overall, effective management strategies can help to minimize the environmental impacts of salt manufacturing in coastal areas and ensure the long-term sustainability of coastal ecosystems and the communities that rely on them.

Environmental impacts land reclamation in the coastal areas

Land reclamation in coastal areas involves the creation of new land by filling in coastal areas with soil, sand, and rocks. This process can have significant environmental impacts on coastal ecosystems and the communities that depend on them. Some of the key environmental impacts of land reclamation in coastal areas include:

- **Habitat loss:** Land reclamation often involves the destruction of coastal ecosystems, such as mangroves, salt marshes, and coral reefs, which provide important habitats for a wide range of marine and terrestrial species.
- **Changes to water circulation:** Land reclamation can alter the natural flow of water in coastal areas, affecting the distribution of sediment and nutrients and altering water quality. This can have negative impacts on aquatic ecosystems and the species that depend on them.
- **Erosion:** Land reclamation can lead to increased erosion of the coastline, particularly in areas where sediment transport is disrupted. This can result in the loss of beaches and other important coastal features.
- **Flooding:** Land reclamation can increase the risk of flooding in coastal areas by reducing the ability of the land to absorb water and increasing the risk of storm surges.
- **Climate change:** Land reclamation can contribute to climate change by releasing stored carbon in the soil and vegetation that is removed during the process. It can also increase the risk of coastal erosion and flooding, which are exacerbated by rising sea levels.

Overall, land reclamation in coastal areas can have significant environmental impacts on coastal ecosystems and the communities that depend on them. It is important to carefully consider these impacts when making decisions about land reclamation and to implement effective management and mitigation strategies to minimize these impacts.

Management

Effective management strategies can help to minimize the environmental impacts of land reclamation in coastal areas. Some key management strategies include:

- **Environmental impact assessments (EIAs):** Conducting EIAs before land reclamation activities begin can help to identify potential environmental impacts and risks. This can help to inform decision-making and ensure that appropriate mitigation measures are put in place.

- **Restoring and rehabilitating ecosystems:** Rehabilitating and restoring areas affected by land reclamation activities can help to reduce the environmental impacts of land reclamation and restore natural habitats. This can include measures such as replanting vegetation and creating new wetlands.
- **Best practices and regulations:** Establishing and enforcing best practices and regulations for land reclamation activities can help to minimize environmental impacts. This can include measures such as minimizing waste and pollution, managing water resources, and protecting critical habitats.
- **Efficient water management:** Implementing efficient water management practices can help to reduce the impact of land reclamation on water resources, such as by reducing the amount of water used for land reclamation activities.
- **Minimizing land use:** Minimizing the amount of land used for reclamation activities can help to reduce the impact of land reclamation on coastal ecosystems. This can be achieved through measures such as using alternative building materials or redeveloping existing land.
- **Monitoring and evaluation:** Regular monitoring and evaluation of land reclamation activities can help to ensure that any negative environmental impacts are identified and addressed in a timely manner.

Overall, effective management strategies can help to minimize the environmental impacts of land reclamation in coastal areas and ensure the long-term sustainability of coastal ecosystems and the communities that rely on them.

Environmental impacts tourism in the coastal areas

Tourism is a major economic activity in many coastal areas, but it can also have significant environmental impacts on coastal ecosystems and the communities that depend on them. Some of the key environmental impacts of tourism in coastal areas include:

- **Habitat destruction:** Tourism development can result in the destruction of coastal habitats, such as mangroves, salt marshes, and coral reefs, which provide important habitats for a wide range of marine and terrestrial species.

- **Pollution:** Tourism can result in increased pollution of coastal waters and habitats, particularly from sewage and waste generated by tourism activities.
- **Erosion:** Tourism development can lead to increased erosion of the coastline, particularly in areas where vegetation is removed or sediment transport is disrupted. This can result in the loss of beaches and other important coastal features.
- **Overfishing:** Tourism can increase demand for seafood, leading to overfishing and depletion of fish stocks in coastal waters.
- **Climate change:** Tourism can contribute to climate change through greenhouse gas emissions from transportation, accommodation, and other tourism-related activities. This can contribute to sea level rise and ocean acidification, which can have negative impacts on coastal ecosystems and communities.

Overall, tourism in coastal areas can have significant environmental impacts. It is important to carefully consider these impacts when making decisions about tourism development and to implement effective management and mitigation strategies to minimize these impacts.

Some key management strategies for minimizing the environmental impacts of tourism in coastal areas include:

- **Sustainable tourism practices:** Promoting sustainable tourism practices, such as eco-tourism and responsible travel, can help to minimize the environmental impacts of tourism.
- **Environmental impact assessments (EIAs):** Conducting EIAs before tourism development activities begin can help to identify potential environmental impacts and risks. This can help to inform decision-making and ensure that appropriate mitigation measures are put in place.
- **Best practices and regulations:** Establishing and enforcing best practices and regulations for tourism activities can help to minimize environmental impacts. This can include measures such as minimizing waste and pollution, managing water resources, and protecting critical habitats.
- **Community engagement and consultation:** Engaging with local communities and stakeholders can help to ensure that their concerns and needs are considered in decision-making and that the impacts of tourism are minimized.
- **Monitoring and evaluation:** Regular monitoring and evaluation of tourism activities can help to ensure that any negative environmental impacts are identified and addressed in a timely manner.

Overall, effective management strategies can help to minimize the environmental impacts of tourism in coastal areas and ensure the long-term sustainability of coastal ecosystems and the communities that rely on them.

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3. Coastal hazards and their management using structural and non-structural measures: Erosion, flood, sand encroachment, dune degeneration, estuarine sedimentation and pollution.

Coastal hazards

Coastal hazards are events or processes that occur in coastal areas that have the potential to cause harm to human populations, infrastructure, and ecosystems. Some of the most common coastal hazards include:

- **Storm surges:** Storm surges occur when a storm pushes a large volume of water towards the coast, causing flooding and damage to coastal infrastructure and communities.
- **Coastal erosion:** Coastal erosion occurs when the shoreline retreats due to natural processes such as wave action and longshore drift, or human activities such as construction and sand mining.
- **Tsunamis:** Tsunamis are large waves caused by earthquakes, volcanic eruptions, or landslides that occur under the ocean. They can cause widespread damage and loss of life in coastal areas.
- **Sea level rise:** Sea level rise is caused by the melting of ice caps and glaciers due to global warming, and can lead to increased flooding, erosion, and saltwater intrusion in coastal areas.

- **Coastal flooding:** Coastal flooding occurs when water levels rise due to storm surges, sea level rise, or heavy rainfall. It can cause damage to infrastructure and property, and can also contaminate freshwater sources with saltwater.
- **Landslides:** Landslides can occur in coastal areas due to natural processes such as erosion and soil saturation, or human activities such as construction and mining. They can cause damage to infrastructure and loss of life.

Overall, coastal hazards are a significant threat to coastal communities and ecosystems. Effective management strategies, such as coastal engineering, disaster preparedness planning, and ecosystem-based approaches, can help to mitigate the impacts of these hazards and improve the resilience of coastal areas. It is also important to consider the potential impacts of climate change on coastal hazards and to take proactive steps to adapt to these changes.

Coastal erosion and its management using structural and non-structural measures

Coastal erosion is the natural process by which waves, currents, tides, and storms wear away and remove sediment and land along the shoreline. It is a natural process that occurs over time, but it can be accelerated by human activities such as sand mining, construction, and poor land use practices.

Coastal erosion can have significant impacts on coastal communities, infrastructure, and ecosystems. Some of the key impacts of coastal erosion include:

- **Loss of land:** Coastal erosion can cause the shoreline to retreat, leading to the loss of land and property. This can have significant economic and social impacts on coastal communities.
- **Damage to infrastructure:** Coastal erosion can cause damage to buildings, roads, and other infrastructure located along the shoreline.
- **Habitat loss:** Coastal erosion can cause the loss of important habitats such as beaches, dunes, and wetlands, which can have negative impacts on coastal ecosystems and the species that depend on them.

- **Increased flood risk:** Coastal erosion can increase the risk of flooding in coastal areas by reducing the natural protection provided by beaches and dunes.
- **Saltwater intrusion:** Coastal erosion can also lead to the intrusion of saltwater into freshwater resources, which can have negative impacts on agriculture and drinking water supplies.

Structural measures

Structural measures are one of the management strategies used to mitigate coastal erosion. These measures involve the construction of physical structures along the shoreline to provide protection against erosion and wave energy. However, these measures can also have negative impacts on coastal ecosystems and should be carefully designed and implemented.

Some of the structural measures used for coastal erosion management include:

- **Seawalls:** Seawalls are vertical barriers constructed along the shoreline to protect against wave energy and erosion. They are typically made of concrete, steel, or stone, and can be effective at providing protection in areas with high wave energy. However, seawalls can have negative impacts on beach and dune systems, and can also lead to increased erosion in adjacent areas.
- **Revetments:** Revetments are sloping structures made of concrete or stone that are constructed along the shoreline to help absorb wave energy and protect against erosion. They can be effective at providing protection while also allowing for natural processes such as beach and dune formation. However, revetments can also alter natural beach processes and lead to the loss of beach habitats.
- **Breakwaters:** Breakwaters are offshore structures designed to break up waves and reduce their energy before they reach the shore. They can be effective at reducing erosion and protecting shorelines, but can also have negative impacts on marine habitats and recreational activities.

- **Groynes:** Groynes are structures constructed perpendicular to the shoreline to trap sediment and build up beaches. They can be effective at reducing erosion and promoting beach accretion, but can also alter natural sediment transport processes and impact beach habitats.
- **Offshore reefs:** Offshore reefs are submerged structures designed to reduce wave energy and promote sediment accumulation along the shoreline. They can be effective at reducing erosion and promoting beach accretion, but can also impact marine habitats and alter natural sediment transport processes.

Overall, structural measures can be effective at mitigating coastal erosion, but should be carefully designed and implemented to minimize negative impacts on coastal ecosystems and the communities that depend on them. It is important to consider the potential long-term impacts of these measures, as well as alternative approaches such as ecosystem-based management and non-structural measures.

Non-structural measures

Non-structural measures are an important component of coastal erosion management, as they rely on natural processes and ecosystem-based approaches to reduce erosion and protect coastal habitats. Non-structural measures can be used in combination with structural measures or as stand-alone approaches, depending on the specific needs and characteristics of the coastline.

Some of the non-structural measures used for coastal erosion management include:

- **Beach nourishment:** Beach nourishment involves adding sand to beaches to help restore eroded shorelines. This can be an effective strategy for managing coastal erosion in some areas. It is often used in combination with structural measures, such as groynes or offshore reefs, to trap and retain the added sediment.
- **Dune restoration:** Dune restoration involves restoring natural dune systems along the coastline to help provide natural protection against erosion and flooding. This can be achieved by planting native vegetation on existing dunes or by building new dunes using natural materials such as sand and vegetation.
- **Wetland restoration:** Wetland restoration involves restoring or creating coastal wetlands such as salt marshes and mangroves. These ecosystems can help to reduce wave energy, trap sediment, and provide important habitat for a variety of species.
- **Land use planning:** Careful land use planning can help to minimize the impacts of coastal erosion by limiting development in areas prone to erosion. This can include setbacks from the shoreline, restrictions on construction in erosion-prone areas, and zoning regulations that promote sustainable coastal development.
- **Beach access management:** Beach access management involves controlling the number and location of access points to beaches to minimize erosion and protect sensitive habitats. This can include limiting vehicular traffic, restricting beach access during sensitive nesting periods for shorebirds and sea turtles, and promoting responsible visitor behavior.

Overall, non-structural measures can be effective at mitigating coastal erosion while also promoting sustainable coastal management practices. By relying on natural processes and ecosystem-based approaches, these measures can help to protect coastal habitats, support biodiversity, and enhance the resilience of coastal communities to the impacts of climate change.

Coastal flooding and its management through structural and non-structural measures

Coastal flooding is a natural hazard that occurs when water from the ocean, sea, or other large bodies of water inundates coastal areas, resulting in damage to infrastructure and property, loss of life, and long-term economic impacts. Coastal flooding can occur due to a range of factors, including storm surges, tidal fluctuations, and sea level rise caused by climate change.

Storm surges are one of the most common causes of coastal flooding. They occur when a storm or hurricane generates strong winds that push water towards the shore, causing the sea level to rise significantly. Tidal fluctuations, which are caused by the gravitational pull of the moon and sun, can also contribute to coastal flooding when they coincide with storms or other extreme weather events.

Sea level rise, which is caused by the melting of polar ice caps and glaciers, is also a major contributor to coastal flooding. As sea levels rise, coastal areas become more vulnerable to flooding and erosion, and the risk of damage to infrastructure and property increases. This can have significant economic and social impacts, particularly in areas with high population densities and significant coastal development.

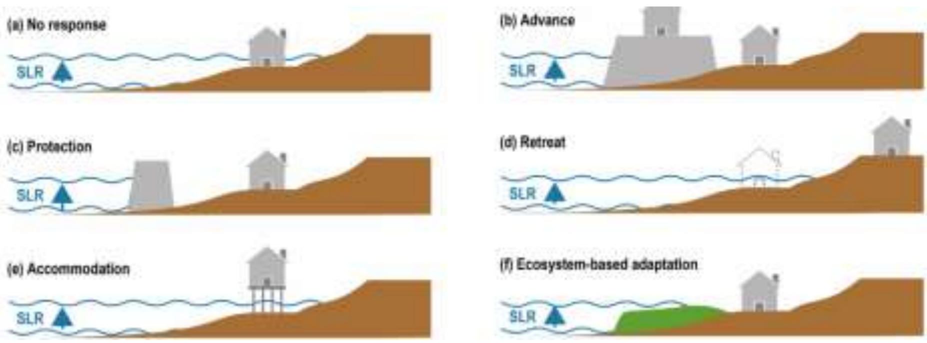
Structural measures

Structural measures for managing coastal flooding typically involve the construction of physical barriers or structures to protect coastal areas from flooding and erosion. Some common examples of structural measures for coastal flooding management include:

- **Seawalls:** Seawalls are structures that are built parallel to the coast to protect against waves and storm surges. They are typically made of concrete, steel, or other durable materials and can be effective at reducing the impact of coastal flooding. However, seawalls can also have negative impacts on natural habitats and ecosystems, and can lead to erosion and other problems if they are not properly designed and maintained.

- **Dikes and levees:** Dikes and levees are embankments or raised areas of land that are built along the coast to prevent flooding. They can be effective at protecting coastal areas from storm surges and tidal fluctuations, but they can also be expensive to construct and maintain. In addition, dikes and levees can sometimes cause water to accumulate in areas that are not protected, leading to increased flooding and erosion.
- **Breakwaters:** Breakwaters are structures that are built offshore to protect coastal areas from waves and storm surges. They can be effective at reducing the impact of coastal flooding, but they can also have negative impacts on natural habitats and ecosystems. In addition, breakwaters can be expensive to construct and maintain, and can sometimes interfere with navigation and other activities.
- **Artificial reefs:** Artificial reefs are structures that are built offshore to provide habitats for marine life and to protect coastal areas from waves and storm surges. They can be effective at reducing the impact of coastal flooding, but they can also have negative impacts on natural habitats and ecosystems if they are not properly designed and maintained.
- **Flood barriers:** Flood barriers are structures that can be deployed to prevent water from entering coastal areas during floods. They can be effective at reducing the impact of coastal flooding, but they can also be expensive to construct and maintain.

Structural measures can be effective at managing coastal flooding, but they should be used in conjunction with other management strategies, such as land-use planning and ecosystem restoration, to ensure that they are sustainable and effective over the long-term.



Non-structural measures

Non-structural measures for managing coastal flooding typically involve planning and management strategies that do not involve the construction of physical structures. Some common examples of non-structural measures for coastal flooding management include:

- **Land-use planning:** Land-use planning can help to prevent the development of vulnerable areas and reduce the risk of damage from coastal flooding. This can involve zoning regulations that prohibit construction in high-risk areas, or incentives for developers to build in safer locations.

- **Ecosystem restoration:** Ecosystem restoration can help to reduce the impact of coastal flooding by restoring natural habitats and increasing the resilience of coastal ecosystems. This can involve planting vegetation along the coast, restoring wetlands, or creating artificial reefs.
- **Early warning systems:** Early warning systems can help to reduce the risk of damage from coastal flooding by providing advanced notice of potential hazards. This can involve monitoring weather patterns and ocean conditions and issuing warnings to coastal communities in advance of storms or other extreme events.
- **Floodplain management:** Floodplain management involves managing floodplains to reduce the risk of damage from coastal flooding. This can involve the creation of buffer zones or the development of flood-resistant building materials and construction techniques.
- **Education and awareness:** Education and awareness campaigns can help to reduce the risk of damage from coastal flooding by increasing public awareness of the risks and promoting actions that can reduce vulnerability. This can involve public outreach programs, educational materials, and community-based initiatives.

Non-structural measures can be effective at managing coastal flooding when they are implemented in conjunction with structural measures and other management strategies. By taking a comprehensive and integrated approach to coastal flooding management, it is possible to reduce the risks of damage and create more sustainable and resilient coastal communities.

Sand encroachment and its structural and non-structural measures

Sand encroachment in coastal areas is a phenomenon where sand from the beach or dunes migrates inland and covers land, buildings, and infrastructure. This can be caused by natural factors, such as wind and ocean currents, or by human activities, such as the construction of coastal structures and the alteration of natural drainage patterns. Sand encroachment can have significant negative impacts on coastal communities, including loss of agricultural land, damage to infrastructure, and reduced tourism opportunities.

Structural measures

Structural measures for managing sand encroachment in coastal areas typically involve the construction of physical barriers and other engineering interventions. Some common examples of structural measures for managing sand encroachment include:

- **Seawalls:** Seawalls are concrete or stone walls that are built along the coastline to protect land and infrastructure from the impact of waves and storms. Seawalls can help to reduce the impact of sand encroachment by providing a physical barrier that prevents sand from migrating inland.
- **Breakwaters:** Breakwaters are offshore barriers that are designed to reduce the impact of waves and protect coastal areas from erosion and flooding. Breakwaters can help to reduce the impact of sand encroachment by altering ocean currents and preventing sand from migrating inland.

- **Groynes:** Groynes are structures that are built perpendicular to the shoreline to trap sand and prevent it from migrating down the coast. Groynes can help to stabilize beaches and dunes and reduce the impact of sand encroachment.
- **Sand fences:** Sand fences are temporary or permanent barriers that are designed to trap sand and prevent it from migrating inland. Sand fences can be used to stabilize dunes and beaches and reduce the impact of sand encroachment.
- **Revetments:** Revetments are sloping structures that are built along the shoreline to reduce the impact of waves and protect land and infrastructure from erosion. Revetments can help to reduce the impact of sand encroachment by providing a physical barrier that prevents sand from migrating inland.

Structural measures can be effective at managing sand encroachment in coastal areas, but they can also have negative environmental impacts and may not always be the most sustainable solution. It is important to carefully consider the potential impacts of structural measures and to use them in conjunction with non-structural measures and other management strategies to create a comprehensive and integrated approach to sand encroachment management.

Non-structural measures

Non-structural measures for managing sand encroachment in coastal areas focus on approaches that do not involve the construction of physical barriers or other engineering interventions. Instead, non-structural measures aim to manage sand encroachment through strategies such as natural resource management, land-use planning, and public awareness campaigns. Some common examples of non-structural measures for managing sand encroachment include:

- **Natural resource management:** Natural resource management involves the protection and restoration of natural ecosystems, such as dunes, wetlands, and beaches. By maintaining healthy ecosystems, it is possible to reduce the impact of sand encroachment and promote sustainable and resilient coastal communities.
- **Land-use planning:** Land-use planning involves the development of policies and regulations that guide the use of land in coastal areas. By restricting development in high-risk areas and promoting the use of building materials and construction techniques that are resistant to sand damage, it is possible to reduce the risk of sand encroachment and protect coastal communities.
- **Public awareness campaigns:** Public awareness campaigns involve education and outreach programs that increase public awareness of the risks of sand encroachment and promote actions that can reduce vulnerability. By increasing public awareness, it is possible to promote more sustainable and resilient coastal communities.
- **Beach cleanups:** Beach cleanups involve the removal of debris and trash from beaches, which can help to reduce the impact of sand encroachment and promote healthy coastal ecosystems.
- **Dune restoration:** Dune restoration involves the planting of vegetation and the construction of fences and other barriers to stabilize dunes and prevent sand from migrating inland. By restoring healthy dunes, it is possible to reduce the impact of sand encroachment and promote sustainable and resilient coastal communities.

Non-structural measures can be effective at managing sand encroachment in coastal areas, particularly when used in conjunction with structural measures and other management strategies. By taking a comprehensive and integrated approach to sand encroachment management, it is possible to create more sustainable and resilient coastal communities.

Dune degradation and its structural and non-structural measures

Coastal sand dune degradation refers to the process of erosion and depletion of sand dunes that occur along coastlines. Sand dunes are formed by the accumulation of wind-blown sand, and they serve as an important barrier between the ocean and inland areas, protecting against storm surges and flooding.

There are several factors that can contribute to coastal sand dune degradation, including human activities such as construction, mining, and recreational activities that involve driving vehicles or walking on the dunes. Climate change is also a significant factor, as rising sea levels and increased storm activity can accelerate erosion and undermine dunes.

Degraded sand dunes can have significant environmental consequences, including loss of habitat for coastal plant and animal species, reduced protection against storm surges and flooding, and increased vulnerability to erosion and coastal hazards. Restoring degraded sand dunes typically involves a combination of measures such as stabilizing the dunes with vegetation, limiting human activities, and implementing erosion control measures such as sand fencing and dune nourishment.

Structural measures

Structural measures can also be used in the context of coastal sand dune management to protect and restore these valuable ecosystems. Some examples of structural measures that can be used for coastal sand dune management include:

- **Sand fencing -** This involves installing fences parallel to the shoreline to trap and retain sand and prevent it from being blown or washed away. Sand fencing helps to stabilize sand dunes and create new dunes, providing additional protection against storm surges and coastal erosion.
- **Dune nourishment -** This involves adding sand to an eroding or degraded dune system to rebuild its height and width. Dune nourishment can be done through natural or artificial means, such as using dredged material from nearby harbors or beaches.
- **Vegetation planting -** This involves planting native coastal vegetation on and around sand dunes to help stabilize the sand and promote dune growth. Vegetation also provides habitat for wildlife and can improve overall ecosystem health.
- **Breakwaters and groynes -** These are physical structures built offshore or along the shoreline to reduce wave energy and protect the coastline from erosion. Breakwaters are long barriers constructed parallel to the shoreline, while groynes are perpendicular structures that extend into the water.
- **Beach nourishment -** This involves adding sand to beaches to increase their width and height, which can help protect the adjacent dune system from erosion and wave damage.

Sand fencing

It is important to note that while structural measures can be effective in managing coastal sand dune degradation, they should be implemented in combination with other management strategies such as monitoring, education, and regulation to ensure long-term success and sustainability.

Non-structural measures

Non-structural measures refer to interventions or strategies that do not involve physical constructions or alterations to the environment. These measures are usually focused on changing behaviors, attitudes, or policies to reduce risks or manage environmental problems.

In the context of coastal sand dune management, non-structural measures can be used in combination with structural measures to provide a comprehensive approach to managing coastal erosion and protecting sand dune ecosystems. Some examples of non-structural measures for coastal sand dune management include:

- **Education and outreach -** This involves raising public awareness about the value of sand dunes and the importance of protecting them. Education and outreach efforts can include public meetings, workshops, brochures, and signage.
- **Regulatory measures -** This includes policies and regulations that restrict certain activities on and around sand dunes, such as construction, off-road vehicle use, and sand mining.
- **Planning and zoning -** This involves land-use planning that takes into account the location and vulnerability of sand dune ecosystems, and ensures that development is done in a way that minimizes impacts to these areas.
- **Monitoring and assessment -** This involves regular monitoring and assessment of sand dune ecosystems to track changes in vegetation, dune height, and erosion rates. This information can be used to inform management decisions and evaluate the effectiveness of management strategies.
- **Restoration and management planning -** This involves developing comprehensive management plans for sand dune ecosystems that prioritize restoration efforts and identify long-term management strategies.

Sand dune stabilization through planting grass

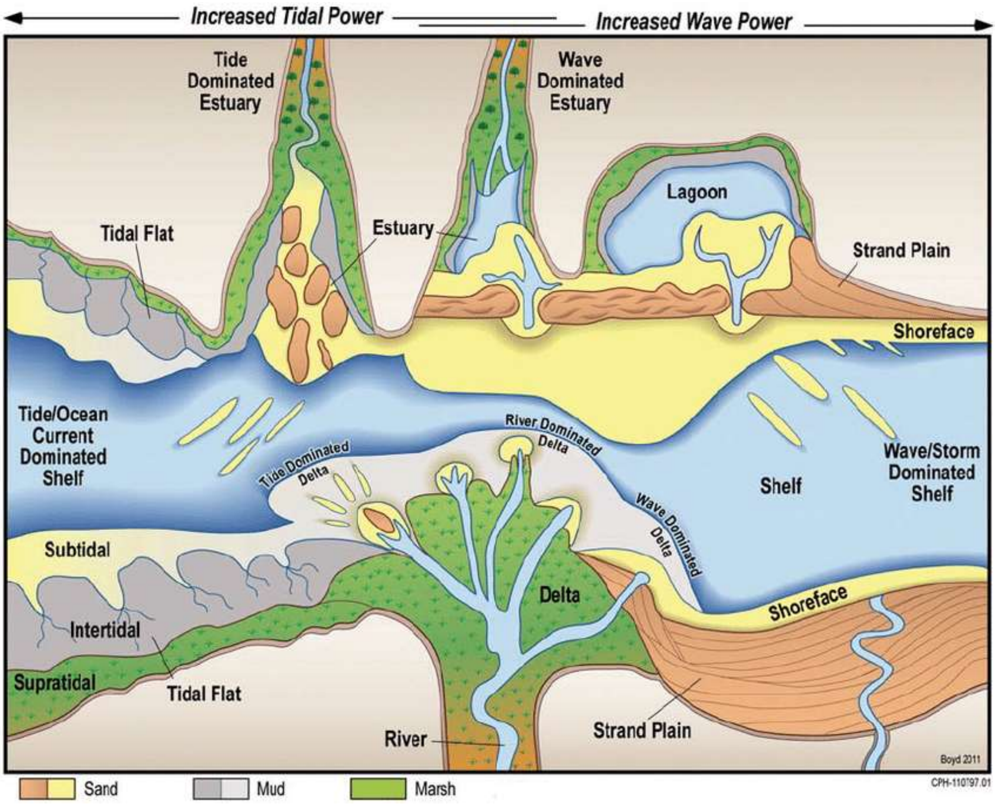
Non-structural measures are often cost-effective and can be highly effective in managing environmental problems, but they can also face challenges such as lack of funding or public support. Therefore, a combination of structural and non-structural measures is often necessary for successful coastal sand dune management.

Estuarine sedimentation and its structural and non-structural measures

Estuarine sedimentation refers to the natural process of accumulation and deposition of sediment in estuaries, which are semi-enclosed bodies of water where freshwater from rivers mixes with saltwater from the ocean. The sediments in estuaries come from both natural sources such as erosion and weathering, as well as from human activities such as land-use changes and construction.

Estuarine sedimentation can have both positive and negative effects on the estuarine ecosystem. Some of the potential benefits of sedimentation include the creation of new landforms, such as islands and marshes, which provide habitat for fish and wildlife. Sediments can also help to trap and remove pollutants from the water column, improving water quality.

However, excessive sedimentation can also have negative impacts on estuarine ecosystems. Excessive sedimentation can lead to the smothering of benthic habitats such as seagrass beds and oyster reefs, reducing the available habitat for fish and other marine life. It can also reduce light penetration in the water column, which can affect photosynthesis and reduce the growth of primary producers such as phytoplankton.



Structural measures

Structural measures for estuarine sedimentation management involve the construction of physical structures to control the movement and accumulation of sediment in an estuary. Some examples of structural measures for estuarine sedimentation management include:

- **Dikes and levees:** These are earthen structures that are built along the edge of the estuary to prevent tidal currents and waves from depositing sediment in unwanted areas. Dikes and levees can be effective in reducing the amount of sediment that enters sensitive areas such as salt marshes and wetlands.
- **Jetties and breakwaters:** These structures are built perpendicular to the shoreline to help control the movement of sediment by reducing wave energy and promoting sediment deposition. Jetties and breakwaters can help to stabilize channels and navigation channels and prevent sediment from accumulating in these areas.
- **Sediment basins:** These are large areas of shallow water that are designed to capture and hold sediment that is carried by tidal currents. Sediment basins can help to prevent sediment from reaching sensitive areas of the estuary and can also provide habitat for fish and wildlife.
- **Channel modifications:** These involve altering the shape and depth of channels in the estuary to control the movement of sediment. Channel modifications can help to reduce sediment accumulation in sensitive areas and improve navigation in the estuary.
- **Dredging:** Dredging involves the removal of sediment from the bottom of the estuary using heavy equipment. Dredging can be used to restore navigation channels or to remove excessive sediment from sensitive areas of the estuary.

Structural measures can be effective in managing estuarine sedimentation, but they can also have negative impacts on the estuarine ecosystem. For example, dikes and levees can alter the natural flow of water and prevent the movement of fish and wildlife, while dredging can disturb benthic habitats and release sediment into the water column. Therefore, it is important to carefully consider the potential impacts of structural measures and to use them in combination with non-structural measures for a comprehensive approach to estuarine sedimentation management.

Non-structural measures

Non-structural measures for estuarine sedimentation management involve the use of techniques that do not require the construction of physical structures. Some examples of non-structural measures for estuarine sedimentation management include:

- **Land-use management:** Land-use management can be used to control the amount of sediment that enters an estuary. For example, regulations can be put in place to limit the amount of sediment that is released into the estuary from construction sites or to promote the use of erosion control measures on agricultural lands.
- **Restoration of riparian buffers:** Riparian buffers are areas of vegetation that are located along the edge of a river or stream. Restoring riparian buffers can help to reduce the amount of sediment that enters an estuary by promoting the retention and absorption of runoff.
- **Soil conservation practices:** Soil conservation practices such as conservation tillage and cover cropping can be used to reduce soil erosion on agricultural lands. This can help to reduce the amount of sediment that enters an estuary.
- **Nutrient management:** Nutrient management practices such as reducing fertilizer application rates and promoting the use of cover crops can help to reduce the amount of nutrients that enter an estuary. Excess nutrients can promote the growth of algae and other aquatic plants, which can lead to increased sedimentation.
- **Education and outreach:** Education and outreach programs can be used to raise awareness about the impacts of sedimentation on estuarine ecosystems and to promote behavior changes that can help to reduce sedimentation. For example, educational materials can be developed to promote the use of green infrastructure practices in urban areas.

Non-structural measures can be effective in managing estuarine sedimentation without the negative impacts that can be associated with structural measures. However, they may be less effective in certain situations, such as in highly developed urban areas where land-use practices are difficult to control. Therefore, a combination of both structural and non-structural measures is often necessary for effective estuarine sedimentation management.

Coastal pollution and its structural and non-structural measures

Coastal pollution refers to the presence or introduction of harmful substances or contaminants into the coastal environment. These contaminants can come from a variety of sources, including industrial activities, agricultural practices, urban runoff, and oil spills. Coastal pollution can have serious impacts on the environment and human health, and therefore, it is important to manage and prevent it.

There are several types of coastal pollution, including:

- **Chemical pollution:** This type of pollution involves the release of toxic chemicals, such as pesticides, heavy metals, and industrial chemicals, into the coastal environment. These chemicals can be harmful to marine organisms and can also contaminate seafood and water sources, posing a risk to human health.
- **Nutrient pollution:** Nutrient pollution occurs when excess nutrients, such as nitrogen and phosphorus, enter the coastal environment. This can happen through agricultural runoff, sewage discharge, and other sources. Excess nutrients can cause harmful algal blooms, which can deplete oxygen in the water and harm aquatic life.
- **Marine debris:** Marine debris is a type of pollution that involves the accumulation of solid waste in the coastal environment, such as plastic bottles, fishing nets, and other trash. Marine debris can entangle and harm marine animals, and can also release harmful chemicals into the water as it breaks down.
- **Oil pollution:** Oil pollution occurs when oil is spilled into the coastal environment, either accidentally or as a result of human activities such as oil drilling or shipping. Oil spills can harm marine life, contaminate seafood and water sources, and damage habitats such as beaches and wetlands.

Structural measures

Structural measures for managing coastal pollution involve the construction of physical structures to prevent or mitigate the impacts of pollution. Some examples of structural measures for coastal pollution management include:

- **Coastal barriers:** Coastal barriers are physical structures such as seawalls, groynes, and breakwaters that are designed to protect the coastline from erosion and storm surges. These barriers can also help to prevent pollutants from entering the coastal environment by blocking or redirecting runoff.

- **Wastewater treatment plants:** Wastewater treatment plants can be constructed to treat sewage and other wastewater before it is released into the coastal environment. This can help to reduce the amount of pollutants that enter the water.
- **Oil spill containment booms:** Oil spill containment booms are floating barriers that can be deployed around a spill to contain and collect the oil. This helps to prevent the oil from spreading and reduces the amount of oil that enters the coastal environment.
- **Stormwater management infrastructure:** Stormwater management infrastructure, such as retention ponds and green infrastructure practices, can be constructed to capture and treat stormwater runoff. This helps to reduce the amount of pollutants that enter the coastal environment.
- **Wetland restoration:** Wetland restoration involves the restoration or creation of wetland habitats in coastal areas. Wetlands can help to filter pollutants from runoff and provide habitat for a variety of marine organisms.

Structural measures can be effective in managing coastal pollution, but they can also have negative impacts on the environment and be expensive to construct and maintain. Therefore, a combination of both structural and non-structural measures is often necessary for effective coastal pollution management.

Non-structural measures

Non-structural measures for managing coastal pollution involve policies, practices, and other non-physical solutions to prevent or mitigate the impacts of pollution. Some examples of non-structural measures for coastal pollution management include:

- **Regulations and policies:** Regulations and policies can be implemented to prevent pollution from occurring in the first place. This can include regulations on industrial and agricultural practices, discharge permits, and zoning ordinances.
- **Education and outreach:** Education and outreach campaigns can be used to raise awareness about the impacts of coastal pollution and to encourage individuals and businesses to adopt practices that reduce pollution. This can include campaigns on proper waste disposal, water conservation, and reducing the use of harmful chemicals.
- **Best management practices:** Best management practices are practices that businesses and individuals can adopt to reduce their impact on the environment. This can include using environmentally-friendly products, properly disposing of waste, and reducing water consumption.
- Monitoring and reporting: Monitoring and reporting programs can be implemented to track changes in the coastal environment over time and to identify sources of pollution. This information can be used to develop effective management strategies and to measure the effectiveness of pollution prevention and cleanup efforts.
- **Restoration and conservation:** Restoration and conservation efforts can be used to restore damaged habitats and to protect coastal ecosystems. This can include efforts to restore wetlands, dunes, and other habitats that can help to filter pollutants from runoff.

Non-structural measures can be effective in managing coastal pollution and are often less expensive and more sustainable than structural measures. However, they can also be more difficult to implement and may require changes in behavior or policy. Therefore, a combination of both structural and non-structural measures is often necessary for effective coastal pollution management.

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4. Principles of Coastal Zone Management. Exclusive Economic Zone and ICZM.

Principles of Coastal Zone Management.

Coastal zone management is the process of managing the use and development of coastal areas in a sustainable manner. There are several principles that guide coastal zone management, including:

1. Integrated management: Coastal zone management should be an integrated process that takes into account the natural, economic, and social aspects of the coastal environment. It should also involve collaboration among multiple stakeholders, including government agencies, businesses, and community members. Integrated Coastal Management (ICM) is a comprehensive and holistic approach to managing the coast and its resources. It involves the coordinated and integrated management of all aspects of coastal areas, including the natural, economic, and social environments.

The aim of ICM is to achieve sustainable development of coastal areas while maintaining the health of the marine and coastal ecosystems. The approach recognizes the interdependence of human activities and the natural environment, and seeks to promote the integration of environmental, economic, and social considerations in decision-making.

ICM is often implemented through a participatory process that involves a range of stakeholders, including government agencies, NGOs, private sector organizations, and local communities. This participatory approach helps to ensure that the needs and perspectives of all stakeholders are taken into account, and that decisions are based on a shared understanding of the issues and goals of coastal management.

Some key elements of an ICM program may include:

1. Developing a comprehensive coastal zone management plan that integrates environmental, economic, and social considerations.
2. Establishing and implementing regulations and guidelines to manage human activities, such as fishing, tourism, and development, in a sustainable manner.
3. Building capacity for sustainable management through training and education programs.
4. Conducting research and monitoring to improve understanding of coastal processes and inform management decisions.

5. Establishing partnerships and networks among stakeholders to promote collaboration and information sharing.
6. Developing mechanisms for public participation, such as public meetings and stakeholder consultations, to ensure that the needs and perspectives of all stakeholders are taken into account.

By adopting an ICM approach, coastal managers can work to balance the competing demands of economic development, environmental protection, and social well-being, while ensuring the long-term sustainability of coastal areas.

2. Adaptive management: Coastal zone management should be adaptive and flexible, allowing for adjustments based on changing conditions and new information. Adaptive coastal management is an approach to managing coastal resources and ecosystems that is based on the principles of adaptive management. It involves continuous monitoring and evaluation of management actions, and the use of this information to adjust management strategies as needed, in order to achieve sustainable management of coastal areas.

Adaptive coastal management recognizes the complexity of coastal systems, and the dynamic nature of coastal processes. It seeks to integrate scientific understanding of coastal ecosystems with social and economic considerations, and to involve stakeholders in the decision-making process.

Some key elements of adaptive coastal management may include:

1. Stakeholder engagement: Engaging stakeholders, including local communities, government agencies, NGOs, and private sector organizations, in the management process, to ensure that their perspectives and needs are taken into account.
2. Identification of management objectives: Setting clear and measurable objectives for management actions, based on a shared understanding of the issues and goals of coastal management.
3. Monitoring and evaluation: Regular monitoring of the coastal system, including environmental, social, and economic indicators, to track changes and assess the effectiveness of management actions.
4. Assessment: Evaluation of the results of monitoring, and analysis of the potential causes of any observed changes.
5. Decision-making: Using the results of assessment to make decisions about future management actions.
6. Implementation: Implementing the management actions that have been decided upon.
7. Learning: Continuing to monitor the system and assess the results of management actions, to identify new information and adjust management strategies as needed.

Adaptive coastal management is particularly useful in the face of climate change, sea level rise, and other environmental pressures that can affect the long-term sustainability of coastal ecosystems. By continuously monitoring and evaluating management actions, and adjusting management strategies as needed, adaptive coastal management can help to build resilience in coastal communities and ecosystems, and ensure their sustainability for future generations.

3. Ecosystem-based management: Coastal zone management should be based on an understanding of the complex interactions between the environment and human activities, and should aim to maintain or enhance the natural functioning of coastal ecosystems. Ecosystem-based coastal management (EBCM) is an approach to managing coastal areas that recognizes the interconnectedness of coastal ecosystems, and seeks to maintain the ecological integrity of these systems while also addressing the needs and priorities of human communities.

EBCM is based on the principle that healthy ecosystems provide a range of benefits and services that are essential for human well-being, such as clean water, food, and recreation opportunities. The approach recognizes that the health and functioning of coastal ecosystems are linked to human activities, and seeks to address the root causes of environmental problems rather than just treating the symptoms.

Key principles of EBCM include:

1. **Taking a holistic approach:** EBCM considers the entire ecosystem, rather than focusing on individual components or species, and seeks to maintain the functioning of the ecosystem as a whole.
2. **Incorporating local knowledge:** EBCM recognizes the importance of local knowledge and engages stakeholders, including local communities, in the management process.
3. **Adopting a precautionary approach:** EBCM takes a precautionary approach to decision-making, recognizing the potential for irreversible damage to ecosystems and the need to avoid unintended consequences.
4. **Promoting sustainable use:** EBCM seeks to promote sustainable use of coastal resources, recognizing that ecosystems can only support human activities within certain limits.
5. **Implementing adaptive management:** EBCM uses adaptive management to adjust management strategies based on new information and changing conditions.

EBCM may involve a range of management strategies, including the protection of important habitats, the restoration of degraded ecosystems, the promotion of sustainable fishing practices, and the reduction of pollution and other human impacts.

EBCM is becoming increasingly important as coastal areas face growing pressures from human activities, including climate change, habitat destruction, and overfishing. By taking an ecosystem-based approach to coastal management, it is possible to maintain the ecological integrity of these systems while also ensuring that they continue to provide essential benefits and services to human communities.

4. Precautionary approach: Coastal zone management should take a precautionary approach to avoid or minimize potential harm to the environment or human health. The precautionary approach is an important principle of coastal management that is aimed at preventing or minimizing potential environmental harm or damage caused by human activities. The precautionary approach is based on the principle that in situations where there is uncertainty or lack of scientific knowledge about the potential environmental impacts of an activity, it is better to err on the side of caution and take preventive measures.

In coastal management, the precautionary approach involves identifying potential environmental risks associated with human activities, and taking steps to avoid or minimize those risks. This approach recognizes that the consequences of environmental damage can be significant and often irreversible, and that it is important to prevent harm before it occurs.

The precautionary approach in coastal management includes several key elements:

1. **Risk assessment:** Coastal managers must conduct a thorough risk assessment to identify potential environmental risks associated with human activities, and determine the likelihood and magnitude of the potential harm.
2. **Scientific uncertainty:** The precautionary approach recognizes that there may be scientific uncertainty about the potential environmental impacts of an activity, and in such cases, decision-makers should err on the side of caution.
3. **Proactive measures:** The precautionary approach requires taking proactive measures to avoid or minimize potential environmental harm, even if there is uncertainty about the risks.
4. **Public participation:** The precautionary approach recognizes the importance of public participation in the decision-making process, to ensure that all stakeholders have a voice in the management of coastal resources.
5. **Adaptive management:** The precautionary approach also involves an adaptive management approach, where management actions are regularly monitored and evaluated, and adjusted as needed based on new information.

The precautionary approach is particularly relevant in coastal management, where there are often complex interactions between human activities and the natural environment. By taking a precautionary approach, coastal managers can ensure that the potential environmental risks associated with human activities are identified and addressed, reducing the likelihood of environmental harm or damage.

5. Public participation: Coastal zone management should involve meaningful participation by the public, including opportunities for input and feedback, and transparent decision-making processes. Public participation is a critical component of effective coastal management, as it helps to ensure that decisions reflect the diverse interests and perspectives of stakeholders. Coastal management involves a wide range of issues, from environmental protection to economic development, and the involvement of the public can help to balance these sometimes competing interests and promote more sustainable outcomes.

There are several key benefits of public participation in coastal management:

- **Improved decision-making:** Public participation can help to ensure that decisions reflect the needs and concerns of all stakeholders, leading to more effective and sustainable management of coastal resources.
- **Greater transparency:** Public participation promotes transparency in decision-making, increasing trust and accountability among stakeholders and decision-makers.

- **Enhanced social equity:** Public participation can help to ensure that all stakeholders, including traditionally marginalized groups, have a voice in the management of coastal resources.
- **Increased awareness:** Public participation can increase public awareness of the importance of coastal resources and the need for sustainable management practices.

There are several ways in which the public can participate in coastal management, including:

- **Public meetings and hearings:** Public meetings and hearings provide a forum for stakeholders to express their views and provide feedback on proposed management actions.
- **Advisory committees:** Advisory committees can be established to provide expert advice on specific coastal management issues, and can include representatives from a range of stakeholder groups.
- **Surveys and feedback mechanisms:** Surveys and feedback mechanisms can be used to gather input from the public on specific coastal management issues, and can help to identify areas of concern and potential solutions.
- **Collaborative planning processes:** Collaborative planning processes involve stakeholders in the development of coastal management plans, and can help to ensure that decisions reflect the needs and concerns of all stakeholders.

Overall, public participation is a key component of effective coastal management, and can help to ensure that decisions are informed, transparent, and reflect the needs and concerns of all stakeholders.

6. Sustainable development: Coastal zone management should promote sustainable development, which meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable coastal development refers to the use of coastal resources in a way that promotes economic growth and social well-being, while also ensuring the long-term health and integrity of coastal ecosystems. The goal of sustainable coastal development is to balance the economic, social, and environmental needs of coastal communities, and to promote a healthy and resilient coastal environment for present and future generations.

Sustainable coastal development involves several key principles, including:

- **Ecosystem-based management:** Sustainable coastal development requires an ecosystem-based approach to management, which considers the complex interactions between human activities and the natural environment in coastal areas.
- **Integrated coastal management:** Integrated coastal management involves the coordination of activities across different sectors and levels of government to ensure that management actions are effective and sustainable.
- **Stakeholder engagement:** Sustainable coastal development requires the active engagement of stakeholders, including local communities, businesses, and government agencies, to ensure that decisions reflect the diverse needs and perspectives of all stakeholders.

- **Precautionary approach:** The precautionary approach involves taking proactive measures to avoid or minimize potential environmental harm, even in cases where there is uncertainty or lack of scientific knowledge about the potential impacts.
- **Adaptive management:** Sustainable coastal development requires regular monitoring and evaluation of management actions, and the ability to adjust strategies and plans as needed based on new information and changing circumstances.

Sustainable coastal development involves a wide range of activities, such as coastal tourism, aquaculture, and coastal infrastructure development. It also involves addressing a range of challenges, such as climate change, pollution, and habitat loss.

Achieving sustainable coastal development requires a long-term commitment from all stakeholders, including governments, local communities, and businesses. By working together to balance social, economic, and environmental considerations, it is possible to promote a healthy and resilient coastal environment while supporting economic growth and social well-being.

7. Science-based decision making: Coastal zone management should be based on the best available scientific information, and decisions should be grounded in scientific analysis. Science-based decision making is a crucial aspect of effective coastal management, as it ensures that management decisions are informed by the best available scientific information. Science-based decision making involves using scientific data, knowledge, and tools to evaluate different management options and predict the potential impacts of those options on coastal ecosystems and human communities.

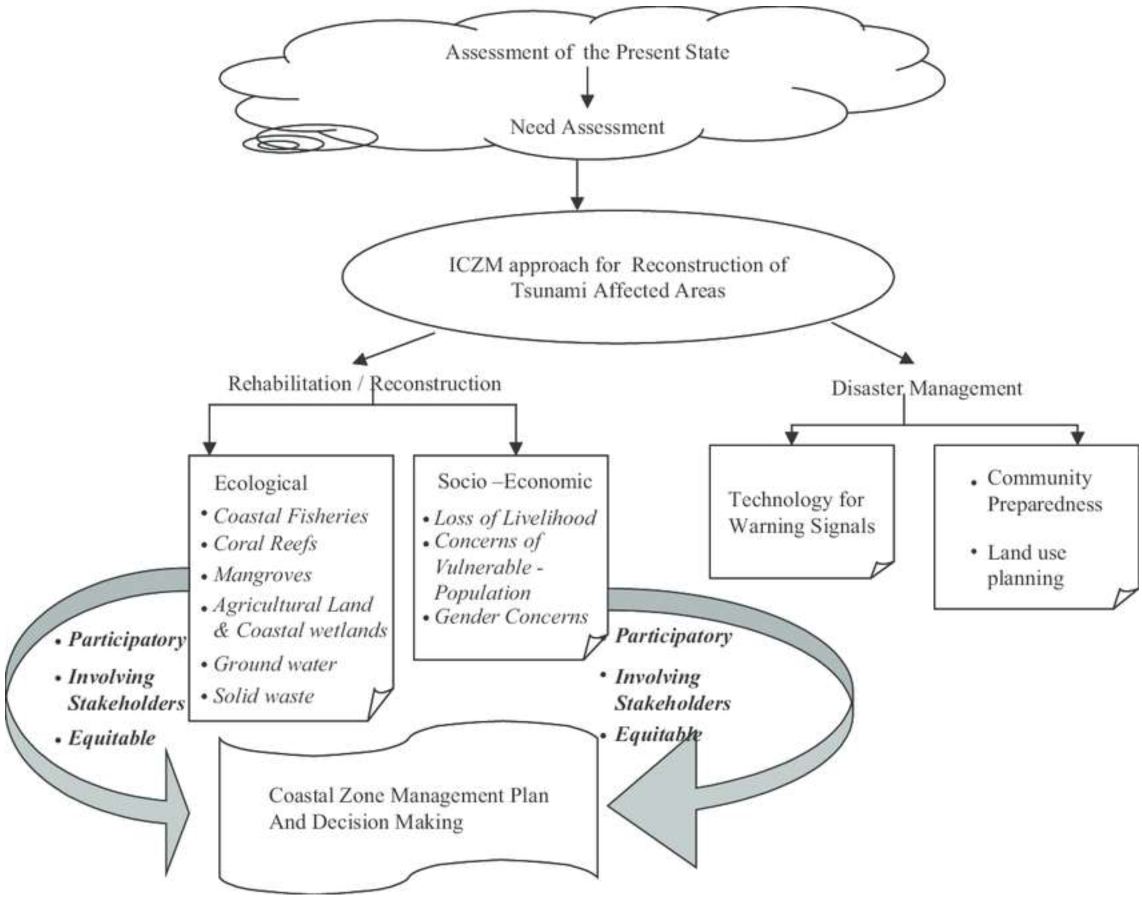
There are several key steps involved in science-based decision making in coastal management, including:

- **Data collection and analysis:** This involves gathering and analyzing data on the physical, biological, and social characteristics of the coastal system, as well as monitoring changes in these characteristics over time.
- **Scientific assessment:** This involves using scientific data and knowledge to assess the potential impacts of different management options on the coastal system and human communities.
- **Modeling and prediction:** This involves using models and other tools to predict the likely outcomes of different management options under different scenarios.
- **Decision making:** This involves using the scientific information gathered and analyzed in the previous steps to inform management decisions.
- **Monitoring and evaluation:** This involves monitoring the results of management decisions to determine whether they have achieved their intended outcomes, and adjusting management strategies as needed based on new information and changing circumstances.

Science-based decision making in coastal management is important because coastal ecosystems are complex and dynamic systems that are subject to many different stressors, including climate change, pollution, and overexploitation. By using scientific information to inform management decisions, it is possible to minimize negative impacts on the coastal ecosystem while achieving sustainable use of coastal resources.

Effective science-based decision making in coastal management requires collaboration between scientists, managers, and stakeholders, as well as access to high-quality scientific information and resources.

By following these principles, coastal zone managers can work to balance the economic, social, and environmental goals of coastal areas, while also ensuring their long-term sustainability.



Framework of ICZM

Exclusive Economic Zone

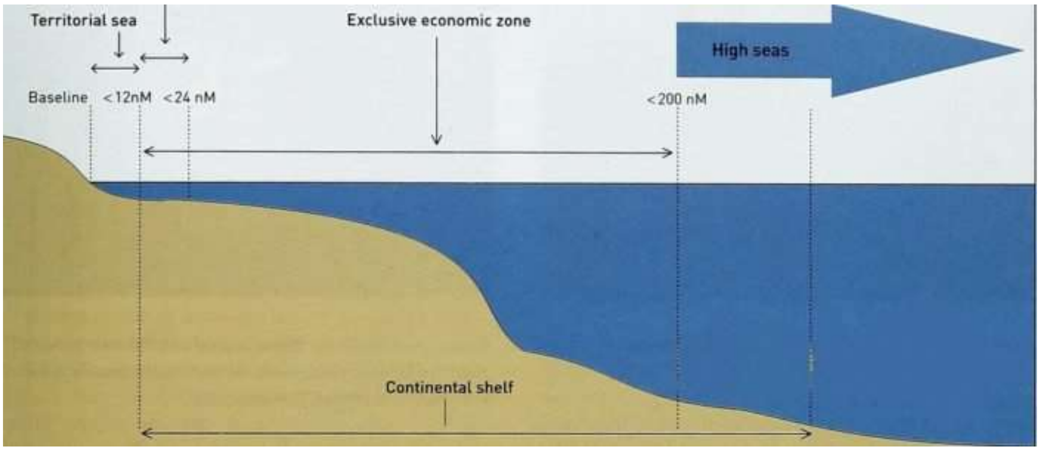
An Exclusive Economic Zone (EEZ) is a maritime zone extending 200 nautical miles (370 kilometers) from a country's coastline, within which the country has special rights to explore and exploit the natural resources of the sea and seabed. The concept of the EEZ was first introduced by the United Nations Convention on the Law of the Sea (UNCLOS) in 1982.

Within the EEZ, the coastal state has exclusive rights to explore and exploit the natural resources of the water column, including living resources such as fish, as well as non-living resources such as oil and gas. However, the coastal state does not have sovereignty over the waters or the airspace above them, which remain international waters.

UNCLOS also recognizes the rights of other states to engage in activities such as navigation and overflight within the EEZ, as long as these activities are conducted in accordance with international law and do not interfere with the rights of the coastal state.

The establishment of EEZs has had a significant impact on the management of marine resources, as it has given coastal states greater control over the exploitation of resources within their maritime boundaries. However, it has also led to conflicts between neighboring states over the sharing of resources that straddle their respective EEZs.

The concept of the EEZ is an important part of modern maritime law and has been adopted by most coastal states around the world. It has played a significant role in the management and conservation of marine resources, and has helped to promote sustainable development in coastal areas.



The salient features of the Exclusive Economic Zone (EEZ) are:

1. **Extent:** The EEZ extends 200 nautical miles (370 kilometers) from a coastal state's baseline.
2. **Sovereign rights:** Within the EEZ, the coastal state has sovereign rights to explore, exploit, conserve, and manage the natural resources, both living and non-living, of the water column and the seabed.
3. **Non-living resources:** The coastal state has exclusive rights to explore and exploit the non-living resources, such as oil and gas reserves, minerals, and sedentary species, within the EEZ.
4. **Living resources:** The coastal state has exclusive rights to explore, exploit, conserve, and manage the living resources, such as fish and other marine organisms, within the EEZ.
5. **Environmental protection:** The coastal state has a responsibility to protect and preserve the marine environment within the EEZ, including the prevention and control of pollution.
6. **Navigation and overflight:** The EEZ does not affect the freedom of navigation and overflight for other states, provided that these activities are conducted in accordance with international law and do not interfere with the coastal state's rights.

Cooperation and dispute resolution: Coastal states are encouraged to cooperate with each other to ensure the sustainable management of shared resources that straddle their respective EEZs, and to resolve disputes through peaceful means in accordance with international law.

These salient features of the EEZ have had a significant impact on the management and conservation of marine resources, as well as on the political and economic relationships between coastal states.

EEZ in India

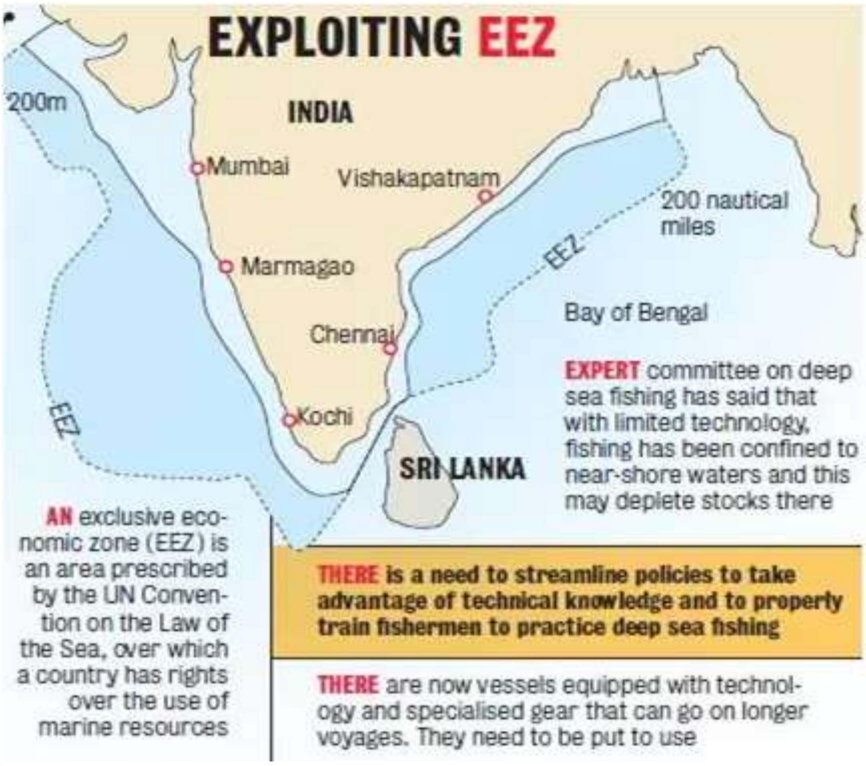
The Exclusive Economic Zone (EEZ) of India is the maritime zone extending 200 nautical miles (370 kilometers) from the country's baseline. The Indian EEZ covers an area of approximately 2.02 million square kilometers and is the seventh-largest in the world.

The EEZ of India is rich in natural resources, including oil and gas reserves, minerals, and a variety of fish and other marine organisms. The Indian government has taken several measures to explore and exploit these resources while also ensuring their sustainable management and conservation.

India has also established a network of Marine Protected Areas (MPAs) within its EEZ to conserve and protect the marine environment and biodiversity. These include the Gulf of Mannar Marine National Park, the Great Nicobar Biosphere Reserve, and the Andaman and Nicobar Islands' Marine National Park.

The Indian government has also taken measures to promote the development of coastal communities and to ensure their participation in coastal management. The National Coastal Zone Management Authority (NCZMA) is responsible for overseeing the management and development of the coastal zone in India, and the government has implemented several programs to support sustainable coastal development.

India's EEZ has played a significant role in the country's economic development and has provided opportunities for growth in the fisheries, oil and gas, and shipping industries. However, the management and exploitation of resources within the EEZ have also raised concerns about environmental sustainability and the rights of local communities. The Indian government continues to work towards balancing economic development with environmental conservation and community participation in coastal management.



Exclusive Economic Zone of India

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5. Coastal Regulation Zones with reference to India (2018-2019).

Coastal Regulation Zones with reference to India

Coastal Regulation Zones (CRZ) are areas along the coastline of India that are regulated to balance development and conservation. The regulation of these zones is intended to protect the coastal environment and its ecosystems, as well as to ensure the sustainable development of the coastal zone.

The CRZs were first established in 1991 under the Coastal Regulation Zone Notification, and have been updated several times since then. The regulations cover a variety of activities within the designated zones, including construction, mining, and fishing.

The CRZs are divided into four categories, each with its own set of regulations:

1. **CRZ-I:** This zone includes ecologically sensitive areas such as mangroves, coral reefs, and sand dunes. Construction and other activities are highly restricted in this zone.
2. **CRZ-II:** This zone includes areas that are developed, such as urban areas and ports. Activities in this zone are regulated to ensure that they do not have a significant impact on the environment.
3. **CRZ-III:** This zone includes areas that are relatively undisturbed, but where development is allowed under certain conditions.

4. **CRZ-IV:** This zone includes the waters extending up to 12 nautical miles from the coastline. Fishing is allowed in this zone, but other activities are regulated to prevent damage to the environment.

The implementation of the CRZ regulations has been a contentious issue, with some arguing that the regulations are too restrictive and hinder development, while others argue that they are necessary to protect the fragile coastal environment. The government of India continues to update and revise the regulations in an effort to balance conservation and development.

Coastal Regulation Zones (CRZ) in India are areas along the coast that are regulated to balance development and conservation. The CRZs were first established in 1991 under the Coastal Regulation Zone Notification, and have been updated several times since then. The implementation of the CRZ regulations has been a contentious issue in India, with some arguing that the regulations are too restrictive and hinder development, while others argue that they are necessary to protect the fragile coastal environment. In recent years, the Indian government has taken steps to simplify the CRZ regulations and reduce bureaucratic hurdles in the process of obtaining environmental clearance for development activities in the coastal areas. The Ministry of Environment, Forests and Climate Change (MoEFCC) is the nodal agency responsible for the implementation of the CRZ regulations in India. It has also established the Coastal Regulation Zone Management Authority (CRZMA) at the central level and Coastal Zone Management Authorities (CZMAs) at the state level to ensure the proper implementation of the CRZ regulations.

CRZ-I in India

CRZ-I in India includes ecologically sensitive areas such as mangroves, corals, sand dunes, and sea turtle nesting sites. Construction and other activities in this zone are highly restricted to protect the environment.

In CRZ-I, the following activities are strictly prohibited:

- Setting up of new industries, including processing plants and ports.
- Mining of minerals, including sand mining.
- Dumping of untreated waste and effluents from industries and cities.
- Reclamation of land from the sea, except for activities related to the defense of the country or for public purposes with the prior approval of the Ministry of Environment, Forests and Climate Change (MoEFCC).
- Felling of trees and other activities that may lead to destruction of mangroves, coral reefs, and sand dunes.

CRZ-I regulations also require the preparation of a Coastal Zone Management Plan (CZMP) by the concerned state governments or union territories. The CZMP is a detailed plan that outlines the strategies and guidelines for the management of the coastal zone in accordance with the CRZ regulations.

Overall, CRZ-I is the most restrictive zone under the CRZ regulations, aimed at protecting the fragile coastal environment in India. However, the implementation and enforcement of the regulations remain a challenge, and continued efforts are required to ensure the effective management of India's coastal zones.

CRZ-II in India

CRZ-II in India covers the urban areas that have been developed up to or close to the shoreline, including areas that fall within the municipal limits or are designated as local self-government areas. The objective of the CRZ-II is to ensure that development activities in these areas do not harm the coastal environment and its natural features.

The following activities are permitted in CRZ-II areas:

- Construction of buildings, houses, and infrastructure necessary for traditional coastal communities, such as fishermen, and other traditional coastal communities.
- Construction of facilities for tourism, such as hotels, resorts, and other tourism-related infrastructure, with prior approval from the state or union territory's coastal zone management authority.
- The development of ports or harbors with the prior approval of the Ministry of Environment, Forests and Climate Change (MoEFCC).
- Any other activity that the state or union territory's coastal zone management authority considers necessary for the economic development of the area, with the prior approval of the MoEFCC.

However, the development activities should not cause any damage to the environment or affect the natural features of the coast. Therefore, the coastal zone management authority has to take into consideration the environmental impact assessment of the proposed project, its location, and its potential impacts on the coastal environment and its natural features before granting approvals.

Overall, the CRZ-II regulations aim to balance the economic development needs of urban areas along the coast with the protection of the coastal environment and its natural features. The effective implementation and enforcement of these regulations are essential to ensure sustainable development of the Indian coastline.

CRZ-III in India

CRZ-III in India includes the coastal areas that are relatively less ecologically sensitive compared to CRZ-I and CRZ-II. This zone covers rural and coastal areas that are not classified as CRZ-I or CRZ-II.

In CRZ-III, the following activities are allowed with necessary precautions:

- Construction of dwelling units for local coastal communities.
- Construction of public infrastructure, such as schools, hospitals, and community centers, with prior approval from the concerned coastal zone management authority.
- Agricultural activities, such as crop cultivation and horticulture, except for the cultivation of salt-resistant crops.

- Setting up of non-polluting industries, such as food processing units and small-scale industries, with prior approval from the concerned coastal zone management authority.
- Any other activity that the concerned coastal zone management authority considers necessary for the economic development of the area, with prior approval from the Ministry of Environment, Forests and Climate Change (MoEFCC).

However, any development activities in CRZ-III should not cause any harm to the environment, and necessary precautions need to be taken to protect the coastal environment and its natural features. The coastal zone management authority has to consider the environmental impact assessment of the proposed project, its location, and its potential impacts on the coastal environment before granting approvals.

Overall, the CRZ-III regulations aim to balance the needs of economic development in rural and coastal areas with the protection of the coastal environment and its natural features. The effective implementation and enforcement of these regulations are essential to ensure sustainable development of the Indian coastline.

CRZ-IV in India

CRZ-IV in India includes the aquatic area up to the territorial limit (12 nautical miles) from the coastline. This zone aims to protect the aquatic environment, biodiversity, and other ecological features in the sea and its shoreline.

In CRZ-IV, the following activities are prohibited:

- Setting up of any new industries, operations, or processes, and expansion of existing industries, operations, or processes that may cause pollution of the sea or affect the shoreline.
- Discharge of untreated sewage and effluents from industries, cities, towns, and other human settlements into the sea or other water bodies.
- Dumping of untreated solid waste, hazardous wastes, and other pollutants into the sea or other water bodies.
- Mining of sand, rocks, and other minerals from the sea-bed, except for some specific activities permitted under the National Mineral Policy, 2008.
- Construction of permanent structures such as jetties, pipelines, or offshore drilling platforms, except for some specific activities permitted under the Coastal Zone Regulation Notification, 2011.

However, some activities such as fishing, navigation, and allied activities related to fisheries and shipping are allowed, subject to necessary precautions and regulations.

The CRZ-IV regulations aim to protect the aquatic environment, marine biodiversity, and other ecological features in the sea and its shoreline. The effective implementation and enforcement of these regulations are essential to ensure sustainable development of the Indian coastline and protect the interests of the coastal communities.

Implementation and failure of CRZ notification in India

The implementation of the Coastal Regulation Zone (CRZ) notification in India has been challenging and has faced various obstacles. The implementation failure is primarily due to the following reasons:

1. **Inadequate resources:** The enforcement agencies, including the State Coastal Zone Management Authorities (SCZMAs) and the district-level committees, do not have sufficient resources such as staff, equipment, and finances to carry out effective monitoring and enforcement of the regulations.
2. **Lack of awareness:** Many coastal communities and stakeholders, including developers and builders, are not aware of the CRZ regulations, leading to non-compliance and violations.
3. **Political interference:** Political pressure on the enforcement agencies, resulting in undue relaxation of the regulations or granting of exemptions, compromises the effectiveness of the CRZ notification.
4. **Weak penalties:** The penalties for violating the CRZ notification are weak and do not act as a deterrent to violations.
5. **Ineffective monitoring:** The monitoring of CRZ violations is ineffective, leading to a lack of deterrence and non-compliance.

The above challenges have resulted in the failure of the CRZ notification in India, and there have been numerous instances of non-compliance and violations.

However, the government has taken various measures to improve the implementation of the CRZ notification, such as increasing the budget for the enforcement agencies, increasing awareness among stakeholders, and strengthening the penalties for violations. The government has also introduced new guidelines to simplify the regulations and increase their effectiveness.

Despite these efforts, the implementation of the CRZ notification continues to face challenges. The effective implementation and enforcement of the CRZ notification require concerted efforts from all stakeholders, including the government, enforcement agencies, and coastal communities.

Coastal Regulation Zones with reference to India (2018-2019)

The Union Cabinet has approved the Coastal Regulation Zone (CRZ) Notification, 2018 which were last reviewed and issued in 2011.

- CRZ Notification 2018 is based on the recommendations of Shailesh Nayak committee.
- The notification was released after a series of representations received by the Ministry of Environment, Forest & Climate Change (MoEFCC) from various Coastal States/UTs for a comprehensive review of the provisions of the CRZ Notification, 2011.

Salient Features of Notification 2018

- **Floor Space Index Norms Eased:** In CRZ, 2011 Notification, for CRZ-II (Urban) areas, Floor Space Index (FSI) was frozen as per 1991 Development Control Regulation (DCR) levels.In the CRZ, 2018 Notification, it has been decided to de-freeze the same and permits FSI for construction projects to enable redevelopment of these areas to meet the emerging needs.

- **New Categories for densely populated rural areas:** For CRZ-III (Rural) areas, two separate categories have now been stipulated as below:
    - **CRZ-III A -** These are densely populated rural areas with a **population density of 2161 per square kilometer as per 2011 Census.**
        - Such areas will have a No Development Zone (NDZ) of 50 meters from the High Tide Line as against 200 meters from the High Tide Line stipulated in the CRZ Notification, 2011.
    - **CRZ-III B -** Rural areas with a **population density of below 2161 per square kilometer as per 2011 Census.** Such areas shall continue to have an NDZ of 200 meters from the HTL.
- **Tourism infrastructure in coastal areas:** Temporary tourism facilities such as toilet blocks, change rooms, drinking water facilities etc. have now been permitted in Beaches. However, a minimum distance of 10 m from HTL should be maintained for setting up of such facilities.
- **CRZ Clearances streamlined:** Only such projects/activities, which are located in the CRZ-I (Ecologically Sensitive Areas) and CRZ IV (area covered between Low Tide Line and 12 Nautical Miles seaward) will be required to be cleared by Ministry of Environment, Forest and Climate Change. For, the CRZ-II (urban) or CRZ III (rural) areas, the CRZ clearance will be considered at the state level by the Coastal Zone Management Authority (CZMA).
- **No Development Zone (NDZ) of 20 meters for Islands:** For islands close to the mainland coast and for all Backwater Islands in the mainland, NDZ of 20 m has been stipulated.
    - Ecologically Sensitive Areas have been accorded special importance: Specific guidelines related to their conservation and management plans have been drawn up as a part of the CRZ Notification.
- **Pollution abatement:** In order to address pollution in Coastal areas treatment facilities have been made permissible activities in CRZ-I B area (the area between the Low tide line and High tide line) subject to necessary safeguards.
- **Defense and strategic projects** are exempted from regulations.

Benefits

- **Economic Growth:** The proposed CRZ Notification, 2018 will lead to enhanced activities in the coastal regions thereby promoting economic growth while also conserving the coastal regions.
- **Boost to Tourism and Employment:** It will result in significant employment generation and in better living standard and add value to the economy of India.
- **Boost to Conservation Efforts:** The new notification is expected to rejuvenate the coastal areas while reducing their vulnerabilities.
- **Boost to Housing:** De-freezing FSI Norms will add to creating additional opportunities for affordable housing. This will benefit not only the housing sector but the people looking for shelter.

Concerns

- The notification has simplified procedures for environmental clearances and will open up fragile intertidal areas to real estate agents adding up to the coastal degradation.
- The notification fails to address the concerns raised by the fishermen.

Suggested Readings:

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DISCLAIMER

This self-learning material is based on different books, journals and web sources.