

UNIT 2

GIS and Map

Geographical Information System (CACS454) — BCA IV/VIII

A map is the traditional medium through which spatial information about the Earth's surface has always been communicated, and it remains the conceptual foundation on which every GIS is built. This unit looks at what a map is and the characteristics that define it, the concepts and techniques used to produce one, and the mathematical problem of map projection — transforming the curved Earth onto a flat surface.

1. Map and Their Characteristics

A map is a symbolic, scaled-down graphical representation of selected features of the Earth's surface (or part of it), drawn on a flat medium and designed to communicate spatial information about the location, distribution and relationship of those features. A map is always a generalized and selective abstraction of reality — it cannot, and does not attempt to, show everything.

Essential Characteristics of a Map

- **Scale** — the ratio between distance on the map and the corresponding distance on the ground (e.g. 1:50,000); determines the level of detail shown.
- **Symbols** — points, lines and area symbols (with colour, pattern and size) used to represent real-world features such as roads, rivers and settlements.
- **Legend (Key)** — an explanatory guide that defines the meaning of every symbol, colour and pattern used on the map.
- **Orientation** — indicates direction, usually shown by a north arrow, so the map can be correctly aligned with the ground.
- **Title** — states the subject, area and sometimes the date of the map, telling the reader at a glance what the map represents.
- **Grid / Graticule** — a reference framework of coordinates (e.g. latitude-longitude or a projected grid such as UTM) used to locate features precisely.
- **Generalization** — the deliberate simplification, selection and exaggeration of features so the map remains legible at its chosen scale.
- **Projection** — the systematic method used to transform the curved surface of the Earth onto the flat plane of the map.

Types of Maps

Maps are broadly classified by the purpose they serve and the type of information they emphasize.

Map Type	Purpose / Content
Topographic Map	Shows general-purpose relief, drainage, settlements, roads and vegetation, usually at medium to large scale.
Thematic Map	Focuses on a single theme or subject, e.g. rainfall distribution, population density, land use.
Cadastral Map	Shows legal property/parcel boundaries and ownership, used for land administration and taxation.
Chart / Navigation Map	Designed for air or marine navigation, emphasizing depths, hazards and routes.
General Reference Map	Provides a broad overview of an area, e.g. a political or physical atlas map.

Example: Reading a Topographic Sheet

A 1:25,000 topographic sheet of a hill district uses brown contour lines to show relief, blue lines for streams, a black grid for UTM coordinates, and a legend defining symbols for schools, temples and footpaths. A student can use the scale bar to measure the actual ground distance between two villages simply by measuring the distance between them on the sheet and applying the map's scale ratio.

2. Mapping Concept and Techniques

Mapping is the process of surveying, measuring and recording the position of features on the Earth's surface and representing them, at a reduced and systematic scale, on a flat plane. The core concept is the accurate transfer of three-dimensional ground reality into a two-dimensional, mathematically consistent representation while preserving relative location, distance, direction and shape as far as possible.

Mapping Techniques

Technique	Description
Ground / Field Survey	Direct measurement of distance, angle and elevation using instruments such as chain, tape, theodolite and total station.
Plane Table Survey	A traditional graphical field method where the map is drawn directly in the field as observations are taken.
Photogrammetry	Deriving precise measurements and maps from overlapping aerial photographs, widely used for topographic mapping.

Technique	Description
Remote Sensing	Using satellite or airborne sensors to capture imagery of the Earth's surface without direct contact, used for large-area and thematic mapping.
GPS / GNSS Surveying	Using satellite positioning receivers to record precise ground coordinates rapidly, even in remote areas.
Digital / Computer-Aided Mapping	Compiling, editing and producing maps using GIS and CAD software from digitized or field-collected data.

Note: Modern mapping projects typically combine several techniques — for example, GPS ground-control points used to precisely align and correct a satellite image before it is digitized in a GIS.

3. Map Projection

The Earth is very nearly spherical, but a map must be drawn on a flat sheet or displayed on a flat screen. Map projection is the systematic mathematical method used to transform the geographic coordinates (latitude and longitude) of locations on the curved Earth onto the flat plane of a map. Because a curved surface cannot be flattened without some distortion, every projection introduces error in at least one of four properties: shape, area, distance or direction. The choice of projection depends on which property must be preserved for a given purpose.

Classification by Developable Surface

Projections are geometrically classified according to the shape of the surface — cylinder, cone or plane — imagined to touch or intersect the globe and onto which the graticule is projected.

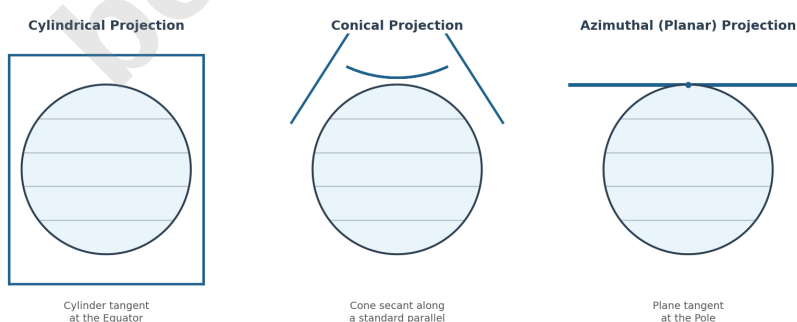


Figure 2.1 — The three families of map projection surfaces.

Type	Developable Surface	Best Suited For
Cylindrical	A cylinder wrapped around the globe, tangent at the Equator	World maps, equatorial regions (e.g. Mercator)
Conical	A cone placed over the globe, tangent or secant along a parallel	Mid-latitude regions with east-west extent (e.g. Nepal, USA)

Type	Developable Surface	Best Suited For
Azimuthal (Planar)	A flat plane touching the globe at a single point, often a pole	Polar regions and directional/route maps

Classification by Property Preserved

- Conformal Projections — preserve local shape and angles (e.g. Mercator); widely used for navigation, but grossly distort area near the poles.
- Equal-Area (Equivalent) Projections — preserve correct relative area (e.g. Mollweide, Albers), useful for thematic maps such as population or land-use distribution.
- Equidistant Projections — preserve true distance from the centre point or along certain lines, useful for radio and flight-range maps.
- Azimuthal (True-Direction) Projections — preserve correct direction/bearing from a central point, useful for navigation and seismic mapping.

Note: No single projection can preserve all four properties (shape, area, distance and direction) at once — every projection is therefore a deliberate compromise chosen to suit its intended use.

In practice, most national and GIS-based topographic mapping — including Nepal's own survey sheets — uses the Universal Transverse Mercator (UTM) system, a conformal, secant-cylindrical projection divided into 60 numbered zones, because it offers a good balance of minimal distortion and consistent metric coordinates over relatively narrow north-south zones.

Key Takeaways

- ✓ A map is a generalized, symbolic and scaled representation of the Earth's surface, defined by scale, symbols, legend, orientation, title, grid and projection.
- ✓ Maps are classified by purpose into topographic, thematic, cadastral, navigational and general reference types.
- ✓ Mapping is the process of surveying and recording ground features and representing them systematically on a flat plane, using techniques ranging from ground survey and photogrammetry to remote sensing, GPS and digital mapping.
- ✓ Map projection mathematically transforms the curved Earth onto a flat plane, and every projection distorts at least one of shape, area, distance or direction.
- ✓ Projections are grouped geometrically as cylindrical, conical or azimuthal, and by preserved property as conformal, equal-area, equidistant or true-direction.
- ✓ UTM, a conformal cylindrical projection, is the most widely used projection system in topographic and GIS mapping.

— *End of Unit 2* —

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