Gis Vision India

ISO 9001:2015 Certified Organization

Course Training Module

6 Months GIS Analyst Post Graduation Certification Program

Geoinformatics & Remote Sensing Training.

Syllabus Structure

The following modules are included in the six-month certificate course

1. GIS Fundamentals, Spatial Data Models & Coordinate Systems

Introduction to GIS

- Definition, history, and evolution
- GIS vs Remote Sensing vs Surveying
- Applications across sectors: environment, agriculture, urban, disaster etc

Components of GIS

- Hardware: GPS, tablets, workstations
- Software: QGIS, ArcGIS Pro, mobile apps
- Data: raster, vector, tabular, multimedia
- People & workflows: analysts, technicians, decision-makers

Types of Geographic Data

- Spatial vs non-spatial data
- Attribute data: nominal, ordinal, interval, ratio
- Geometry types: point, line, polygon

Vector Data Model in Detail

- Features: discrete, object-based
- Geometry structure and topological rules
- File types: SHP, GeoJSON, KML, GPKG
- Applications: roads, buildings, parcels

Raster Data Model in Detail

- Grid-based: continuous data representation
- File types: GeoTIFF, IMG, GRID
- Pixel size, resolution, and band structure
- Applications: land cover, elevation, NDVI, temperature

Comparing Raster vs Vector

- File size, performance, applications
- Data precision and generalization
- Visual comparison in QGIS using satellite image and road shapefile

Coordinate Systems & Location Reference

- What is a CRS?
- Geographic vs Projected CRS
- Introduction to latitude/longitude and UTM system
- EPSG codes and CRS identification

Map Projections and Distortions

- Why projections are necessary
- Types: Conformal, Equal-area, Equidistant
- Visual distortion examples (Mercator vs UTM)
- Practical: Reproject a vector layer in QGIS

Datum and Reference Surfaces

- Ellipsoids and datums (WGS84, Everest, NAD83)
- How datum influences position
- Lab: Load same dataset in two different datums and compare
- Finding the right CRS for your region
- Reprojecting vector and raster layers
- Setting project CRS and on-the-fly transformation

Georeferencing Principles

- Definition and importance of spatial referencing
- Source of non-spatial data: scanned toposheets, old maps
- Role of Ground Control Points (GCPs)

Hands-On: Georeferencing a Toposheet

- Import raster map
- Add GCPs, apply transformation (1st order polynomial, Thin Plate Spline)
- Assess RMSE (Root Mean Square Error)
- Export a georeferenced GeoTIFF

Accuracy and Precision in GIS

- Types of accuracy: positional, attribute
- Precision vs accuracy in spatial data
- GPS accuracy, digitizing errors, scale mismatch

Map Scale and Generalization

- Large vs small scale maps
- How scale affects symbol size, feature representation
- Measuring distance and area based on scale

Understanding Resolution Types

- Spatial resolution (raster), attribute resolution (classification), temporal resolution
- Application examples: MODIS vs Sentinel-2 imagery
- Lab: Compare two raster layers with different resolutions

Working with Real GIS Data

- Load base maps
- Add vector and raster layers for your district
- Adjust symbology and CRS
- Measure distance, inspect attributes

2. Cartographic Design, Symbology & Map Composition

Introduction to Cartography in GIS

- What is cartography?
- Why map design matters in GIS workflows
- Map as a communication tool vs data analysis tool

Thematic Mapping Fundamentals

- Difference between reference and thematic maps
- Choosing the right thematic map based on data type
- Examples: literacy maps, land use, rainfall zones

Types of Thematic Maps

- Choropleth maps (e.g., population density)
- Dot density maps (e.g., rainfall stations)
- Proportional symbol maps (e.g., earthquake magnitude)
- Isopleth/Contour maps (elevation, temperature)
- Heatmaps (e.g., accident zones, complaints)

Colour Theory for Map Design

- Colour models: RGB, HSV
- Sequential, diverging, and qualitative colour schemes
- Colour blindness considerations and design accessibility

Symbology: Points, Lines, Polygons

- Applying different symbols for different feature types
- Use of icon libraries and SVG shapes
- Lab: Style a land use layer using unique values

Classification Methods for Graduated Symbols

- Natural Breaks (Jenks), Equal Interval, Quantile, Standard Deviation
- How classification affects interpretation
- Practical: Classify forest area by tree density using 3 methods

Layer Transparency & Blending

- Overlay multiple layers using transparency
- Set blending modes to reveal background information
- Example: Display roads over semi-transparent satellite imagery

Labelling Features Dynamically

- Label placement rules: lines, polygons, points
- Scale-based labelling and conflict resolution
- Expression-based labels using field values only

Advanced Label Customization

- Labelling priority, font styling, halo effects
- Preventing label overlap and clutter
- Manual annotation layer creation for static layouts

Multi-scale Mapping Concepts

- What changes at different zoom levels?
- Symbol scaling and detail visibility
- Lab: Create a map that switches between highway and street-level detail

Designing a Map Layout

- Map elements: legend, north arrow, scale bar, title
- Visual hierarchy and balance in map design
- Use Print Layout Designer to create different size map

Using Insets and Locator Maps

- Purpose and design of inset maps
- Create zoomed-in views of small features
- Add locator to show national/state context

Legend Customization and Clarity

- Grouping similar layers
- Editing legend entries for reader clarity
- Positioning and design principles

Exporting High-Quality Maps

- Output formats: PNG, PDF, SVG
- Map resolution and DPI settings
- Export tips for reports, printing, and web

Cartographic Errors to Avoid

- Too many colors, inappropriate scales, cluttered layouts
- Misleading symbols or lack of contrast
- Real-world examples of poor cartographic communication

3. GIS Data Creation, Digitization & Topology Rules

Understanding Digitization in GIS

- What is digitization and why is it important?
- On-screen vs tablet digitization
- Raster-to-vector conversion (manual and semi-auto)

Creating New Vector Layers

- Create point, line, polygon layers from scratch
- Set CRS, geometry type, and fields
- Save layers as SHP, GeoPackage, or KML

Digitizing from Base Maps

- Load Google Satellite / OSM as base
- Digitize roads, buildings, rivers manually
- Adjust zoom levels and snapping for precision

Snapping Tools for Precision Editing

- Enable snapping to vertex, segment, end-point
- Set snapping tolerance
- Avoid slivers, overlaps, and gaps while digitizing boundaries

Using the Advanced Digitizing Toolbar

- Add vertices with angle/distance constraints
- Use parallel, perpendicular, and offset tools
- Digitize perfect rectangles, circles, and curves

Geometry Editing Techniques

- Reshape, split, merge features
- Move vertex, simplify, and rotate geometry
- Practical: edit parcel boundaries after field updates

Understanding Topological Errors

- Dangles, overlaps, slivers, self-intersection
- Implications for analysis: wrong area, double counting
- Real-world examples: urban planning conflicts due to bad data

Topology Rules

- Define rules: no overlaps, no gaps, must not intersect
- Use QGIS Topology Checker
- Validate and fix errors interactively

Working with Attribute Tables

- View, sort and filter attribute records
- Add/edit fields, update values
- Set primary identifiers (e.g., parcel ID, building code)

Field Calculator for Deriving Attributes

- Use field calculator to compute area, perimeter, density
- Create new fields based on mathematical expressions
- Example: calculate population density per ward

Joining Spatial and Non-Spatial Data

- Perform table joins based on common fields (ID, name)
- Import Excel/CSV tables and relate to spatial data
- Visualize attribute-based colour themes post-join

Geometry Validation & Fixing

- Use “Check Validity” tool to detect geometry issues
- Fix geometry with “Fix geometries” tool
- Batch fix multiple features in a layer

Layer Properties and Metadata Entry

- Set coordinate reference system
- Add description, source, author, creation date
- Ensure data documentation best practices

Symbology Based on Digitized Attributes

- Style based on area/length/class values
- Apply rule-based symbology (e.g., classify roads by type)
- Create legend-ready symbology for layout use

Digitization Lab: Create a Base GIS Dataset

- Digitize buildings, roads, land parcels from satellite imageries
- Set attribute fields like Name, Area, Usage, ID
- Create a layout with your digitized layers and export map

4. Field Data Collection, GPS & Mobile GIS

Basics of Field Data Collection

- Why field data is important in GIS workflows
- Primary vs secondary data
- Survey methods: total station, mobile GPS, paper-to-digital workflows

Understanding GPS and GNSS Concepts

- What is GPS and how it works
- Difference between GPS, GNSS, GLONASS, Galileo
- Sources of GPS errors: atmospheric, multipath, signal delay

Handheld GPS vs Smartphone GPS

- Accuracy comparison: sub-meter vs 3–10 meter
- Use cases: cadastral surveys vs quick mapping
- Connecting external GPS to mobile devices (Bluetooth)

File Formats: GPX, KML, CSV, GeoPackage

- Saving and exporting GPS points, routes, and tracks
- Importing .gpx into QGIS
- Visualizing routes and waypoints in Google Earth and QGIS

Collecting Data

- Capture GPS point and fill attribute
- Attach photos and voice notes
- Real-time tracking and editing on the map

Field Survey Planning Techniques

- Define area of interest (AOI)
- Identify layers to be collected (e.g., water points, health facilities)
- Create printed field map if required

Data Transfer and Synchronization

- Exporting collected data
- Merge field layers into master shapefiles
- Visualize and review collected attributes and photos

Using Google Earth for Field Mapping

- Plot and save field features in KML
- Overlay KML/KMZ in QGIS
- Measure distance, elevation, and terrain profile (Google Earth Pro)

Offline Mapping Techniques

- Use of offline basemaps
- Download XYZ tiles or MBTiles for offline use
- Project planning for areas with no internet

Field-to-Desktop GIS Workflow

- Best practices for project folder setup
- Using consistent CRS across devices
- Ensuring geometry and attribute integrity post-field work

Digitizing Field GPS Data in QGIS

- Convert GPX to shapefile or GeoPackage
- Edit points and add missing attributes
- Lab: Create a map layout of field-collected assets

Real-World Use Cases for Field GIS

- Mapping borewells, handpumps, schools
- Rural housing survey with geotagged photos
- Utility pole and transformer mapping by local bodies

5. Spatial Databases & Attribute Data Management

Introduction to Spatial Databases

- What is a spatial database?
- Why use databases instead of folders of shapefiles?
- Differences between SHP, GPKG, and Spatialite formats
- Real-world use cases: utility mapping, land records, monitoring systems

GeoPackage (GPKG) Format Overview

- What is GeoPackage and why it's better than shapefile
- Stores multiple layers and tables in one file
- Supports styling and projections inside the file
- Lab: Convert SHP to GPKG and store multiple layers

Creating and Managing GPKG in QGIS

- Create a new GPKG file and add new layers
- Organize project layers into a single database
- Add metadata for each layer

Understanding Attribute Tables in Depth

- Fields, records, data types (text, integer, decimal, date)
- Edit mode, field calculator, and multi-field management
- Sorting and filtering rows
- Lab: Add and edit fields in an existing land parcel layer

Joining Tables

- Use "Join Attributes by Field Value" tool
- Match spatial layer with non-spatial Excel or CSV table
- Real case: Add population data to a village boundary layer

Working with Excel/CSV in GIS

- Prepare tabular data: clean headers, remove merged cells
- Import and inspect encoding and delimiters
- Use tables for statistical overlays and choropleth mapping

Attribute-Based Selection and Filtering

- Use the Select Features by Expression tool
- Examples: select villages with population > 1000
- Save selected features to a new layer
- Use case: find drought-prone villages with low irrigation

Field Calculator: Deriving New Fields

- Calculate area, length, density
- Create conditional fields (e.g., if population > threshold)
- String manipulations (e.g., merge names)

- No scripting — only graphical expression input

Layer Styling Based on Attributes

- Use categorized, graduated, and rule-based symbology
- Visualize village types (urban/rural), rainfall zones, literacy levels
- Use case: color-code roads by traffic volume

Merging and Splitting Layers

- Combine multiple district layers into one state layer
- Split state into multiple regions using an attribute field
- Tool: Merge Vector Layers, Split Vector Layers

Group Stats and Summary Tables

- Use Group Stats plugin to calculate totals, averages, counts
- Export summary reports from attribute tables
- Example: average literacy rate by district

Geometry-Aware Tables

- Add geometry fields (X, Y, area, perimeter)
- Useful for spatial calculations and layouts
- Lab: create a table showing area and centroid coordinates

Working with Lookup Tables

- Create drop-downs using Value Map in attribute forms
- Prevent data entry errors in surveys
- Example: land use types, risk levels, facility types

Attribute-Driven Layouts and Legends

- Use attributes in map titles and dynamic legends
- Example: auto-display total number of features in a region
- Lab: Print layout showing population-based map title

6. Geo Spatial Analysis

What is Spatial Analysis?

- Core concept: answering questions using location
- Examples: Where is the nearest facility? Which areas are underserved?
- Vector vs raster-based analysis

Understanding Spatial Relationships

- Proximity: distance to features
- Containment: what lies within another feature
- Intersection: shared space between features

Buffering Techniques

- Creating fixed-distance buffers (e.g., 500m around schools)
- Multiple ring buffers (e.g., 1 km, 3 km, 5 km zones)
- Side-specific and dissolve options
- Real-world example: water point coverage in a village

Overlay Analysis – Union, Intersect and Difference

- Union: combining attributes of overlapping features
- Intersect: common area of two layers
- Difference: subtraction of one layer from another
- Application: land use changes, protected areas vs new roads

Clip and Extract Tools

- Clip a layer to the boundary of another (e.g., cut rivers to a district boundary)
- Extract features by location: features inside or touching another layer
- Application: restrict datasets to project area

Spatial Join (Location-Based Attribute Transfer)

- Assign values from one layer to another based on overlap or proximity
- Example: assign district names to village points
- Tool: Join Attributes by Location

Centroid and Distance Analysis

- Generate centroids of polygons (e.g., village centers)
- Calculate distance between centroids and nearest hospitals or roads
- Use Distance Matrix tool

Site Suitability Analysis

- Combine slope, land use, and distance to roads
- Apply weight-based logic without using scripts
- Example: ideal site for new school or water tank

Multi-Criteria Overlay (Visual Method)

- Combine layers visually using transparency
- Use rule-based symbology to show suitability
- Generate report map for planning authorities

Containment Analysis: Within/Touching Features

- Identify features fully inside or partially overlapping
- Example: Forests inside tribal zone boundary
- Tool: Select by Location

Statistical Summary Post Analysis

- Count and area of affected zones
- Export statistics using “Basic Statistics” or “Group Stats” plugin
- Use table summaries for reports

Handling Output Layers and Metadata

- Save outputs with meaningful names and descriptions
- Apply symbology and layer notes
- Add source and date to attribute table metadata

Real-World Application Scenarios

- School buffer and underserved villages
- Industrial zone suitability based on transport proximity
- Flood-prone area identification using river buffer

Map Layout for Analysis Results

- Display buffer zones, analysis results, legends
- Include interpretation text in the map layout
- Add pie chart or table from attribute data

Hands-On Analysis Lab

- Select a town boundary
- Perform:
  a. Buffer of hospitals (1 km)
  b. Clip roads to town
  c. Identify residential areas outside buffer
  d. Create suitability output layer

7. Remote Sensing & Satellite Data used For Earth Observation and Space-Based Data Analysis

Principles of Remote Sensing?

- Definition, importance, and application fields
- Passive vs active remote sensing
- Scientific definition and theoretical framework
- Strategic importance in Earth and environmental observation
- Core application domains: climate monitoring, urban expansion, forestry, agriculture, disaster response

Remote Sensing Mechanisms: Passive vs Active Systems

- Physical principles of electromagnetic energy detection
- Comparative analysis of passive (e.g., optical) and active (e.g., radar, LiDAR) systems

Electromagnetic Radiation & Spectral Signatures

- EM spectrum in remote sensing
- Vegetation, water, soil, and built-up spectral curves
- Interaction of EMR with Earth's surface materials

Remote Sensing Platforms & Sensors

- Satellites: Landsat, Sentinel, IRS, MODIS, WorldView
- Sensor types: multispectral, hyperspectral, thermal, SAR
- Performance characteristics and spatial footprints

Satellite Orbits Dynamics

- Polar, Sun-synchronous, Geostationary
- Revisiting times and coverage
- Applications per orbit type

Resolution Parameters in Earth Observation

- Definition and impact on applications
- Understanding the four dimensions of resolution:
- Spatial Resolution – granularity of detail
- Spectral Resolution – bandwidth specificity
- Temporal Resolution – frequency of data capture
- Radiometric Resolution – bit depth and sensitivity
- Compare Landsat vs Sentinel vs MODIS

Major Satellite Missions & Their Uses

- Landsat for land cover
- Sentinel for environment
- MODIS for global change
- Indian missions: IRS, CartoSAT, Resourcesat

Image Formats & Data Structures

- TIFF, IMG, HDF, NetCDF, JP2
- Single-band vs multi-band images

Introduction to Multispectral Imagery

- What is a band?
- Visible Bands (Blue, Green, Red)
- Near Infrared (NIR)
- Short-Wave Infrared (SWIR)
- Visible and near-infrared use cases

Sources of Free Satellite Data

- USGS Earth Explorer, Copernicus, Bhuvan, NASA Earthdata
- Step-by-step data download

Visualizing Imagery in Google Earth & QGIS

- Load satellite images as layers
- Check date, bands, and resolution
- Example: Compare 2010 vs 2020 imagery

False Colour Composites (FCC)

- Why use FCCs?
- Band combinations for vegetation, soil moisture, urban features

File and Projection Handling of RS Data

- Set CRS for images
- Reproject to match vector data

Quality Indicators (Cloud, Shadows, Scanline)

- Identify and avoid low-quality images
- Understand metadata and QA bands

Metadata & Image Identification

- Satellite, sensor, date, path/row
- Understand Landsat naming conventions

Lab Exercise

- Download an image for your city
- Create FCC using bands
- Print layout showing base satellite image and basic legend

8. Satellite Image Processing & Band Combinations

Understanding Image Bands & Stacking

- What are bands in multispectral imagery
- Stack individual bands to create composite images

Layer Stacking

- Use Build Virtual Raster (VRT) to combine bands
- Save raster composites

Creating False Color Composites (FCC)

- Vegetation (NIR-R-G), Urban (SWIR-NIR-Red), Water-sensitive
- Apply custom stretch and contrast

Contrast Enhancement Techniques

- Linear stretch, histogram equalization, min-max stretch
- Apply for better feature visibility

Image Interpretation Fundamentals

- Tone, texture, shape, pattern, shadow, association
- Visual interpretation

Using Raster Calculator for Simple Indices

- NDVI
- NDWI
- NDBI
- LST

Histogram Analysis of RS Data

- View brightness distribution
- Identify over/under-exposure
- Use stretching or reclassification

Image Reprojection and Resampling

- Match projections of raster and vector data
- Change resolution using resampling methods

Image Clipping by Area of Interest (AOI)

- Use polygon shapefile to extract specific region
- Save clipped raster with metadata

Masking & Raster Extraction Tools

- Mask by land cover or thematic zones
- Extract NDVI only in agriculture zone, for example

Colour Ramps and Classification of Rasters

- Apply color palettes (green for NDVI, blue for water)
- Classify into value ranges (e.g., low, medium, high)

Exporting Processed Rasters

- Save final outputs with compression
- Ensure file compatibility and coordinate info

Practical Interpretation Examples

- Identify barren lands, forest, water, built-up
- Compare before and after monsoon NDVI

Introduction to Image Classification

- What is classification in RS?
- Difference between land cover and land use
- Applications: agriculture, urban, environment

Unsupervised Classification Basics

- How clustering works
- K-means and ISODATA explained without coding

Running Unsupervised Classification

- Use Iso Cluster classification tab
- Choose number of classes, run and visualize

Reclassification of Results

- Assign class names to spectral clusters
- Use Google Earth to interpret clusters

Accuracy Considerations

- Visual match with base maps
- Ground verification via Google Earth

Layer Post-Processing

- Convert raster to vector (optional)
- Smooth or reclassify using raster calculator

NDVI Threshold-Based Land Classification

- Apply ranges to identify forest, agriculture, scrub
- Map seasonal vegetation zones

LULC Change Comparison

- Run classification on two time periods
- Compare statistics and visual change

Data Sources for LULC Reference

- NRSC LULC datasets, Bhuvan, Copernicus CORINE, MODIS LULC
- Use for validation or training

Zonal Statistics for Land Cover Classes

- Calculate area by class using QGIS Zonal Statistics
- Add statistics to attribute table of boundary layer

Symbology and Map Preparation

- Apply standard LULC color code
- Prepare a clean map layout

Limitations of Unsupervised Classification

- Mixed pixels, spectral similarity issues
- When to prefer supervised methods

Applications of LULC Maps

- Urban planning, watershed management, agriculture zoning

Real-World Examples of LULC Use

- Deforestation alerts, monitoring mining zones
- Industrial area expansion visualization

Lab Exercise

- Perform classification, reclassify output, calculate area by class
- Export results to printable map layout

10. Image Classification, Supervised Classification, Accuracy Assessment & Thematic Mapping

What is Supervised Classification?

- How it differs from unsupervised
- Role of user-defined training samples
- Applications in precision mapping and decision-making

Training Sample Collection

- Create regions of interest (ROIs) for known land cover types
- Label each ROI class with category (e.g., Forest, Water, Built-up)
- Use true color/FCC images and Google Earth reference

Band Set Selection for Classification

- Choose appropriate bands (e.g., Red, NIR, SWIR)
- Add band set into SCP interface
- Create RGB display for better visual reference

Classification Algorithms Overview (GUI Only)

- Maximum Likelihood (default)
- Minimum Distance, Spectral Angle Mapper
- Select and apply classifier via SCP GUI (no coding)

Running Supervised Classification

- Use SCP's "Classification" tab to process ROI samples
- Visualize classified raster output
- Apply legends and color scheme

Post-Classification Processing

- Smoothing output using majority filter
- Remove noise, small patches
- Optional: raster to vector conversion for clean layouts

Accuracy Assessment Basics

- Use confusion matrix and reference points
- Generate error matrix in SCP
- Assess user accuracy, producer accuracy, kappa statistics

Ground Truthing with Google Earth

- Compare classified results with high-res imagery
- Validate sampled areas using visual inspection
- Mark disagreements and refine ROIs

Reclassification & Thematic Mapping

- Group similar classes (e.g., combining dense and open forest)
- Use raster calculator or reclassification tools
- Prepare thematic maps with custom labels

Zonal Statistics by Admin Boundaries

- Overlay classified raster on village or district boundaries
- Calculate area (in ha or km^2) by land cover type
- Add summary tables to layout

Symbolization and Colour Codes for LULC Maps

- Use standard LULC colour schemes (e.g., green for forest, red for urban)
- Create a consistent legend

Exporting Classification Outputs

- Save in TIFF/GeoTIFF for GIS use
- Export to PNG/JPEG for reports and web

Print Layout Design for Final Map

- Include title, legend, scale, north arrow
- Insert classification summary chart/table
- Add metadata: source, date, satellite

Case Study: Thematic Map Generation

- Forest area mapping using Sentinel-2 imagery
- NDVI support + supervised classification
- Output comparison: 2015 vs 2024 forest extent

Lab Activity

- Download Sentinel-2 image of a selected AOI

- Collect ROI samples (min 4 classes)
- Perform supervised classification
- Validate accuracy and export final map layout

11. Terrain Analysis using DEMs – Elevation, Slope, Aspect, and Watershed Mapping

Introduction to Digital Elevation Models (DEMs)

- What are DEMs, DSMs, and DTMs?
- Raster structure of elevation data
- Applications: terrain modelling, flood analysis, road design

Sources of DEM Data

- SRTM (30m), ALOS (12.5m), ASTER
- How to download DEM from USGS Earth Explorer, Bhuvan, Open Topography
- Checking vertical accuracy and voids

Visualizing DEMs

- Load and project DEM raster
- Apply single band pseudo colour for elevation display
- Identify valleys, ridges, and plains

Creating Hillshade Maps

- Simulate sunlight on terrain using azimuth and altitude
- Combine hillshade with land use or satellite image
- Useful for cartography and terrain interpretation

Deriving Slope and Aspect Maps

- Slope: rate of elevation change (degrees or %)
- Aspect: direction terrain faces (e.g., N, S, E, W)
- Applications: landslide risk, agriculture planning, solar exposure

Generating Contours from DEM

- Extract contours at custom intervals (e.g., every 10m)
- Style major/minor contours differently
- Label elevations on map layout

Creating 3D Terrain Models

- Use QGIS 3D Map View
- Extrude elevation and overlay satellite imagery
- Great for presentations and interpretation

DEM Pre-processing (Fill Sinks)

- DEMs often have pits or sinks that disrupt flow
- Use “Fill Sinks” tool before hydrological modelling
- Compare filled vs unfilled DEMs

Flow Direction and Flow Accumulation

- D8 flow direction algorithm explained
- Derive flow accumulation map
- Visualize potential stream lines and water flow

Stream Network Extraction

- Apply threshold to flow accumulation raster
- Extract vector stream network
- Overlay with roads or villages for flood assessment

Watershed Delineation Using Outlet Points

- Digitize pour point (outlet)
- Use “Watershed” tool
- Generate watershed polygon and stream network

Zonal Statistics on Terrain Layers

- Calculate average slope, elevation, aspect per zone (e.g., village, block)
- Add values to attribute table for planning purposes

Terrain Suitability Analysis

- Identify areas with moderate slope and good elevation
- Use raster calculator to combine multiple terrain factors
- Application: site selection for agriculture or infrastructure

Overlaying Terrain Data with Other Layers

- Combine DEM derivatives with land use, soil, rainfall layers
- Derive insights like erosion zones, flood-prone areas

Terrain-Based Decision Map

- Prepare a map showing slope, aspect, watershed boundaries
- Include summary table with statistics
- Export high-resolution PDF layout for reporting

12. Hydrological Analysis & Flood Zone Mapping Using DEMs

Hydrological Modelling Concepts

- What is hydrological modelling in GIS?
- Importance for water management, flood mitigation
- DEM as the base for all hydrological processing

Pre-processing DEM for Hydrology (Sink Filling)

- Pits and depressions distort flow modelling
- Fill sinks tool
- Compare filled vs raw elevation surfaces

Flow Direction and Flow Accumulation (D8 Algorithm)

- Assign flow direction to each cell (D8 method)
- Generate flow accumulation raster
- Identify streamlines and flow intensity visually

Stream Network Extraction from DEM

- Apply accumulation threshold
- Derive stream network as raster or vector
- Symbolize streams by width or intensity

Stream Order Classification (Strahler Method)

- Assign orders to streams: 1st order to main river
- Visualize hierarchy of river systems
- Use for water body linking and planning drainage infrastructure

Delineation of Watersheds and Sub-Watersheds

- Use outlet points or pour points
- Apply “Catchment area” and “Watershed segmentation” tools
- Save and symbolize polygon results

Mapping Catchment Boundaries

- Use delineated watershed boundaries for zoning
- Overlay administrative units to identify responsibility
- Label catchments and drainage basins on maps

Watershed Characteristics Analysis

- Area, shape, slope, stream length, drainage density
- Use QGIS zonal stats and manual measurements
- Add summary to attribute table

Identification of Depressions and Sinks

- Use “Closed depressions” or “Sink analysis” tools
- Potential artificial or natural water storage zones
- Export and overlay on land use or ownership parcels

Flood Risk Zone Mapping Using Terrain

- Low elevation + high flow accumulation = potential risk zone
- Use reclassification to highlight elevation < x m
- Apply NDVI masking to exclude vegetated areas

Flood Simulation with Rainfall Intensity

- Conceptual overlay of rainfall zones on flow accumulation
- Derive “flood risk index” using raster calculator
- Use only GUI-based steps — no hydrological coding

Integration with Land Use and Infrastructure

- Identify houses, roads in flood zones
- Label vulnerable assets and regions

- Map affected schools, hospitals, agricultural fields

Water body Extraction from DEM & NDWI

- Delineate natural depressions and verify with NDWI
- Combine terrain and remote sensing outputs
- Use for tank rehabilitation or new pond siting

Map Layout of Drainage and Flood Risk

- Show main rivers, sub-watersheds, risk zones
- Add flow arrows, stream order labels, cross-sections
- Include graph or table with flood zone statistics

Final Lab: Hydrological Planning Map

- Select a taluk/mandal/county
- Delineate watershed, derive stream order
- Overlay land use, identify flood-prone villages
- Export as printable planning document

13. LiDAR Data Processing & Applications

What is LiDAR?

- Light Detection and Ranging — how it works
- Components: laser scanner, GPS, IMU
- Airborne vs terrestrial vs UAV LiDAR

LiDAR Data Characteristics

- Point cloud data (.las/.laz formats)
- Multiple returns (first, last, ground, vegetation)
- Point classification (ground, building, vegetation, water)

LiDAR Applications Overview

- Terrain modelling (high-precision DEMs)
- Urban mapping, vegetation height, flood risk zones
- Infrastructure, forestry, archaeology

LiDAR Data Sources & Download

- USGS Earth Explorer, Open Topography, NOAA, ISRO Bhuvan (India)
- Understand metadata: point density, vertical accuracy, EPSG code

Visualizing Point Clouds

- Load .las or .laz files using LAStools
- Color by classification, elevation, intensity
- Rotate and zoom through 3D viewer

Ground Classification & Filtering

- Separate ground vs non-ground returns

- Use lasground to extract bare earth
- Compare raw vs filtered point clouds

Creating Digital Elevation Model (DEM)

- Generate ground-only raster surface (bare earth model)
- Choose resolution (e.g., 1m or 5m)
- Save as GeoTIFF for further analysis

Creating Digital Surface Model (DSM)

- Include all returns: buildings, trees, power lines
- Useful for urban height analysis
- Use lasheight or las2dem with all points

Generating Canopy Height Model (CHM)

- CHM = DSM - DEM
- Shows vegetation height or building heights
- Useful in forestry or green cover estimation

Contour Generation from LiDAR DEM

- High-resolution contours (1m/2m interval)
- More detailed than SRTM or ALOS DEM
- Use in flood and slope modelling

Urban Feature Extraction from LiDAR

- Identify rooftops, buildings, elevated features
- Visualize buildings using last returns and DSM
- Use cases: 3D urban models, solar potential

Vegetation Structure Analysis

- Use return numbers and CHM to measure canopy height
- Identify forest density, tree cover gaps
- Correlate with NDVI and other RS datasets

Flood Simulation Using LiDAR DEM

- Higher precision models give better flood mapping
- Use LiDAR-based elevation to simulate floodwater spread
- Compare SRTM-based vs LiDAR-based flood zones

Final Lab: LiDAR Terrain Analysis

- Download sample .las file
- Visualize and classify ground points
- Generate DEM, DSM, CHM and extract slope map
- Create 3D terrain layout using LiDAR-derived DEM

14. Google Earth Engine (GEE) for Remote Sensing & Environmental Analysis (with JavaScript)

What is Google Earth Engine (GEE)?

- Overview of platform capabilities
- Advantages over desktop GIS for big data analysis
- Key GEE datasets: Landsat, Sentinel, MODIS, CHIRPS, SRTM

Setting Up GEE Environment

- Sign up for Earth Engine
- Access the GEE Code Editor interface
- Overview of panels: Script, Map, Console, Inspector

Introduction to JavaScript in GEE

- Variables, functions, comments, and syntax
- Simple print, map, and log statements
- Introduction to geometry and region of interest (ROI) drawing

Loading and Visualizing Satellite Imagery

- ee.ImageCollection for Sentinel or Landsat
- Filter by date, region, and cloud cover
- Visualize FCC using .select and .visualize
- Example: Sentinel-2 FCC of a city

Cloud Masking Techniques

- Cloud filtering for Landsat and Sentinel
- Use predefined functions (e.g., maskL8sr() or cloudMaskS2())
- Generate cleaner composites

Creating Image Composites

- Median composite from a date range
- Visualizing vegetation or land use seasonally
- Add layer to map with true colour and FCC options

Calculating NDVI and Other Indices

- NDVI formula using .normalizedDifference()
- Apply NDVI threshold to classify vegetation
- Visualize NDVI map and add legend

Time-Series Charting of Vegetation Change

- Use .reduceRegions() and ui.Chart.image.series()
- Plot NDVI over time for one region
- Export chart as PNG or JSON

Land Use / Land Cover Mapping using Classification

- Sample points and training data
- Supervised classification (e.g., CART or Random Forest)
- Display and export LULC map

Change Detection Between Two Dates

- Load two satellite images from different years

- Subtract NDVI or NDBI
- Highlight zones of change using thresholds and colour ramps

Terrain and Water Mapping in GEE

- Load SRTM DEM for elevation and slope
- Use NDWI for waterbody extraction
- Apply temporal water mapping using JRC Global Surface Water dataset

Creating Maps with Layers and Legends

- Add multiple layers (NDVI, LULC, elevation)
- Add custom legends using ui.Panel
- Share interactive map links

Exporting Results

- Export image to Google Drive or asset
- Export chart and tabular summaries
- Define scale and CRS during export

GEE for Environmental Monitoring Case Study

- Example: forest degradation in Central India
- Composite, NDVI change, classification, charting
- Final result exported and visualized

15. Web Mapping & GIS Web Application Creation

Introduction to Web Mapping

- What is web mapping?
- Web GIS vs traditional GIS
- Benefits: accessibility, interactivity, mobile/web integration

Types of Web Mapping Platforms

- Cloud-based: Google My Maps, Mapbox Studio
- Desktop export: QGIS2Web
- Open-source: Leaflet (through GUI export only)

Preparing Data for Web Mapping in QGIS

- Clean and symbolize vector layers
- Set proper coordinate system (WGS 84 / EPSG:4326)
- Add meaningful attributes for popups

Introduction to QGIS2Web Plugin

- Install and open the plugin
- Select Leaflet or OpenLayers output
- Configure export settings without touching code

Styling Layers for Web Display

- Customize colors, symbols, and transparency
- Apply categorized or graduated symbology
- Ensure web-friendly colors and legends

Configuring Popups & Legends (GUI)

- Enable popups for attributes
- Select which fields appear
- Include HTML-style content without code

Adding Basemaps in QGIS for Export

- Use QuickMapServices plugin
- Add OpenStreetMap, Google Satellite, Bing, or ESRI

Exporting Web Maps using QGIS2Web

- Export project as interactive HTML folder
- Structure includes map.html, CSS, JS (auto-generated)
- Open locally in a browser without internet

Uploading Web Maps to GitHub Pages

- Create GitHub account
- Upload exported files to a GitHub repository
- Enable GitHub Pages to publish map online (e.g., username.github.io/map)

Using Google My Maps for Simple Web Maps

- Add point, line, polygon layers
- Style with simple GUI options
- Embed or share via public links

Creating Interactive Maps

- Upload shapefile/GeoJSON
- Design styles and popups
- Export shareable link or embed code

Adding Multimedia & Labels to Maps

- Add images, links, and info into popups
- Label features with dynamic or static text
- Add logos, titles, scale bar, and copyright

Responsive Layouts for Mobile & Desktop

- Use QGIS2Web's responsive export
- Test map layout on different screen sizes
- Zoom, pan, search features with built-in controls

Embedding Web Maps in Websites or Reports

- Use iframe code to embed
- Add GitHub or Mapbox map in HTML page or Google Sites
- Share links for mobile use or PDF reports

Web Mapping Project

- Choose a topic: Flood Zones, Tourist Sites, Land Use, Soil Data
- Prepare GIS layers and export using QGIS2Web
- Publish on GitHub Pages or Google My Maps
- Present live link and embed it into a document