

CURRICULUM  
FOR  
POSTGRADUATE DEGREE COURSE

**M.Tech.**  
in  
**REMOTE SENSING**  
[W.E.F. 2023-2024]



DEPARTMENT OF GEO ENGINEERING & RDT  
A.U. COLLEGE OF ENGINEERING (AUTONOMOUS)  
ANDHRA UNIVERSITY VISAKHAPATNAM-530 003

**M.Tech. (REMOTE SENSING)**  
**Scheme of Instruction and Examination**  
(with effective from 2023-24 admitted batch)

**SEMESTER – I**

Code	Course Title	Scheme of Instructions		Scheme of Examinations		Total	Credits
		Theory	Lab	Internal	Externals		
<b>RS 1.1</b>	Remote Sensing and Photogrammetry	3	0	70	30	100	<b>3</b>
<b>RS 1.2</b>	Geographic Information Systems	3	0	70	30	100	<b>3</b>
<b>RS 1.3</b>	Research Methodology and IPR	2	0	70	30	100	<b>2</b>
<b>RS 1.4</b>	Program Elective-I	3	0	70	30	100	<b>3</b>
<b>RS 1.5</b>	Program Elective -II	3	0	70	30	100	<b>3</b>
<b>RS 1.6</b>	Remote Sensing Lab-I	0	3	50	50	100	<b>2</b>
<b>RS 1.7</b>	Geographic Information System Practical	0	3	50	50	100	<b>2</b>
<b>RS 1.8</b> (Audit Course)	Spatial Data Science	3	0				<b>0</b>
<b>Total</b>							<b>18</b>

**RS 1.4:** a) Environmental Planning & Impact Assessment  
b) Natural Hazards & Disaster Risk Management  
c) Earth Systems and Processes  
d) Geodesy and GNSS

**RS 1.5:** a) Agriculture & Soil Resources Management  
b) Forest Resource & and Ecosystem Analysis  
c) Coastal Zone Management  
d) Planetary Remote Sensing

## SEMESTER – II

Code	Course Title	Scheme of Instructions		Scheme of Examinations		Total	Credits
		Theory	Lab	Internal	Externals		
<b>RS 2.1</b>	Python & Java Script Programming	3	0	70	30	100	<b>3</b>
<b>RS 2.2</b>	Digital Image Processing	3	0	70	30	100	<b>3</b>
<b>RS 2.3</b>	Program Elective-III	3	0	70	30	100	<b>3</b>
<b>RS 2.4</b>	Program Elective-IV	3	0	70	30	100	<b>3</b>
<b>RS 2.5</b>	Digital Image Processing Practical	0	3	50	50	100	<b>2</b>
<b>RS 2.6</b>	Python & Java Script Practical	0	3	50	50	100	<b>2</b>
<b>RS 2.7</b>	Remote Sensing-II practical	0	3	50	50	100	<b>2</b>
<b>RS 2.8</b> (Audit Course)	Cloud-based Geospatial Analysis	1	2				<b>0</b>
<b>Total</b>							<b>18</b>

**RS 2.3:** a) Water Resources Development  
b) Water Resources Management  
c) Water Resources Assessment  
d) Hydrology and Water Resources Engineering

**RS 2.4:** a) Urban & Regional Studies  
b) Geological Remote Sensing  
c) GIS for Utilities  
d) GIS for Transportation Engineering

### SEMESTER – III

Code	Course Title	Scheme of Instructions		Scheme of Examinations		Total	Credits
		Theory	Lab	Internal	Externals		
RS 3.1	Program Elective-V	3	0	70	30	100	3
RS 3.2	Open Elective	3	0	70	30	100	3
RS 3.3	Dissertation (Phase-I)			Viva-voce		100	10
Total							16

**RS 3.1:** a) Drone & UAV Remote Sensing  
b) Climate Change Studies  
c) Health GIS  
d) Airborne and Terrestrial LIDAR

**RS 3.2:** a) WebGIS Development  
b) Spatial Data Warehousing and Data Mining  
c) Spatial Relational Database Management Systems  
d) Digital Cartography

### SEMESTER – IV

Code	Course Title	Scheme of Instructions		Scheme of Examinations		Total	Credits
		Theory	Lab	Internal	Externals		
<b>RS 4.1</b>	Dissertation (Phase-II)			Viva-voce		100	<b>16</b>

## SEMESTER I

### RS 1.1 REMOTE SENSING & PHOTOGRAMMETRY

#### Unit-I

**Fundamentals of Remote Sensing:** Definition of Remote Sensing: Principles of Remote Sensing, History of Remote Sensing. Electromagnetic Radiation, Radiation Laws, EM spectrum.

**Interaction of EMR:** With atmosphere, Atmospheric Windows, imaging spectrometry, Interaction with Earth. Spectral signature of various land cover features.

#### Unit-II

**Platforms:** Types of platforms. Orbits of satellites, Kepler's Law, satellite characteristics, satellites for Earth observations studies, and planetary missions.

**Sensors:** Types and classification of sensors, imaging modes, Characteristics of optical sensors, sensor resolution-spectral, radiometric and temporal, Characteristics of detectors.

#### Unit-III

**Data Reception, Processing and Image Interpretation.**

Ground station, Data generation, Data processing & corrections. Errors and Corrections: Radiometric, Geometric and Atmospheric. Ground Investigation in support of Remote sensing. Training sets, Accuracy evaluation, test sites. Ground truth Instruments and spectral signature, Spectral Reflectance and spectral signature of vegetation Sources of RS data: Global and Indian data products.

**Visual Image Interpretation:** Basic principles of Visual Interpretation Elements of Visual Interpretation, Techniques of Visual Interpretation, Interpretation Keys

#### Unit-IV

**Photogrammetry:** Fundamentals of Aerial Photography Systems: Historical development – classification– geometry of vertical photographs – scale –relief displacement – tilted and oblique photographs, Flight Planning. Stereoscopy: Stereoscopes-parallax equation – parallax measurement– parallax bar-measurement of heights and determination of slopes- stereoscopic plotting instruments.

**Analytical and Digital Photogrammetry:** Concepts of orientation-interior, relative and absolute orientation of aerial photographs, Strip triangulation, Block Adjustment of Independent Models (BAIM), Special cases (resection, intersection, and stereo-pair generation), Aerial triangulation, Block adjustment, Orthophotos, mosaics.

#### Unit-V

**Thermal Imaging:** Introduction - Kinetic and radiant temperature, Thermal properties of materials, Emissivity, Radiant temperature. Thermal conductivity. Thermal capacity, thermal inertia, apparent thermal inertia, Thermal diffusivity. IR – radiometers. Characteristics of IR images. Effects of weather on images. i) Clouds, ii) Surface winds, iii) Penetration of smoke plumes. Interpretation of thermal imagery. **Microwave Remote Sensing & LiDAR:** Introduction - Electromagnetic spectrum, Airborne and Space borne radar systems basis instrumentation. System parameters - Wave length, Polarization, Resolutions, Radar geometry. Target parameters - Back scattering, Point target, Volume scattering, Penetration, Reflection, Bragg resonance, Cross swath variation. Speckle, radiometric calibration. Microwave sensors and Image characteristics, Microwave image interpretation. Introduction to LiDAR. Hyperspectral Remote Sensing.

#### Text Books:

1. Floyd, F. Sabins, Jr: Remote Sensing Principles and Interpretation, Waveland Pr Inc, 2020
2. Lillesand and Kiefer: Remote Sensing and Image interpretation, John Wiley, 2015.
3. Manual of Remote Sensing Vol. I&II, 2<sup>nd</sup> Edition, American Society of Photogrammetry.
4. Mikhail, E. M., Bethel, J. S., McGlone, J. C. (2001). Introduction to modern photogrammetry. India: Wiley.

## **RS 1.2 GEOGRAPHIC INFORMATION SYSTEMS**

### **Unit-I**

**Fundamentals of cartography and GIS:** Definition of Map - Classification based on Function, Scale, Characteristics – Ellipsoid and Geoid – Co-ordinate Systems - Rectangular and Geographic Coordinates – UTM and UPS - Projection – Function - Types of Map Projections – Transformations – Function - Affine transformation - Choice of Map Projection – Evolution of cartography- Geo-Spatial, Spatial and Non-spatial Data – Definition of GIS – Evolution GIS – Components of GIS.

### **Unit-II**

**Data models & Inputs:** Point, Line Polygon / Area, elevation and surface –Tessellations - Attributes and Levels of Measurement - Data Sources – Ground and Remote Sensing survey – Collateral data collection –Input: Map scanning and digitization, Registration and Georeferencing – Concepts of RDBMS - Raster Data Model – Grid – Data Encoding - Data Compression – Vector Data Model – Topological properties – Arc Node and sphagetti Data Structure – Raster Vs. Vector Comparison – File Formats for Raster and Vector – Data conversion between Raster and vector

### **Unit-III**

**Raster and Vector data analysis:** Raster Data analysis: Local, Neighborhood and Regional Operations – Map Algebra – Vector Data Analysis: Topological Analysis, point-in-polygon, Line-in-polygon, Polygon-in-Polygon – Proximity Analysis: buffering, Thiessen Polygon – Non-topological analysis: Attribute data Analysis- concepts of SQL.

### **Unit-IV**

**Network Analysis and Surface Analysis:** Network – Creating Network Data - Origin, Destination, Stops, Barriers – Closest Facility Analysis, Service Area Analysis, OD Cost matrix analysis, Shortest Path Analysis – Address Geocoding – Surface Analysis – DEM, DTM - Point data to Surface interpolation – DEM Representation – Applications

### **Unit-V**

**Data Output And Web Based GIS:** Map Compilation – Cartographic functionalities for Map Design – Symbolization – Conventional signs and symbols – Spatial Data Quality – Lineage, Positional Accuracy, Attribute Accuracy, Completeness, Logical Consistency - Meta Data – Web based GIS: Definition, Merits - Architecture – Map Server – Spatial Data Infrastructure – Spatial Data Standards

### **Text Books:**

1. C.P. Lo, Albert K.W. Yeung, Concepts and Techniques of Geographic Information Systems, 2nd Edition, Prentice Hall, 2006.
2. John Jensen, Ryan Jensen, Introductory Geographic Information Systems, International Edition, Pearson Publishers, 2012,
3. Kang-Tsung Chang, Introduction to Geographic Information Systems, 6th Edition, Mc Graw Hill, 2013.

## **RS 1.3 RESEARCH METHODOLOGY & IPR**

### **Unit-I**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem - Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

### **Unit-II**

Effective literature studies approaches, analysis Plagiarism, Research ethics.

Effective technical writing, How to write a report, Paper Developing a Research Proposal, Format of a Research Proposal, Presentation and assessment by a review committee.

### **Unit-III**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property - Procedure for grants of patents, Patenting under PCT.

### **Unit IV**

Patent Rights: Scope of Patent Rights - Licensing and transfer of technology - Patent information and databases - Geographical Indications.

### **Unit V**

New Developments in IPR: Administration of Patent System - New developments in IPR; IPR of Biological Systems, Computer Software etc. - Traditional knowledge Case Studies, IPR and IITs.

### **Text Books & References:**

1. Goddard, W., Melville, S. (2004). Research Methodology: An Introduction. South Africa: Juta.
2. Kumar, R. (2010). Research Methodology: A Step-by-Step Guide for Beginners. United Kingdom: SAGE Publications.
3. Halbert, D. J. (2006). Resisting Intellectual Property. (n.p.): Taylor & Francis.
4. Ramappa, T. (2000). Intellectual Property Rights Under WTO: Tasks Before India. India: Wheeler Pub.

## RS 1.4 Program Elective-I

### a. ENVIRONMENTAL PLANNING & IMPACT ASSESSMENT

#### Unit-I

**Introduction to Environmental Planning & Policy:** Principles of environmental planning and policy; The historical evolution of environmental policies; International environmental agreements and treaties; Sustainable development goals and their relevance; The role of government agencies and NGOs in environmental policy-making. **Environmental Policy Development: Environmental policy formulation and implementation process:** Stakeholder engagement and public participation; Regulatory frameworks and compliance;

#### Unit-II

**Satellite Missions for Environmental Monitoring:** Introduction - Environmental satellite Mission: GEOS, NOAA, AVHRR, CZCS, Oceansat, Kalpana and others – Spectral characteristics - Data Products – Analysis Tools - Monitoring land, water, atmosphere and ocean using Remote Sensing Data.

#### Unit-III

**Environmental Data and GIS Analysis:** Geospatial analysis techniques for informed planning decisions; **Integration of remote sensing and GIS for environmental planning:** Data fusion approaches for enhancing planning data, Ensuring interoperability between remote sensing and GIS technologies. **Spatial analysis methods:** Geostatistics and spatial interpolation, Multi-criteria decision analysis (MCDA) for environmental assessment.

#### Unit-IV

**Environmental Planning & Resource Management:** Using GIS for land-use planning, Zoning and land suitability analysis; Urban and regional planning applications; **Applications of remote sensing in ecosystem monitoring and conservation:** Forest cover analysis, Wetland mapping and monitoring; **Sustainable resource management:** Water resource management with GIS, Agriculture and natural resource management

#### Unit-V

**Environmental Impact Assessment (EIA):** Need of EIA; Scope and objectives; Types of environmental impacts; Steps involved in conducting the EIA Studies; Environmental Impact Assessment techniques- Ad-hoc method, checklist method, overlay mapping method, network method, simulation and modeling technique, matrix method, and system diagram technique; Merits and Demerits of EIA studies.

#### Textbooks:

1. "Environmental Policy: New Directions for the Twenty-First Century" by Norman J. Vig and Michael E. Kraft.
2. Raman, N. S., Gajbhiye, A. R., Khandeshwar, S. R. (2014). Environmental Impact assessment. India: I.K. International Publishing House Pvt. Limited.
3. "Remote Sensing and GIS for Ecologists: Using Open-Source Software" by Martin Wegmann.



## **b. NATURAL HAZARDS AND DISASTER RISK MANAGEMENT**

### **Unit-I**

**Concepts and overview of Disaster Management:** Fundamentals and concepts of Vulnerability, Susceptibility, Risk Assessment and DRR. An overview of Natural Hazards (Geological, Hydrological and Environmental), Urban and industrial Hazards. Global Disaster Management Frameworks and International charter. Impact of Climate Change & Global Warming on frequency, intensity and recurrence of Natural Hazards.

### **Unit-II**

**Geological Hazards:** Image Interpretation for Geological Hazards. Overview of mass wasting features, Slope failure, and Landslides (types, causes, and prevention) .Overview of mapping and modeling of Landslide Hazards . Fundamental of EQ seismic waves & their characterization, intensity, magnitude, & seismographs . Overview of Seismic micro-zonation, liquefaction, surface Rupture/ deformation mapping & modeling.

### **Unit-III**

**Hydrological Hazards:** Overview of optical and microwave remote sensing for floods. Overview of hydrological modelling for runoff estimation. Overview of geospatial applications for urban flooding. Snow, GLOF, avalanche and glaciers mapping & modelling.

### **Unit-IV**

**Environmental and Meteorological Hazards:** Agromet parameters observations and analysis for drought assessment. Agricultural drought management: monitoring, prediction and vulnerability analysis. Forest Fire, Damage and risk Assessment. Modelling of atmospheric pollution and impact on human health. Satellite RS for spatio-temporal distribution of heat and cold waves.

### **Unit-V**

**Coastal and Extreme weather events Hazards:** Mapping and monitoring of coastal hazard – cyclones, erosion, salt water intrusion. Overview of space technology for tsunami hazard and early warning system (GL). Satellite remote sensing for extreme rainfall events. Fog, Haze, Smog & dust storm analysis & prediction with emphasis on DRR & mitigation. Overview of space technology for air quality related hazards – Aerosol, PM 2.5, PM 10.

### **Textbooks:**

1. Hyndman, D., & Hyndman, D. (2016). *Natural hazards and disasters*. (6th ed.). Cengage Learning.
2. Smith, K. (2013). *Environmental hazards: assessing risk and reducing disaster*. (6th ed.). Routledge.
3. Twigg, J. (2004). Disaster risk reduction. (2015 ed.). Good Practice Review, (Chapter 9)
4. Gupta, R.P. (2003). *Remote Sensing Geology*. 3rd ed.). Springer Verlag, Berlin.
5. James R. Holton (2004). *An Introduction to Dynamic Meteorology*. Elsevier Academic Press
6. Schultz G.A. and Engman E.T. (2000). *Remote Sensing in Hydrology and Water Management*. Springer Verlag, Berlin, Germany.

## **c. EARTH SYSTEMS AND PROCESSES**

### **Unit-I**

Earth - Orbit, Rotation, Time. Oceans - Depth, Bottom relief. Oceans - Temperature, Salinity, Density of seawater. Oceans - Waves, Tides, Currents. Climate and the atmosphere – Origin, nature, composition and vertical division of the atmosphere.

### **Unit-II**

Meteorological parameters and their measurements - Geographical, seasonal and vertical distribution of temperature, pressure, wind and precipitation. Solar and terrestrial radiation: Distribution in clear, cloudy and average conditions. Mean heat balance. Weather disturbances: Air mass and Front, Cyclone and anti-cyclone. Thunderstorm and tornado. Weather analysis and Forecasting  
Climate and agricultural factors in crop production.

### **Unit-III**

Climate Change: Causes and Impacts. Monsoons : Concepts of the origin of monsoon - Indian Monsoons. Fundamental concepts of Geomorphology. Weathering, Mass wasting and erosion.

### **Unit-IV**

Wind and associated land forms. Seas and associated land forms. Land forms associated with faults and folds. Rivers and associated land forms. Glaciers associated land forms

### **Unit-V**

Soil forming processes, Soil profile, Soil components. Pedogenic regimes. Classification of soils  
Soils of India

### **Text Books:**

1. Structural Geology by Billings, M. 1984
2. Earth History & Plate Tectonics by Carl K. Seyfert, Leslie A. Sirkin
3. Geology of India & Burma by M.S. Krishna 6th, Ed.
4. General Climatology by H.J. Critchfield
5. Physical Geology by Arthur Holmes
6. Physical Geography by Stahler
7. The Atmosphere by Frederick K. Lutgens and Edward J. Tarbuck

#### **d. GEODESY AND GNSS**

**Basic principles of Geodesy;** History of Geodesy; Spherical Earth; Ellipsoidal Earth; Geoidal Earth; Geodetic Survey Systems; Horizontal Positioning – Determination of Astronomic position, Triangulation, Trilateration; Vertical Positioning.

**Fundamentals of Reference Systems and Frames:** Geodetic and Cartesian coordinate system; principles of coordinate transformation; Datums: Horizontal and vertical datums – national, regional and local datums; Major datums and Indian datum; World Geodetic System (WGS) WGS84; tidal datums. **Satellite Geodesy:** definition; observational systems: Historical systems; Doppler; laser; radar altimetry.

**Global Positioning System (GPS):** Definition; GPS elements – space segment, user segment and control segment; Observation principles; phase measurement techniques; determining orthometric heights; GPS Error Sources and Error Handling Procedures: Atmospheric effects, clock and orbital errors, multipath, anti-spoofing and selective availability, etc; interference and jamming. Accuracy issues, GPS satellite navigation message; GPS time, fundamental and derived frequencies. Multi-Channel, sequential and multiplexing receivers

**Surveying with GNSS:** Planning a GNSS Survey, Positioning methods – point positioning, relative positioning, Static, Differential, RTK, and Field data collection. **Data Processing:** Ambiguity resolution, Post-processing, real-time processing, Accuracy measures, software modules, GIS and GNSS data integration, Applications of GNSS

Applications: Defense, civilian, Navigational and Geodetic applications; GPS-GIS integration; GPS applications in surveying, mapping, GIS and land navigation and precision farming; integration with other sensors: GPS in intelligent transportation and fleet management.

#### **Textbooks:**

1. Physical Geodesy by Weikko A. Heiskanen and Helmet Moritz, Freeman and Company.
2. GPS: Theory and Practice, B. Hofmann-Wellenhof, H. Lichtenegger and J. Collins, 5th Revised Edition, Springer, Wien, New York, 2001
3. GNSS: Global Navigation Satellite Systems, Hofmann-Wellenhof, Lichtenegger and Wasle., Springer-Verlag Wein, New York, 2008.
4. Springer Handbook of Global Navigation Satellite Systems, Peter J.G. Teunissen, Oliver Montenbruck., Springer International Publishing, 2017
5. GNSS Insights into GPS, GLONASS, Galileo, Compass and Others, B. Bhatta., CRC Press, 2011
7. Satellite Geodesy Foundations-Methods and Applications, Gunter Seeber., 2003

## **RS 1.5 Program Elective-II**

### **a. AGRICULTURAL & SOIL RESOURCES MANAGEMENT**

#### **Unit-I**

**LULC & Crop Inventory:** Land Use / Land Cover classification system (Global). Multi-temporal RS data for LULC mapping. Optical Spectral characteristics of crops, Spectral Vegetation Indices and Crop Inventory & mapping. Microwave sensors parameters and signatures of vegetation in reference to Polarization, incidence angle, frequency. Crop discrimination, crop growth monitoring retrieval from microwave RS.

#### **Unit-II**

**Crop Condition Assessment, Crop Yield Modelling and Agriculture Informatics:** Crop condition and stress assessment (Biotic and abiotic). Hyperspectral RS applications in Agriculture. RS based crop yield modelling: Principles and approaches. Integrating RS and crop growth models for crop yield Modelling and Regional crop production assessment: production efficiency models. Agriculture Information system, Wireless Sensors, Decision support system, ICT applications in agriculture including Crop insurance.

#### **Unit-III**

**Soil Resource Mapping & Land Evaluation:** Physico-chemical characteristics of soils and pedogenic (soil forming) factors. Spectral characteristics of soils, need and scale of soil survey and soil map units. Soil Resource Mapping: Physiographic-soil analysis of various landforms for soil resource mapping. Soil Taxonomy: Soil morphological characteristics, diagnostics soil horizons and soil classification. Land Evaluation : Concept of land use planning, FAO Framework of land evaluation for crop suitability analysis

#### **Unit-IV**

**Land Degradation and Watershed Management:** Land degradation: Characteristics of degraded lands, Hyperspectral Remote Sensing in characterization and mapping degraded lands. Watershed: Digital terrain analysis for watershed delineation, terrain characterization and terrain indices. Soil Erosion Modelling for erosion risk assessment and soil conservation planning. Digital soil mapping: need, concept and methods• Soil carbon and soil quality assessment

#### **Unit-V**

**Agromet Parameters Retrieval and Agricultural Water Management:** Agro-meteorology: Importance, Meteorological parameter Observations and analysis & Advanced instrumentation (Bowen Ratio, Eddy Covariance, Large Aperture Scintillometer). Satellite sensors and their characteristics for Agromet studies(Optical, TIR, Active/Passive microwave sensors). Agromet parameters retrieval: algorithm and modeling techniques(viz, Shortwave radiation, rainfall, surface temperature, air temperature, albedo, LAI, ET, Soil moisture). Principles, instrumentation and approaches for estimating crop water requirement/ crop ET and Irrigation scheduling. Agricultural drought management: monitoring, prediction and vulnerability analysis.

**Textbooks:**

1. Remote sensing applications (2009), Published by NRSC, ISRO, Hyderabad, Chapters – 1, 4 &13
2. Quantitative Remote Sensing of Land Surfaces (2005) By Shunlin Liang), Willey Publishers
3. Soil Erosion and Conservation by R. P. C. Morgan (2005), Longman Publishing Group
4. Remote Sensing and Large-Scale Global Processes (ed. by A. Rango) (Proc. Baltimore Symp.),
5. 67–74. IAHS Publ. 186. IAHS Press, Wallingford, UK.
6. Ustin, S. (2001). Manual of Remote Sensing, Volume 4, Remote Sensing for Natural Resource Management and Environmental Monitoring, 3rd Edition, Willey Publishing.

## **b. FOREST RESOURCE & ECOSYSTEM ANALYSIS**

### **Unit-I**

**Forest mapping and monitoring:** Geographical distribution, types, extent and status of vegetation (World and Asia-Pacific region). Global forest resource assessment (FRA), forest cover classification scheme (FAO, IGBP). Phenology as discriminator for vegetation mapping and vegetation indices. High resolution remote sensing for vegetation mapping. Hyperspectral remote sensing for plant community/species mapping. Forest degradation mapping and monitoring.

### **Unit-II**

**Forest Inventory:** Forest inventory concept and scope. Sampling design survey. Sampling concept and methods, statistical treatment of inventory data. Growing stock, biomass estimation using optical RS data. LiDAR applications in forest inventory (Forest height, structure, and biomass estimation). SAR applications in forest inventory (Forest height, structure, and biomass estimation).

### **Unit-III**

**Forest informatics:** Multi-criteria decision making for ecological applications. Ecological niche concept and Species distribution modelling. Wildlife habitat suitability analysis and protected areas. Satellite telemetry for wildlife dispersal studies.

### **Unit-IV**

**Forest ecosystem analysis:** Definition, principles and scope of forest ecosystem; Forest ecosystem structural and functional analysis. Forest productivity estimation and Carbon flux monitoring. Definitions and concepts of Landscape ecology, Patch-matrix, Spatial metrics. Biodiversity characterization and conservation prioritization. Assessment and valuation of ecosystem services.

### **Unit-V**

**Climate change and impact assessment:** Broad concept on forest ecosystem and climate linkages, climate change impacts on forest ecosystems. Fire ecology, Global and Asia-Pacific region issues, EO-based active fire detection and monitoring, Burnt area mapping and recovery assessment. Forest fire risk zonation and danger rating, Forest fire alert systems. Environmental impact assessment.

### **Textbooks & References**

1. India State of Forest Report (2017) Forest Survey of India, Dehra Dun, India
2. Collinson A.S. (1988) Introduction to world vegetation (2nd Edition). Academic Division of Unwin Hyman Ltd., London
3. Addo-Danso S. D., Prescott C. E. and Smith A. R. (2016) Methods for estimating root biomass and production in forest and woodland ecosystem carbon studies: a review. Forest Ecology and Management, 359 : 332-351
4. Singh J.S., Singh S.P. and Gupta S.R. (2006) Ecology, Environment and Resource Conservation, Anamaya Publishers, New Delhi
5. IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press
6. Tang L., Shao G. (2015) Drone remote sensing for forestry research and practices, Journal of Forestry Research, 26(4): 791-797

## **c. COASTAL ZONE MANAGEMENT**

### **Unit-I**

**Introduction:** Coastal and littoral zones – definitions and scope of study Shore zone processes – waves, tides and currents Coastal landforms; River deltas: types and their morphological variations. Anthropogenic impact of deltas. Coastal wetlands – Mangrove swamps, marshes, lagoons, tidal channels/creeks and their significance in coastal stability and economic importance. Continental margins – forms and processes; territorial waters and Exclusive Economic Zone.

### **Unit-II**

**Overview of geospatial technologies for coastal zones:** Coastal data sources: Satellite imagery, LiDAR, bathymetry; Data collection methods: Field surveys, buoys; Spatial analysis techniques for coastal data: Elevation modeling, shoreline analysis, habitat mapping.

### **Unit-III**

**Coastal Hazards:** Storm surges, erosion, tsunamis; Global warming and Sea-level rise - impact on coastal zones; coastal vulnerability assessment Vulnerability assessment using geospatial data: Population density, land use, infrastructure. Coastal hazard preparedness – coastal protection, education and awareness of coastal communities.

### **Unit-IV**

**Human activity and coastal environment** – deforestation, Agriculture/aquaculture, pollution and coastal structures, and their effect on coastal zones; Coastal vegetation; shelter belts; coastal aquifers; freshwater-seawater interface. Morphology of Indian coasts.

### **Unit-V**

**Coastal Zone Management**—concepts, models and information systems Coastal Regulations Zones (CRZ) and Coastal Management Zones (CMZ): Indian context Application of remote sensing in coastal zone studies; Role of Geographic Information Systems in coastal zone studies.

### **Textbooks:**

1. Geomorphology, Bloom, A.L., Prentice-Hall, 1978
2. Deltas, Coleman, J.M., Continuing education Publication Co. Inc. 1976
3. Coastal Sedimentary Environments, Davis, A.R. (Jr.), Springer-Verlag, 1985.
4. Beaches and Coasts, King, C.A.M., Edward Arnold, 1972
5. Introduction to Marine Geology and Geomorphology, King, C.A.M., Edward Arnold, 1974
6. Applications in Coastal Zone Research Management, Martin, K. St. (ed), U.N. Institute for Training and Research, 1993.
7. Integrated Ocean and Coastal Management, Sain, B.C., and Knecht, R.W., UNESCO Publication, 1998.
8. Subtle Issues in Coastal Management, Sudarshan et al., (ed), IIRS, Dehra Dun, 2000.

## **d. PLANETARY REMOTE SENSING**

### **UNIT I**

Universe and solar system: Origin of Universe - Big Bang, Steady state and Inflationary hypothesis, Illustris model, Solar System - planets, satellites, asteroids, meteorites and comets and internal differentiation of the planets; general features of Terrestrial planets.

### **Unit II**

Earth as a reference material: Geology and geophysics of terrestrial planets: Mars, Venus and Mercury; Jupiter, Uranus and Saturn and their satellites; physical properties, composition, mineralogy and petrology of the Moon.

### **UNIT III**

Planetary atmosphere: Exo- and endogenic processes associated with origin and internal evolution of planets – planetary volcanism, craters, impact of cratering processes, mineralogy and petrology; thermal, seismic and magnetic properties, and chronological techniques.

### **UNIT IV**

Remote sensing techniques applicable to planetary geology : Approaches to remote sensing analysis of the composition of planetary surfaces, applications derived from interaction of electromagnetic radiation (X-ray, gamma-ray, visible, near-IR, mid-IR, radar) with geologic materials.

### **UNIT V**

Past, present and future planetary exploration missions : Analyses and Interpretation of data gathered through various missions: identification of surface and morphological features.

### **References:**

1. Impact cratering mechanics and structures, in Shock Metamorphism of Natural Materials, B.M. French and N.M. Short, eds., pp. 87-99, Mono Books, Baltimore. Gault, D.E., W.L. Quaide, and V.R. Oberbeck, 1968.
2. Introduction to planetary remote sensing gamma ray spectroscopy, in Remote Geochemical Analysis: Elemental and Mineralogical Composition, C.M. Pieters and P.A.J. Englert, eds., Cambridge Univ. Press, pp. 167-198. Evans, L.G., R.C. Reedy, and J.I. Trombka, 1993.
3. Manual of Remote Sensing, Third Edition, Volume 3, pp. 509-564, A.N. Rencz, Editor, John Wiley & Sons, 1999.
4. Meteorites and the Early Solar System, Univ. Arizona Press, Tucson AZ, 1269 pp. Kerridge, J.F. and M.S. Matthews, editors, 1988.
5. Origin of Electronic Spectra of Minerals in the Visible-Near Infrared Region. In Remote Geochemical Analysis: Elemental and Mineralogical Composition, ed. C.M. Pieters and P.A.J. Englert, pp. 3-29. Cambridge: Cambridge Univ. Press. Burns R.G., 1993.
6. Planetary Landscapes, Allen and Unwin, Inc., Winchester, MA, 275 pp. Greeley, R., 1987.



## **RS 1.6 REMOTE SENSING LAB-I**

### **(A) REMOTE SENSING**

1. Map reading - Survey of India Topo sheets.
2. Importing Satellite/Aerial Data from various sources
3. Geometric Corrections and Rectifications
4. Satellite Image Interpretation of various Terrestrial Features.
5. Preparation of Base Map from Survey of India Topo sheets
6. Thematic Mapping (Geomorphology, Forestry, Urban, Waterbodies)

### **(B) PHOTOGRAMMETRY**

7. Use of Pocket & Mirror Stereoscope, parallax bar and measurement of distance and height.
8. Differential parallax measurement and contouring by parallax bar method
9. Digital Photogrammetry project creation and orientations (Internal & External)
10. Bundle Block Adjustment and 3D surface generation DEM
11. Orthophoto Generation

## **RS 1.7 GEOGRAPHIC INFORMATION SYSTEMS PRACTICAL**

### **List of Exercises**

1. Introduction to GIS software (ArcGIS, QGIS)
2. Georeferencing and rectifying aerial imagery, Toposheets
3. Digitizing and editing spatial data.
4. Data Querying.
5. Vector Data Analysis
6. Raster Data Analysis
7. Terrain Analysis with DEM
8. Map Layout
9. Surface hydrology Analysis
10. Network Analysis
11. Image Classification (Supervised and Unsupervised)
12. Model Builder

## Audit course

### RS 1.8. SPATIAL DATA SCIENCE

#### Unit-I

**Introduction:** Data Science; Fundamentals of Python, Python Libraries for Data Science; Data: Database Tables, Data Frame, Data preparation; Math: Linear functions, Plotting functions, Slope and Intercept.

#### Unit-II

**Statistics:** Basics of Statistics: Intro. To Statistics, Population and Samples, Parameters, Mean, Mode, Median, Data Distribution and types, Quartiles and percentiles, Standard Deviation, variance and covariance, Correlation, Correlation Matrix, Correlation vs. Causality, Hypothesis Testing and proportion and mean (left-tailed, two-tailed).

**Advanced Statistics:** Linear Regression, Regression Table, Regression Info., Regression Coefficients, Regression P-Value, Regression R-Squared, Linear Regression Case; Stat Z-Table, Stat T-table.

#### Unit-III

**Spatial Data, Manipulation, And Visualization:** Spatial Data Science and its Applications; Importance of Spatial Thinking and Analysis; Spatial databases; Data types and sources in spatial data science, Data preprocessing and cleaning for spatial datasets, Spatial data structures and indexing, Cartographic principles and effective map design, Interactive mapping tools and libraries (Leaflet, Mapbox).

#### Unit-IV

**Spatial Analysis Techniques & Geostatistics And Spatial Regression:** Exploratory spatial data analysis (ESDA) methods; Spatial autocorrelation and spatial weights matrices; Point pattern analysis and spatial clustering; Spatial interpolation techniques (Kriging, IDW, etc.)

Principles of Geostatistics and Variogram analysis; Ordinary least squares (OLS) regression vs. spatial regression; Spatial regression models (Spatial Lag, Spatial Error, etc.); Model interpretation and spatial diagnostics.

#### Unit-V

**Spatial Machine Learning & Advanced Spatial Applications:** Introduction to Machine Learning algorithms for spatial data; Unsupervised learning (clustering, dimensionality reduction) with spatial data; Supervised learning (classification, regression) in spatial context; Deep learning for remote sensing and image analysis.

**Applications:** Spatial epidemiology and disease mapping; Urban planning and spatial decision-making; Environmental and ecological analysis; Location-based services and business analytics; Geospatial web services and APIs.

#### Textbook:

1. "Spatial Analysis: A Guide for Ecologists" by Fortin, M.J., & Dale, M.R.T.

#### Additional Resources:

1. Online tutorials for GIS software (e.g., ArcGIS, QGIS)
2. Code snippets and examples in Python/R for spatial data analysis
3. Academic papers and research articles on spatial data science applications.

## SECOND SEMESTER

### RS 2.1 PYTHON AND JAVASCRIPT PROGRAMMING

#### Unit-I

**Foundations of Python Programming:** Introduction to programming concepts and Python's role. Setting up the Python development environment. Python syntax and basic data types (variables, strings, numbers). Control structures: if statements and loops (while, for). Input and output handling in Python.

#### Unit-II

**Core Programming Concepts and Data Manipulation:** Functions: definition, parameters, return values, and scope. **Lists and Tuples:** creation, indexing, slicing, and methods. String manipulation and formatting. **File handling:** reading, writing, and working with files. Comprehensive exercises combining functions and data manipulation.

#### Unit-III

**Advanced Python Concepts Dictionaries and Sets:** key-value pairs, unique elements, and methods. **Exception handling:** try-except blocks, raising exceptions. Introduction to modules and libraries. Introduction to object-oriented programming (OOP) concepts. **File handling in Python:** reading and writing files. Error handling and exceptions in Python. Introduction to web development concepts. Creating simple web pages using HTML and CSS. **Introduction to Flask:** Building a basic web application with Python

#### Unit-IV

##### **JavaScript Fundamentals, DOM Manipulation and Event Handling**

Introduction to JavaScript and its role in web development. Setting up the development environment for JavaScript. JavaScript syntax and basic data types (variables, strings, numbers). **Control structures:** if statements and loops (while, for). Basic input and output in JavaScript. Introduction to the Document Object Model (DOM). Selecting and manipulating DOM elements using JavaScript. Event listeners and handling user interactions. Creating interactive web pages with JavaScript. Practical exercises combining DOM manipulation and event handling

#### Unit-V

**Advanced JavaScript Concepts: Functions:** definition, parameters, return values, and scope. **Asynchronous JavaScript:** callbacks, promises, and async/await. Fetching data from APIs using JavaScript. Introduction to frontend frameworks (e.g., React or Vue.js). Building a dynamic web application using JavaScript.

#### **Textbooks:**

1. Matthes, E. (2015). Python Crash Course: A Hands-On, Project-Based Introduction to Programming. United States: No Starch Press. "Eloquent JavaScript" by Marijn Haverbeke.
2. Quigley, E. (2010). JavaScript by Example. United States: Pearson Education.

#### **Additional Resources:**

1. <https://www.w3schools.com/python/>
2. <https://www.freecodecamp.org/news/learn-javascript-full-course/>

## RS 2.2 DIGITAL IMAGE PROCESSING

### Unit-I

**Data Products and Image Preprocessing:** Data Products and Their Characteristics, Digital image formation, digital image display mechanism, image histograms, look-up table data, Pre-processing – Atmospheric, Radiometric, Geometric Corrections - Basic Principles of Visual Interpretation, Ground Truth, Orthorectification, Applications.

### Unit-II

**Image Enhancement:** Linear and non-linear Contrast enhancement techniques, density slicing, pseudo color images, spatial enhancement techniques (convolution filtering), spectral enhancement techniques, Image algebra, PCA, and data fusion techniques.

### Unit-III

**Image Classification Techniques:** Supervised Classification, Training set - Statistical computation, understanding feature space & scatter plots, signature purity & separability, Signature Baye's decision rule, non-parametric & parametric classification techniques, minimum distance rule, Parallelepiped algorithm, maximum like-hood method, unsupervised and hybrid classification techniques, classification analysis - confusion matrix, error analysis & kappa coefficient, Analysis of Multi-Temporal series and change detection.

### Unit-IV

**Advanced classification techniques:** Learning methods, Object, Texture, Object based Fuzzy, ANN and SVM classification techniques, sub-pixel mixture analysis; Object Oriented Image Classification.

### Unit-V

**Image Processing:** Segmentation - Methods, MDL, Watershed, Mean-shift, Edge detection; Spectral indices - Vegetation indices, water-related indices, Indices related to cloud properties, Google Earth Engine platform for satellite data processing.

### Text Books:

1. Digital Image Processing, John R J, Introductory Prentice Hall, New Jersey, 2016.
2. Remote Sensing Imagery, Florence Tupin, Jordi Inglada and Jean-Marie Nicolas, ISTE and Wiley, 2014
3. Remote Sensing and Digital Image Processing, Jarocińska, Anna, van der Meer, Freek D., Springer, 2016.

### Reference Books:

1. An Introduction to Support Vector Machines, Nello Cristianini and John Shawe Taylor., Cambridge University Press, 2013
2. Remote Sensing and Image Interpretation, Lillesand, T.M., Kiefer, R.W. and Chapman, J.W., Fifth Edition, John Wiley & Sons, 2007.
3. Digital Image Processing, Gonzalez, Rafael C. and Richard E. Woods, Third Edition, Pearson Education, London.
4. <https://www.nrcan.gc.ca/maps-tools-publications/satellite-imagery-air-photos/tutorialfundamentals-remote-sensing/9309>
5. <https://nptel.ac.in/courses/105/107/105107160/>

## **RS 2.3 Program Elective-III**

### **a. WATER RESOURCES DEVELOPMENT**

#### **Unit-I**

**River Valley Project Planning:** Purpose of planning, stages in the planning process, benefit-cost ratio, advantages of river valley projects, classification of reservoirs, technical aspects in river valley project planning- engineering surveys, geological investigations, hydrological investigations, selection of site for a reservoir, remote sensing applications in river valley project planning.

#### **Unit-II**

**Geo-Engineering Consideration for Investigation of Hydel Resources:** Introduction, application of remote sensing data for site selection, type of information – lithology, structure, types of lineaments, unconsolidated material, watershed characteristic, study of surface drainage, study of river geometrics, study of sedimentation, soil erosion survey, location and extent of landslides, location of field check points and the necessity and planning of future surface geophysical investigations in the reservoir and dam sites. economic factors, supply of construction material, access route location.

#### **Unit-III**

**River Morphology:** Introduction, early history, geomorphological approach, key definitions; graded stream, base level, laminar flow, turbulent flow, gradient, discharge, sinuosity, wavelength, natural level, sandbar/braided bar, meander cutoff, oxbow lake, point bar. Paleochannel/ abandoned channel, types of river, river engineering aspects, meandering: bends, crossing, transitional sections, meanders and its relationship to hydrological variables (empirical approach), braiding, straight, river behaviour and its plan form, bank material, remote sensing approach- data, methodology, instruments

#### **Unit-IV**

**Evaluation of Water Management in Irrigation Command Area:** Geoinformatics for efficient water management in irrigation systems - agricultural crop land inventory, assessment of water resources, estimation of irrigation water requirement, estimation of agricultural crop areas, status of irrigation water supply and irrigation water demand.

#### **Unit-V**

**Environmental Impact Assessment of River Valley Project:** Importance of River Valley Project, concept of environment – environment, environmental impact, environmental impact assessment. environmental benefits of river valley project - hydro-electric power, irrigation, drinking water supply, flood control, navigation. adverse environmental impact of river valley projects - submergence of agricultural land and human settlement, loss of forest, waterlogging problem, water pollution effect to flora and fauna. Remote Sensing as a tool in EIA of River Valley Projects – Monitoring, deforestation and afforestation in the river valley, identification of erosion prone areas, reservoir sedimentation, irrigation command area development, water pollution.

**Text Books:**

1. Bell, F.G., 1993 - Engineering Geology, Blackwell, Oxford.
2. Foiker, P.G., 1986 - Engineering Geomorphology. Chapman and Hall, New York.
3. Edward Goldsmith & Nicholas Hildyard (1986), The Social and Environmental Effects of Large Dams, Sierra Club Books, ISBN: 0-87156-848-9.
4. Gert A. Schultz, Edwin T. Engman (Editors) (2011), Remote Sensing in Hydrology and Water Management, Springer, ISBN 3642640362

**Reference Books:**

1. Ministry of Irrigation (1984). A guide for estimating Irrigation Water requirements, Govt. of India, Ministry of Irrigation, Water management division, New Delhi, Technical Series No. 2 (Revised), PP. 144.
2. Proceedings of National Symposium on Remote Sensing for Sustainable Development, 1992.
3. Remote sensing for Resource Development and Environmental Management. Vol. 2, by M.C.J. Damen, G. Siccosmit and H. Th. Verstapper.
4. The Social and Environmental Effects of Large Dams by E. Goldsmith & N. Nittildyard.
5. Balakrishnan, P., 1986. A technical report on issues in Water Resources Development and Management and the role of Remote Sensing. ISRO-NNRMS-TR67-86.

## **b. WATER RESOURCES MANAGEMENT**

### **Unit-I**

**Drought Monitoring:** Introduction and definition. Classification; meteorological drought, hydrological drought and agricultural drought. Factors affecting drought; climatic factor, soil factor, plant factor. Drought indicators; meteorological, hydrological, agriculture, delayed sowing, socio- economic indicators. Conventional drought monitoring - statistical analysis of rainfall data and water balance methods. Remote sensing approach for drought assessment.

### **Unit-II**

**Reservoir Sedimentation:** Introduction, effects of reservoir sedimentation, sediment deposition in reservoir, sediment distribution in reservoir, Remote Sensing and GIS based reservoir sedimentation studies. Discussion on a case study to compute reservoir volumes, including loss of storage capacity due to sedimentation using RS and GIS.

### **Unit-III**

**Flood Risk Zone Mapping and Flood Damage Assessment:** Introduction, need for Flood Risk Zone Mapping (FRZM), concept of FRZM. Estimation of flood peaks - Rational method, empirical method, unit hydrograph technique and flood frequency studies (Gumbel's method and Log Pearson Type - III method). Role of Remote Sensing and GIS approach in the preparation of risk zone maps.

### **Unit-IV**

**Site Suitability Analysis for Water Harvesting Structures** – Introduction, decision rules in suitable site selection for water harvesting structures as per IMSD guidelines. Input GIS layers; DEM, classified slope map, soil map, runoff potential map, buffer maps for proximity analysis, geological map, etc. GIS analysis for site selection.

### **Unit-V**

**Spatial information systems:** Introduction, organization and design of spatial and non-spatial data in water resources engineering. - characterization of spatial information systems, data quality, the time element, spatial objects. Spatial data models; raster and vector data models, Attribute data; spatial attributes, non-spatial attributes, attribute tables. Design of data base and its use and management in hydrology applications, Discussion on a case study.

### **Text Books:**

1. Banham carter, Graeme F. 1994. "Geographic Information Systems for Geoscientists: Modelling with GIS, Elsevier, 1994.
2. Handbook of Hydrology, Ministry of Agriculture (1972) Govt. of India, New Delhi.
3. Integrated Mission for Sustainable Development technical guidelines, National Remote Sensing Agency, 1995, Department of Space, Govt. of India.
4. Robert Laurini and Derek Thompson, 1992. "Fundamentals of Spatial Information Systems" (APIC Series), Academic Press, London, UK.

### **Reference Book:**

1. Anon (1991) "Integrated Approach to Flood Disaster Management and Rural Area Development" Water Resources Journal, ESCAP/UN, Bangkok, Thailand, PP 106.



## c. WATER RESOURCES ASSESSMENT

### Unit-I

**Water Resources Assessment:** Introduction to the role of remote sensing, water sector perspective. Water resources issues, minor irrigation tank inventory, snow-melt runoff forecasting, flood management, evaluation of water management in irrigation command area, watershed prioritisation for conservation planning.

### Unit-II

**Hydrologic Elements and Quantification:** Elements of hydrology. Introduction to quantification through remote sensing. Precipitation; Form of precipitation. Measurement of precipitation - Symon's rain gauge, self-recording type, radar, satellite data, cloud indexing techniques. Snow and its spectral characteristics, evapotranspiration, electromagnetic properties of soil moisture.

### Unit-III

**Hydromorphogeologic Mapping:** Groundwater exploration in consolidated material or hard rock terrain-introduction. Hills - Denudational Hill, Inselberg/ Residual Hill, Structural Hill, Denudo- Structural Hill, Dyke. Pediment Rock Cut Rolling Topography, Buried Pediment, Infilled Channels/Valley Fills. Hydromorphogeologic maps for targeting groundwater. Groundwater Exploration in Unconsolidated Material - Introduction, identification of landforms on unconsolidated materials using remote sensing data. Discussion on case studies.

### Unit-IV

**Surface Water Inventory:** Surface water resources, interaction of light and water, Visible data and LiDAR for water depth and penetration Studies. Identification of surface water – Sensors and their mapping capabilities. Applications of remote sensing for the identification of water bodies; Visual Methods and digital techniques.

### Unit-V

**Snowmelt Runoff Forecasting:** Introduction, Model types and their use for various hydrologic applications -Energy Balance Method.

### Text Books:

1. Manual of remote sensing, Vol. II chapter on “Water Resources Assessment”, American Society of Photogrammetry.
2. Gert A. Schultz, Edwin T. Engman (Editors) (2011), Remote Sensing in Hydrology and Water Management, Springer, ISBN 3642640362
3. Seidel K, Martinec J. 2004. Remote Sensing in Snow Hydrology: Runoff Modelling, Effect of Climate Change. Springer: Berlin.

### Reference Books:

1. Balakrishnan, P., 1986. A technical report on issues in Water Resources Development and Management and the role of Remote Sensing. ISRO-NNRMS-TR67-86
2. E.C. Barret, M.J. Beaumont & R.W. Herschy, (1990), Satellite remote sensing for Operational Hydrology, Remote Sensing Reviews, Vol 4(2), Pages 451-466 | Published online: 19 Oct 2009, <https://www.tandfonline.com/>
3. Mohsin Jamil Butt and Muhammad Bilal, (2011), Application of snowmelt runoff model for water resource management, Hydrological Processes, Hydrol. Process. 25, 3735–3747 (2011) Published online 29 April 2011 in Wiley Online Library.

#### **d. HYDROLOGY AND WATER RESOURCES ENGINEERING**

**Introduction:** Hydrology – definition and its importance, hydrological cycle, water budgeting, water demand estimation, surface water bodies, water content in ocean, sea, ice, lakes, dams, tanks, rivers and ground, water resource scenario in India, RS and GIS applications in water resources development and management.

**Meteorology, Glaciology and Surface Fresh Water:** Rainfall mapping, potential and actual evapo-transpiration, atmospheric water content, cloud mapping, rain forecasting, water quality parameters, cyclone forecasting; Glaciology: monitoring of snow melt and snow formation, snowmelt runoff estimation, estimation of damages; Surface Fresh Water: river diversion studies, site suitability for surface storages and hydro-electric power plants, storage yield analysis and reservoir sizing.

**Hydrograph analysis:** infiltration, effective rainfall, design storm, direct runoff hydrograph, unit hydrograph theory, derivation of runoff hydrograph from unit hydrograph; runoff analysis, rational method, NRCS approach, derivation of UG for ungauged catchments, synthetic unit hydrograph.

**Flood and drought studies:** flood frequency analysis, floodplain zoning, estimation of flood for different frequencies, flood forecasting, drought assessment and monitoring.

**Irrigation and Watershed:** Mapping and monitoring of catchment and command areas, land irrigability mapping, agriculture water demand estimation for different crops, tank information system, wetland mapping, siltation mapping; Watershed: delineation, morphometric analysis, rainfall-surface runoff model, reservoir sedimentation, water-harvesting structures, watershed development planning, mapping of drought prone areas.

#### **Text Books:**

1. GIS for Water Resources and Watershed Management - John G Lyon
2. Application of GIS in Hydrology and Water Resources Management - K.Kovar
3. Geographic Information Systems in Water Resources Engineering - Lynn E.Johnson
4. Developments In Water Science – Water Resources Systems Planning and Management - Jain S.K and Singh V.P.

#### **Reference Books:**

1. Water, Wastewater and Storm Water Systems - U.M. Shamsi
2. Introduction to Environmental Remote Sensing – Barrett E C
3. Remote Sensing principles and interpretation – Sabins F. F.
4. Remote Sensing and Image Interpretation – Thomas M Lillesand.

## **RS 2.4 Program Elective-IV**

### **a. URBAN & REGIONAL STUDIES**

#### **Unit-I**

**Basic concepts and mapping principles:** Terminology and Concepts of Urban and Regional Planning, Town Planning Practices in Developing Countries; Characteristics of Development/ Master/Zonal Plans. Regional Studies: Concepts, Resource Regions; Decentralized Planning. Concepts and components of Smart cities. Base Maps: Characteristics, Scale and Utility for Urban/Regional/District Planning; Cadastral Maps: Concepts, History and Geo-Referencing; Preparation of Building Footprint Map. Urban Land Use/Land Cover Classification System and Mapping, Accuracy Assessment.

#### **Unit-II**

**Urban Area Analysis and Modeling:** Urban Sprawl, Indices for Built-Up Area Extraction; Spatial Metrics, Urban Development Indicators. Urban Growth Models, Basic Concepts and Prediction of Future, Growth Pattern using CA-ANN, MCE-CA Models; Use of NightTime Light Data in Urban Studies. Census Operations, Basic Principles; Population Estimation through Remote Sensing, Updating of Population Data, Case Studies; Population Projection Techniques. 3D Modelling Techniques for Urban Surface Profiling: Concepts and Techniques of Space Use Mapping.

#### **Unit-III**

**Urban Resources and Regional Studies:** Urban Open Spaces and Green Spaces. Municipal GIS, RS and GIS for Property Tax Assessment; Tourism Resources. Renewable and Non-Renewable Energy Resources, Use of Geospatial Data for Solar and Hydro (In Hills) Energy Potential, Power GIS. Urban Heritage: Definition, Classification, Issues and Challenges; Mapping and Documentation, Damages and Disaster Risk Analysis. Basic Concepts Multi-Hazards, Risk and Vulnerability Assessment, Urban Hydrology and Flood Modelling.

#### **Unit-IV**

**Urban Services and Facility Analysis:** Geospatial Technologies for Urban Utility Mapping, Mobile Mapping and Mobile Apps for Facilities Mapping; Urban Water Supply. Suitability analysis for Infrastructure development. Service Area Analysis, Optimum Path Finding, OD Matrix, Location-Allocation of Urban Services, AM/FM, LBS. Urban and Regional Information Systems, Spatial data cube for urban environs.

#### **Unit-V**

**Urban Micro-climate environment and Advances techniques:** Urban Climate: Factors Affecting Urban Micro-climate, Impact of Urban Surfaces, Diseases and Human Health. Urban Pollution Studies. Thermal Images for Assessment of Urban Heat Island and other microclimatic problems. Solid Waste Management at Macro and Micro Level. Applications of advanced techniques (Hyperspectral, Microwave and UAV) Remote Sensing Data for Built-Up Area, Urban Features, and Material Characterization.

#### **Textbooks & References:**

1. Bracken, Ian (1981). Urban Planning Methods, Research and Policy Analysis. Mathew and Co., USA.
2. C.J.G. Morris (2005), Urban Heat Islands and Climate Change – Melbourne, Australia. School of Earth Sciences, The University of Melbourne, Victoria.
3. Sen, J. (2013). Sustainable Urban Planning. India: Energy and Resources Institute.
4. GIS in Sustainable Urban Planning and Management: A Global Perspective. (2018). Netherlands: CRC Press.
5. Kumar, M., Singh, R. B., Singh, A., Praves, R., Majid, S. I., Tiwari, A. (2023). Geographic Information Systems in Urban Planning and Management. Germany: Springer Nature Singapore.

## **b. GEOLOGICAL REMOTE SENSING**

### **Unit-I**

**Remote Sensing for Earth & Planetary Science:** Remote Sensing image interpretation for geological feature extraction. Overview of Thermal Remote Sensing for geological applications. Overview of Microwave Remote Sensing for geological applications. Overview of Planetary Geology studies using Remote Sensing Techniques.

### **Unit-II**

**Data Processing and Analysis for Geosciences:** Digital image enhancement techniques for geological applications. Hyperspectral image processing for rock and mineral characterization. Interferometric SAR data analysis for geological applications. Applications of DEM and DTM for geological and geomorphological studies.

### **Unit-III**

**Application of Remote Sensing in Mineral and Hydrocarbon Exploration:** Multi-spectral and Hyperspectral Remote Sensing for Mineral Exploration: selected case studies. Remote Sensing applications for hydrocarbon exploration. Applications of Remote Sensing for exploration of radioactive and unconventional mineral resources.

### **Unit IV**

**Remote Sensing applications in Applied and Tectonic Geomorphology:** Overview of geomorphological studies with emphasis on basic and applied geomorphological mapping. Glacial dynamics and climate change studies: monitoring of glacier and glacial lakes dynamics, impact of climate change and glacial hazards (GLOFs, Surging Glaciers and Avalanche). Earthquake Geology: Active Tectonics studies by geomorphological, geophysical (GPR and MASW: Ground Penetrating Radar and Multi-channel Analysis of Surface Waves) and geodetic techniques (DInSAR and GNSS) techniques.

### **Unit V**

#### **Application of Remote Sensing and GIS in Engineering Geology and Ground water**

Overview of engineering geology, rock strength and environmental impact assessment. Mapping, monitoring and modelling of landslides. Hydrogeological properties and groundwater prospect Zonation (RGNDWM), introduction to groundwater modelling in geospatial environment, assessment of change in groundwater storage using spaceborne (GRACE, INSAR) and in-situ (Geophysical & groundwater level) observations.

### **Textbooks & References:**

1. Gupta, R.P., (2003). Remote Sensing Geology, Springer Verlag, Berlin
2. Varshney, Pramod K., Arora & Manoj K. (2004). Advanced Image Processing Techniques for Remotely Sensed Hyperspectral Data, Springer.
3. K S Valdiya, (2009). The Making Of India: Geodynamic Evolution, Macmillan Publishers India
4. Bloom, A. L., (2004). Geomorphology: a systematic analysis of late Cenozoic landforms (3 rd Ed.). Waveland Pr Inc
5. Price, D.G. and Freitas, M. H. D., (2009). Engineering Geology: Principles and Practice. Springer
6. NRSC, (2009). Manual for National Geomorphological and Lineament Mapping on 1:50,000 scale.
7. Jensen, J.R., (1996). Introductory Digital Image Processing (3rd edition). Prentice Hall

## **c. GIS FOR UTILITIES**

### **Unit-I**

Introduction to Utilities and Geoinformatics. Introduction to utility sectors (water, electricity, gas, telecommunications). Historical context: How utilities have evolved and the role of technology. Significance of geoinformatics in utility management. Benefits and challenges of using geospatial technologies in utilities.

### **Unit-II**

Overview of data collection technologies used in utility mapping. (Remote sensing, Aerial Surveys, GPS, LiDAR, Ground Surveys). Data sources specific to utility sectors. IoT Sensors. Data Integration Techniques for Utility mapping.

### **Unit-III**

Asset Mapping and Management. Utility asset inventory and mapping: Principles and practices. Using GIS for asset management (e.g., utility networks, substations). Maintenance scheduling and tracking using geospatial data. Asset lifecycle management and cost optimization. Real-time asset monitoring and sensor integration. Hands-on exercises on asset mapping and management using GIS tools.

### **Unit-IV**

Spatial Analysis for Utilities. Spatial analysis techniques for optimizing utility operations. Network analysis for routing, distribution, and connectivity in utilities. Spatial analysis in demand forecasting and load management. Risk assessment and emergency response using geospatial data. Environmental impact assessment in utilities. Practical application of spatial analysis tools for utilities.

### **Unit-V**

Geoinformatics Applications in Utilities. Remote sensing applications in monitoring utility infrastructure. Decision support systems and geospatial analytics for utilities. Case studies in utilities management: Water distribution and wastewater management. Electric power grid monitoring. Natural gas and pipeline management. Telecommunications network optimization.

### **Textbooks:**

1. Heywood, J. D., Furious, J. S., Jr., & Wemple, S. C. (2011). Geographic information systems and science (GIS&T): A Wiley-Blackwell companion. John Wiley & Sons.
2. Barnsley, M. J. (2016). Geospatial analysis: A comprehensive guide with case studies. (2nd ed.). Routledge.
3. Environmental Systems Research Institute (ESRI Press). (2012). GIS for asset management: A practical guide. Esri Press.
4. Borland, M. J. (2003). Utility asset management: A practical guide to implementing, operating, and optimizing asset management systems. McGraw-Hill.
5. Wang, Y., & Lin, J. (2016). Geoinformatics for sustainable infrastructure: A practical guide. Springer
6. Muller, R. A. (2013). GIS applications in water, wastewater, and stormwater management. (2nd ed.). Routledge.
7. Meehan, B. (2013). GIS for Enhanced Electric Utility Performance. United States: Artech House.

## **d. GIS FOR TRANSPORTATION ENGINEERING**

### **Unit-I**

**Traffic Engineering Studies and Analysis:** Objectives, Sampling in traffic studies, sample size; Data collection, analysis and interpretation -Spot speed, Speed and delay, Volume, Origin – destination, Parking. Concept of PCU, Factors affecting capacity and level of service, Types of maneuvers and conflict points.

### **Unit-II**

**GIS based Spatial Analysis and Modeling:** GIS and spatial Analysis; Urban sprawl; GIS Analytical functions; Coupling Transportation Analysis and Modeling with GIS; Customizing GIS; Supporting Advanced Transportation Analysis in GIS.

### **Unit-III**

**Transportation Planning using GIS:** Travel Demand Estimation-Application of GIS, Traffic Analysis Zone (TAZ) and screen lines, Four Stage Planning Process (Brief description only), Network representation of a transportation System, Shortest Path determination, GIS based Transportation Planning, Spatial and Non spatial data for land use and transportation.

### **Unit-IV**

**ITS: Introduction to Intelligent Transport System:** Components of ITS, Application of ITS to Traffic Management System- Public Transportation Management System, Application of GIS in vehicle routing analysis and visualizations of traffic data in GIS, Integration of GPS and GIS, Travel time analysis using GPS-GIS integration.

### **Unit-V**

**GIS – T Data Models:** Data Domains and Data Modeling in GIS – T; Data Modeling and Design Issues; Graph Theory and Network Analysis; Network representation of a Transportation System; Linear referencing methods and systems; Transportation Data Models for ITS. GIS-T applications: Scope of TransCAD and EMME in Transportation Planning (Introduction only).

### **Text Books:**

1. Hensher D. A., Button K. J., Haynes K. E., and Stopher P. R. (Eds.), Handbook of Transport Geography and Spatial Systems”, Elsevier, 2004.
2. Thill Jean-Claude, Geographical Information Systems in Transportation Research, Pergamon, 2000.
3. Caliper Corporation, Travel Demand Modeling with TransCAD, 2009.
4. Hutchinson, B. G., Principles of Urban Transportation Planning, McGraw Hill, 1979
5. Kadiyali, L.R.Traffic Engineering and Transportation Planning, Khanna Publishers

### **Reference Books:**

1. Longley P. A., Barnsley M. J., Donnay Jean-Paul, Remote Sensing and Urban Analysis, Taylor & Francis, 2001

## **RS 2.5 DIGITAL IMAGE PROCESSING PRACTICAL**

1. Introduction to ERDAS Imagine Software. (Importing data, Visualization)
2. Image stacking, subsetting, Mosaicking, and Image statistics
3. Georeferencing / Image rectification (Map rectification, Map to Image, Image to Image)
4. Image Enhancement Techniques (Histogram equalization, Contrast Enhancement, Density Slicing)
5. Image Filtering Techniques (High pass, Low pass, Edge Enhancement)
6. Principal Component Analysis, Image Fusion techniques
7. Image Indices
8. Image Classification (Unsupervised, Supervised)
9. Change detection studies
10. Accuracy Assessment.

## **RS 2.6 PYTHON & JAVASCRIPT PRACTICAL**

### **(A) PYTHON PRACTICALS**

1. Read a Geo-TIFF image using rasterio and display it using matplotlib
2. Calculate basic statistics (mean, median, standard deviation) of pixel values in a satellite image
3. Generate a histogram to visualize the distribution of pixel values in a satellite image
4. Apply histogram equalization to enhance the contrast of a satellite image
5. Apply a Gaussian filter to reduce noise and smooth a satellite image
6. Calculate NDVI from a multi-band satellite image and visualize it as a grayscale image
7. Perform image differencing to detect changes between two satellite images and visualize the change map
8. Read and visualize a shapefile using geopandas
9. Perform a spatial query (e.g., point in polygon) on a shapefile
10. Implement a simple supervised classification using pixel values and reference data to classify a satellite image.

### **(B) JAVASCRIPT PRACTICALS**

1. Create an interactive map using Leaflet.js and add a georeferenced satellite image as a raster layer.
2. Add multiple image bands as layers to the Leaflet map and allow users to toggle layers on and off.
3. Implement a slider to control the transparency of image layers, enabling users to visualize different bands simultaneously.
4. Enhance the map with markers representing specific points of interest and display additional information when clicking on them.
5. Calculate NDVI using JavaScript and pixel values from image bands and display NDVI values on the map using color gradients.
6. Display two images side by side and visualize the changes between them using a slider that transitions between images and highlights changes
7. Integrate a search feature to find specific locations on the map and display coordinates and related information for the selected location.
8. Enable users to explore a time series of satellite images using a slider that updates the map with images corresponding to the selected time period.
9. Implement custom polygon drawing functionality on the map and calculate statistics within the drawn polygon area.
10. Combine multiple features from previous exercises to create a comprehensive remote sensing web application, including image display, NDVI computation, change detection, and interactive features.



## **RS 2.7 REMOTE SENSING-II PRACTICAL**

1. SAR data download and preprocessing.
2. Generation of interferogram and coherence from SAR imagery.
3. Data fusion of SAR and optical datasets.
4. Thermal data analysis (Calibration and atmospheric corrections, UHI).
5. Spectral signature analysis with hyperspectral data.
6. LIDAR data processing, classification and DTM, DSM generation.
7. Multi-sensor data fusion.
8. Time series analysis.
9. UAV data processing.

## **Audit Course**

### **RS 2.8 CLOUD-BASED GEOSPATIAL ANALYSIS**

**Introduction:** Google Earth Engine (GEE) is a cloud-based platform for planetary scale geospatial data analysis and communication. By placing more than 17 petabytes of earth science data and the tools needed to access, filter, perform, and export analyses in the same easy to use application, users are able to explore and scale up analyses in both space and time without any of the hassles traditionally encountered with big data analysis. Constant development and refinement have propelled GEE into one of the most advanced and accessible cloud-based geospatial analysis platforms available, and the near real time data ingestion and interface flexibility means users can go from observation to presentation in a single window.

#### **Exercises:**

1. Getting started with Google Earth Engine. Basics of Java Script
2. Understanding band combinations and image visualizations
3. Calculating Spectral Indices (NDVI, NDWI)
4. Image Classification
5. Classification Validation & Accuracy Assessment
6. Monitoring Vegetation changes over time
7. Working with SAR data in Google Earth Engine

#### **References:**

1. <https://spatialthoughts.com/courses/google-earth-engine/>
2. <https://tutorials.geemap.org/>

## **THIRD SEMESTER**

### **RS 3.1 Program Elective-V**

#### **a. DRONE & UAV REMOTE SENSING**

##### **Unit-I**

**Introduction:** UAV Remote Sensing and surveying - Historical Development. Types of Drones/UAVs. Basic components of a Drone/UAV system. Basics of aerodynamics relevant to drones.

##### **Unit 2:**

**Payloads and Onboard Sensors:** Payloads on Drones. Sensors-RGB, Multispectral, Hyperspectral, Thermal and LIDAR sensors. Advantages and Disadvantages.

##### **Unit 3:**

**Mission Planning and Data Acquisition:** Flight planning considerations. Manual and Autonomous Mission Planning. Software tools for flight planning and simulation. Regulations and guidelines for UAV operation.

##### **Unit 4:**

**Data Processing:** Data collection and storage from UAVs. Basics of point clouds and digital elevation models (DEMs). Image stitching. Generation of Ortho mosaics, Digital elevation models, Point Clouds and 3D models.

##### **Unit 5:**

**Applications:** Drone Remote Sensing in Utilities, Construction and Infrastructure Management, Drone Remote Sensing in Oil and Gas Industry, Drone Remote Sensing in Precision Agriculture, Drone Remote Sensing in Marine Projects, Drone Remote Sensing in Surveying and 3D City Models, Drone for Surveillance and Search & Rescue, UAV Humanitarian Applications, Archaeological Applications.

##### **Text Books:**

1. Barnhart, R., Michael, M., Marshall, D., and Shappee, E. ed. 2016. Introduction to Unmanned
2. Aircraft Systems, 2nd edition. Boca Raton. CRC Press. Fahlstrom, P. and Gleason, T. 2012. Introduction to UAV Systems. 4th edition. United Kingdom. John Wiley & Sons Ltd.

##### **Reference Books:**

1. Wolf, P., DeWitt, B., and Wilkinson, B. 2014. Elements of Photogrammetry with Applications in GIS, 4th edition. McGraw-Hill.

## **b. CLIMATE CHANGE STUDIES**

### **Unit-I**

Fundamentals of Climate: Introduction to climate science and global climate systems; Historical climate change trends and observations; Climate models and climate change scenarios; Understanding climate change impacts on ecosystems and societies.

### **Unit-II**

Remote Sensing Sensors and GIS for Climate Studies and Methods: Selection criteria for Remote Sensing sensors in climate studies; Various sensors and data types for climate study. Advanced GIS techniques for climate analysis: spatial analysis, geoprocessing, and modeling; Spatial data management and integration in climate research; GIS-based climate modelling approaches; Case studies on GIS applications in climate studies.

### **Unit-III**

Monitoring Climate Variables: Remote sensing applications for monitoring climate variables: Temperature monitoring using thermal infrared data; Precipitation estimation from satellite data; Vegetation health assessment using NDVI; Sea-level rise monitoring with radar altimetry; GIS- based climate variable monitoring techniques; Integration of Remote sensing and GIS for comprehensive climate monitoring.

### **Unit-IV**

Climate Change Preparedness and Adaptation: Climate vulnerability assessment: identifying at-risk regions and populations; Developing climate adaptation strategies at the local and regional levels; Climate resilience planning and policy development; Incorporating GIS-based data and tools into adaptation strategies.

### **Unit-V**

Advanced Trends in Remote Sensing and GIS: Hyperspectral remote sensing and its applications in climate monitoring; Lidar technology and its role in assessing climate-related phenomena (e.g., forest canopy heights, coastal erosion); Machine learning and AI applications in climate modeling; Advanced spatial statistics for climate analysis. Climate Change Data Visualization: Effective data visualization techniques for communicating climate data; Creating interactive GIS-based climate maps and dashboards; Storytelling with data: Crafting compelling narratives on climate change impacts through visualization; Data visualization tools and software for climate change monitoring.

### **Text Books:**

1. Climate Change Science: A Modern Synthesis by G. Thomas Farmer and John Cook
2. Remote Sensing and Image Interpretation by Thomas Lillesand, Ralph W. Kiefer, and Jonathan Chipman
3. GIS Fundamentals: A First Text on Geographic Information Systems by Paul Bolstad
4. Remote Sensing and GIS for Ecologists: Using Open Source Software by Martin Wegmann
5. Climate Resilience and Adaptation Planning: An Integrated Approach by Rohit Jigyasu and Mariko Sato
6. Advanced Remote Sensing: Terrestrial Information Extraction and Applications by Shunlin Liang and Xiaowen Li
7. Data Points: Visualization That Means Something by Nathan Yau.

## **c. HEALTH GIS**

### **Unit-I**

**Introduction to GIS and Public Health:** Introduction to GIS and its applications in public health. Basic concepts of spatial data and geographic information. Public health challenges and the role of GIS. Importance of geospatial analysis in understanding public health issues. Overview of GIS software and tools used in public health research

### **Unit-II**

**Data Collection and Management in Public Health GIS:** Data sources for public health GIS: health data, demographic data, environmental data. Data collection methods: surveys, remote sensing, GPS. Data preprocessing and georeferencing techniques. Data quality and data integration challenges in public health GIS.

### **Unit-III**

**Spatial Analysis for Public Health:** Spatial interpolation techniques for health data visualization. Disease mapping and hotspot analysis. Proximity analysis: buffer zones and spatial relationships. Accessibility analysis for healthcare facilities and services

### **Unit-IV**

**Epidemiological Applications of GIS:** Spatial epidemiology: Exploring disease-environment relationships. Disease mapping concepts: Incidence, prevalence, and rates Exploring disease patterns using spatial statistics Spatial modeling of disease transmission and spread. Disease surveillance and outbreak detection using GIS. Analyzing health disparities and social determinants of health spatially

### **Unit-V**

**Public Health Decision-Making and Visualization:** Public health surveillance and early warning systems. GIS in health planning: Site selection and resource allocation. Equity analysis: Identifying vulnerable populations and disparities. Visualizing public health data on maps and dashboards. Geovisualization techniques: choropleth maps, heatmaps, time series. Communicating spatial information to stakeholders. Integrating GIS into public health policy and interventions.

### **Textbooks:**

1. "GIS for the Health Professions" by Terry A. Bloyd and Gary A. Spoelma.
2. "GIS Tutorial for Health" by Kristen S. Kurland and Wilpen L. Gorr.

### **Additional Resources:**

1. Public health datasets, case studies, and real-world examples.
2. Online tutorials and resources for GIS and public health integration.
3. GIS software documentation and tutorials.

## **d. AIRBORNE AND TERRESTRIAL LIDAR**

### **Unit-I**

**Laser and space-borne laser profilers:** Components of LASER: Active Material, Energy Source, Reflection Mirror – LASER Production- LASER Classification: Eye Safety, Class I to Class IV Lasers - Comparison of Various methods of deriving terrain height – LASER RANGING- Types of LiDAR: Range Finder LiDAR, Doppler LiDAR, DIAL – Principles of Laser Ranging: Pulse Laser, Continuous Wave Laser – Space Borne Laser Missions – GeoScience Laser Altimeter System (GLAS), LiDAR In-Space Technology Experiment (LITE), Chandrayan.

### **Unit-II**

**Airborne laser scanners:** Components of Airborne Laser Scanning System – GPS, IMU, LASER Scanner, Position and Orientation System (PoS) – Types of Scanning Mechanism and Ground Measuring Pattern – Synchronization of Laser Scanner and PoS- LASER Scanners Specification and Salient Features – Concept of Multi return – 3D Cloud Points – Reflectivity of Ground features – Range Correction Factor.

### **Unit-III**

**LiDAR data processing:** Pre-Processing: Direct Georeferencing, Combining Inertial and Navigation Data - Determination of Flight Trajectory - Data processing – Coordinate Transformations – Geolocating Laser footprints – Strip Adjustment – Digital Surface Model to Digital Elevation Model: Filtering, Ground Point Filtering – Flight Planning – Quality Control Parameters – Preparation of flight plan.

### **Unit-IV**

LiDAR data management and applications: Airborne Laser Scanner Error Sources - LiDAR data format: ASCII vs Binary, LAS Format – Software used for LiDAR data processing and management – Merits of Airborne Laser Terrain Mapping - Overview of LiDAR Applications - 3D city models – Road and Building Extraction – Forestry Applications – Power Line Mapping.

### **Unit-V**

**Terrestrial and bathymetric laser scanner:** Terrestrial LiDAR: Static and Mobile (Vehicle Mounted) LiDAR -Terrestrial LASER Scanner Specification – Applications of Terrestrial LASER Scanning –Bathymetric LASER Scanner – Specification – Depth of Penetration: Secchi Depth – Applications of Bathymetric LASER Scanner.

### **Text Books:**

1. Jie Shan and Charles K., Topographic laser ranging and scanning: principles and processing, CRC Press, Taylor & Francis Group, 2008
2. Mathias Lemmens, Laser Altimetry: Principles and Applications, CRC Press 2006.
3. Roger Read and Ron Graham, Manual of Aerial Survey: Primary Data Acquisition, Whittles Publishing, 2002.

**Reference Books:**

- i. Zhilin Li Qing Zhu, Chris Gold, Christopher Gold, and Digital Terrain Modeling: Principles and Methodology, CRC Press, 2004.
- ii. Zhilin Li, Jun Chen, Emmanuel Baltsavias, Advances in Photogrammetry, Remote Sensing and Spatial Information Sciences, CRC Press; 1 edition, 2008
- iii. Percival, H.F. Small unmanned aircraft systems for low-altitude aerial surveys. J. Wildl. Manage

## **RS 3.2 Open Elective**

### **a.WebGIS Development**

#### **Unit-I**

**Introduction to WebGIS and Web Development:** Introduction to WebGIS: Concepts, advantages, and applications. Overview of web development technologies: HTML, CSS, JavaScript. Role of WebGIS in spatial data visualization and analysis. Introduction to web mapping libraries and frameworks. Setting up a development environment: Code editors, version control.

#### **Unit-II**

**Frontend Development for WebGIS:** HTML basics: Structure, elements, Styling, Tags and Layouts. Styling with CSS: Selectors, properties, responsive design. Introduction to JavaScript: Variables, data types, functions.

#### **Unit-III**

**Mapping, Spatial Analysis and Geospatial Visualization:** Introduction to mapping libraries: Leaflet, Mapbox, OpenLayers. Creating interactive maps: Adding layers, markers, popups and interactive features. Geospatial data visualization using web-based maps. Spatial analysis on the web: Buffering, overlay, proximity analysis. Interactive queries and filtering of geospatial data. Implementing routing and directions using routing APIs. Displaying charts and graphs based on geospatial data.

#### **Unit-IV**

**Backend Development and APIs:** Introduction to backend development: Server, database, APIs. Back end or Server-side scripting technologies : Node.js, Express.js. Building RESTful APIs for data retrieval and manipulation. Data formats: GeoJSON, JSON, XML.

#### **Unit-V**

**WebGIS Application Development:** Integrating the frontend and backend using AJAX or Fetch API. Authentication and user management in WebGIS applications. Introduction to GIS database integration (PostgreSQL, PostGIS). Working with geospatial data services (WMS, WFS, GeoJSON). Developing a complete WebGIS application: Data display, interaction, and analysis. Deploying WebGIS applications: Hosting options and considerations.

#### **Textbooks:**

1. "Leaflet.js Essentials" by Paul Crickard III
2. "Full Stack Web Development with Node.js" by Colin J. Ihrig and Adam Bretz.

#### **Additional Resources:**

1. Online tutorials, documentation, and resources for web development and WebGIS
2. Access to web mapping libraries and APIs (e.g., Leaflet.js, Mapbox, OpenLayers)
3. Code editors or integrated development environments (IDEs) for web development.



## **b. SPATIAL DATA WAREHOUSING AND DATA MINING**

### **Unit-I**

**Introduction to Data Warehousing and Big Data:** Data warehousing fundamentals: Data warehousing architecture, Data warehousing vs. traditional databases. Big data concepts: The 5 Vs of big data (Volume, Velocity, Variety, Veracity, Value), Challenges in handling geospatial big data. Remote Sensing and GIS applications: Use cases where data warehousing and big data are crucial, Geospatial analytics in disaster management and urban planning

### **Unit-II**

**Data Warehousing for Geospatial Data:** Design principles of data warehouses: Star schema and snowflake schema, Fact and dimension tables in geospatial context. ETL processes for geospatial data: Data extraction techniques for remote sensing imagery, Transformation and geospatial data preparation, Loading geospatial data into data warehouses. Data modelling and schema design: Designing geospatial data models, Handling metadata and spatial indexes. Spatial OLAP (Online Analytical Processing) for geospatial data analysis: Multidimensional data cubes for geospatial insights.

### **Unit-III**

**Big Data Management and Storage:** Scalable storage solutions: Distributed file systems (e.g., Hadoop HDFS), Cloud-based storage for geospatial big data. NoSQL databases for geospatial applications: Document-based (e.g., MongoDB) and column-family databases (e.g., Cassandra), Geospatial indexing and querying. Handling spatiotemporal data: Data compression techniques for efficient storage, Time-series data storage and retrieval

### **Unit-IV**

**Data Mining Techniques for Geospatial Analysis,** Data mining concepts and algorithms: Clustering techniques (e.g., k-means, DBSCAN) for spatial pattern recognition, Classification algorithms (e.g., decision trees, SVM) for land cover mapping, Association rule mining for spatial relationships. Spatial data preprocessing: Data reduction and sampling methods, Outlier detection and treatment. Geospatial data visualization: Effective visualization techniques for spatial data' Interpretation of data mining results using maps and plots.

## **Unit-V**

**Applications of Data Mining in Remote Sensing & GIS:** Predictive modeling for environmental monitoring: Using data mining for climate prediction and natural disaster risk assessment. Land cover classification using data mining: Techniques for automatic land cover mapping, Case studies in land use/land cover change detection. Spatial pattern recognition and anomaly detection: Identifying spatial outliers in environmental data, Detecting anomalies in satellite imagery. Case studies and real-world projects: Data mining applications in various geospatial domains

### **Textbooks:**

1. Data Warehousing Fundamentals for IT Professionals by Paulraj Ponniah.
2. The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling by Ralph Kimball and Margy Ross.
3. Hadoop: The Definitive Guide; by Tom White.
4. NoSQL for Mere Mortals by Dan Sullivan.
5. "Data Mining: Concepts and Techniques" by Jiawei Han, Micheline Kamber, and Jian Pei.
6. "Principles of Data Mining" by Max Bramer.

### **Reference Material:**

1. "Big Data: A Revolution That Will Transform How We Live, Work, and Think" by Viktor Mayer-Schönberger and Kenneth Cukier.
2. "Building the Data Warehouse" by W. H. Inmon.
3. "The Data Warehouse ETL Toolkit" by Ralph Kimball.
4. "Hadoop Operations" by Eric Sammer.
5. "Designing Data-Intensive Applications" by Martin Kleppmann.
6. "Spatial Data Mining and Geographical Knowledge Services" edited by Shuliang Wang, Lixin Li, and Zhong Su.
7. "Data Mining for Geoinformatics: Methods and Applications" edited by Guido Cervone and Jessica Lin.
8. "Geospatial Analysis: A Comprehensive Guide" by Michael J. de Smith, Michael F. Goodchild, and Paul A. Longley.
9. "Remote Sensing Image Analysis: Including the Spatial Domain" by Paul Mather and Magaly

## **c. SPATIAL RELATIONAL DATABASE MANAGEMENT SYSTEMS**

### **Unit-I**

Introduction to SRDBMS: Evolution and history of spatial databases. Key components of SRDBMS architecture. Comparative analysis of popular SRDBMS platforms (e.g., PostgreSQL/PostGIS, Oracle Spatial, Microsoft SQL Server). Spatial data standards and formats (e.g., OGC standards, GeoJSON, Shapefile). Case studies of SRDBMS applications in remote sensing and GIS projects.

### **Unit-II**

Designing Geospatial Databases: Advanced data modeling for spatial databases. Hierarchical, network, and object-oriented data models, Schema design for multidimensional spatial data, Spatial data quality and accuracy considerations in database design, Spatial indexing techniques (e.g., R-tree, Quadtree) and their implementation, Denormalization strategies for optimizing geospatial queries, Practical exercises in geospatial database design and normalization.

### **Unit-III**

Data Management in SRDBMS: Data loading and transformation for geospatial datasets: ETL processes for remote sensing data. Spatial data loading tools and best practices. Managing large volumes of geospatial data: Data partitioning and sharding, Data compression techniques Versioning and change detection in geospatial databases Security models, and access control for spatial data. Hands-on experience in data management tasks using SRDBMS.

### **Unit-IV**

Querying and Analysis with SRDBMS: Advanced SQL for spatial data. Spatial query operators (e.g., ST\_Contains, ST\_Intersects), Geospatial functions and expressions, Combining spatial and non-spatial queries. Spatial analysis with SRDBMS: Buffering and proximity analysis, Spatial joins and overlays, Network analysis and routing. Geospatial data visualization techniques: Creating dynamic maps and reports, Integration with GIS software (e.g., QGIS, ArcGIS), Querying and analyzing geospatial data.

### **Unit-V**

Advanced Topics and Applications: Spatial data mining and knowledge discovery. Clustering and classification of spatial data. Association rule mining for geospatial patterns, Integration of SRDBMS with GIS software and web applications: Building web-based mapping applications, Real-time data streaming and sensor integration. Case studies and projects in advanced geospatial database applications: Environmental monitoring and modelling, Urban planning and smart cities, Disaster management and response.

**Textbooks:**

1. "Geographic Information Systems and Science" by Paul A. Longley, Michael F. Goodchild, David J. Maguire, and David W. Rhind.
2. "Geospatial Databases: Concepts, Design, and Management" by Mike Hinchey and David O'Sullivan.
3. "PostGIS in Action" by Regina O. Obe and Leo S. Hsu.

**Reference Material:**

1. "Spatial Databases: With Application to GIS" by Philippe Rigaux, Michel Scholl, and Agnès Voisard.
2. "Geographic Information Systems and Science" by Paul A. Longley, Michael F. Goodchild, David J. Maguire, and David W. Rhind.
3. "Principles of Geographic Information Systems" by Peter A. Burrough and Rachael A. McDonnell.
4. "Spatial Database Systems: Design, Implementation and Project Management" by Albert K. W. Yeung and Tung X. Bui.
5. "Geospatial Analysis: A Comprehensive Guide" by Michael J. de Smith, Michael F. Goodchild, and Paul A. Longley.
6. "Database Systems: Concepts, Design, and Applications" by Shio Kumar Singh.
7. "PostGIS in Action" by Regina O. Obe and Leo S. Hsu.
8. "Introduction to Geographic Information Systems" by Kang-tsung Chang.
9. "Data Mining for Geoinformatics: Methods and Applications" edited by Guido Cervone and Jessica Lin.

## **d. DIGITAL CARTOGRAPHY**

### **Unit-I**

Introduction to Cartography. Map Design Principles: Hierarchy of map elements, Typography and font selection, Color theory in cartography, Labeling and annotation guidelines. Evolution of Cartographic Tools: From hand-drawn maps to digital cartography, Historical maps and their significance, The role of cartography in contemporary society. Ethical considerations in map design, including issues related to representation, bias, and the impact of maps on decision-making.

### **Unit-II**

Map Elements and Layout. Advanced Map Projections: Conic, cylindrical, and azimuthal projections, Equal-area vs. conformal projections, Specialized projections for thematic mapping (e.g., Albers Equal Area, Lambert Conformal Conic). Layout Design: Grids and graticules for map organization, Legends for complex datasets, Design principles for multi-map layouts (e.g., atlas design).

### **Unit-III**

Data Visualization and Representation. Multivariate Mapping: Techniques for representing multiple variables on a single map, Bivariate and multivariate symbolization, Use of small multiples and thematic maps with insets. Advanced Data Classification: Beyond basic classification methods, including natural breaks, quantile, and custom classification, Dynamic classification for web mapping, Spatial statistics for data-driven classification Geovisualization: Time-series visualization and animation, 3D modeling and terrain representation, Virtual reality (VR) and augmented reality (AR) in cartography.

### **Unit-IV**

OpenSource Mapping Tools: In-depth exploration of QGIS and other open-source GIS software, Customization and extensions in open-source mapping environments. Web Mapping APIs and Libraries: Introduction to JavaScript-based mapping libraries (e.g., Leaflet, OpenLayers), Creating custom web maps with interactivity and user-driven features, Mobile Mapping : Collecting and editing geospatial data in the field, Integration of mobile mapping apps with cloud-based GIS platforms, Augmented reality (AR) applications for mobile mapping.

### **Unit-V**

Big Data in Cartography: Handling and visualizing large geospatial datasets, Big data analytics and spatial data mining, Scalable mapping solutions for big data. AI and Machine Learning in Cartography: Automated feature detection and extraction, Machine learning for image classification and object recognition, Incorporating AI-driven insights into cartographic design. Emerging Technologies: Location-based services (LBS) and real-time mapping, Blockchain and geospatial applications, The role of 5G and IoT in digital cartography.

**Text Books:**

1. Thematic Cartography and Geo visualization by Terry A. Slocum, Robert B. McMaster, Fritz C. Kessler, and Hugh H. Howard
2. Map Design for Visual Learners by Jon Kimerling, Aileen R. Buckley, Phillip C. Muehrcke, and Juliana O. Muehrcke
3. Web Cartography: Map Design for Interactive and Mobile Devices by Ian Muehlenhaus
4. Landscape Ecology Principles in Landscape Architecture and Land-Use Planning by Wenche Dramstad, James D. Olson, and Richard T.T. Forman
5. GIS Tutorial 1: Basic Workbook by Wilpen L. Gorr and Kristen S. Kurland
6. Cartography: Visualization of Spatial Data by Menno-Jan Kraak