DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY, UTTAR PRADESH, LUCKNOW

Syllabus

For

M.Tech. (Remote Sensing and GIS)

(Effective from the Session: 2016-17)

SCHEME OF EVALUATION & COURSE STRUCTURE

Course Structure and Evaluation Scheme for M.Tech. Courses (Remote Sensing and GIS)
(from session 2016-17)

SEMESTER I

S. N.	Subject Code	Name of the Subject	Periods			Credit	Evaluation Scheme					Subject Total
							Theory			Practical		
			L	T	P		CT	TA	ESE	TA	ESE	
1.	MTRG-101	Photogrammetry & Remote Sensing	3	0	0	3	20	10	70	--	--	100
2.	MTRG-102	Geographical Information System	3	0	0	3	20	10	70	--	--	100
3.		Elective-I:	3	0	0	3	20	10	70	--	--	100
4		Elective-II:	3	0	0	3	20	10	70	--	--	100
5	MTCC-101	Research process & Methodology	3	0	0	3	20	10	70	--	--	100
6	MTRG-151	Photogrammetry & Remote Sensing	-	-	3	2	--	--	--	20	30	50
7	MTRG-152	Geographical Information System	-	-	2	1	--	--	--	20	30	50
Total						**18**						**600**

SEMESTER II

S. N.	Subject Code	Name of the Subject	Periods			Credit	Evaluation Scheme					Subject Total
							Theory			Practical		
			L	T	P		CT	TA	ESE	TA		
1.	MTRG-201	Digital Image Processing	3	0	0	3	20	10	70	--	--	100
2.	MTRG-202	Global Positioning System	3	0	0	3	20	10	70	--	--	100
3.		Elective-III:	3	0	0	3	20	10	70	--	--	100
4		Elective-IV:	3	0	0	3	20	10	70	--	--	100
5		Elective-V:	3	0	0	3	20	10	70	--	--	100
6	MTRG-251	Digital Image Processing & GPS	-	-	3	2	--	--	--	20	30	50
7	MTRG-252	Seminar-I	-	-	2	1	--	--	--	50	--	50
Total						**18**						**600**

SEMESTER III

S. N.	Subject Code	Name of the Subject	Periods			Credit	Evaluation Scheme					Subject Total
							Theory			Practical		
			L	T	P		CT	TA	ESE	TA	ESE	
1.	MTRG-351	Seminar-II	0	0	6	3	--	--	--	--	100	100
2.	MTRG-352	Dissertation	0	0	30	15	--	--	--	200	300	500
Total						**18**						**600**

SEMESTER IV

S. N.	Subject Code	Name of the Subject	Periods			Credit	Evaluation Scheme					Subject Total
							Theory			Practical		
			L	T	P		CT	TA	ESE	TA	ESE	
1.	MTRG-451	Dissertation (Final)	0	0	36	18	--	--	--	200	400	600
Total						**18**						**600**

NOTE:

For dissertation, the students are required to compile a report including title of the dissertation, literature review, methodology of work to be pursued and activity schedule in the III Semesters. The compiled report shall be presented at the end of the III semester. Same dissertation shall be continued in the IV semester and dissertation work (final) shall be submitted to AKTU at the prior to end of the IV semester.

ELECTIVE - I

1. MTRG-011 Applications of Remote Sensing in Geosciences
2. MTRG-012 Remote Sensing & GIS for Hydrology and Water Resources
3. MTRG-013 Remote Sensing & GIS for Urban Planning and Management

ELECTIVE -II

1. MTRG-021 Applications of Remote Sensing in Natural Sciences
2. MTRG-022 Remote Sensing & GIS for Agriculture & Forestry
3. MTRG-023 Sustainable Agriculture

ELECTIVE - III

1. MTRG-031 Thermal and Hyper spectral Remote Sensing
2. MTRG-032 Advanced Remote Sensing Techniques
3. MTRG-033 Emerging Trends in Geoinformatics

ELECTIVE -IV

1. MTRG-041 Natural and Man-made Disasters
2. MTRG-042 Disaster Preparedness
3. MTRG-043 Disaster response and disaster management

ELECTIVE-V

1. MTRG-051 Environmental Monitoring and Assessment
2. MTRG-052 Environmental pollution
3. MTRG-053 Environment and Natural Resources

DETAILS OF COURSES

SEMESTER - I

PAPER 1

MTRG-101 PHOTOGRAMMETRY & REMOTE SENSING

Theory: Definition and terms, history of photogrammetry, concepts, principles and types of photogrammetry, types of aerial photographs vertical photographs, tilted photographs, orthophotographs, aerial cameras, geometry and scale orientation and measurements, distortions, displacements and their corrections, rectification and orthophotographs,

Basic Principles of Remote Sensing : Physics of remote sensing, Characteristics of electro-magnetic radiation; Interactions between matter and electro-magnetic radiation; energy interaction in the atmosphere; energy interactions with the earth's surface-spectral reflectance curves. Types of remote sensing with respect to wavelength regions; active and passive remote sensing, Sensor types characteristics: imaging systems, photographic sensors, characteristics of optical sensors; FOV, IFOV; Sensor resolution - spectral, spatial, radiometric and temporal; Dispersing element; Spectroscopic filter; Spectrometer; Characteristic of optical detectors; imaging sensors, Thermal sensors; Atmospheric sensors; Sonar; Laser, radar, hyperspectral sensors. Products from scanner data, Image data characteristics, data selection criteria, Types of platforms- airborne remote sensing, space borne remote sensing; Atmospheric condition and altitude; Attitude of platform; Attitude sensors; Orbital elements of satellite; Orbit of satellite; Satellite positioning systems; satellites for Land, Ocean, and atmospheric studies.

Remote Sensing satellites and data products; EMR characteristics and interaction in atmosphere and with ground objects; Atmospheric errors and removal; Geometric and radiometric distortions, Applications of optical remote sensing techniques in natural resources management. Interpretation elements; Systems and techniques of extraction and analysis of information from aerial/satellite stereo data.

Photograph v/s image, Panchromatic, Multispectral, hyperspectral, stereo images, Optical mechanical line scanner; Pushbroom scanner; Imaging spectrometer;

MTRG-151 **Practical :** Fundamentals of aerial photos and satellite image interpretation; Types of imaging, elements of interpretation; Techniques of Visual interpretation; Generations of Thematic maps. Study of satellite image annotation, Demarcation of contours & watershed using toposheets, Drainage Morphometric Analysis, Remote sensing applications: features extractions from remote sensing data, Understanding of spectral response pattern of different landforms. Image Interpretation and Analysis.

References:

1. Remote Sensing and Image Interpretation Thomas M. Lillesand & Palph W .Kiefer
2. Elements of Photogrammetry with application in GIS Paul R. Wolf & Bon A. Dewitt
3. Remote Sensing Geology Ravi P. Gupta

4. Remote Sensing and GIS Basudeb Bhatta
5. Fundamental of Remote Sensing Noam Levin
6. Remote Sensing, Principal and Interpretation Floid F.Savins,
7. Elements of Photogrammetry with applications in GIS by Paul R Wolf and Bon A. Dewitt, 3rd edition, 2004, ISBN 007-123689-9
8. Aerial Photography and Image interpretation second edition by David P paine, and James D Kiser, 2003, John Wiley and Sons Inc. ISBN 0-471-20489-7
9. Interpretation of Aerial Photographs: TE Avery
10. Elementary Air Survey: W. Kilford.
11. Manual of Photogrammetry: ASP Falls Church Virginia.
12. Modern Photogrammetry by Edward M Mikhail
13. Photogrammetry Vol. I- Kranss
14. Fundamentals of Remote Sensing: George Joseph
15. Remote Sensing and Image Interpretation: Lillesand & Keifer.
16. Manual of Remote Sensing: ASP Falls Church Virginia USA.
17. Physical aspects of Remote Sensing: PJ Curran.
18. Remote Sensing Principles and Interpretation: F.F. Sabins.
19. Introduction to Remote Sensing: J.B. Campbell.
20. Introductory Digital Image Processing: A Remote Sensing Perspective, John R Jensen.
21. Remote sensing Models and methods for image processing by Robert A. Schowengerdt, second edition, 1997, Academic Press

PAPER 2

MTRG-102 **GEOGRAPHICAL INFORMATION SYSTEM**

Theory: Introduction, Definitions, Basic Concepts, history and evolution, Components, Need, Scope, interdisciplinary relations, applications areas, and overview of GIS. GIS data: spatial and non-spatial, spatial data model: raster, vector, Topology and topological models; Spatial referencing using coordinates and geographic identifiers, metadata; Spatial data acquisition; Attribute data sources; Spatial and attribute data input; Data storage, RDBMS, database operations; Spatial and non-spatial data editing functions; Quality of spatial data; GIS analysis functions: Retrieval, classification, measurement, neighborhood, topographic, interpolation, overlay, buffering, spatial join and query, connectivity, network functions, watershed analysis, view-shed analysis, spatial pattern analysis, spatial autocorrelation, trend surface analysis; GIS presentation functions: data visualization methods, exporting data; Modern trends: Internet GIS, 3DGIS.

Basic Spatial Analysis, Integration and Modelling: Logic operations, general arithmetic operations, general statistical operations, geometric operations, query and report generation from attribute data, geometric data search and retrieval, complex operations of attribute data, classification reclassification, integrated geometry and attributes, overlay, buffer zones, raster data overlay, integrated data analysis.

Introduction to DTM: Digital surface modeling by DTM/DHM and DSM/DEM, Interpolation techniques, GRID and TIN, break lines, profiles, mass points, / random points, factors influencing choice of sampling patterns, DTM generation process, preprocessing, main processing, post processing, differential rectification, mosaicing, automatic production of digital orthophotos. Differential sampling techniques- manual, semiautomatic, automatic sampling techniques, storage of TIN Grid and its data base structure. Data sources, / input to DTM, Direct and indirect data collection method,

Web GIS: Definition, concept of Web GIS, History of web GIS, components of web GIS, internet, web GIS v/s Internet GIS, Fundamentals of computer networking – network environment –network communication models –protocols – TCP/IP. Applications of web GIS, users and stake holders of web GIS, advantages and limitations of web GIS, Participatory GIS -Web-based GIS For Collaborative Planning And Public Participation, Digital Democracy for planning, web GIS An Aid To Local Environmental Decisionmaking, web GIS for regional and local level planning. Community GIS, Internet GIS Applications in intelligent transportation systems, planning and resource management.

MTRG-152 **Practical:** Familiarization with GIS softwares, Geo-referencing & Projection, Spatial data entry, Spatial data editing & topology creation, Linking spatial & non-spatial data entry, Spatial & non-spatial query and analysis, Output map generation. Overlay Analysis, Buffer Creation and Analysis, Network Analysis & DEM and TIN Creation

References:

1. Principal of GIS for Land Resources Assessment P.A.Vurrough
2. GIS Principal Vol-1 Goodchild

3. Zhong- Ren Peng, Ming-Hsiang Tsou, (2003) Internet GIS: Distributed Geographic
4. **Information Services for the Internet and Wireless Networks,** Wiley.
5. **Concepts and Techniques of Geographic Information Systems,** CP Lo Albert K W Yeung, 2005 Prantice Hall of India.
6. **Principles of GIS for Land Resources Assessment** by P.A.Burrough, Oxford: Science publications, 1986.
7. **Geographic Information Systems – An introduction** by Tor Bernhardsen, John Wiley and Sons, Inc., New York, 2002.
8. **GIS – A computing Perspective** by Micheal F. Worboys, Taylor & Francis, 1995.
9. **Remote Sensing and Image Interpretation** by Thomas M. Lillesand and Ralph W. Kiefer, John Wiley and Sons Inc., New York, 1994.
10. **Geographical Information Systems** – Principles and Applications, Volume I edited by David J. Maguire, Micheal F Goodchild and David W Rhind, John Wiley Sons. Inc., New York 1991.
11. **Geographical Information Systems** – Principles and Applications, Volume II edited by David J. Maguire, Micheal F Goodchild and David W Rhind, John Wiley Sons. Inc., New York 1991.

PAPER 3 – ELECTIVE - I

MTRG-011 **APPLICATIONS OF REMOTE SENSING IN GEOSCIENCES**

Theory: An overview of - origin of earth, structure of earth, geological time scale, plate tectonics and continental drift, rocks and minerals, different geomorphic processes. **A**pplications of remote sensing and GIS in mineral targeting, geomorphological studies, engineering geological studies, lithological and structural mapping. Hydrological cycle, river systems and river dynamics, river morphometric analysis, wetlands mapping and monitoring, watershed concept and its management, behavior of different Remote Sensing sensors in surface water studies, water quality monitoring, basics of ground water and ground water hydro-geology, aquifer mapping, ground water targeting in hard rock and alluvial area, ground water modeling, ground water quality modeling, different geophysical methods for ground water targeting, artificial recharge and rain water harvesting. Basics of snow and ice, spectral response of snow and ice, application of remote sensing and GIS in snow cover monitoring and mapping, glaciological studies, monitoring and mapping glacio-geomorphic features, advance and retreat of glaciers, surging phenomena, glacial lakes outburst monitoring, paleo-geographic reconstruction, impact of climatic various in snow and ice. Basics of land use/land cover, land use/land cover mapping, land transformation studies, monitoring of urban sprawl, urban infrastructure mapping.

Urban Mapping and Spatial Analysis: Urban process, the physical structure and composition of urban areas, Urbanisation process, growth trend, problems of urbanisation, information requirements for perspective planning, Scale and resolution concepts and interpretation techniques for urban and regional analysis, urban GIS, spatial analytical techniques, statistics and visualization, conceptual modelling of urban processes; Urban Sprawl: Change detection in Land Use Land Cover monitoring physical growth of urban area, trends in urban sprawl and associated problems.

Urban Planning: Plans – planning needs, types of plans, urban and regional planning; LU/LC mapping Urban Planning: Zoning of Land Use, Zonal Land Use Plan, Object oriented GIS data modeling for urban design, landscape architecture, urban infrastructure, Site selection for urban development, site suitability analysis for utilities and civic amenities, interim master plan, Master Plan.

Urban Disaster and Emergencies Management: Mapping vulnerable zones with respect to earth quake, flood, fire, terrorist attacks, and finding optimum routes for ambulances, and emergency services, GIS modeling for Hazard risk and emergencies management

Large Scale Mapping and Cadastral Information System: Technologies for Large Scale Mapping (LSM) of urban areas – Aerial Photography - High- Resolution Satellite Remote Sensing - Electronic Distance Measurement (EDM) -Total Station - Differential Global Positioning System (DGPS) – Issues in Large Scale Mapping – Selecting appropriate technologies and methodologies. Concept of Cadastre, History of cadastral survey, Cadastral survey methods and survey maintenance, cadastral map reproduction, development of cadastral information system.

Practical: Ground truth data collection, Collection of surface water, ground water and soil samples, Analysis of field data, Resistivity survey: determination of layered parameters (resistivity and thickness of layers), demo on LiDAR data processing.

References:

1. Remote Sensing of Geology Prof. R.P.Gupta
2. Gemorphological process Savindra Singh
3. Remote Sensing in Geosciences Nitin K. Tripathi & Vishwanath Bajpai
4. Earth Surface System Richard J. Huggett

MTRG-012 **REMOTE SENSING AND GIS FOR HYDROLOGY AND WATER RESOURCES**

UNIT I BASICS OF HYDROLOGY

hydrological cycle – estimation of various components of hydrology cycle – clouds – rainfall – runoff – evaporation – transpiration – evapo–transpiration – interception – depression storage – spectral properties of water – GIS application in surface water modeling – case studies.

UNIT II DRAINAGE BASIN

Watershed divide – stream networks – Delineation and codification of watersheds morphometric analysis – linear – areal –relief aspects – Rainfall- runoff modeling – urban hydrology – case studies.

UNIT III AREAL ASSESSMENT

Mapping of snow covered area – snow melt runoff – flood forecasting, risk mapping and flood damage assessment soil moisture area – drought forecasting and damage assessment – GIS application in aerial assessment – case studies

UNIT IV GROUND WATER AND WATER QUALITY

Ground water prospects – surface water indicators – vegetation , geology, soil aquifer – aquifer parameters – well hydraulics – estimation of ground water potential – hydrologic budgeting – mathematical models – GIS application in ground water modeling – study on sea water intrusion – modeling of sea water intrusion – water quality parameters –physical, chemical, biological properties. Water quality mapping and monitoring –correlation model for pollution detection and suspended sediment concentration– case studies

UNIT V IRRIGATION AND WATERSHED MANAGEMENT

Project investigation, implementation, maintenance stage- location of storage/ diversion works – canal alignment –depth-area capacity curve generation, - conjunctive use of surface and ground water – Mapping and monitoring the catchment command area – artificial recharge of groundwater – water harvesting structures – sediment yield – modeling of reservoir siltation – prioritization of watershed –modeling of sustainable development – Development of information system for Natural resource management case studies.

REFERENCES:

1. Eric C. Barrett, Clare H.Power, Satellite Remote Sensing for Hydrology and Water Management, gordon @ Breach Science publications - new york 1990,

2. Dr. David Maidment, Dr. Dean Djokic, Hydrologic and Hydraulic Modeling Support with Geographic Information Systems, Esri Press 2000,

3. Wilfried Brutsaert, Hydrology: An Introduction Cambridge University Press, 2005,

4. Andy D. Ward and Stanley W. Trimble, Environmental Hydrology, second edition, Lewis Publishers, 2004,

5. U.M. Shamsi, GIS Applications for Water, Wastewater, and Stormwater Systems,CRC; first edition 2005,

MTRG-013 **REMOTE SENSING AND GIS FOR URBAN PLANNING AND MANAGEMENT**

UNIT I INTRODUCTION

Remote sensing for detection of urban features – Scale and resolution – Scope and limitations – Interpretation from Aerial and satellite images – Digital image processing techniques – Image fusion – Case studies.

UNIT II SETTLEMENT MAPPING

Classification and settlement – settlement structure – Segmentation of Built-up areas – Classification algorithms – Land use/ Land cover mapping – change detection – high resolution remote sensing – case studies.

UNIT III ANALYSIS AND PLANNING

Urban morphology – Housing typology – Population estimation from remote sensing – Infrastructure demand analysis – Urban renewal Land suitability analysis – Plan formulation – Regional, Master and detailed development – Use of remote sensing and GIS in plan preparation – Urban information system – Web GIS – case studies.

UNIT IV TRANSPORTATION PLANNING

Mapping transportation network – Classification – Optimum route/ shortest route –

Alignment planning – Traffic and parking studies – Accident analysis – case studies.

UNIT V CURRENT TRENDS

Urban growth modeling – Expert systems in planning – 3D city models – ALTM – Land use Transportation interaction models – Intelligent transportation systems – case studies

REFERENCES:

1. Juliana Maantay, John Ziegler, John Pickles, GIS for the Urban Environment, Esri Press 2006.

2. Allan Brimicombe, GIS Environmental Modeling and Engineering, CRC; 1 edition 2003.

3. Paul Longley, Michael Batty, Spatial Analysis: Modeling in a GIS Environment Wiley,1997.

4. Michael F. Goodchild, Louis T. Steyaert , Bradley O. Parks, Carol Johnston, David Maidment, Michael Crane , Sandi Glendinning, GIS and Environmental

Modeling: Progress and Research Issues (Hardcover) by,Publisher: Wiley; 1 edition, 1996.

5. Roland Fletcher, The Limits of Settlement Growth: A Theoretical Outline (New Studies in Archaeology) (First edition), Cambridge University Press; 2007.

PAPER 4 – ELECTIVE- II

MTRG-021 APPLICATIONS OF REMOTE SENSING IN NATURAL SCIENCES

Theory: Applications of remote sensing technique in agriculture - Type of crops, crop rotation and cropping seasons, Agriculture practices of major crops/Horticulture and Sericulture etc., Stages of crops, duration of major agricultural crops, introduction of important insects & pest infestation of major crops. Crop production forecasting/yield modeling and condition assessment, Mapping of cropping pattern and Cropping System Analysis, Precision agriculture; Definition, Importance , Components, limitations of its adoption in developing countries, prospects and scope in India.

Applications of remote sensing technique in forest resources; Introduction of Forest Resources and its Management, Use of Multispectral & Temporal Remote Sensing data, GIS and GPS in Forest Studies, Identification and classification of forest type and forest density, Quantification of forest resources, Wildlife Management, Identification of suitable site for Afforestation and assessing the Bio-diversity and Forest Carbon Dynamics, Social Forestry.

Applications of remote sensing technique in soil resources: Basics of soil types, characteristics and spectral response, soil plant relationship, soil genesis, soil erosion, Soil survey, mapping and classification, physical and chemical behavior of soils, Mapping of waste and degraded lands, Sodic land mapping and reclamation monitoring at plot level, desertification mapping and monitoring.

Practical: Integration of spatial & non-spatial data using GIS, Raster & Vector data analysis, Network analysis, Generation of DEM/DTM, Generation of derived maps, Change detection analysis, Demo on Hyper spectral data processing, Exercise on Microwave data processing, laser distance finder, radiometric survey.

References:

1. Forestry Handbook Reginald D. Forbes & Arthur B.Meger
2. Local Forest Managenent David Edmunds & Eva Wellenbera
3. Forest Environment & Biodiversity Singh and Vinita Vishwakarma
4. Soil Condition and Plant Growth Russel
5. The Surface Chemistry of Soil Garrison Sposito
6. Soil E.A.Fitzpatrick

MTRG-022 **REMOTE SENSING AND GIS FOR AGRICULTURE & FORESTRY**

UNIT I CROPS ACREAGE AND YIELD ESTIMATION

Introduction – Spectral properties of crops in optical & TIR region, Microwavebackscattering behavior of crop canopy – crops identification and crop inventory – crop acreage estimation – vegetation indices – Yield modeling – crop production forecasting through digital analysis – crop condition assessment – command area monitoring – land use and land cover analysis – Microwave RS for crop inventory – Case studies

UNIT II SOIL MAPPING AND CONSERVATION

Introduction – soil genesis, Soil morphological characters, Soil pedology – Soil survey, Types and methods of soil surveys – Soil classifications – Hydrological Soil grouping – Characteristics of saline & alkaline Soils – Factors influencing soil reflectance properties – principle component analysis and orthogonal rotation transformation-Soils mapping using RS data - Problem soil identification and mapping – land evaluation – Soil sedimentation & erosion – Soil loss assessment – Soil conservation – Case studies.

UNIT III DAMAGE ASSESSMENT

Detection of pest & diseases – Flood mapping and Assessments of crop loss – Remote sensing capabilities & contribution for drought management – Land degradation due to water logging & Salinity – crop stresses reflectance properties of stressed plants and stress detection.

UNIT IV FORESTRY

Introduction – Forest taxonomy – inventory of forestlands – forest types and density mapping using RS techniques – Forest stock mapping – factors for degradation of forest – Delineation of degraded forest - Forest change detection and monitoring – Forest fire mapping & damage assessment – LiDAR remote sensing for Forest studies.

UNIT V INTEGRATED SURVEYS

Introduction – Integrated surveys for agriculture & forest development – RS & GIS for drawing out action plans – water shed approach – Rule of RS & GIS for watershed management – Land use planning for sustainable development – Precision forming - Case studies.

REFERENCES:

1. John G. Lyon, Jack MCcarthy, Wetland & Environmental application of GIS,1995.

2. Margareb Kalacska, G. Arturosanchez, Hyper spectral RS of tropical and sub tropical forest, 2005.

3. Shunlin liang , Advances in land RS: System, modeling invention and applications, 2001.

4. Joe Boris dexon, Soil mineralogy with environmental application, Library of congress catalog, 2004.

5. James B, Introduction of Remote sensing, Third edition Campbell, third edition Guilford Press, 2002.

MTRG-023 **SUSTAINABLE AGRICULTURE**

- Landuse and soil resouces management
- Agri-informatics
- Environmental Soil Science
- SateAgrometrology

REFERENCES:

1. Shunlin liang , Advances in land RS: System, modeling invention and applications, 2001.

2. Paul Longley, Michael Batty, Spatial Analysis: Modeling in a GIS Environment Wiley,1997.

3. James B, Introduction of Remote sensing, Third edition Campbell, third edition Guilford Press, 2002.

SEMESTER II

PAPER 1

MTRG-201 **DIGITAL IMAGE PROCESSING**

Theory: Image processing system; Satellite data acquisition –Storage and retrieval – Data Formats – Compression – Satellite System – Data products – Image display system – Current Remote Sensing Systems. Preprocessing of remotely sensed data; Radiometric and Geometric distortions and corrections- Geometric correction- Radiometric correction – Noise removal. Spectral Ratioing –Principal and Canonical Components– Vegetative Components. Image Rectification and Restoration. Image enhancement- Contrast Manipulation – Gray-Level Thresh holding- Level Slicing Contrast Stretching. Convolution – Edge Enhancement – Spatial feature manipulation. Image transformations; Pattern recognition, Image classification, Image fusion and change detection.

Image Analysis and Understanding: Pattern recognition – Shape analysis- Textural and contextual analysis.

Data Merging and GIS Integration: Multitemporal Data merging – Change detection procedures- Multisensor image merging – Merging of image data with Ancillary data- Incorporating GIS Data in automated land cover classification.

Hyper-spectral Image Analysis and Radar image analysis: Atmospheric correction – Hyper-spectral image analysis techniques.

MTRG-251 **Practical -** Familiarization with digital image processing & image processing software, Importing raw data, Displaying image data, Image Rectification & Registration, Image Enhancement & Transformation, Unsupervised Classification, Training site marking & Supervised Classification, Accuracy Assessment, Map Composition, Image Data Fusion. Calculation of area and Accuracy Assessment

References:

1. Remote Sensing & Image Interpretation Thomas M. Lillesand, Ralph W.Kiefer,
2. Image Interpretation in Geology Drury S.A.
3. John R Jenson „Introducing Digital Image Processing" Prantice Hall. New Jersy 1986.
4. R. A. Schowengergt, „Techniques for Image Processing and Classification in Remote Sensing'; 1983
5. Robert A Schowengergt, „Remote Sensing – Models and Methods for Image Processing Academic Press 1997 Hord R M, Academic Press, 1982.

PAPER 2

MTRG-202 **GLOBAL POSITIONING SYSTEM**

Theory: Maps & their numbering, Map projection and co-ordinate system, Geo-referencing and datums, **Basic concepts of GPS**: History and timeline, overview. pseudo range and carrier phase measurements; Signal structure; GPS coordinate systems: WGS-84, GPS time; GPS Errors and biases; GPS orbital Geometry and Navigational solution.

Technical Description and GPS Observables: System Segmentation – Space segment; control segment, user segment- types of receivers ; GPS satellite signals, GPS data, position and time from GPS, code phase tracking, pseudorange navigation, receiver position, time and velocity, carrier phase tracking, GPS positioning types – absolute positioning, differential positioning; Navigation signals -GPS frequencies; Calculating positions using C/A code using P(Y) code, code phase v/s carrier phase, augmented GPS, local augmentation; Accuracy and error sources – atmospheric effects, multipath effects, ephemeris and clock errors; selective availability, relativity, sagnac distortion. Factors that affect GPS - number of satellites, multipath, ionosphere, troposphere, satellite geometry, satellite health, signal strength, distance from the reference receiver, RF interference, loss of radio transmission; Other satellite based navigational systems: GLONASS, GALILEO.

GPS interference and jamming – natural sources, artificial sources; Techniques to improve accuracy- augmentation, precise monitoring, GPS time and data, GPS modernization.

DGPS – History, need for DGPS, concepts and principles, differential corrections, accuracy in DGPS, local area DGPS, wide area DGPS, carrier phase DGPS, pseudolites, LAAS, WAAS; rapid methods with GPS – rapid static method, semikinematic method, kinematic method. Real time DGPS. Data post-processing; GIS and GPS integration; Georeferencing of map.

Applications of GPS and DGPS: Military – airborne, marine and land based navigation, and civilian –surveying and mapping, control surveys, cadastral surveying, navigation, RS, GIS and photogrammetry, geodesy, location, navigation, tracking, mapping and timing, Engineering and Monitoring; Special applications of GPS, etc.,

MTRG-252 **Practical:** Familiarization with different types of GPS and software, Measurement of location with the help of GPS, GPS Survey of Natural and Man-made features, Field exercise on GPS data collection in standalone mode. GPS & GIS data integration and output preparation.

DGPS setting up for observation; data collection in differential mode. Ground control points, Criteria for Selecting reference station, reference station equipments, operational procedures, post processing of data, Ground control for geometric correction of satellite imagery using DGPS.

References:

1. Introduction to GPS: The Global Positioning System Ahmed El-Rabbany
2. Integrating GIS and the Global Positioning System Karen Steede-Terry

3. Understanding GPS: Principles and Applications Elliott Kaplan, Christopher Hegarty
4. GPS Mapping Rich Owings
5. GPS Made Easy: Using Global positioning Systems in the Outdoors Lawrence Letham
6. Outdoor Navigation with GPS Stephen W. Hinch
7. Satellite Geodesy: Gunter Seebar,
8. GPS satellite surveying**:** Alfred leick
9. Essentials of GPS, N K Agrawal

PAPER 3 ELECTIVE-III

MTRG-031 THERMAL AND HYPERSPECTRAL REMOTE SENSING

Physics of Thermal Remote Sensing, Kinetic & Radiant temperature, emissivity of different material Atmospheric effects, Thermal properties of materials. Satellite Thermal Systems (Characteristics of sensors, Resolutions) Characteristics of images and different types of available data products, Thermal Image Interpretation. Information extraction from thermal imagery: Apparent thermal inertia mapping, brightness and temperature retrieval. Hyper-spectral Remote Sensing-Principles, Platforms and Sensors (Characteristics: resolution, SNR), Sensor calibration and ground/laboratory spectra acquisition. Spectral signatures of variety of surface materials, causes of absorption. Data Processing & Algorithms, Optimum narrow bands

Thermal Remote Sensing: Thermal radiation principles, processes and thermal properties of materials, thermal conductivity, thermal capacity, thermal inertia, thermal diffusivity, emissivity, sensing radiant temperatures, radiant versus kinetic temperatures, blackbody radiation, atmospheric effects, interaction of thermal radiation with terrain elements, IR detection and imaging technology, thermal sensors and scanners, airborne IR surveys, satellite thermal IR images, spatial resolution and ground coverage, thermal IR broad band scanner and multispectral scanner, geometric characteristics of across track and along track IR imageries, distortions and displacements, radiometric calibration of thermal scanners, interpretation of thermal IR imagery, temperature mapping with thermal scanner data, thermal inertia mapping, apparent thermal inertia, applications of thermal remote sensing in geology, hydrogeology, urban heat budgeting.

Hyper-spectral Remote Sensing: Hyper-spectral Imaging: Hyper spectral concepts, data collection systems, calibration techniques, data processing techniques; preprocessing, N-dimensional scatter-plots, Special angle mapping, Spectral mixture analysis, Spectral Matching, Mixture tuned matched filtering, Classification techniques, airborne and space-borne hyperspectral sensors, applications. High resolution hyper-spectral satellite systems: Sensors, orbit characteristics, description of satellite systems, data processing aspects, applications.

Hyper-spectral Image Analysis and Radar image analysis: Atmospheric correction – Hyper-spectral image analysis techniques.

References:

1. Hyper Spectral Remote Sensing Zhong Ping Lee and Kendall L. Carder
2. Hyper Spectral Remote Sensing & Space Signal applications Rajendran,S , S.Arvindan & R.Shivkumar.
3. Fawaz T Ulaby, Richard K Moore and Adrian K Fung, Microwave Remote Sensing active and passive, Vol. 1, 2 and 3 Addison – Wesly Publication company 1981, 1982, and 1986.
4. Philip N Slater, Remote Sensing, optics and optical systems. 1980
5. Robert M Haralick and Simmonet, Image processing for remote sensing 1983.
6. Robert N Colwell Manual of Remote sensing Volume1, American Society of Photogrammetry 1983.

7. Travett J W Imaging Radar for Resources surveys, Chapman andHall, London 1986.
8. Remote sensing and Image Interpretation by Thomas M Lillesand and Ralph W. Keifer fourth Edition, 2002, 2003, John Wiley and Sons Inc.
9. Remote Sensing Geology by Ravi P Gupta, Second edition, 2003, Springer
10. Remote Sensing Principles and Interpretation by Floyd F Sabins, 1997, W H Freeman And Company

MTRG-032 **ADVANCED REMOTE SENSING TECHNIQUES**

Thermal Remote Sensing: Thermal radiation principles, processes and thermal properties of materials, thermal conductivity, thermal capacity, thermal inertia, thermal diffusivity, emissivity, sensing radiant temperatures, radiant versus kinetic temperatures, blackbody radiation, atmospheric effects, interaction of thermal radiation with terrain elements, IR detection and imaging technology, thermal sensors and scanners, airborne IR surveys, satellite thermal IR images, spatial resolution and ground coverage, thermal IR broad band scanner and multispectral scanner, geometric characteristics of across track and along track IR imageries, distortions and displacements, radiometric calibration of thermal scanners, interpretation of thermal IR imagery, temperature mapping with thermal scanner data, thermal inertia mapping, apparent thermal inertia, applications of thermal remote sensing in geology, hydrogeology, urban heat budgeting.

Passive Microwave Remote Sensing: Basics –physics of RADAR waves, spectral characteristics of RADAR waves, microwave radiometers, passive microwave scanners and sensors, applications in atmosphere, ocean and land.

Precision Remote Sensing: Introduction, Spatial, Spectral, Temporal precision and their requirement.

Active Microwave Remote Sensing: RADAR- definition and development, Radar Systems –airborne and space borne SLRs and their components, imaging systems, typical images, radar wavelengths, scattering theory, RADAR equation, Depression angle, slant range and ground range images, spatial resolution and theoretical limits, azimuth resolution, real aperture and synthetic aperture RADAR systems, geometric characteristics of radar imagery and transmission characteristics of radar signals, SLR stereoscopy and RADARgrammetry, RADAR return and image significance, coherence, phase unwrapping, polarization, image registration, baseline determination, measurement of surface topography and deformation analysis, satellite radar systems and images, image processing, RADAR image interpretation. SAR interferometry-principle, image processing, differential SAR interferometry, factors affecting SAR interferometry, Applications of RADAR soil response, vegetation response, water and ice response, urban area response.

LIDAR Remote Sensing: Altimetric LiDAR: Physics of laser, spectral characteristics of laser, laser interaction with objects, Airborne Altimetric LiDAR: principle, Multiple return, Components of LiDAR system, INS technology, INS-GPS integration, measurement of laser range, calibration, flight planning, laser range to xyz coordinates, accuracy of various components of LiDAR, error analysis of data and error removal, raw data of DEM processing, filtering of data uses of return strength/waveform, data classification techniques, LiDAR data integration with spectral data, LiDAR Applications.

Hyper-spectral Remote Sensing: Hyper-spectral Imaging: Hyper spectral concepts, data collection systems, calibration techniques, data processing techniques; preprocessing, N-dimensional scatter-plots, Special angle mapping, Spectral mixture analysis, Spectral Matching, Mixture tuned matched filtering, Classification techniques, airborne and space-borne hyperspectral sensors, applications. High resolution hyper-spectral satellite systems: Sensors, orbit characteristics, description of satellite systems, data processing aspects, applications.

REFERENCE BOOKS:

1. Fawaz T Ulaby, Richard K Moore and Adrian K Fung, **Microwave Remote Sensing active and passive**, Vol. 1, 2 and 3 Addison – Wesly Publication company 1981, 1982, and 1986.

2. Philip N Slater, **Remote Sensing, optics and optical systems**. 1980

3. Robert M Haralick and Simmonet**, Image processing for remote sensing** 1983.

4. Robert N Colwell **Manual of Remote sensing** Volume1, American Society of Photogrammetry 1983.

5. Travett J W **Imaging Radar for Resources surveys**, Chapman andHall, London 1986.

6. **Remote sensing and Image Interpretation** by Thomas M Lillesand and Ralph W. Keifer fourth Edition, 2002, 2003, John Wiley and Sons Inc.

7. **Remote Sensing Geology** by Ravi P Gupta, Second edition, 2003, Springer

8. **Remote Sensing Principles and Interpretation** by Floyd F Sabins, 1997, W H Freeman And Company

MTRG-033 **EMERGING TRENDS IN GEOINFORMATICS**

Global and Indian Scenario of Geo-informatics- Current status and Recent Advances in the field of RS, GIS, Photogrammetry, GPS, products and process, software and hardware.

Global and Indian R&D Organisations : Global Institutions- NASA, ESRI, ERDAS, Canadian Institute of Remote Sensing, International Institute of Photogrammetry and Remote Sensing, Google, India- ISRO and its subunits, NRSA, SAC, Antrix, IIRS, RRSSCs; State Remote Sensing Centres; Funding Sources for R&D projects; Global and National Spatial Data Centres, Satellite data sources and procurement procedures.

World and Indian Space Programmes : Satellites and sensors and their products and applications; Geoinformatics usage by Government and Private Sectors - User Departments of Central Govt. and State Govt. and their major projects: Central - SOI, MOEF, MOUD, MOD, few Case studies.

Global and Indian Geoinformatics Market: Present trends and future prospects and problems, GIS BPO in private sector in India, GIS companies in India.

Global and National Major Initiatives in RS and GIS: Digital Earth, GSDI, 3D Cities, NSDI.

Education and Training facilities in Geoinformatics : Global Geoinformatics Courses, scholarships; Web Resources for e-learning; eBooks; open sources of free softwares; International Journals, Review magazines, News Letters, e-journals.

Laws and Policy Perspectives and International Co-operations : Laws and policy matters at international and national level with respect to Space, Sea, photogrammetry, data sharing and data security, interoperability; Global and national Geoinformatics survey reports, case-studies, show cases of best practices.

REFERENCE BOOK:

1. **“GIS Development”**.net, ESRI web site, NCGIA, UCGIA, Google Earth, Yahoo Maps, NASA web site, ISRO website.

PAPER 4 ELECTIVE-IV

MTRG-041 NATURAL AND MAN-MADE DISASTERS

Understanding Disasters

Meaning, nature, characteristics and types of Disasters, Causes and effects, Disaster:

A Global View, Disaster Profile of India, The Disaster Management cycle.

Introduction: Definition, classification of disasters, types of Disaster, importance of RS and GIS in Disaster Management- Reconnaissance, forecast, forewarning systems, Disaster preparedness with respect to different disasters. SDI to facilitate Disaster Management. GIS based DSS for disaster management. Satellite surveillance for disaster mitigation.

Geological and Mountain Area Disasters

Earthquakes, Volcanic Eruption, Landslides, Snow Avalanches

Earthquake: Causes of earthquake, prediction of earthquake, Geomatics in earthquake mitigation, seismic damage evaluation and loss estimation, RS and GIS application for post quake rehabilitation, GIS database for previous earthquakes, space technology and earthquake prediction, geospatial information system for earthquake disaster management, mapping tectonic lineaments. El-Nino damage assessment using RS and GIS.

Fire: Forest fire, causes, forest fire management using geospatial information system, forest fire risk zonation mapping, forest fire monitoring, forest fire, forecasting system using internet GIS and Satellite Remote Sensing, delineation of coal fire risk zonation.

Landslide: Landslides, causes, types, and mitigation measures, land slidezonation, land slide susceptibility mapping, land slide monitoring, landslide analysis in GIS, geospatial technology for landslide management, sand drift in Indian desert, topographic and morphometric features affecting in landslide.

Soil Erosion: Types, causes, and mitigation measures, application of RS and GIS for soil erosion and sediment estimation, RS and GIS application for desertification studies, desertification studies, estimation of soil erosion, soil erosion mapping universal soil loss equation and GIS, land degradation studies, sodic soil mapping.

Volcano: Volcanoes, types causes of volcanoes, hazards of volcanoes, remote sensing of geothermal field, mapping lava flows, ashfalls and lahars, mapping damage, volcano hazard management.

Wind and Water Related Natural Disaster

Floods and Flash Floods, Droughts, Cyclones, Tsunamis

Drought: Drought types, causes, mitigation measures, delineation of drought vulnerable areas using RS and GIS; Drought Information System; Drought monitoring; GIS based drought analysis; Desertification factors, Assessment of drought impact using RS and GIS. Monitoring vegetative biomass, Drought management- prediction, preparedness, monitoring of drought.

Flood, Cyclone and Tsunami: Floods types-flash and riverine floods, snowmelt floods, ice jams, and mud flows; causes and mitigation measures, flooding potential zonation mapping, flood hazard assessment, flood risk analysis using RS and GIS, tropical cyclone monitoring using INSAT, ERS-1,NOAA, and DMSP satellites, RS and

GIS in Hurricane mapping and mitigation, flood disaster monitoring and reporting system, terrain modeling for flood plain zoning, digital surface modeling and flood hazard simulation, ice cover monitoring and its role in flooding. Flood damage impact minimization, damage assessment in hurricane / tornado affected areas. Cyclone tracking, Cyclone warning, cyclone management. Tsunami- types, causes, RS and GIS applications for post Tsunami damage assessment and rehabilitation

Man Made Disasters

Understanding Man-Made Disasters Fires, Nuclear, Biological and Chemical disaster.

Disaster Management in Human Settlements: Mapping disaster vulnerable zones, fire hazards, flood and storm water inundations, earthquake impact assessment

References:

1. Natural Hazards, Bryant Edwards
2. Disaster Management, Carter, W. Nick
3. Flood Atlas of India, CWC, New Delhi.
4. Manual of Flood Forecasting, Central Water Commission New Delhi.
5. Vulnerability Atlas of India, New Delhi.
6. Disaster Mitigation Experiences and Reflections, Sahni, Pardeep et.al. (eds.)
7. Amdahl G (2002) Disaster Response: GIS for Public Safety,
8. Published by ESRI, Redlands California.
9. http://www.esri.com/news/arcnews/winter0102articles/gishomeland.
10. html - visited on October 2002.

MTRG-042 **DISASTER PREPAREDNESS**

Introduction to disaster Preparedness

Disaster Management: Prevention, Preparedness and Mitigation, Disaster Preparedness: Concept & Nature, Disaster Preparedness Plan, Disaster Preparedness for People and Infrastructure, Community based Disaster Preparedness Plan

Roles & Responsibilities of Different Agencies and Govt.

Roll of Information, Education, Communication & Training, · Role and Responsibilities of Central, State, District and local administration, · Role and Responsibilities of Armed Forces, Police, Para Military Forces, Role and Responsibilities of International Agencies, NGO's, Community Based, Org. (CBO's)

Technologies for Disaster Management

Role of IT in Disaster Preparedness, Remote Sensing, GIS and GPS, Use and Application of Emerging Technologies, Application of Modern Technologies for the Emergency communication., Application and use of ICST for different disasters.

Disaster Mitigation

Disaster Mitigation: meaning and concept, Disaster Mitigation Strategies, Emerging Trends in Disaster Mitigation, Mitigation management, Role of Team and Coordination

References:

1. Natural Hazards, Bryant Edwards
2. Space Technology for Disaster management: A Remote Sensing & GIS Perspective, Roy, P.S.
3. Natural Disaster, Corporation, Sharma, R.K. & Sharma, G.

MTRG-043 **DISASTER RESPONSE AND DISASTER MANAGEMENT**

Response Essential Components

Disaster Response Plan, Communication, Participation and Activation of Emergency Preparedness Plans, Search, Rescue, Evacuation and other logistic management, Needs and Damage Assessment; Types and Technique

Stakeholders Co-ordination in Disaster Response

Disaster Response: Central, State, District and Local Administration., Armed Forces in disaster Response: Role and Responsibility, Disaster Response: Police and Other organisations

Role of Multiple stakeholders in Disaster Response

Human Behaviour and Response Management

Psychological Response and Psychological Rehabilitation, Trauma and Stress Management

Rumour and Panic Management, Medical and Health Response to Different Disasters, Role of Information and Communication Technology in Response Management.

Relief Measures

Minimum Standard of Relief, Relief Management- essential components, Funding Relief- short term and long term, Disaster Site Management Recovery.

References:

1. Natural Hazards: Local, National, Global, White, G.F,
2. Disaster Management through Panchayati Raj, Taori, K

PAPER 5 ELECTIVE-V

MTRG-051 ENVIRONMENTAL MONITORING AND ASSESSMENT

Environmental Monitoring: What is environmental quality? Quality of environment for life on earth and man; Advantages of Environmental Monitoring, Deterioration of environmental quality with reference to anthropogenic impact; Methods of assessment of environmental quality; Short term studies/ surveys; Rapid assessment; Continuous short and long term monitoring

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.

Remote sensing and its applications in Environmental Monitoring: Principles and Basic concepts of Remote sensing; EMR & its interaction with matter; Aerial Photography and image recognition; Sensors & platforms; IRS satellites & their sensors; Application of remote sensing in environmental studies: land use mapping, forest survey, habitat analysis, water management, drought monitoring and flood studies, wetland survey ; rainfall estimation, pollution studies, soil conservation, watershed management and vegetation mapping.

Geographical Information System (GIS): Basic principles, Techniques Application in Environmental Sciences. Types of Geographical Data; Data Structure; Vector and Raster data: their Advantages and Disadvantages; Input, verification, storage and output of geographical data; Importance of Geographical Information System in environmental studies. Global Positioning System (GPS): basic principles, Applications to environmental studies -Point source pollution, hazard monitoring and assessment.

References:

1. Environmental Impact Assessment: Practical Solutions to Recurrent Problems, D. P. Lawrence
2. Environmental Impact Analysis Handbook: J. G. Rau and D. C. Wooten;
3. Environmental Impact Assessment, L. W. Canter,
4. Methods of Environmental Impact Assessment, P. Morris and R. Therivel

MTRG-052 **ENVIRONMENTAL POLLUTION**

Introduction to Environmental pollution, Air and Water Pollution: Definition and sources of pollution; Different types of pollution and their global, regional and local aspects. Types and sources of air pollutants; Reaction of pollutants in air forming smog, PAN, Acid rain; Atmospheric diffusion and stack performance; Transport of pollutants; Effects of air pollutants on flora and fauna; Sinks of atmospheric gases. Sources of water and their contamination; Types of pollutants, various industrial effluents such as pulp and paper mills, oil exploration and refinery, petrochemicals, iron and steel industries, domestic wastes ,organic debris, agricultural wastes, pesticides; Eutrophication - causes and effects and control measures.

Soil pollution and solid waste pollution: Causes of soil pollution; Effects of Fungicides and weedicides on soil components, residual toxicity and pollution. Different kinds of synthetic fertilizer (N, P, K), and their interactions with different components of soil, their toxicity and pollution. Industrial effluents and their interactions with soil components, Contamination by radio nuclides. Solid waste pollution: sources, nature, classification and environmental effects.

Radiation and Noise pollution: Radioactive decay; Interaction of radiation with matter; Biological impact and health hazards associated with radiation, Units of radioactivity and radiation dose; Protection against ionizing isotopes and their applications in waste water and air pollution analysis and treatment; Radioactive waste disposal. Basic properties of sound waves – plane and spherical waves, sound pressure, loudness and intensity levels, decibel; Sources of Noise Pollution–Measurement and analysis of sound, Measures to control noise pollution. 10

Thermal pollution, Oil Pollution and Electronic waste (E-waste): Definition and sources, Chemical and biological effects of thermal pollution, Effect on marine life, bacteria and water quality and other aquatic biota; Thermal pollution from power plants and their control. Oil pollution and marine ecology, sources of oil pollution, factors effecting fate of oil after spillage movement, spreading, evaporation, emulsification, dispersion, remote sensing in water quality monitoring. Sources and types and constituents of E-wastes and its environmental consequences.

References:

1. Air Pollution and Plant Life, J.N.B. Bell
2. Environmental Pollution Control Engineering: C. S. Rao
3. Environmental Chemistry : B.K. Sharma, and H. Kaur
4. Air pollution – threat and response: D. A. Lynn
5. Air pollution and Environmental Protection – Legislative policies, Judicial trend and Social perceptions: N. Kumar;

MTRG-053 **ENVIRONMENT AND NATURAL RESOURCES**

Environment: Definition of Environment, Earth, Man and Environment, Evolution of environment, Physico-chemical and Biological Characteristics of environment. Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. Geographical classification, Distribution and zones.

Mass and energy: Transfer of mass and energy across various interfaces. First and second laws of thermodynamics, heat transfer processes, Biochemical cycles, gaseous and sedimentary turnover rate and turnover item, General relationship between landscape and climate. Climates of India, Indian monsoon, Drought, Tropical cyclones and western disturbances. Atmosphere stability and instability, tem8 perature inversion and mixing heights, heat balance of the earth- atmosphere system, global climate change.

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Natural resources: Types of natural resources, Forest resources: use and over-exploitation,
deforestation, timber extraction, mining, dams and their effects on forests and tribal people. Water resources: use and utilization of surfaces and ground water, floods drought, dams-benefits and problems. Mineral resources: environmental effects of extracting and using mineral sources. Food resources: World food problems overgrazing, effects of modern agriculture, fertilizers-pesticides problems, Water logging, salinity. Land resources: Land as a resource, Land degradation, man induced landslides, soil erosion and desertification

Energy resources: Concept and demand of energy, Growing energy needs, Renewable and nonrenewable sources, use of alternate energy sources, Wind energy, Solar energy, water as source of energy, Biofuels prodution, use and sustainability, use and over exploitation of energy sources and associated problems. Role of an individual in conservation of natural resources. Equitable use resources for sustainable lifestyles.

References:

1. Renewable Energy – Environment and Development: M. Dayal;
2. Alternative Energy: S. Vandana;
3. Environmental Sciences- A study of Inter relationships, E.D.Enger, B.E. Smith,
4. Bio-Energy Resources: Chaturvedi;
5. National Energy – policy, crisis and growth: V S. Mahajan;
6. Geography and Energy – Commercial energy systems and national policies: J. D.Chapman

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