Remote Sensing & Geographic Information System (RS&GIS)

Post Graduate Course

Syllabus

September 2018

Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP)

(Affiliated to the United Nations)
IIRS, Campus
Dehradun, India

Contents

Background and Objectives

Background

The benefits of space technology have introduced new dimensions in the study and understanding of earth's processes and in improving the quality of life of people. All countries should have access to space technology and must share the benefits as well. An essential pre-requisite to fruitfully use these opportunities is to develop human skills to adopt and adapt the space technology for the societal benefits. In recognition of this, a consensus has emerged in the international community that if effective assimilation and appropriate application of space technology are to succeed in the developing countries, devoted efforts must be made at local level, for the development of necessary high level knowledge and expertise in space technology fields.

Recognizing this, the United Nations General Assembly resolution (45/72 of 11th December, 1990 and 50/27 of 6th December, 1995) endorsed the recommendation of Committee on the Peaceful Uses of Outer Space (COPUS) that regional centres for space science and technology education should be established on the basis of affiliation to United Nations in developing countries. Under the auspices of the United Nations through Office for Outer Space Affairs (UN-OOSA) prepared a project document (A/AC. 105/534) envisaging the establishment of Centres for Space Science &Technology Education in the developing countries. The objective of the centres is to enhance the capabilities of the member states in different areas of space science & technology that can advance their social and economic development. The first of such centres, named as Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) was established in India in November 1, 1995. Department of Space, Government of India has made available appropriate facility and expertise to the Centre through the Indian Institute of Remote Sensing (IIRS), Dehradun, Space Applications Centre (SAC), Physical Research Laboratory (PRL), Ahmedabad and ISRO Satellite Centre (ISAC), Bengaluru.

The centre is an educational and research institution that is capable of high attainments in the development and transmission of knowledge in the fields of space science & technology. The initial emphasis of the Centre has been in-depth educational programmes and application programmes, linkage with the global programmes/databases, execution of pilot project, continuing education, awareness and appraisal programmes. The Centre offers Post Graduate level courses in the fields of (a) Remote Sensing and Geographic Information System (RS & GIS), (b) Satellite Communications (SATCOM), (c) Satellite Meteorology and Global Climate (SATMET), (d) Space & Atmospheric Science.

Vision

Human resource development in the Asia-Pacific region may be achieved through academic excellence which enables all learners to reach their individual potential. Strategies for developing of human resources should be based on broad and long-term perspectives of the regional needs and resources through capacity building. Space science and technology offers a wide range of innovative and cost effective solutions for sustainable development of resources in the region. All levels of training are to be considered for different sections such as technical specialists, data interpreters, professionals, researchers,

decision makers, project managers, etc. An essential pre-requisite to partaking in these opportunities is to build various indigenous capacities for development and growth of technically and managerially competent human network who can use various aspects of space science, technology and applications for social and economic development of country.

The Centre is deemed to emerge as a nodal institution in the region which will focus, in addition to education, on specific regional issues of development through close cooperation between the countries, leading to integrated programme of space applications for regional development. It is hoped that in years to come, no country in the region will have to look abroad for expertise in space science & technology application, but will find them ready at home.

The Centre, as envisioned, is growing into an internationally acclaimed and reputed institution directly addressing the advancement of knowledge in the ever-expanding field of space technology and applications. The Centre is emerging as a nodal institution in the region which focuses on specific regional issues of development through its multi-faceted programmes of education, research projects and short-term training programmes. The Centre endeavors to adopt modern education concepts with the best faculty drawn from the experts in the region, state-of-art facilities for hands-on applications training advanced teaching tools and balanced theoretical and practical learning.

It is combined support and co-operation of the host country, the United Nations and the Governing Board members that sets the Centre through into the 2000's and makes it an international INSTITUTION OF EXCELLENCE.

Centre and Campuses

The Centre's headquarters is located at Dehradun, India and is situated in the campus of Indian Institute of Remote Sensing, Indian Space Research Organisation, Department of Space, Government of India. IIRS provides infrastructural support to the CSSTEAP headquarter office. The centre also has operational offices of ISRO/DOS Centres at Ahmedabad in the campuses of Space Applications Centre (SAC), Physical Research Laboratory (PRL) and ISRO Satellite Centre (ISAC), Bengaluru, Government of India.

To carry out all the educational programmes, CSSTEAP has arrangements with Indian Institute of Remote Sensing (IIRS), Dehradun for RS & GIS course; with Space Applications Centre (SAC), Ahmedabad for SATCOM and SATMET courses; and Physical Research Laboratory (PRL), Ahmedabad for Space & Atmospheric science course. The RS & GIS PG course is conducted every year since 1996. While SATCOM course is conducted every odd alternate year since 1997, SATMET & Space Science PG courses are conducted every even alternate year since 1998. The centre also organizes theme-specific short courses on Disaster Risk Reduction, Coastal Hazards, Microwave remote sensing, Hyperspectral remote sensing, etc., at IIRS Dehradun; Navigation and Satellite Positioning at SAC Ahmedabad and on Small Satellite Missions at IIRS, Dehradun and ISAC Bengaluru.

Role of the Centre

The Centre aspires to grow into a nodal organization in the region responsible for comprehensive capacity building. The guiding principles of the Centre are as follows:

1. Developing indigenous capacity building at local level
2. Provision of technical advisory services in the region
3. Provision of information in space science & technology
4. Providing long-term fellowship programmes
5. Organisation of technology transfer programmes and
6. Promotion of greater cooperation in space science & technology between developed countries and developing countries of Asia Pacific region, as well as amongst developing countries themselves

Towards this, the Centre would engage itself in educational and training programmes, application activities, research and pilot projects, data management, extension activities and awareness programmes.

Goals of the Centre

The issues in the Asia-Pacific region make it imperative to generate self-sustained and qualified human resources. The goals of the centre are:

1. Increasing knowledge and understanding in Space science, technology and applications.
2. Building/Enhancing national and regional capacity.
3. Education, research and applications.
4. Socio-Economic development, regional co-operation, support to international programmes, etc.

Organizational Structure of CSSTEAP

Ten countries signed the agreement for the establishment of CSSTEAP during a meeting held on November 1, 1995 at New Delhi. As of today, 15 countries have signed the agreement. In addition to providing a formal UN affiliation to the Centre, UN-OOSA extends support in terms of expert advise, technical assistance and relevant documentation.

The Government of India has concluded a host country agreement with the centre (March 1998) by which it has accorded specific privileges and international status to the centre, similar to the privileges enjoyed by UN specialized agencies. Under the host country agreement the centre also has access to facilities, infrastructure and expertise of DOS institutions, including IIRS, SAC, PRL and ISAC. The Government of India has brought out an official gazette notification in pursuance of the host country agreement.

Administrative Body of CSSTEAP

Governing Board

CSSTEAP is administered by an international Governing Board (GB) consisting of one representative from each contracting party. The Governing Board is the principal policy making organ of the Centre. The Governing Board elects one of the members as Chairman of the GB. Any other country, international organization or funding agency which has concluded a cooperation agreement with the Centre shall be

invited to the meetings of the Governing Board in the capacity of observers. Currently representatives of UN-OOSA Vienna (Austria) and the International Institute for Geoinformation Science and Earth Observation (ITC), in Enschede, Twente University, Twente, The Netherlands are observers. Director of the Centre acts as secretary to GB. The Governing Board decides the policy of the Centre, approves its long range plans and annual programmes and the budget. GB determines the functions and composition of the Advisory Committee.

Advisory Committee

The technical activities of the centre are guided by an Advisory Committee (AC) consisting of international subject experts. Members of the Advisory Committee are nominated by the Governing Board and serve for such a period as may be determined by the Governing Board. AC is chaired by the representative of UN-OOSA and reviews all technical aspects such as curriculum, technical facilities, future directions, etc.

Rationale of Educational Programmes

The major objective of the Centre is to create awareness regarding the potential of space science, technology and applications for the solution of the environmental and natural resources related problems, and to establish and strengthen national capabilities in space science technology and applications through education, training, application programmes and regional cooperation.

Educational Programmes

The educational programme of the centre is oriented towards the dissemination of knowledge in relevant aspects of space science and technology. The centre offers post graduate level courses in the areas of Remote Sensing and Geographic Information System, Satellite Communications, Satellite Meteorology and Global Climate, Space and Atmospheric Science. These courses are carried out at various centres of ISRO/DOS. A set of standard curricula developed by the United Nations is adapted for the educational programmes. The centre also organizes short-term workshops and awareness programmes in the above mentioned disciplines. The centre is affiliated to the United Nations and its educational programmes are recognized by Andhra University, India. A board of studies has been set up for each course that reviews the performance and suggests modifications if found necessary for the future courses taking into account of the faculty and students feedback and the advancement in the subject.

A set of standard curricula and course syllabus developed by the United Nations is adopted for the educational programmes and revised time to time. The Centre is affiliated to the United Nations and its educational programmes are recognized by Andhra University, India.

The post graduate courses are organized in two phases. The Phase-I is conducted in India for 9 months. It consists of core modules where the emphasis is on the development and enhancement of knowledge and skills through classroom lectures, tutorials, seminars and hands on experiments/practicals. The performance of the candidates is periodically assessed through oral, written and practical examinations. This is followed by pilot projects, giving practical training towards how the skills gained can be used for

solving problems by applying input from space as one of the information content. At the end of this Phase successful candidates are awarded post graduate diploma by the centre.

During Phase-II, each eligible student as per the criteria of Andhra University on return is expected to carry out an approved project in his or her home country for a period of one year. The project is formulated jointly by the scholar, his/her advisor of the sponsoring organization and an advisor from CSSTEAP in an area relevant to the development of their country. This gives an opportunity to the scholar to apply their knowledge and training received to tackle a 'real life' problem, where space science input can be used. These scholars, whose academic qualifications satisfy Andhra University, Visakhapatnam, India norms can submit a thesis based on their research work for the award of Master of Technology (M.Tech.) degree.

Award of Diploma/Degree

The structure of the programme is given in Fig. 1. In all the above mentioned programmes after the completion of the Phase-I study i.e. nine-month course, the participants will be awarded Post Graduate Diploma. If the eligible participant is able to complete Phase-II project work satisfactorily i.e., research project in home country within four years, the work can be submitted to the Andhra University (India) for the award of M. Tech. degree.

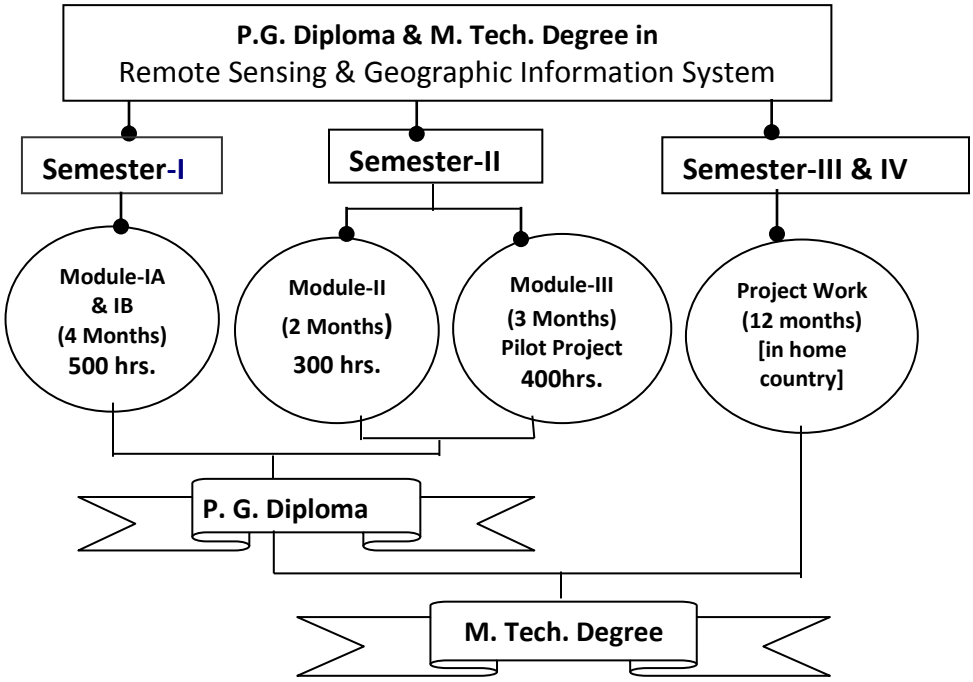

Fig. 1 Structure of Educational Programme of CSSTEAP

Since 2004, a few meritorious post graduate students are awarded fellowship to complete their one year research work at CSSTEAP, India. **Those who fail to clear the examinations will be given Certificate of Attendance**. Module-wise number of examination conducted is given below:

Module-I: (Compulsory) con sists of 5 Theory papers + 5 Practical papers

Module-II: (Optional streams) consists of 4 Theory papers + 4 Practical papers

Module-III: (Compulsory) consists of Pilot Project

Besides the post graduate level courses, the centre also conducts short courses (4 to 6 weeks) on specific themes in the four areas, highlighting how space inputs can be used for national development. Centre has also plans to support research programme leading to Ph.D. degree. Currently CSSTEAP is extending facility for carrying out Ph.D. degree research work to its alumnus in the centre for short duration.

Admission Process

Course Announcement

RS&GIS course begins every year on 1st of July. The announcement through course brochures or website (*www.cssteap.org*) is made during October-November every year. However, in view of the delays in clearances at different levels, candidates may apply anytime during the year, same will be considered for upcoming academic course.

Admission Requirements

The Candidates from Asia and the Pacific region only need to apply. All the candidates need to be sponsored (i.e. endorsed) by recognized institutions (e.g. ministries or universities in their respective countries). Sponsoring institution/ authority should ensure that on return, the scholar will be allowed to apply newly acquired knowledge and skills in the respective countries. Sponsoring organizations cannot withdraw nomination without valid reason or after having joined the course. Figure-2 shows the pProcedure for submission and forwarding the application

The duly filled application form need to be submitted through the CSSTEAP Governing Board member to the Indian Embassy/ Indian High Commission in their country. However, the applicants from non-Governing Board Member countries need to submit complete application forms to the centre through the Embassy/ High Commission of the respective country in New Delhi, India. The application should be completed in all respects and accompanied by attested and/or certified copies of all the certificates (School, Bachelor and Master, TOEFL, English Proficiency, etc.). Wherever these certificates are issued in a language other than English, the same may be translated in English and certified by the Head of the organization or provide English transcription of all such documents. However, an advance copy may be forwarded at CSSTEAP Hqrs. for advance action and follow-up.

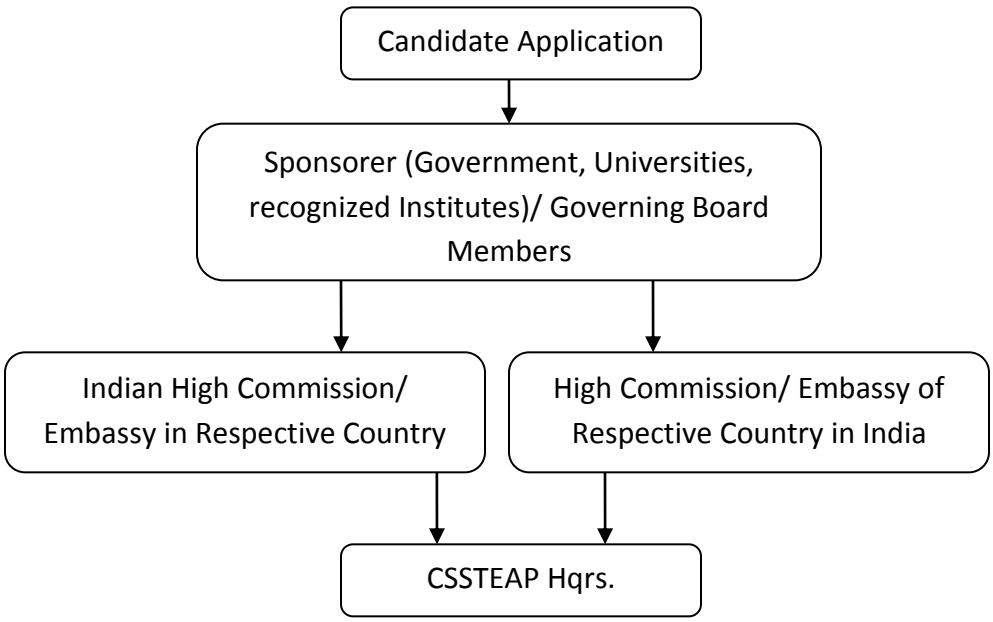

Fig. 2 Procedure for submission and forwarding the application

Required Qualifications for Admission

Master's degree in science or Bachelor's degree in engineering, Information Technology; Geoinformatics, Geoinformation Engineering or equivalent qualification relevant in the field of study with at least 5 years of experience in teaching/research or professional experience in the field of RS&GIS technology, natural resources or environment, e.g. agriculture, soils, forestry, ecology, geosciences, water resources, human settlement, land use planning, oceanography, environmental analysis, etc.

Criteria for selection of Candidates for RS&GIS Post Graduate Course

The centre selects the candidates through a well laid procedure, which includes satisfying academic eligibility, proficiency in English language, funding/forwarding by sponsoring authority/ organization, country representation etc. Preference in selection is given to female and those candidates whose expenses are borne by the candidate/ sponsoring agency.

Criteria for selection of Candidates for M. Tech. (Phase II)

As per Andhra University norms, a total of 16 years of education is compulsory to be eligible for M. Tech. admission. The execution of a one year project work in their respective countries is the beginning of this process and it is assumed that sponsoring authority will facilitate one year project work in the home country. However, the centre provides long distance technical guidance. A limited number of short-term and long-term fellowships may be made available to meritorious participants to complete Phase II research work in India.

Rules of Examination

Regulations for Post Graduate Course

Requirement of Attendance

A regular course of study during the course duration means a minimum attendance of 90% of all the subjects computed by totaling the number of periods conducted over the semester. However, in special cases and if sufficient causes are shown, Director, CSSTEAP may condone the deficiency in the average attendance to an extent of 10% for reasons such as ill-health or any other eventualities, and the application for condonation is submitted at the time of actual illness and is supported by certificate of Authorized Medical Officer (AMO).

The criteria for promotion from semester-I to semester-II and to the subsequent semesters is based on the requisite attendance put up by the candidate. A candidate, who fails to satisfy the required attendance, shall not be allowed for the Semester End Examination and shall not be allowed for promotion to the next semester of study.

Examination Pattern

Written examinations will be held during the framework of first two semesters. There will be two examinations: internal assessment and semester end examination (external).

Internal Assessment and Semester End Examinations

Assessment of each paper and related practical is of 100 marks. Out of which 30 marks are for internal assessment and 70 marks are for external assessment. The internal assessment will have **30 marks each for theory and 30 marks for practical**. The marks for the internal evaluation shall be awarded based on the internal assessment through assignments (written and/or computer based), tutorial, seminars, quiz, etc. At the end of each semester there will be external examination of three hours duration each for theory and practical of **70 marks** each.

Detail break-up for marks in each Semester

1. **Theory maximum marks** = 100 marks
   - Internal Assessment = 30 marks
   - Semester End examination = 70 marks

2. **Practical maximum marks** = 100 marks
   - Internal Assessment = 30 marks
   - Semester End examination = 70 marks

As per Andhra University rules minimum pass mark for each theory and practical paper is 40% and 50 % respectively in each practical subject**.** E.g. Candidates shall be required to obtain a minimum of **28 (40%)** marks out of **70** in the semester-end examination. However, to pass the exam the candidate must have overall marks of >= 50% (Theory & Practical put together).

The marks obtained in each paper will be converted to grades on a 10 point scale and a Semester Grade Point Average (SGPA) is calculated and subsequently to cumulative grade point average (CGPA). The Grade Card with grades in individual subjects, SGPA and CGPA is awarded at the end of the course. At the end of each semester, SGPA with grades in individual subjects will be notified for all the students together as and when two-tier evaluation by the internal and external examiners are ready. Table-1 provides the grades and grade point details.

Table-1: Grades and Grade Point Details

(As per AU order no LII(3)/New grading system/2016)

S.No.	Range of Marks (%)	Grade	Grade Points	
1.	> 90 ≤ 100	O	10	Outstanding
2.	> 80 ≤ 90	A+	9	Excellent
3.	>70 ≤ 80	A	8	Very Good
4.	>60 ≤ 70	B+	7	Good
5.	>55 ≤ 60	B	6	Above Average
6.	≥ 50 ≤ 55	C	5	Average
7.	≥ 40 < 50	P	4	Pass
8.	40	F	0	Fail
9.			0	Ab (Absent)

Calculation of SGPA (Semester Grade Point Average) & CGPA ()

Calculation of Semester Grade Point Average (SGPA)

SGPA = Σ(Grade Points X Subject Credit Points) / Total Available Subject Credits in Semester

Calculation of Cumulative Grade Point Average (CGPA)

CGPA = Σ (SGPA $_{\text{Sem-I}}$ X Total Available Subject Credits $_{\text{Sem-I}}$) + (SGPA $_{\text{Sem-II}}$ X Total Available Subject Credits $_{\text{Sem-II}}$)/ Total Available Subject Credits $_{\text{Sem-I+ Sem-II}}$

A candidate shall be declared to have passed in a subject / Paper, if the candidate secures a minimum of 'C' Grade in theory examination and a minimum of 'C' Grade in practical examination / Project / viva-voce. This includes tutorial / assignments wherever applicable. Further, a student has to secure a minimum of 5.0 SGPA for a pass in each semester in case of P.G. Diploma. Further, a student will be permitted to choose any paper(s) to appear for improvement in case the student fails to secure the minimum prescribed SGPA/CGPA to enable the student to pass at the end of any semester examination.

Pass/fail shall not be indicated in the marks statement against each individual paper. A student will be declared to have passed in a course if he/she secures 5.0 CGPA. CGPA will be calculated from Semester -I onwards up to the final semester. Further, classification of successful students is based on CGPA is as follows:

1. First Class with Distinction (CGPA 7.0 or more and cleared all exam. in first attempt).
2. First Class (CGPA 6.0 to 6.9 or more than 7.0 and failed in any subject)
3. Pass (CGPA 5.0 to 5.9)

CGPA multiplied by "10" gives aggregate percentage of marks obtained by a candidate.

Re-examination Rules

In case a student fails in first attempt **he/she can re-sit only once**. Any change in the norms of evaluation will be jointly modified by the authorities of CSSTEAP & AU. Summary of maximum marks and credits in different semester is given in Figure 3.

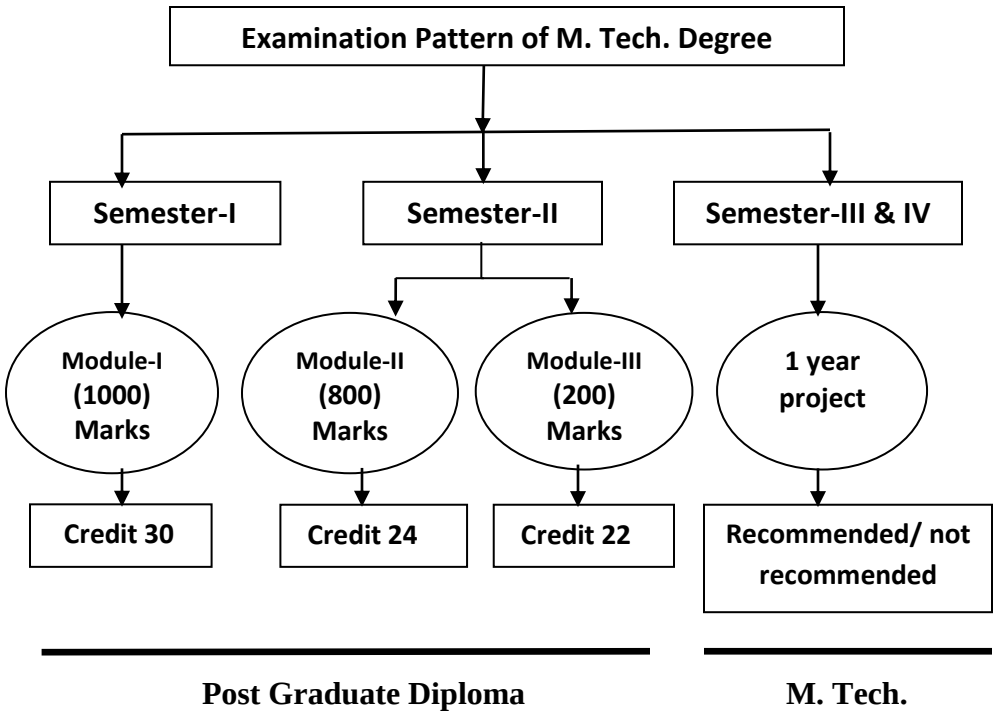

Fig. 3: Examination Pattern Semester-I, II, III & IV

Total credits for theory and practical in Module I, II & II are 76 (Table-2). Since Semester III and Semester IV is purely project work oriented and has no written examination (internal and /or external), therefore, instead of credits, recommended/ not recommended is given.

Course Structure and Credit Distribution

Number of papers per module and credits for each paper (theory as well as practical) for Post Graduate course are shown in Table-2.

Table-2: Course Structure and Credit Distribution

Semester/ Module	Duration	Paper	Max. Marks	M. Tech. Credits
Semester –I				
Module 1	4 months	Paper 1	100(Th.)+100(P)	4 + 2
		Paper 2	100(Th.)+100(P)	4 + 2
		Paper 3	100(Th.)+100(P)	4 + 2
		Paper 4	100(Th.)+100(P)	4 + 2
		Paper 5	100(Th.)+100(P)	4 + 2
		Total	**1000**	**30**
Semester –II				
Module 2	2 months	Paper 1	100(Th.)+100(P)	4 + 2
		Paper 2	100(Th.)+100(P)	4 + 2
		Paper 3	100(Th.)+100(P)	4 + 2
		Paper 4	100(Th.)+100(P)	4 + 2
		Total	**800**	**24**
Module 3	3 months	Pilot Project		22
		Total	**200**	**22**
Semester-III & Semester-IV	1 year	Project Work	**Recommended/ not Recommended**	
Total			**2000**	**76**

M. Tech. — Post Graduate Diploma

Course Syllabus

The syllabus is based on IIRS Post-Graduate Diploma course. The brief course syllabus has been presented in the following tables. The contents of the Semester-I have been covered in Module-1 viz. basics of remote sensing, photogrammetry, image interpretation, advanced topics on remote sensing and geographical information system and GPS etc. Duration of Semester-I is four months. The Semester-II covers the different specialized themes that are being taught in IIRS. The Semester-II

consists of two modules: Module-2 and Module-3. The duration of Module-2 is two months and it covers the theory and practical aspects of each specialized discipline. The specialized themes are:

1. Agriculture & Solis
2. Forest Ecosystem Assessment and Management
3. Geosciences & Geo-hazards
4. Urban and Regional Analysis
5. Marine and Atmospheric Science
6. Water Resources
7. Satellite Image Analysis & Photogrammetry
8. Geo-informatics

Module-3 of Semester II is of 3 months duration which covers the pilot project work and is taken up by individual candidate under the supervision of a guide from IIRS.

Syllabus for Semester-I

Photogrammetry & Remote Sensing

(Compulsory)

Module - I

1.0 Fundamentals of Remote Sensing & GIS

Code	Subjects	Code	Lectures* (L)	Practical		Total
				Lab + Assign.	Field Work	
Module-1A						
1.1	Remote Sensing	RS	25	40	10	75
1.2	Image Interpretation & Analysis	IA	25	40	10	75
1.3	Photogrammetry	PG	25	40	10	75
1.4	Geoinformatics	GE	25	40	10	75
Module-1B						
1.5	Recent Trends in RS and GIS & Environmental Assessment and Monitoring	RE	40	60	-	100
	Total		140	220	40	400

*Includes guest lectures & tutorials

Module – 1A

1.1 Remote Sensing

(Lecture – 25; Practical + Tutorial – 40; Field Work – 10; Total –75 hrs.)

Theory

Units	Topics	Sub Topics
1	**Physics of Remote Sensing**	• Definition and Overview of Remote Sensing and Remote Sensing Systems • Electromagnetic Radiation, Terms and Definitions, Laws of Radiation, EM Spectrum, Sources of EMR • Interaction between EM Radiation and matter, Reflection, Absorption and Transmission • Interactions between EM Radiation and Atmosphere, Atmospheric windows
2	**Spectral Signature, In-situ measurements and Visual image interpretation**	• Spectral Signatures for common LULC features, e.g., Water, Soil, Vegetation and Snow • Instruments for ground truth data collection (e.g., instatherm, spectroradiometers, etc.) • Principles of visual Interpretation of aerial photos and satellite imagery • Recognition Elements and Interpretation keys for Visual Interpretation • Interpretation of Multispectral Imagery and High resolution data
3	**Platforms & Sensors**	• Remote Sensing Systems - Active and Passive Systems, Imaging and Non Imaging Systems, Concept of Resolutions in RS - Spatial, Spectral, Radiometric and Temporal • Orbits and Platforms for Earth Observation • Earth Observation Satellites for land, ocean & atmosphere (global and Indian) (e.g., Resourcesat, Oceansat, INSAT, Sentinel, MODIS etc.), high resolution sensors and sensors for Stereo Data (Worldview, CARTOSAT, etc.) and their characteristics • Satellite Imaging modes
4	**Remote Sensing Data Errors, Data Products and their sources**	• Radiometric, geometric and atmospheric errors; Image Quality • Data Reception, Types of Data Products (e.g., Spectral Indices, Orthoproducts, Pan Sharpened Products, etc.) • Sources of RS data- Global and Indian
5	**Principles of Thermal & Microwave Remote Sensing**	• Principles of Thermal Remote Sensing & its applications • Interpretation of Thermal Imagery • Principles of Microwave Remote Sensing & its applications • Interpretation of SAR Imagery

Practical (Lab + Field)

Practical No.	Description
EX. RS 1	Study of spectral and image characteristics of optical data for identification /characterization of major landcover features
EX. RS 2	Spectra collection using ground based spectro-radiometer
EX. RS 3	Identification of Features on single vertical aerial photograph
EX. RS 4	Study of given area in B/W, B/W IR, Colour IR Imagery
EX. RS 5	Study of Satellite imagery (B/W) in different bands and visual interpretation
EX. RS 6	Interpretation of cultural details from High resolution Satellite image data (IKONOS)
EX. RS 7	Referencing Scheme and Browsing of Satellite data
EX. RS 8	Interpretation of land cover detail from satellite imagery
EX. RS 9	Interpretation of Thermal Image for land cover identification
EX. RS 10	Interpretation of SAR image for land cover identification

Suggested Readings

Books

1. Lillesand Thomas M. & Kiefer Ralph: Remote Sensing and Image Interpretation Third Edition John Wiley
2. Campbell John B.: Introduction to Remote Sensing Taylor & Francis
3. Floyd F. Sabins : Remote Sensing and Principles and Image Interpretation
4. Manual of Remote Sensing: American Society of Photogrammetry and Remote Sensing.
5. George Joseph: Fundamentals of Remote Sensing; Universities Press India Pvt Ltd, Hyderabad,India
6. Editors:John D. Bossler; John R. Jensen; Robert B. McMaster; Chris Rizos, 2001. Manual of Geospatial Science and Technology, November 2001, Vol 1 Part 1and II.
7. Paul M. Mather, 1999. Computer Processing of Remotely sensed Images: An Introduction. John Wiley.

Journal Articles

1. Dozier J 1984 Snow reflectance from Landsat-4 Thematic Mapper; IEEE Transactions on Geoscience and Remote Sensing, GE-22 (3) 323{328

2. Dozier J 1985 Spectral signature of snow in visible and near- infrared wavelengths; In: Proceedings of the Third Inter-national Colloquium on Spectral Signatures of Objects in Remote Sensing, ESA SP-247, pp. 437{442, Les Arcs, France, Dec 16{20)
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9. T Toutin,. Review article: Geometric processing of remote sensing images: models, algorithms and methods International. Journal of Remote Sensing, 20 May, 2004, Vol. 25, No. 10, 1893–1924
10. U.R. Rao; S. Chandrashekar, 1986. An international regime for remote sensing-problems and prospects. International Journal of Remote Sensing, Volume 7, Issue 1, 1986, Pages 3 – 18

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1. http://www.itc.nl/~bakker/rs.html
2. www.ccrs.nrcan.gc.ca/resource/tutor/fundam/index_e.php
3. rst.gsfc.nasa.gov/
4. http://www.r-s-c-c.org/rscc/v1m1.html
5. www.isprs.org
6. www.spaceimaging.com
7. www.landsat.usgs.gov
8. www.spotimage.fr
9. www.nrsc.gov.in
10. IRS 1C handbook: http://www.euromap.de/docs/doc_013.html
11. IRS P6 Users handbook. http://www.nrsc.gov.in/IRS_Documents/Handbook/Resourcesat-1_handbook_HTML
12. asterweb.jpl.nasa.gov

1.2 Image Interpretation and Analysis

(Lecture – 25; Practical + Tutorial – 40; Field Work – 10; Total –75 hrs.)

Theory

Units	Topics	Sub Topics
1	**Statistics for Image Processing**	• Introductory Statistics: Histogram, Measures of Central tendency, Correlation, Regression, Variance-Covariance
2	**Image Pre-processing**	• Image Processing Systems- Open Source & Commercial Tools • Fundamentals of Image Display & Data Formats • Fundamentals of Pre-processing- Radiometric correction: DN to TOA, Image Rectification and Registration
3	**Image Enhancement**	• Image Enhancement Techniques- Linear & Non Linear Contrast Enhancement • Filtering - Low Pass, High Pass and Edge Enhancement, Non Linear Filters
4	**Image Transforms & Fusion**	• Spectral Indices (e.g., for vegetation, water, soil, snow, etc.) • Image Transformations: IHS, PCA • Image Fusion Techniques
5	**Image Classification**	• Principles of Image Classification • Land cover classification schemes • Feature Selection & Separability Analysis • Unsupervised & Supervised classification • Classification Accuracy

Practical (Lab + Field)

Practical No.	Description
EX. IA 1	Familiarization with image Processing system, Importing data into software's format, Creating subset image, Loading image data and display, Display of Histograms
EX. IA 2	Radiometric correction
EX. IA 3	Image Registration - Image to Map, Image to Image, Image to user coordinates
EX. IA 4	Image enhancement techniques: Contrast Enhancement, Density Slicing and Transfer functions
EX. IA 5	Filtering: High Pass, Low Pass, Edge Enhancement
EX. IA 6	Principal Component Analysis, Spectral Indices
EX. IA 7	Image Fusion
EX. IA 8A &8B	Image classification techniques - unsupervised and supervised
EX. IA 9	Ground data collection for training sets in Image processing system for classification of image (FIELD EXERCISE)
EX. IA 10	Accuracy Assessment

Suggested Readings

Books:

1. Jensen John R. Introduction to Digital Image Processing: A Remote Sensing Perspective Prentice hall, New Jersey
2. Richards John A& Xiuping Xia, 2006. Remote Sensing Digital Image Analysis: An Introduction. Birkhäuser.
3. Lillesand Thomas M. & Kiefer Ralph: Remote Sensing Image Interpretation John Wiley and Sons, New York
4. Campbell John B. Introduction to Remote Sensing, Taylor & Francis, London
5. Sabins Floyd. F: Remote Sensing and Principles of Image Interpretation, W H Freeman, New York
6. Manual of Remote Sensing: American Society of Remote Sensing and Photogrammetry, Virginia, USA
7. Gonzalez Rafael C and Woods Richard E.: Digital Image Processing Addison Wesley, New York
8. Pratt William K.: Digital Image Processing, John Wiley and Sons, New York
9. Jain Anil K. Fundamentals of Digital Image Processing, Prentice Hall, New Jersey:
10. Pohl Christine: 1996 Geometric Aspects of Multisensor Image Fusion for Topographical Map updating in humid Tropics: ITC Publication, Enschede

Journal Articles:

1. Govil S.K, Kumar Minakshi. 2005. Accuracy evaluation of Different rectification methods for aerial photographs, Map India
2. Huete, A. R. (1988)'A soil-adjusted vegetation index (SAVI)', Remote Sensing of Environment, 25, 53-70.
3. Kaufman, Y. J. and D. Tanre (1992) 'Atmospherically resistant vegetation index (ARVI) for EOS-MODIS', in 'Proc. IEEE Int. Geosci. and Remote Sensing Symp. '92, IEEE, New York, 261-270.
4. Mondal, S., Kumar, Minakshi,et. al, (2004). Land use / Land cover assessment and its spatio-temporal dynamics using multi-temporal satellite images in the southern parts of lower Garhwal Himalayas, Proc. National Seminar on 'Role of Geoinformatics in decentralized planning for better governance', Dept. Of Remote Sensing, Birla Institute of Technology, Mesra, Ranchi, October 7-8, 2004.
5. Myneni, R. B., F. G. Hall, P.J. Sellers, and A.L. Marshak (1995) 'The interpretation of spectral vegetation indexes', IEEE Transactions on Geoscience and Remote Sensing, 33, 481-486.
6. Prince, S. 1991, Satellite Remote Sensing of Primary Production: Comparison of Results for Sahelian Grassland 1981-1988-Special Issue - Coarse Resolution Remote Sensing of Sahelian Environment. International Journal of Remote Sensing. Vol. 12, pp. 1301-1311.
7. Richardson, A. J. and C. L. Wiegand (1977) 'Distinguishing vegetation from soil background information', Photogrammetric Engineering and Remote Sensing, 43, 1541-1552.
8. Sellers, P. J. (1985) 'Canopy reflectance, photosynthesis, and transpiration', International Journal of Remote Sensing, 6, 1335-1372.
9. Tucker, C.J. (1979) 'Red and Photographic Infrared Linear Combinations for Monitoring Vegetation', Remote Sensing of Environment, 8(2), 127-150.
10. Holben, B. N. (1986)'Characteristics of Maximum-Value Composite Images from Temporal AVHRR Data', International Journal of Remote Sensing, 7(11), 1417-1434.
11. Tucker, C.J., Townshend, J.R.G., and Goff, T.E. (1985) African Landcover Classification using Satellite Data. Science. Vol. 227, pp. 369-375.
12. Unganai, L. S., and Kogan, F. N. (1998) Drought Monitoring and Corn Yield Estimation in Southern Africa from AVHRR data. Remote Sensing of Environment. Vol. 63, No. 3, pp. 219-232.

Websites:

1. www.ccrs.nrcan.gc.ca/resource/tutor/fundam/index_e.php
2. http://www.r-s-c-c.org/rscc/v1m1.html
3. A comparative assessment of classification methods http://portal.acm.org/citation.cfm?id=873866
4. Classification Techniques in Pattern Recognition
5. http://wscg.zcu.cz/wscg2005/Papers_2005/Poster/K43-full.pdf
6. http://en.wikipedia.org/wiki/NDVI
7. Manipulation of Normalized Difference Vegetation Index (NDVI) for Delineating Drought Vulnerable Areas http://www.gisdevelopment.net/application/natural_hazards/drought/nhdr0005.htm
8. http://www.csc.noaa.gov/crs/definitions/NDVI.html
9. http://en.wikipedia.org/wiki/Principal_components_analysis
10. http://www.cs.otago.ac.nz/cosc453/student_tutorials/principal_components.pdf
11. http://en.wikipedia.org/wiki/High-pass_filter
12. http://www.fmrib.ox.ac.uk/analysis/techrep/tr01mw1/tr01mw1/node15.html
13. http://www.photoshopessentials.com/photo-editing/sharpen-high-pass/
14. http://www.cas.sc.edu/geog/rslab/Rscc/mod6/6-3/linear.html
15. http://www.cee.hw.ac.uk/hipr/html/stretch.html
16. http://www.fas.org/irp/imint/docs/rst/Sect1/Sect1_12a.html
17. http://www.castle.geographie.uni-kiel.de/r-kiel4/s3l4p080.htm
18. http://www.cee.hw.ac.uk/hipr/html/histeq.html
19. http://www.ph.tn.tudelft.nl/Courses/FIP/noframes/fip-istogram.html
20. http://en.wikipedia.org/wiki/Histogram_equalization

1.3 Photogrammetry

(Lecture – 25; Practical + Tutorial – 40; Field Work – 10; Total –75 hrs.)

Theory

Units	Topics	Sub Topics
1	**Aerial Photography**	• Basics of aerial Photography • Basic Geometry of Aerial Photograph, Central and orthographic projection, Difference between map and aerial photograph, Types of Aerial photographs- wide angle, narrow angle, Horizontal, Vertical, Oblique • Scale and Ground coverage of aerial photographs
2	**Stereo Photographs & its Geometry**	• Relief Displacement in aerial photographs and its characteristics • Geometry of tilted/oblique photograph, Isocentre, Nadir point, Principle point and Principle plane, Tilt Displacement • Stereoscopy and binocular vision, Concept of Depth perception in Monocular and Binocular vision, Base-height ratio, stereoscopic exaggeration • Stereoscopes, Stereoscopic parallax, Parallax bar, Floating mark • Use of Parallax bar in height measurement, Parallax formula
3	**Stereo Photogrammetry**	• Stereophotogrammetry • Orientation of aerial photographs – Inner, Relative and Absolute orientation • Basics of Analytical Photogrammetry- Collinearity and Coplanarity conditions, Concept of Rotation Matrix
4	**Digital Photogrammetry**	• Introductory concepts in Digital Photogrammetry (Digital data input (photogrammetric scanners, Digital Photogrammetric camera), H/W and S/W requirements, Photogrammetric triangulation in Digital Photogrammetric Workstation (DPWS), Stereo view in DPWS, feature extraction on DPWS) • Concept of DEM, DSM and DTM, DEM extraction and Orthoimage generation- Concept of Image Matching, Automatic DEM generation, Digital maps and their characteristics
5	**Satellite Photogrammetry**	• Satellite based Digital Photogrammetry (Orbital Parameters, Orbital modeling, Data Processing for stereo generation) • Stereo Sensors in Space- Tilt across the track, Tilt along the track, Single push broom scanners (CARTOSAT, SPOT, IKONOS, etc.), Three camera system (KOMSAT-3)

Practical (Lab + Field)

Practical No.	Description
EX. PG 1	Stereo Test and Determination of photo scale
EX. PG 2	Preparation of Base map from topo sheet including legend, scale and annotation
EX. PG 3	Locating nadir point and principal point on aerial photo and determination of height from single vertical aerial photograph
EX. PG 4	Orientation of Stereo model under mirror stereoscope
EX. PG 5	Tracing of details from Stereo pair
EX. PG 6	Use of parallax bar and determination of heights
EX. PG 7	Familiarization with DPWS, Project creation, data input, orientation, generation of DEM and orthoimage
EX. PG 8	Feature extraction of topographic details using DPWS
EX. PG 9A and 9B	GCPs collection using GNSS and Satellite Stereo Data Processing

Suggested Readings

Books:

1. Toni Schenk: Digital Photogrammetry, Volume I., TerraScience.
2. Paul Wolf, Elements of Photogrammetry, McGraw Hill.
3. Cliff Greve and ASPRS Digital Photogrammetry: An Addendum to Manual of Photogrammetry
4. Mikhail Edward, bethel James and Mcglone J Chris Introduction to Modern Photogrammetry, John Wiley & sons Inc.
5. Kasser Michel and Egles Yves Digital Photogrammetry. Taylor & Francis. London & New York.
6. Sanjib K. Ghosh, 1979: Analytical Photogrammetry, New York: Pergamon Press
7. Sanjib K. Ghosh. 2005. Fundamentals of computation Photogrammetry. Concept publishing, New Delhi.
8. Schmidt Milton O and Rayner William Horace Fundamentals of Surveying, Van Nostrand Reinhold Company
9. Leick Alfred, 1995: GPS Satellite Surveying, Wiley Interscience.
10. Robinson, A.; Morrison, J.; Muehrke, P.; Kimmerling, A.; & Guptill, S. *Elements of Cartography* New York: Wiley

Journal Articles

1. Ackermann F (1996) Techniques and strategies for DEM generation. In: Greve C (ed) Digital Photogrammetry: An Addendum to the Manual of Photogrammetry. American Society of Photogrammetry and Remote Sensing, Falls Church, VA, pp 135-141.

2. Chen, L. C., and Liang-Hwei Lee. 1993. Rigorous Generation of Digital Orthophotos from SPOT Images. Photogrammetric Engineering and Remote Sensing. Volume 59. Number 5. Pages 655 - 661.

Web sites

1. www.univie.ac.at/Luftbildarchiv/wgv/intro.htm
2. http://www.geodetic.com/Whatis.htm
3. http://www.kth.se/student/studiehandbok/index.asp?lang=1
4. http://web.pdx.edu/~emch/maps/maps.html#A
5. http://www.ccrs.nrcan.gc.ca/resource/tutor/fundam/index_e.php
6. http://www.r-s-c-c.org/rscc/v1m1.html
7. ISPRS website: Links to several related sites
8. www.asprs.org/

1.4 Geoinformatics

(Lecture – 25; Practical + Tutorial – 40; Field Work – 10; Total –75 hrs.)

Theory

Units	Topics	Sub Topics
1	**Overview of GIS, Geodesy and DEM**	• Overview of Geographical Information System (GIS) and its Applications; • Geodesy: An Overview; • Map Projections and datums in GIS, • Data Quality and Sources of Errors in GIS; • Digital Elevation Models and its Derivatives (first order and second order);
2	**Data models,** **and Data Quality**	• Data Models: An Overview; • Conceptual Model of Spatial Information; • Concept of databases and Conceptual Models of Non-Spatial Information; • GIS Data Creation and Organization;
3	**Spatial Data Analysis**	• Spatial data Analysis (Vector-based); • Spatial data Analysis (Raster-based); Network Analysis in GIS
4	**GNSS and Its Applications**	• Fundamental concepts of satellite based radio navigation; • Global Operational GNSSs; GNSS Satellites, Constellation of GNSS Satellites; Measurement techniques, Sources of errors, Positioning Techniques, Survey Styles; • Regional Navigation System & SBAS; • Applications of GNSS in Resource Surveys, Mapping and Navigation.
5	**SDI and Recent trends in GIS**	• Overview of FOSS4G and COT'S; Basics of Spatial Data Infrastructure (SDI); Recent Trends in Geoinformatics

Practical (Lab + Field)

Practical No.	Description
EX. GE 1	Familiarization with GIS Software
EX. GE 2	Georeferencing and Projection
EX. GE 3	GIS Data Creation - Digitization and Topology editing
EX. GE 4	GIS Data Creation - Domain Values, Data Types & Attribution
EX. GE 5	Spatial and Non-Spatial Queries
EX. GE 6	Vector-based Spatial Analysis
EX. GE 7	Raster-based Spatial Analysis
EX. GE 8	Network Analysis
EX. GE 9	Generation of DEM
EX. GE 10	Map Composition
EX. GE 11	Demonstration on different Types of GNSS receivers; Checking of existing map coordinates using IRNSS Receiver
EX. GE 12	Survey of small area using IRNSS receiver
EX. GE 13	Data Collection and Updation using Mobile GIS (Qrealtime)

Suggested Readings

Books:

1. Burrough, P. P. & McDonnel, R. A. (1998). Principles of GIS. Oxford University Press.
2. Chang, K. T. (2006). Introduction to Geographic Information Systems. The McGraw-Hill.
3. DeMers, and Michael, N. (2005). Fundamentals of Geographic Information Systems. John Wiley and Sons.
4. Hoffmann-Wellenhof, B. (1994). GPS Theory and Practice. Springer-Verlag, New York (2nd edition).
5. Maguire, D. J., Goodchild, M. F., and Rhind, D. W. (eds.) (1991). Geographical Information Systems: Principles and Applications. Avon, Longman Scientific and Technical.
6. Parkinson,B. W., Spilker, J. J. (Jr.) (1996). Global Positioning System: Theory & Applications (Volume-I). AIAA, USA

Online resources:

1. http://www.colorado.edu/geography/gcraft/notes/sources/sources_f.html
2. http://www.ncgia.ucsb.edu/giscc/units/u055/u055.html.
3. http://www.trimble.com/
4. http://www.pasda.psu.edu/tutorials/gisbasics.asp
5. http://nptel.iitm.ac.in/video.php?subjectId=105107121

Module – 1B

1.5 Recent Trends in RS and GIS and Environmental Assessment and Monitoring

(Lecture – 40; Practical + Assignments – 60; Total –100 hrs.)

Units	Topics	Sub Topics
1	**Advances in Remote Sensing**	• Principles and applications of hyperspectral Remote Sensing; • Principles and applications of Laser Remote Sensing
2	**Advances in GIS**	• Concept and approaches of multi-criteria decision making; • Fundamentals & applications of participatory GIS
3	**Frameworks for sustainable development & disaster risk reduction**	• Overview of Sustainable Development Goals (SDGs); • Overview of Sendai Framework for disaster risk reduction (SFDRRR)
4	**Application of Earth Observation (EO) data for land resources**	• Role of EO data in promoting sustainable agriculture (SDG-2 "Zero Hunger") and addressing desertification and land degradation (SDG-15 "Life on Land"); • Role of EO data in sustainable forest management resources (SDG-15 "Life on Land"); • Role of EO data in urban and regional studies (SDG-11 "Sustainable Cities and Communities")
5	**Application of EO data for climate, water & ocean resources**	• Role of EO data in climatic studies (SDG-13 "Climate Action"); • Role of EO data in integrated water resources management (SDG-6 "Clean Water and Sanitation"); • Role of EO data in mapping, monitoring & management of ocean & marine resources (SDG-14 " Life Below Water")

Practicals (Lab+Assignment+Demonstration)

Practical No.	Description
EX. 1	Exposure to Hyperspectral Remote Sensing
EX. 2	Exposure to Multi-criteria decision making
EX. 3	Exposure to open source disaster monitoring and mitigation portals
EX. 4	Exposure to agriculture related portals Exposure to forest resources related portals Exposure to urban growth studies related portals
EX. 5	Exposure to climate studies related portals Exposure to water related portals Exposure to ocean and marine resources related portals

Suggested Readings

1. Borengasser, M., Hungate, W. S., & Watkins, R. (2007). Hyperspectral remote sensing: principles and applications. CRC press.
2. Collis, R. T. H., & Russell, P. B. (1976). Laser applications in remote sensing. In Remote sensing for environmental sciences (pp. 110-146). Springer, Berlin, Heidelberg.
3. Tannenbaum, H. (1974, March). Laser Applications In Remote Sensing. In Impact of lasers in spectroscopy (Vol. 49, pp. 81-86). International Society for Optics and Photonics.
4. John Randolph, Environmental Land Use Planning and Management, Island Press 576 pages, 2004.
5. J. R. Jensen, Remote Sensing of the Environment: An Earth Resource Perspective (2nd Edition) (Prentice Hall Series in Geographic Information Science)
6. Engman, E. T., and R. j. Gurney. Remote Sensing in hydrology. London, Chapman and Hall, 1991.
7. Ustin Susan, Remote Sensing for Natural Resource Management and Environmental Monitoring. Wiley; 3 edition (April 19 2004)
8. Peter M. Atkinson, Nicholas J. Tate, Advances in Remote Sensing and GIS Analysis.
9. Chein-I Chang, Hyperspectral Imaging: Techniques for Spectral Detection and Classification, Springer; 1 edition (July 31, 2003).
10. Andrew Skidmore, Environmental Modelling with GIS and Remote Sensing, Published 2002 CRC Press.
11. Gert A. Schultz, Edwin T. Engman, Remote Sensing in Hydrology and Water Management, Springer; 1 edition (June 8, 2000).
12. Jonathan Li, Sisi Zlatanova, Andrea Fabbri, Geomatics Solutions for Disaster Management, Springer; 1 edition (Jun 12 2007)
13. Kenneth N. Brooks, Hydrology and the management of Watersheds, Blackwell Publishing (2003).
14. Wood, J. E., Gillis, M. D., Goodenough, D. G., Hall, R. J., Leckie, D. G., Luther, J. E., & Wulder, M. A. (2002, June). Earth observation for sustainable development of forests (EOSD): project overview. In *Geoscience and Remote Sensing Symposium, 2002. IGARSS'02. 2002 IEEE International* (Vol. 3, pp. 1299-1302). IEEE.
15. Malczewski, J. (1996). A GIS-based approach to multiple criteria group decision-making. International Journal of Geographical Information Systems, 10(8), 955-971.
16. Malczewski, J. (2006). GIS-based multicriteria decision analysis: a survey of the literature. *International journal of geographical information science*, *20*(7), 703-726.
17. Abbot, J., Chambers, R., Dunn, C., Harris, T., Merode, E. D., Porter, G., & Weiner, D. (1998). Participatory GIS: opportunity or oxymoron. PLA notes, 33, 27-33.
18. Voss, A., Denisovich, I., Gatalsky, P., Gavouchidis, K., Klotz, A., Roeder, S., & Voss, H. (2004). Evolution of a participatory GIS. Computers, Environment and Urban Systems, 28(6), 635-651.
19. Aitsi-Selmi, A., Egawa, S., Sasaki, H., Wannous, C., & Murray, V. (2015). The Sendai framework for disaster risk reduction: Renewing the global commitment to people's resilience, health, and well-being. International Journal of Disaster Risk Science, 6(2), 164-176.
20. Jha, M. K., Chowdhury, A., Chowdary, V. M., & Peiffer, S. (2007). Groundwater management and development by integrated remote sensing and geographic information systems: prospects and constraints. Water Resources Management, 21(2), 427-467.
21. Green, E. P., Mumby, P. J., Edwards, A. J., & Clark, C. D. (1996). A review of remote sensing for the assessment and management of tropical coastal resources. *Coastal management*, *24*(1), 1-40.
22. http://www.undp.org/content/undp/en/home/sustainable-development-goals.html
23. http://eohandbook.com/sdg/part2_2.html
24. http://eohandbook.com/sdg/files/CEOS_EOHB_2018_SDG.pdf
25. http://peoplebuildingbettercities.org/wp-content/uploads/2013/04/MDGs-to-SDGs-Lancet.pdf

Syllabus for Semester-II

Agriculture & Soils

(Optional)

2.1 Agriculture & Soils

Code	Papers	Lecture* Hrs.	Practical		Total Hrs.
			Lab Hrs.	Field Hrs.	
2.1.1	Land Use & Soil Resources Management (LSM)	25	42	8	75
2.1.2	Agri-Informatics (AI)	25	42	8	75
2.1.3	Environmental Soil Science (ES)	25	42	8	75
2.1.4	Satellite Agrometeorology (SA)	25	42	8	75
	Total	100	164	36	300

*Include guest lectures & tutorials

2.1.1 Land Use & Soil Resource Assessment (Theory)

Units	Topics	Sub Topics
1	**Land use / Land cover (LULC) Analysis**	• Land Use / Land Cover Classification System : India and Global • Visual Analysis for LULC Mapping • Digital Methods for LULC Mapping • LULC Change Detection
2	**Soil characteristics & Pedogenesis**	• Basics of soil and physico-chemical Characteristics of soils • Pedogenic (Soil forming) factors • Pedogenic (Soil Forming) processes • Spectral characteristics of soils
3	**Soil Resource Mapping**	• Need and scope of soil survey, scale of soil survey, remote sensing data requirements • Physiographic-soil analysis for delineation of soilscape units • Soil Resource Mapping using RS data • Landforms and soils : Structural, Denudational, Fluvial and Aeolian
4	**Soil Classification**	• Soil morphological characteristics • Characteristics of surface, sub-surface diagnostic horizons • Soil Taxonomy: Salient characteristics of soil orders • Soil Taxonomy : Soil classification at family level (particle size classification, soil temperature and moisture regimes)
5	**Land Evaluation**	• Concept and approaches of land evaluation for Land Use Planning • Land capability classification • Soil and land irrigability Classification • FAO Framework of land evaluation • Soil and Land productivity indices

2.1.1 Land Use & Soil Resource Assessment (Practical)

Practical No.	Topics	Sub Topics
1	**Land use / Land cover (LULC) Analysis**	• Agricultural Land Use /Land Cover mapping – Visual analysis of satellite data
		• Agricultural Land Use /Land Cover mapping – Digital analysis of satellite data & Mapping accuracy assessment
		• Field work for LULC ground truth data collection, soil spectral reflectance & soil profile study
2	**Soil Characteristics**	• Soil texture, pH & Electrical Conductivity (EC) analysis of soil sample in laboratory
3	**Soil Classification**	• Soil profile description: Horizon designation (Field Visit)
		• Soil morphological characteristics
		• Characterization of surface and sub-surface diagnostic horizons
		• Soil Classification following soil Taxonomy
4	**Soil resource mapping**	• Physiographic analysis using Satellite data (Hilly landforms)
		• Physiographic analysis using Satellite data (Fluvial Landforms)
		• Digital image processing in soil mapping
5	**Land Evaluation**	• Land Evaluation : Land capability classification
		• Land Evaluation : Land irrigability classification
		• Land Evaluation : FAO method of Land Evaluation and Land Productivity Index

Suggested Readings

Books

Soil Properties & Pedogenesis

1. The Nature and Properties of Soils. Twelfth ed. (1999), Prentice Hall, Inc. by Brady, N.C., and Weil, R.R
2. Huete Alfredo (2004). Remote Sensing of Soils and Soil Processes. In: Susan Ustin (ed.) Remote Sensing for Natural Resource Management and Environmental Monitoring: Manual of Remote Senasing, Vol. 4, John Wiley & Sons, Inc.
3. Remote sensing applications (2009), Published by NRSC, ISRO, Hyderabad, Chapters – 2 & 4
4. Encyclopedia of soils in the environment (2007) Editor-in-chief, Daniel Hillel, 4 volumes, Academic Press

Soil Resource Mapping

5. Encyclopedia of Soil Science - Second edition (2010) Edited by Rattan Lal, Publisher – Taulor & Francis
6. Tropical Soils and Soil Survey. Cambridge (1976), Univ. Press, Cambridge, 468 pp. by Young, A.,
7. FAO, 1977. Guidelines for Soil Profile Description. FAO, Rome, 66 pp.
8. McKenzie, N.J., Gessler, P.E., Ryan, P.J., O'Connell, D.A., 2000. The role of terrain analysis in soil mapping. In:Wilson, J.P., Gallant, J.C. (Eds.), Terrain Analysis: Principles and Applications (Chapter 10). John Wiley and Sons Ltd., New York.

Soil Classification

9. Soil Survey Staff, 2010. Soil Taxonomy. US Department of Agriculture, Washington, DC, 754 pp.

Land Evaluation for Land use planning

10. The Evaluation of Land Resources. Longman, Harlow, (1992) by Davidson, D.A.
11. FAO (1976) A framework for land evaluation. Rome: Food and Agriculture Organisation of the United Nation
12. FAO (1979) Land Evaluation Criteria for Irrigation. Rome: Food and Agriculture Organisation.
13. FAO (1983) Guidelines: land evaluation for rainfed agriculture. Rome: Food and Agriculture Organisation of the United Nation.
14. Soil Survey and Land Evaluation. London: George (1980), by Dent, D. & Young, A. Allen & Unwin Ltd.

Journal Papers

1. Anderson, J.R. et al. (1976), A land use/land cover classification system for use with remote sensing data. Professional Paper 964, USGS Publication 1976.
2. Baumgardner. M. F., L. F. Silva, L. L. Biehl. and E. R. Stoner (1985). Reflectance properties of soils. *Adv. Agron.* 38: 1-44.
3. Dwivedi, R.S. (2001). Soil resource mapping: A remote sensing perspective. Remote Sensing Reviews, Vol. 20, 89-122.
4. Zhu, A. X., Hudson, B., Burt, J. Lubich, K. and Simonson D. (2001). Soil Mapping Using GIS, Expert Knowledge, and Fuzzy Logic, Soil Sci. Soc. Am. J. 65:1463–1472

5. Cihlar J (2000) Land cover mapping of large area from satellites:status and research priorities, International Journal of Remote Sensing,21(6-7): 1093-1114.
6. Agarwal c, Green g m, Grover, J M, Evans T and Schweik C (2000) A review and assessment of land use change models: Dynamics of space, time, and human choice, Proc. 4th International conference on integrated GIS and environmental modeling(GIS/EM4), Sept. 2-8, Banff, Canada.
7. Rossiter, D.G. (1996) A theoretical framework for land evaluation. *Elsevier,* Geoderma 72(1996)165-190, 35.
8. McBratney, A.B., Mendonça Santos, M.L., Minasnya, B.(2003). On digital soil mapping. Geoderma 117, 3–52.

Copping, p r and Marvin E V (1996) Digital change detection in forest ecosystems, Remote Sensing Reviews, 13207 -13234.

2.1.2 Agri-informatics (Theory)

Units	Topics	Sub Topics
1	**Crop Inventory : Optical Remote Sensing**	• Overview and need for Agri-informatics • Spectral characteristics of crops and EMR interaction • Spectral Vegetation Indices for crop studies • Crop identification, mapping and acreage estimation
2	**Crop inventory : Microwave Remote Sensing**	• Microwave sensors parameters and signatures of vegetation in reference to Polarization, incidence angle, frequency • Crop discrimination and crop growth monitoring from microwave RS • Synergy of optical and microwave satellite data for crop Inventory • Microwave RS for retrieval of crop parameters
3	**Crop condition and cropping system analysis**	• Crop Biophysical parameters • Crop condition and stress assessment (Biotic and abiotic) • Cropping Pattern and Cropping System analysis • Crop biophysical parameter retrieval : Empirical, semi-empirical models • Crop biophysical parameter retrieval using canopy reflectance models
4	**Crop Management : Hyperspectral Remote Sensing**	• Hyperspectral RS in Agriculture : Scope and current status • Hyperspectral indices in crop condition assessment • Crop Identification and Mapping using Hyperspectral RS • Precision agriculture: Scope and Limitations
5	**Crop Informatics**	• Agriculture Information system: Crop Yield Forecasting System; Yield Gap Analysis; Pest Information System • Wireless Sensor networking for crop and soil health studies • Decision support systems: Spatial decision support systems (SDSS) and crop input optimization for Crop Planning • ICT applications in agriculture including crowdsourcing

2.1.2 Agri-informatics (Practical)

Practical No.	Topics	Sub Topics
1	**Crop Inventory : Optical Remote Sensing**	• Crop discrimination using visual and digital classification of satellite data (Field Visit)
		• Crop area estimation using digital analysis of satellite data
2	**Crop inventory : Microwave Remote Sensing**	• SAR data analysis using different SAR satellite datasets
		• SAR data analysis for crop discrimination and area estimation
		• Synergistic use of SAR & Optical satellite data for crop inventory
3	**Crop condition and cropping system analysis**	• Cropping pattern & cropping indices analysis
		• Atmospheric and radiometric correction of satellite data
		• Crop biophysical parameter retrieval using satellite data
4	**Crop Management : Hyperspectral Remote Sensing**	• Crop classification using hyperspectral satellite data
		• Crop stress assessment using hyperspectral satellite data
5	**Crop Informatics**	• ICT application in agriculture at village/ block scale
		• Demonstration on DSS in agriculture

Suggested Readings

Books

1. Remote sensing applications (2009), Published by NRSC, ISRO, Hyderabad, Chapters – 1 &13
2. Manfred Owe; Guido D'Urso (2005). Remote Sensing for Agriculture, Ecosystems, and Hydrology VII : Proceedings of SPIE Volume: 5976
3. Quantitative Remote Sensing of Land Surfaces (2005) By Shunlin Liang), Willey Publishers
4. Applications of remote sensing in agriculture (1990) edited by M.D. Steven, J.A. Clark, Publisher – Butterworth, London
5. Ustin, S. (2001). Manual of Remote Sensing, Volume 4, Remote Sensing for Natural Resource Management and Environmental Monitoring, 3rd Edition, Willey Publishing
6. Precision Agriculture in the 21st Century - Geospatial and Information Technologies in Crop Management (1997) National Academy Press, Washington D. C.
7. Holmes M.G., 1990, Application radar in Agriculture, Remote sensing applications to agriculture, ed. M.D. Steven and J.A. Clark, Butterworhs, p. 307.

Journal Papers

1. Moriondo, M., Maseli, F. and Bindi, M. (2007). A simple model of regional wheat yield based on NDVI data. Europ. J. Agronomy, 26:266-274
2. Michel Deshayes et al. (2006). The contribution of remote sensing to the assessment of crop yield. Ann. For. Sci. 63 (2006) 579–595.
3. Kanchdeva R. et al. (2006).Plant Spectral Signatures as Growth Stress Indicators. Information and Communication Technologies, 2006. ICTTA '06. 2nd
4. Navalgund, R.R., Parihar, J.S.; Ajai and Rao, P.P.N. (1991). Crop inventory using remote sensed data. Current Science, 61: 162-171.
5. Dadhwal, V.K. (1999). Remote Sensing Applications for Agriculture- Retrospective and Perspective. Proc. ISRS National Symposium on RS applications for Natural Resources-Retrospective and Perspective, Bangalore, 11-22pp.
6. Badhwar, G.D.(1982) Profile modeling for crop discrimination, Machine Processing of Remotely Sensed data, 454-459pp.
7. Baier, W (1973) Crop –weather analysis models and their use yield in yield assessment, WMO, TN, NO. 151, Geneva.
8. Saha, S.K. and Jonna, S.(1994) Paddy acreage and yield estimation and irrigated crop land inventory in Nellore district (Andhra Pradesh, India) using satellite and agro-meteorological data. Asian Pacific Journal, 6(2): 79-88.
9. Singh, R.; Goyal, R.C.; Saha, S.K.; and Chhikara, R.S. (1992) Use of satellite spectral data in crop yield estimation surveys, 13(14): 2583-2592.
10. Kogan, F. (1997) Global drought watch from space. Bulletin of the Americal Meteorological Society, 78: 626-636pp.
11. Singh, R.P. and Kogan, F. (2003) Monitoring vegetation condition from NOAA operational polar-orbiting satellite over Indian region, J. Indian Soc. Rem. Sens.; 30(3),117-118.

2.1.3 Environmental Soil Science (Theory)

Units	Topics	Sub Topics
1	**Land degradation and Desertification**	• Land degradation and desertification – Definition, factors and processes, and their current status in India and Asia – Pacific. • Characteristics of various types of degraded soils. • Land degradation mapping - visual & digital approaches. • Monitoring land degradation.
2	**Watershed Management**	• Watershed: Concept, principles and need of watershed management, characterization, delineation & codification. • Digital terrain analysis: Morphometric analysis, terrain indices, soil-hydrological analysis. • Soil Erosion assessment and watershed prioritization for conservation planning: Empirical, semi empirical and process based erosion models. • Soil conservation measures: Agronomic, soil and mechanical. • Monitoring & Impact assessment of watershed development program.
3	**Digital soil mapping**	• Digital soil mapping – need, concept and scope • Terrain analysis for soil mapping. • Geostatistical methods for soil mapping. • Hyperspectral RS in soil salinity/soil characteristics studies.
4	**Soil carbon and soil quality**	• Soil carbon assessment: SOC stock, dynamics and modelling. • Soil carbon sequestration and Impact of climate change on soil carbon • Soil Quality: Scope, need and Indicators. • Soil quality: measurement and assessment.
5	**Optimal Land use Planning**	• Optimum land use planning – concept, issues and approaches. • Agro-ecological characterization using RS and GIS. • FAO method of Agro-climatic Suitability Analysis for Land Use Planning. • Advances in Land Evaluation Methods: Multi-criteria evaluation approach and fuzzy set method

2.1.3 Environmental Soil Science (Practical)

Practical No.	Topics	Sub Topics
1	**Land degradation and Desertification**	• Visual analysis of satellite data in degraded land mapping • Digital analysis : Image enhancement and spectral indices for mapping degraded lands • Digital Analysis: Digital classification for mapping degraded lands
2	**Watershed Management**	• Watershed analysis : Watershed and sub watershed delineation and codification based on digitization and Automatic Drainage pattern analysis and sub-watershed delineation • Digital Terrain analysis: generation of terrain parameters • Digital Terrain analysis : Terrain indices • Soil Erosion modelling : RUSLE in Soil Erosion Risk Mapping (Field Visit) • Soil Erosion modelling: Silt Yield Index model
3	**Digital soil mapping techniques**	• Hyperspectral data analysis for soil studies • Digital Soil mapping
4	**Soil carbon and soil quality**	• Soil quality indicators and assessment • Soil Carbon Stock Assessment
5	**Optimal Land use Planning**	• FAO method for Agro-climatic Suitability Analysis

Suggested Readings

Books

Land degradation (Unit -1)

1. FAO/UNEP, 1977. Assessing Soil Degradation. FAO Soils Bulletin 34, FAO, Rome.
2. Remote sensing applications (2009), Published by NRSC, ISRO, Hyderabad, Chapter – 4.
3. Remote Sensing of soil salinization: impact on land management, edited by Graciela Metternicht, J. and Alfred Zinck, CRC Press, Taylor & Francis Group, 2009.
4. Oldeman, R.T.A. Hakkeling, W.G. Sombroek (1991). Global Assessment of Soil Degradation GLASOD, Publ. in cooperation with Winand Staring Centre, International Society of Soil Science, Food and Agricultural Organization of the United Nations, International Institute for Aerospace Survey and Earth Sciences.
5. Soil and Water Conservation Research in India (2000) by V V Dhruva Narayana Indian Council of Agricultural Research, Krishi Bhavan, Dr. Rajendra Prasad Road, New Delhi-110 114. India.

6. Huete Alfredo (2004). Remote Sensing of Soils and Soil Processes. In: Susan Ustin (ed.) Remote Sensing for Natural Resource Management and Environmental Monitoring: Manual of Remote Senasing, Vol. 4, John Wiley & Sons, Inc.

Watershed Management (Unit-2)

7. Soil Erosion and Conservation by R. P. C. Morgan (2005), Longman Publishing Group.
8. Environmental Soil Physics - Fundamentals, Applications and Environmental Considerations (2008) by Daniel Hillel.
9. Soil Erosion - Processes, Prediction, Measurement, and Control, Edited by Toy, Terrence J.; Foster, George R.; Renard, Kenneth G.
10. Foster, G.R. (1988) Modelling soil erosion and sediment yield. *In*: Lal, R.,*Soil erosion research methods* . Ankeny, Iowa: Soil and Water Conservation Society, 97-] 111.

Optimal Land use Planning (Unit-3)

11. Applications of remote sensing in agriculture (1990) edited by M.D. Steven, J.A. Clark, Publisher – Butterworth, London.
12. Fischer, G., Granat, G., and Makowski, M. (1998). AEZWIN. An interactive multiple-criteria analysis tool for land resources appraisal. Report IR-98-051. International Institute for Applied Systems Analysis, Laxenburg, Austria.
13. Sehgal, J. L., Mandal, D. K., Mandal, C. & Vadivelu, S. (1990). Agro-Ecological Regions of India. *NBSS Publ.*, **24,** (NBSS & LUP: Nagpur).
14. FAO/IIASA, (2000). Global Ago-Ecological Zones (Global-AEZ).
15. Ustin, S. (2001). Manual of Remote Sensing, Volume 4, Remote Sensing for Natural Resource Management and Environmental Monitoring, 3rd Edition, Willey Publishing

Soils & the Environment (Unit-4)

16. Environmental Soil Science (2009) by Kim H Tan, CRE Press
17. Cycles of Soils - Carbon, Nitrogen, Phosphorus, Sulfur, Micronutrients (2006) by Stevenson, F. J.; Cole, M. A.
18. Mulla, D.J. and Mc Bratney, A.B. (2002). Soil Spatial variability, In Book "Soil Physics Companion", Pub. By CRC Press, LIC, pp 343-373.
19. Soil Pollution - Origin, Monitoring and Remediation, Edited by Mirsal, Ibrahim
20. Soils and Environmental Quality (2008), Third Edition, Edited by Gary M Pierzynski, J. Thomas Sims, George F Vance.
21. Quantitative Remote Sensing of Land Surfaces (2005) By Shunlin Liang, Willey Publishers.
22. Alcamo j (1994) Integrated modeling of global climatic change, Kluwer Academic Publishers, Dordrecht, Germany

Journal Papers

1. Arshad, M.A. and Martin, S. (2002). Identifying critical limits for soil quality indicators in agro-ecosystems, Agriculture, Ecosystems and Environment, 88: 153–160.
2. Mougenout, B., Pouget, M., Epema, G., 1993. Remote sensing of salt-affected soils. Remote Sensing Rev. 7, 241–259.
3. Metternicht, G., Zinck, A., 2003. Remote sensing of soil salinity: potentials and constraints. Remote Sensing of Environment.

4. Lal, R. (2003). Soil erosion and the global carbon budget, Environment International 1036: 1 – 14.
5. Lal, R. (2001). Soil Degradation by Water, Land Degradation & development, 12: 519-539.
6. Kumar, S.; Sharma, S. Soil erosion risk assessment based on MMF model using remote sensing and GIS. Hydrology J. 2005, 28, 47-58.
7. Moore, I.D., Gessler, P.E., Nielson, G.A., 1993. Soil attributes prediction using terrain analysis. Soil Science Society of America Journal 57, 443–452.
8. Singh, V. P. (1996). Agro-ecological analysis for sustainable development of rainfed environments in India. Indian Society of Soil *Science*, **44**(4), 601.
9. Vrieling A. (2006). Satellite Remote Sensing for water erosion assessment: A review, Catena 65: 2-18.
10. Ziadat, F.M., 2005. Analyzing digital terrain attributes to predict soil attributes for a relatively large area. Soil Science Society of America Journal 69, 1590–1599.

2.1.4 Satellite Agro-meteorology (Theory)

Units	Topics	Sub Topics
1	**Agromet variables**	• Agro-meteorology: Importance, factors of weather and climate and instrumentations • Meteorological parameters : observations and analysis • Agro-meteorological consideration for sustainable agriculture • World Summit action plans for agricultural monitoring and Global networking : GEOGLAM
2	**Agromet parameters retrieval from satellites**	• Satellite sensors and their characteristics for Agro-met studies • Agro-met parameter retrieval: algorithm and modelling techniques (viz, Shortwave radiation, rainfall, surface temperature, air temperature). • Crop parameter retrieval: albedo, leaf area index, fAPAR and evapotranspiration. • Soil moisture estimation: active & passive microwave and thermal remote sensing techniques.
3	**Crop yield modelling and production forecasting**	• RS based crop yield modelling: Principles and approaches. • Integrating RS and crop growth models for crop yield Modelling. • Satellite derived phenological metrices and indicators • Regional crop production assessment: production efficiency models and early warning system.
4	**Agricultural water and drought management**	• Principles, instrumentation and approaches of estimating crop water requirement/ crop ET. • Remote sensing of water stress (thermal/optical approaches). • Irrigation scheduling for crops. • Agricultural drought management: assessment, monitoring, prediction and vulnerability.
5	**Land surface processes and climate change**	• Introduction to mass exchanges (energy and water vapour and CO2) and measurement techniques. • Bowen ratio, Eddy covariance, LAS for Land surface studies. • Land surface climatology: land surface processes, driving forces and land surface parameterization from RS and weather prediction. • Climate change and climate variability: climate change impact on agriculture, earth observation signal for climate change.

2.1.4 Satellite Agro-meteorology (Practical)

Practical No.	Topics	Sub Topics
1	**Agromet variables**	• Various weather parameters observations and their analysis
		• Weather parameters : diurnal & seasonal trends and variation
2	**Agromet parameters retrieval from satellites**	• Agrometeorological parameters retrieval: Surface temperature & albedo
		• Estimation of biophysical parameters (Empirical & semi-empirical models)
		• Estimation of Soil Moisture using Satellite Data
3	**Crop yield modelling and production forecasting**	• Single date spectral vegetation index based yield model
		• Regional yield estimation from satellite data using production efficiency model
		• Demonstration on crop simulation model
4	**Agricultural water and drought management**	• Regional Crop Water requirement and Irrigation Water Requirement Estimation using RS data & GIS
		• Computation of meteorological drought indices
		• Remote sensing based drought indices
5	**Land surface processes and climate change**	• Eddy-covariance measurements & simulation of energy, water, CO_2 exchange (Field Visit)
		• Large aperture scintillometer: Diurnal and seasonal pattern of energy fluxes

Suggested Readings

Books

1. Patel NR and Saha, SK (2004).Satellite remote sensing and GIS applications in Sustainable Agriculture In: Geoinformatics in Tropical Ecosystems (PS Roy Ed).
2. Sivakumar et al. 2005. Remote sensing and GIS applications in Agriculrural Meteorology, Proce. International workshop, WMO
3. M.V.K. Sivakumar;_, R. Gommes, W. Baier Agrometeorology and sustainable agriculture. Agricultural and Forest Meteorology 103 (2000) 11–26
4. Deering, D. W. (1989). Field measurements of bidirectional reflectance: In Theory and Application of Optical Remote Sensing (Ed, Asrar, G.) John Wiley and Sons, New York, pp. 14-65.
5. Remote Sensing and Large-Scale Global Processes (ed. by A. Rango) (Proc. Baltimore Symp.), 67–74. IAHS Publ. 186. IAHS Press, Wallingford, UK.
6. Quantitative Remote Sensing of Land Surfaces (2005) By Shunlin Liang), Willey Publishers
7. Allen G. (2000).Crop evapotranspiration(guidelines for computing crop water requirements) FAO Irrigation and Drainage Paper No. 56
8. Scaling up in Hydrology using Remote Sensing (1996). John Wiley Publication. Edited by J.B. Stewert, E.T. Engman, R.A. Feddes and Y. Ken.
9. Introduction to Agrometeorology (1994), Second edition by H.S. Mavi, Oxford & IBH Publishing Co. Pvt. Ltd.
10. Mutreja, K.N. (1986). Applied Hydrology. Tata McGraw-Hill Pub. New Delhi, pp: 314-171.
    Applications of Remote Sensing to agrometeorology (Ed. F Toselli), Kluwer Academic Publishers

Journal Papers

1. Petropoulos et al 2010. Review of Ts/VI remote sensing based methods for the retrieval of land surface energy fluxes and soil surface moisture. Progress in physical geography, Progress in Physical Geography April 2009 vol. 33 no. 2 224-250
2. Bhattacharya et al., 2010. Regional clear sky evapotranspiration over agricultural land using remote sensing data from Indian geostationary meteorological satellite. Journal of Hydrology
3. Baret, F. and Guyot, G. (1991). Potentials and Limits of Vegetation Indexes for LAI and APAR assessment. Remote Sens.Environ., 35: 161-173
4. Moulin, S., Bondeau, A. and Delecolle, R. (1998). Combining agricultural crop models and satellite observations from field to regional scale. International Journal of Remote Sensing, 19: 1021 – 1036
5. Moran, M. S., Mass, S. J. and Pinter, P. J. (1995). Combining remote sensing and modeling for estimating surface evaporation and biomass production. Remote Sensing of Environment, 12:335-353
6. W.A. Dorigo , R. Zurita-Milla , A.J.W. de Wit , J. Brazile ,R. Singh , M.E. Schaepman A (2006). A review on reflective remote sensing and data assimilation techniques for enhanced agroecosystem modeling. International Journal of applied earth observation and geoinformation
7. Desai, P. and Joseph, G. (2003). Satellite observations for the geosphere–biosphere programme. CURRENT SCIENCE, VOL. 85, NO. 6, pp. 737-754.
8. Jackson, R. D., Pinter, P. J., Reginato, R. J. and Idso, S. B. (1986). Detection and Evaluation of Plant Stresses for Crop Management Decisions. IEEE Transactions on Geosciences and Remote Sensing, 24: 99-106

9. Qiaozhen et al., 2007. Development of a global evapotranspiration algorithm based on MODIS and global meteorology data. Remote Sensing of Environment, vol. 111, pp. 519-536
10. Jackson et al., (1996). Remote sensing applications to hydrology: soil moisture. Hydrological Sciences Journal, 41(4):517-530.
11. Kustas, WP and Norman, JM (1996). Use of remote sensing for evapotranspiration monitoring over land surfaces. Hydrological sciences Journal, 41(4):495-515.

Syllabus for Semester-II

Forest Ecosystem Assessment and Management

(Optional)

2.2 Forest Ecosystem Assessment and Management

Code	Paper	Lectures* Hrs.	Practical		Total Hrs.
			Lab Hrs.	Field Hrs.	
2.2.1	Forest Mapping and Monitoring	25	34	16	75
2.2.2	Forest Inventory	25	26	24	75
2.2.3	Forest Informatics	25	38	12	75
2.2.4	Forest Ecosystem Analysis	25	38	12	75
Total		100	136	64	300

*Include guest lectures & tutorials

2.2.1 Forest Mapping and Monitoring (Theory)

Units	Topics	Sub Topics
1	**Natural Vegetation & Classification Schemes**	Geographical distribution, types, extent and status of vegetation (Global and Asia-Pacific region), Global forest resources assessment (FRA), Hierarchical forest cover classification scheme (FAO-LCCS, IGBP-Biome and country specific)
2	**Vegetation Phenology and Spectral Characteristics**	Phenology for vegetation differentiation, Spectral properties of vegetation and factors affecting spectral properties of vegetation, Spectral vegetation indices
3	**Forest Cover and Type Mapping**	Forest information extraction from aerial and satellite images, Visual image interpretation and digital image classification methods for forest cover and type mapping, Accuracy assessment, Forest canopy density mapping
4	**Forest Plant Community/ Species Mapping**	Utility of VHR multi-spectral remote sensing (including object based classification), Hyperspectral remote sensing for forest, mangrove and grassland community/species mapping
5	**Forest Change Monitoring**	Forest cover change detection, Forest degradation (human disturbance, insect pest/disease, invasive plants, etc.) mapping and monitoring

2.2.1 Forest Mapping and Monitoring (Practical)

Practical No.	Topics
EX 1	Familiarization with RS data types and sources
EX2	Spectral profiling of vegetation and other associated features
EX3	Spectral vegetation indices generation and interpretation
EX4	Visual image interprétation for Forest type and density mapping
EX5	Digital image classification for forest cover type mapping
EX6	Forest classification accuracy assessment
EX7	Forest canopy density mapping using biophysical spectral modelling
EX8	In-situ hyperspectral spectra collection and image analysis
EX9	Forest cover change detection analysis
EX10	Forest condition (encroachment, logging etc.) monitoring using VHR data

Suggested Readings

Books and Reports

1. Champion H.G. and Seth S.K. (1968). A revised survey of the forest types of India. Manager of Publications, Govt. of India, New Delhi.
2. Collinson A.S. (1988) Introduction to world vegetation (2nd Edition). Academic Division of Unwin Hyman Ltd., London.
3. FCD Mapper-Semi-expert remote sensing system for forest density mapping, User's Guide,

ITTO/JOFCA
4. India State of Forest Report (2017) Forest Survey of India, Dehra Dun, India.
5. Jensen J. R. (2007) Remote sensing of environment: An earth resources perspective, 2nd Ed., NJ: Prentice Hall.
6. Joseph G. (2005) Fundamentals of remote Sensing, Universities Press, Hyderabad

Journal Articles

1. Congalton R.G. (1991) A review of assessing the accuracy of classifications of remotely sensed data. Remote Sensing of the Environment, 37: 35-46
2. Coppin P., Leuven B., Jonckheere I., Nackaerts K., Muys B. and Lambin E. (2004) Digital change detection methods in ecosystem monitoring: a review, International Journal of Remote Sensing, 25 (9): 1565–1596
3. Glenn E., Huete A., Nagler P., Nelson S. (2008) Relationship between remotely-sensed vegetation indices, canopy attributes and plant physiological processes: What vegetation indices can and cannot tell us about the landscape,Sensors, 8 (4): 2136-2160
4. Xie Y., Sha Z., Yu M. (2008) Remote sensing imagery in vegetation mapping: a review, Journal of Plant Ecology, 1 (1): 9-23

Websites

1. http://www.fao.org/
2. www.cbd.int/
3. www.wri.org/
4. www.itto.int/

2.2.2 Forest Inventory (Theory)

Units	Topics	Sub Topics
1	**Forest Inventory Planning**	Concept and Scope, Terminology, Elements, Planning Guidelines, Periodicity
2	**Sampling Design**	Sampling design survey, Sampling concepts and methods, Sample size determination
3	**Statistical analysis and Forest dynamics models**	Statistical and geostatistical treatment of forest inventory data, Preparation of volume table, Growth and yield prediction models
4	**Growing Stock and Biomass Assessment**	Growing stock and biomass estimation (including Trees Outside Forests (TOFs)) using optical remote sensing, Forest height, structure, volume & biomass estimation using SAR and LiDAR remote sensing
5	**Carbon Forestry**	Kyoto protocol, Clean Development Mechanism (CDM), NATCOM, REDD, REDD+ and EO inputs

2.2.2 Forest Inventory (Practical)

Practical No.	Topic
EX1	Demonstration of forest inventory instruments
EX2	Forest cover stratification for field sampling
EX3	Pilot study for sample size determination
EX4	Field inventory in different strata
EX5	Statistical analysis of field inventory data using R
EX6	Above-ground biomass/carbon estimation using optical data
EX7	Above-ground biomass/carbon estimation using SAR data
EX8	Geostatistical analysis for above-ground biomass estimation
EX9	Forest structure analysis using LiDAR

Suggested Readings

Books and reports

1. Chaturvedi A.N., Khanna L.S. (2011) Forest mensuration, International Book Distributors, Dehradun
2. Dalgaard P.(2008) Introductory statistics with R, Springer, ISBN 978-0-387-79054-1
3. Forest Survey of India (1996) Volume equations for forests of India, Nepal, and Bhutan, Ministry of Environment & Forests, Govt. of India, Dehradun
4. National Working Plan Code -2014, MoEFCC, Government of India, New Delhi

Journal Articles

1. 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
2. Ligot G., Balandier P., Courbaud B. and Claessens H. (2014) Forest radiative transfer models: which approach for which application? Canadian journal of forest research, 44(5): 391-403
3. Matieu H., Réjou-Méchain M., Cifuentes-Jara M., Wayson C. et al., (2015) An overview of existing and promising technologies for national forest monitoring, Annals of Forest Science, 72(6): 779–788
4. Rodríguez-Veiga P., Wheeler J., Louis V., Tansey K., and Balzter H. (2017) Quantifying forest biomass carbon stocks from space. Current Forestry Reports, 3(1):1-18
5. Santilli M., Moutinho P., Schwartzman S., Nepstad D., Curran L. and Nobre C. (2005) Tropical Deforestation and the Kyoto Protocol, Climatic Change, 71(3): 267-276
6. Tang L., Shao G. (2015) Drone remote sensing for forestry research and practices, Journal of Forestry Research, 26(4): 791-797
7. Wulder M. A., White J. C., Nelson R. F., Naesset E. et al., (2012) Lidar sampling for large-area forest characterization: A review. Remote Sensing of Environment, 121:196-209

Websites

1. http://www.r-project.org/
2. http://www.un-redd.org/

2.2.3 Forest Informatics (Theory)

Units	Topics	Sub Topics
1	**Geospatial Modelling in Forestry and Ecology**	Geospatial modelling concepts, Types of modelling approaches, Multi-criteria decision making for forestry & ecological applications
2	**Species distribution Prediction**	Ecological niche concept, Species distribution modelling (SDM) approaches, Species response curves, calibration and validation of SDM models
3	**Wildlife habitat Assessment and Protected Areas Planning**	Wildlife conservation, Concept of protected areas and biosphere reserve, Wildlife habitat suitability analysis, Wildlife corridor analysis, Satellite telemetry for wildlife dispersal studies
4	**Forest fire Monitoring and Assessment**	Fire ecology, Issues in Global and Asia-Pacific region, EO-based active fire detection and monitoring, Burnt area mapping, recovery assessment, forest fire risk zonation and danger rating
5	**Forest Information and Decision Support Systems**	Biodiversity Information Systems, Global Biodiversity Information Facility (GBIF), Plantation Monitoring System, Forest Fire Alert Systems

2.2.3 Forest Informatics (Practical)

Practical No.	Topics
EX 1	Spatial database generation for elevation, slope, aspect, road, rail and settlements, water body etc.
EX2	Spatial analysis (overlay, proximity and zonal statistics) for forestry and ecological studies
EX3	Species niche modelling using MaxENT
EX4	Wildlife habitat survey (Field)
EX5	Wildlife habitat modeling using AHP
EX6	Active fire detection using satellite data
EX 7	Forest burnt area assessment using pre- and post-fire data
EX 8	Forest fire hazard and risk zonation
EX 9	Utilisation of Geoportals for informed decision making

Suggested Readings

Books and Reports

1. Johnson E.A. and Miyanishi K. (2001) Forest fires: Behavior and ecological Effects. Academic Press, U.S.A.
2. Morrison M.L., Marcot B.G. and Mannan R.W. (2006) Wildlife-habitat relationships:Concepts and applications. 3rd Ed. Island Press, Washington D. C.

Journal Articles

1. Alex H., Dave R. and The Biodiversity Informatics Community, (2013) A decadal view of biodiversity informatics: challenges and priorities, BMC Ecology, 13:16
2. Allison R. S., Johnston J. M., Craig G., and Jennings S. (2016) Airborne optical and thermal remote sensing for wildfire detection and monitoring, Sensors, 16(8):1310
3. Ananda J., and Herath G. (2009) A critical review of multi-criteria decision making methods with special reference to forest management and planning, Ecological economics, 68(10): 2535-2548
4. Groot D. W. J., Wotton B. M. and Flannigan M. D. (2015) Wildland fire danger rating and early warning systems, Wildfire Hazards, Risks and Disasters, 207-228
5. Sinclair S. J., White M. D., and Newell G. R. (2010) How useful are species distribution models for managing biodiversity under future climates?, Ecology and Society 15(1): 8

Websites

1. http://cwfis.cfs.nrcan.gc.ca/home
2. www.ibin.gov.in/

2.2.4 Forest Ecosystem Analysis (Theory)

Units	Topics	Sub Topics
1	**Forest Ecology and Ecosystem Analysis**	Definitions, principles and scope, Forest ecosystem structural and functional analysis, nutrient cycling, forest productivity estimation including eddy flux studies
2	**Landscape Ecology**	Definitions, Patch-matrix, Spatial metrics, Biodiversity characterization and conservation prioritization
3	**Ecosystem Goods, Services and Conservation**	Assessment and valuation of ecosystem services, Wetland habitats monitoring and conservation planning, Global conventions (UN Agenda-21, Aichi Targets) and SDGs 13 & 15 for biodiversity conservation
4	**Environmental planning and management**	Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), Environmental monitoring (mining, biomass burning, etc.)
5	**Forest and Climate Change**	Broad concepts on forest ecosystem and climate linkages, Climate change impacts on forest ecosystems, IPCC climate change scenarios and DGVMs

2.2.4 Forest Ecosystem Analysis (Practical)

Practical No.	Topics
EX1	Field sampling for phytosociological analysis
EX2	Phytosociological analysis
EX3	Landscape analysis using FRAGSTATS
EX4	Ecosystem services assessment using InVEST model
EX5	EIA field tour to mining/hydroelectric power sites
EX6	EIA using RS and GIS

Suggested Readings

Books and Reports

1. Forman R.T.T. and Godron M. (1986) Landscape Ecology. John Wiley and Sons, New York
2. Heywood V.H. and Watson R.T. (1995) Global Biodiversity Assessment, Cambridge University Press, U.K.
3. IPCC (2014) Climate Change 2014 Synthesis Report Fifth Assessment Report, Intergovernmental Panel on Climate Change (IPCC)
4. Magurran A.E. (2004) Measuring Biological Diversity. Blackwell Publishing, Oxford, UK
5. Mueller-Dombois D. and Ellenberg H. (1974) Aims and Methods of Vegetation Ecology. Wiley, New York
6. Odum E.P. (1975) Funamentals of Ecology. W.B. Saunders, Philadelphia
7. Singh J.S., Singh S.P. and Gupta S.R. (2006) Ecology, Environment and Resource Conservation, Anamaya Publishers, New Delhi

Journal Articles

1. Baldocchi D. (2014) Measuring fluxes of trace gases and energy between ecosystems and the atmosphere–state and future of EC method, Global change biology, 20(12): 3600-3609
2. Barbosa d. A. C. C., Atkinson P. M., and Dearing J. A. (2015) Remote sensing of ecosystem services: a systematic review, Ecological Indicators, 52:430-443
3. McDowell N. G., Coops N. C., Beck P. S., Chambers J. Q., et al., (2015) Global satellite monitoring of climate-induced vegetation disturbances, Trends in plant science, 20(2):114-123
4. Roy P. S. and Tomar S.(2000) Biodiversity characterization at landscape level using geospatial modeling techniques, Biological Conservation, 95(1): 95-109

Websites

1. http://www.ipcc.ch/
2. http://www.biodiversityhotspots.org/Pages/default.aspx
3. http://www.igbp.kva.se/
4. http://cdm.unfccc.int/index.html
5. http://unfccc.int/kyoto_protocol/items/2830.php

Syllabus for Semester-II

Geosciences

(Optional)

2.3 Geosciences

Code	Papers	Lecture Hrs.	Tutorials & Practicals	Total Hrs.
2.3 1.	Remote Sensing for Earth & Planetary Science (G-EPS)	25	50	75
2.3.2	Data Processing and Analysis for Geosciences (G-DPAG)	25	50	75
2.3.3	Applied and Tectonic Geomorphology (G-ATG)	25	50	75
2.3.4	Engineering Geology and Ground Water (G-EGGW)	25	50	75
Total		100	200	300

2.3.1 Remote Sensing for Earth & Planetary Science (Theory)

Units	Topics	Sub Topics
1	**Geological Interpretation-I**	Image elements for geological interpretation; Remote sensing image interpretation for identification of different geological provinces; Identification of rock types from remote sensing images; Mapping and analysis of geological structures from remote sensing images.
2	**Geological Interpretation-II**	Principles of Thermal Remote Sensing; Thermal properties of geological materials and thermal inertia based interpretation; Microwave Remote Sensing: Radar wave properties and interaction with terrain & geology; Geological interpretation of radar imagery; Radar remote sensing for geological applications.
3	**Mineral Exploration**	Types of Mineral Deposits and Surface indicators of Mineral Deposits; Spectroscopy of Rocks and Minerals; Multi-spectral and Hyperspectral Remote Sensing for Mineral Exploration; Geophysical and Geochemical methods of mineral exploration. Integration of Geological, Geophysical and Geochemical methods for Mineral Exploration.
4	**Hydrocarbon Exploration**	Types of Hydrocarbon Resources, Mode of occurrences and surface indicators; Remote Sensing for mapping geomorphologic anomalies related to petroleum occurrences; Hyperspectral and Microwave Remote Sensing for Hydrocarbon Exploration; Exploration of non-conventional Hydrocarbon resources.
5	**Planetary Geology**	Overview of Planetary Geology; Global and Indian Planetary Missions; Remote sensing of planetary surfaces with special emphasis on Moon and Mars; Missions to Moon and Mars and case studies.

2.3.1 Remote Sensing for Earth & Planetary Science (Practical)

Practical No.	Topics
1	Identification and interpretation of igneous, metamorphic and sedimentary rock types from EO data. Detection, identification and analysis of structural elements: bedding, folds, joints, faults, unconformities etc.
2	Interpretation of thermal imagery for lithological and geoenvironmental applications; Interpretation of microwave data and its comparison with optical RS data.
3	Spectroscopic analysis of important rocks and minerals; Mineral mapping using hyperspectral RS and GIS techniques.
4	GIS and RS based case examples for oil exploration.
5	Analysis of Lunar and Martian planetary data sets for geological interpretation.

Suggested Readings

Books/Reports

1. Miller, V.C. and Miller C.F., 1961. Photogeology.
2. Sabins, F.F., 2007. Remote Sensing, Principles and Interpretation, W.H. Freeman & Co., San Francisco, USA (3rd Ed.).
3. Gupta, R.P., 2003. Remote Sensing Geology, Springer Verlag, Berling.
4. Ryerson**,** R**.**A., Rencz. A. N., 1999**.** Manual of Remote Sensing: Remote sensing for the earth sciences, Volume 3, American Society for Photogrammetry and Remote Sensing**.**
5. Carranza, E.J.M., 2009. Geochemical Anomaly and mineral prospective mapping in GIS
6. Pater D. I, and Lissauer, J.J., 2001. Planetary Sciences, Cambridge University Press.

Journal Articles

1. Ernst, G. G. J., Kervyn, M., Teeuw, R. M., 2008. Advances in the remote sensing of volcanic activity and hazards, with special consideration to applications in developing countries, International Journal of Remote Sensing, Volume 29, Issue 22, pp 6687-6723.
2. Francis, P. W. and Rothery, D., 2000. Remote sensing of active volcanoes. Annual Review of Earth and Planetary Science, 28, pp. 81-106.
3. Sabins, F. F., 1999. Remote sensing for mineral exploration, Ore Geology Reviews, Volume 14, Issues 3-4, September 1999, Pages 157-183.
4. Goetz, A.F.H., Rock, B.N., Rowan, L.C., 1983. Remote sensing for exploration – an overview. Economic Geology and the Bull. of Soc. of Economic Geologists. 78(4), 573-590.
5. Goetz, A. F. H., Vane, G., Solomon, J. E., and Rock, B. N., 1985, Imaging spectrometry for earth remote sensing: Science, 228, 1147-1153.

6. Green, R.O., Eastwood, M.L., Sarture, C.M., Chrien, T.G., Aronsson, M., Chippendale, B.J., Faust, J.A., Pavri, B.E., Chovit, C. J., Solis, M., Olah, M. R. and Williams, O., 1998. Imaging Spectroscopy and the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), Remote Sensing of Environment, 65(3), 227-248.
7. Cloutis, E.A., 1989. Spectral Reflectance Properties of Hydrocarbons: Remote-Sensing Implications, Science, 245(4914), 165 – 168.
8. Kruse, F.A., and Lefkoff, A.B., 1993. Knowledge-based geologic mapping with imaging spectrometers, Remote Sensing Reviews, 8, 3-28.
9. Halbouty, M.T., 1980. Geologic significance of Landsat data for 15 Giant oil and gas fields, Bull. Am. Assoc. Pet. Geol., 64, 8-36.
10. Current Science, 2009. Special Section: Chandrayaan-1 (First Results from Chandrayaan-1), 96(4), 486-546.
11. Pieters, C.M., Goswami J. N., Clark R. N., Annadurai M., Boardman J., Buratti B., Combe J.-P., Dyar M., Green D., R., Head J. W., Hibbitts C., Hicks M., Isaacson P., Klima R., G. Kramer, Kumar S., Livo E., Lundeen S., Malaret E., McCord T., Mustard J., Nettles J., Petro N., Runyon C., Staid M., Sunshine J., Taylor L. A., Tompkins S., Varanasi P., 2009, Character and Spatial Distribution of OH/H2O on the Surface of the Moon Seen by M3 on Chandrayaan-1, Science, 23, Vol. 326. no. 5952, pp. 568-572, DOI: 10.1126/science.1178658

Websites

USGS: http://www.usgs.gov/
ISPRS proceedings: www.isprs.org
http://wapi.isu.edu/Geo_Pgt/Mod07_RemoteSensing/mod7.htm
Mineral/oil exploration: http://geosun.sjsu.edu/paula/285/keil/index.htm
Geological Survey of Japan: http://www.gsj.jp/
Geological Survey of India: http://www.portal.gsi.gov.in/
Geological Society of India: http://www.geosocindia.org/
Canada Centre for Remote Sensing: http://*www.ccrs.nrcan.gc.ca/resource/*
http://www.geologynet.com/geologylinks.htm
Cornell University: http://marswatch.astro.cornell.edu/rsm.html
Information Technology for Field Science Education and Research: http://geopad.org/
Journal of Indian Society of Remote Sensing:
http://www.springer.com/earth+sciences+and+geography/journal/12524
Planetary geology papers: http://www.planetary.brown.edu/html_pages/pieters_pubs.htm
http://www.jpl.nasa.gov/
Journal of Geophysical Research (JGR): http://www.agu.org/journals/jgr/

2.3.2 Data Processing and Analysis for Geoscience (Theory)

Units	Topics	Sub Topics
1	**Digital Image Analysis for Geological Applications**	Digital enhancement and visualization, Image transformation (band arithmetic, Indices, Principal Component Analysis, Decorrelation stretching) and Spatial Filtering for geological applications; Data Fusion and Change Detection: Methods and applications of data fusion and change detection for geological applications
2	**Hyperspectral Data Processing in Geology**	Hyperspectral image processing: Data compression & Atmospheric Correction; PPI, n-Dimensional visualization and classification; Mineral abundance and alteration zone mapping; Spectrometric analysis of spaceborne, airborne and ground-based spectral data; Advanced classification techniques and band depth analysis.
3	**Thermal and Microwave Data Processing in Geology**	Thermal Infra-red data processing: Retrieval of land surface temperature (LST), emissivity and thermal inertia mapping; Microwave data processing: SAR data processing and geological feature extraction; InSAR data processing for terrain mapping; DInSAR data processing for land surface deformation studies.
4	**Geospatial Modelling and Terrain Analysis**	DEM generation from satellite data; Derivation of terrain elements, terrain mapping and analysis for geological applications.
5	**Geostatistics**	Population and sample, Sampling pattern and analysis; Statistical Hypotheses and Statistical Tests; ANOVA, Regression Analysis (Multiple and logistic regression). Regionalized variables: Properties, Semivariogram and Correlogram Analysis; Point Data Interpolation Techniques including Kriging methods for geological applications.

2.3.2 Data Processing and Analysis for Geoscience (Practical)

Practical No.	Topics
1	Data processing for geological and geomorphological applications; Data fusion and change detection for geological hazards (earthquake/ landslide).
2	Hyperspectral image analysis for mineral abundance and alteration zone mapping.
3	Single channel and Multi-channel TIR data processing for LST retrieval; Thermal inertia and thermal anomaly mapping; Microwave image analysis for InSAR-based DEM generation, crustal deformation and land subsidence studies.
4	Geological database organisation, data conversion, spatial analysis, modelling and layout for professional map making (geological symbols, colour coding etc.). Terrain parameter extraction and analysis.
5	Geological data analysis using multivariate statistics and geostatistics.

Suggested Readings

Books/Reports

1. Mather, P.M., 2004. Computer processing of remotely sensed images: an introduction
2. Jensen, J.R., 1996. Introductory Digital Image Processing.
3. Bonham-Carter, G.F., 1994. Geographic Information Systems for Geoscientists. Love Printing Service Ltd., Ontario, Canada.
4. Burrough, P.A. and McDonnell, R., 1998. Principles of GIS for land resources assessment. Oxford Scientific Publ., Claredin Press, Oxford, U.K. (Monograph on Soil and Resources Survey No. 12).
5. Meer F. V. and Jong, S.M.D. 2001. Imaging spectrometry: basic principles and prospective applications, Vol 1
6. Ketelaar, V. B. H. 2009. Satellite Radar Interferometry Subsidence Monitoring Techniques, Remote Sensing and Digital Image Processing, Vol. 14, Springer.
7. Davis, J.C., 2002. Statistics and Data Analysis in Geology, 3rd Edition.

Journal Articles

1. Massonnet, D., and Feigl, K.L., 1998, Radar interferometry and its application to changes in the earth's surface: Reviews of Geophysics, 36, 441-500.
2. Ferretti, A., Prati, C. and Rocca, F., 2001. Permanent scatterers in SAR interferometry. IEEE Transactions on Geoscience and Remote Sensing, 39, pp. 8-20.
3. Carrara A., Cardinali M., Detti R., Guzzetti F., Pasqui V., and Reichenbach P., 1991. GIS techniques and statistical models in evaluating landslide hazard, Earth Surface Processes and Landforms v. 2, 172-183.

4. Chung C. F., Fabbri A.G., and Westen C.J. van, 1995. Multivariate regression analysis for landslide hazard zonation. Carrara A., and Guzzety F., (Editors), Geographical Information Systems in Assessing Natural Hazards, Kluwer Pub., Dordrecht, The Netherlands, 107-133.
5. Kruse, F. A., Boardman, J. W., and Huntington, J. F., 2002, Comparison of Airborne and Satellite Hyperspectral Data for Geologic Mapping: in Proceedings, SPIE International Symposium on AeroSense, 1-5 April 2002, Orlando, FL, v. 4725, p. 128-139.
6. Bonham-Carter, G. F., Agterberg, F. P. and Wright, D. F., 1988. Integration of geological datasets for gold exploration in Nova Scotia. Photogramm. Eng. Remote Sens., 54, 1585–1592.

Websites

NASA Remote Sensing Tutorial: rst.gsfc.nasa.gov/Front/tofc.html
Canada Centre for Remote Sensing: http://*www.ccrs.nrcan.gc.ca/resource/*
ESA: http://earth.esa.int/
JAXA: http://www.jaxa.jp/index_e.html
Hyperspectral imaging applications: www.asdi.com
Image processing place for Matlab routines etc.: http://www.imageprocessingplace.com/
http://geology.com/news/category/gps-and-gis.shtml
Photogrammetric Engineering & Remote Sensing Journal: http://www.asprs.org/publications/pers/
International Journal of Remote Sensing Journal: http://www.tandf.co.uk/journals/tres
http://www.esri.com/industries/mining/community/data_model.html
Geoscience Australia: http://www.ga.gov.au/
Statistics and data analysis in geology: http://geomechanics.geol.pdx.edu/Courses/G423/syllabus.xml
The R Project for Statistical Computing: http://www.r-project.org/
Geostatistics portal: http://www.itc.nl/library/portals/geostatistics/software.aspx
IEEE Transactions on Geoscience and Remote Sensing:
http://ieeexplore.ieee.org/xpl/tocresult.jsp?isnumber=5580173
Computers & Geosciences Journal:
http://www.elsevier.com/wps/find/journaldescription.cws_home/398/description#description
Mathematical Geology (now known as Mathematical Geosciences) Journal:
http://springerlink.metapress.com/content/1573-8868/
Computational Geosciences Journal: http://www.springerlink.com/content/1420-0597

2.3.3 Applied and Tectonic Geomorphology (Theory)

Units	Topics	Sub Topics
1	**Geomorphic Processes & Landform Analysis**	Geomorphic processes and landform evolution; Landforms formed due to weathering/ denudation, mass wasting, fluvial action, aeolian, coastal, karst, and volcanic eruptions; Fluvial systems: models, landforms and modeling of catchment process.
2	**Glacial Landforms, Dynamics and Response to Climate Change**	Glacial processes and landforms, glacier geometry and size; Linkage between cryosphere and climate variability, glacier facies mapping, monitoring of glacier health & glacial lakes.
3	**Tectonic Geomorphology**	Introduction to Active Tectonics and Neotectonics; Tectonic geomorphology: Landforms due to folding and faulting; Geomorphic Indices for active tectonics; Active fault mapping using remote sensing and geophysical techniques.
4	**Earthquake Geology and Geodynamics**	Earthquake geology; Seismotectonics, seismic hazard zonation and microzonation; Coseismic and interseismic deformation using DInSAR and GNSS; Space based earthquake precursor studies.
5	**Applied Geomorphologic Mapping**	Applied Geomorphologic mapping: Geomorphic classification systems, Role of geomorphic maps in different geological applications.

2.3.3 Applied and Tectonic Geomorphology (Practical)

Practical No.	Topics
1	Geomorphic process identification and genetic landform mapping (denudational, aeolian, coastal, volcanic and karst); Fluvial landform mapping and analysis; Mass wasting features (including landslides) mapping and analysis using aerial and satellite images.
2	Glacier and snow cover mapping; Snout position identification; Glacier landform/feature mapping; Glacier facies mapping
3 & 4	Tectonic landforms/active tectonics related mapping and analysis using remote sensing and digital terrain models; Geophysical techniques for fault detection/confirmation (field and lab); GNSS/DInSAR for crustal deformation analysis; Space based earthquake precursor studies.
5	Applied geomorphological mapping using satellite data.

Suggested Readings

Books/Reports

1. Bloom, A. L., 2004. Geomorphology: a systematic analysis of late Cenozoic landforms.
2. Anderson R.S., Anderson S. P. 2010. Geomorphology: The Mechanics and Chemistry of Landscapes
3. Cooke, R.U., Doornkamp, J.C., 1990 – Geomorphology in environmental management – a new introduction. Clarendon Press, Oxford.
4. Townshend, J.R.G., 1981 – Terrain analysis and remote sensing (Edited), George Alter and Unwin, London.
5. Keller, E.A., and Pinter, N., 2002. Active Tectonics - Earthquakes, Uplift, and Landscapes
6. Burbank D.W., and Anderson, R.S. 2001. Tectonic Geomorphology
7. McKlay, K.R. 2004. Thrust Tectonics & Hydrocarbon Systems
8. Yeats, R.S., Sieh, K.E., and Allen, C. R., 1997. The Geology of Earthquakes
9. Scholz, C.H., 2002. The Mechanics of Earthquakes and Faulting
10. NRSC, 2009. Manual for National Geomorphological and Lineament Mapping on 1:50,000 scale.
11. Bull W.B., 1991. Geomorphic Responses to Climatic Change, The Blackburn Press.
12. Elorza M. G., Benito G., 2005. Climatic Geomorphology, Elsevier.

Journal Articles

13. Bannerjee, P., Burgmann, R., 2002. Convergence across the northwest Himalaya from GPS measurements. Geophysical Research Letters 29(13), 30-1-30-4.
14. Bilham, R., Larson, K., Freymueller, J., Project Idylhim members, 1997. GPS measurements of present-day convergence across the Nepal Himalaya. Nature 386, 61-64.
15. Bilham R., Gaur, V.K., Molnar, P., 2001. Himalayan seismic risk. Science 293, 1442-1444.
16. Kumar, S., Wesnousky, S.G., Rockwell, T.K., Ragona, D., Thakur, V.C., Seitz, G.G., 2001. Earthquake recurrence and rupture dynamics of Himalayan Frontal Thrust, India. Science 294, 2328-2331
17. Nakata, T., 1972. Geomorphic History and Crustal Movements of Foot-hills of the Himalaya, Institute of Geography, Tohuku University, Japan.
18. Nossin, J.J., 1971. Outline of the geomorphology of the Doon valley, Northern UP, India, Z. Geomorphology N.F. 12, 18-50.
19. Phillip, G. 1996. Landsat Thematic Mapper data analysis for quarternary tectonics in parts of Doon valley, NW Himalaya, India. Int. Journal of Remote Sensing 17 (1), 143-153.
20. Thakur, V.C., Pandey, A.K., 2004. Late quarternary tectonic evolution of Dun in fault bend/ propagated fold system, Garhwal Sub-Himalaya, Current Science 87(11), 1567-1576.
21. Burbank, D.W., Blythe, A.E., Putkonen, J., Pratt-Sitaula, B., Gabet, E., Oskin, M., Barros, A., Ojha, T.P., 2003. Decoupling of erosion and precipitation in the Himalayas. Nature 426, 652-655.
22. Allison, R. J., 2002. Geomorphology, Human Activity and Global Environmental Change. Geographical Journal, http://findarticles.com/p/articles/mi_go2454/is_1_168/ai_n6805991/

Websites

Geomorphology from Space: http://daac.gsfc.nasa.gov/DAAC_DOCS/geomorphology/
Arizona State University geomorphology group: http://geomorphology.sese.asu.edu/
University of California, Burbank group: http://www.geol.ucsb.edu/faculty/burbank/

Earthquakes and Plate Boundary Processes: cires.colorado.edu/~bilham/
University of Nevada, Reno: http://www.unr.edu/cos/geology/programs/grad/programs.html
USGS: earthquake.usgs.gov
Earth Surface Processes and Landforms Journal:
http://onlinelibrary.wiley.com/doi/10.1002/esp.v35:13/issuetoc
Geomorphology Journal:
http://www.elsevier.com/wps/find/journaldescription.cws_home/503334/description

2.3.4 Engineering Geology and Ground Water (Theory)

Units	Topics	Sub Topics
1	**Engineering Geology and Site Investigations**	Engineering properties of rocks and soil; Strength and failure behavior of rocks and soil; Rock mass strength classification; R.S. application in engineering geology mapping; Construction material survey; dam/reservoir site selection and route alignment; Environmental impact assessment of dam and reservoir.
2	**Mass Movement, Mapping, Monitoring and Modelling**	Mass movement types and classifications of landslides; Causes of landslide; R.S. applications for mapping and monitoring of landslides; Overview of ground based technique for landslide studies; Ground based geophysical techniques for slip surface mapping; Landslide hazard zonation; Landslide early warning
3	**Principles of Ground Water Geology**	Hydrogeological properties of different rocks, structures and landforms; Ground water flow, surface and ground water interaction; Controls of ground water occurrence and movement.
4	**Ground Water Targeting**	Concept of hydrogeomorphic unit and hydrogeomorphological mapping with case examples; Ground water targeting in different geologic terrains using EO data and GIS techniques; Satellite gravity observations vis-a-vis ground water development and geophysical techniques.
5	**Ground Water Quality Assessment and Ground Water Resource Management**	Ground water quality and pollution assessment; Rain water harvesting; Artificial ground water recharge using RS and GIS; GW resource assessment and sustainable development of groundwater.

2.3.4 Engineering Geology and Ground Water (Practical)

Practical No.	Topics
1	Demonstration of rock/ soil strength and failure; Rock mass strength and 3-D logging of engineering structures; Engineering geological mapping using different types of R.S. data; Route alignment between two points; Suitable site selection for dam/reservoir.
2	Landslide mapping and monitoring; Landslide hazard analysis: vulnerability, susceptibility and risk mapping, debris flow modelling.
3	Satellite image interpretation and analysis for ground water prospects; Ground water prospect zonation using satellite images in different geological terrains: alluvial terrain, hard rock terrain, hilly terrain.
4	Integration of RS and geophysical techniques for GW recharge/spring rejuvenation.
5	Hydrochemical data processing and analysis for quality assessment.

Suggested Readings

Books/Reports

1. Price, D.G. and Freitas, M. H. D.2009. Engineering Geology: Principles and Practice.
2. Blyth, F.G.H. and Freitas, M.H.D., 1984. A Geology for Engineers.
3. Bell, F.G. 2004. Fundamentals of Engineering Geology
4. Krynine, D.P. and Judd, W.R., 1957. Principples of Engineering Geology and Techniques
5. Cornforth, D. 2005. Landslides in Practice: Investigations, analysis, and Remedial / Prevention Options in Soils.
6. Hoek, E. and Bray, J.W. 1997. Rock Slope Engineering.
7. Rahn, P.H. 1996. Engineering Geology-An Environmental approach.
8. Townshend, J.R.G., 1981 – Terrain evaluation and remote sensing – George Allen and Unwin, Sydney.
9. Fetter, C.W., 1988. Applied Hydrogeology. Merrill Publishing Company, Ohio, USA.
10. Karanth, K.R., 1987. Groundwater Assessment, Development and Management. Tata McGraw Hill Pub., Delhi.
11. Schwartz, F.W. and Zhang, H., 2003. Fundamentals of Ground Water. John Wiley & Sons, Inc. USA.
12. Todd, D.K. and Mays, L.W. 2005. Ground Water Hydrology. John Wiley & Sons, Inc. USA.
13. Westen C. J. van, 1993. GISSIZ Training Package for Geographic Information Systems in Slope Instability Zonation, UNESCO-ITC Project. ITC Publication No. 15, Enschede.
14. NRSC, Ground water prospect Atlas produced under Rajiv Gandhi National Drinking Water Mission (RGNDWM).
15. NRSC, Manual for Rajiv Gandhi National Drinking Water Mission (RGNDWM).

Journal Articles

1. Soeters, R.; Van Westen, C.J. Slope instability recognition, analysis, and zonation. In Landslides, Investigation and Mitigation; Turner, A.K., Schuster, R.L., Eds.; Transportation Research Board Special Report 247; National Research Council: Washington, DC, USA, 1996; pp. 129-177.
2. Carrara A., Cardinali M., Guzzetti F., and Reichenbach P., 1995. GIS technology in mapping landslide hazard. Carrara A., and Guzzetti F., (Editors), Geographical Information Systems in Assessing Natural Hazards, Kluwer Pub., Dordrecht, The Netherlands, 135-175.
3. Varnes, D.J., 1984. Landslide Hazard Zonation: A Review of Principles and Practice, Natural Hazards (UNESCO), v. 3.
4. Guzzetti, F. Carrara, A., Cardinali, M., and Reichenbach, P., 1999. Landslide hazard evaluation: a review of current techniques and their application in a multi-scale study, Central Italy, Geomorphology, Vol. 31, pp. 181–216.
5. van Westen, C.J., Castellanos Abella, E.A. and Sekhar, L.K. (2008) Spatial data for landslide susceptibility, hazards and vulnerability assessment : an overview. In: Engineering geology, 102 (2008)3-4, pp. 112-131.
6. Waters, P., Greenbaum, D., Smart, P.L. and Osmaston, H. (1990). Applications of remote
7. Sensing to groundwater hydrology. Remote Sensing Rev., 4(2): 223–264.
8. Meijerink, A.M.J. (1996). Remote sensing applications to hydrology: groundwater. Hydrol. Sci., 41(4): 549–561.
9. Meijerink, A.M.J., Bannert, D., Batelaan, O., Lubczynski, M.W. and Pointet, T. (2007). Remote sensing applications to groundwater. IHP-VI Series on Groundwater, No. 16, UNESCO, Paris, France.
10. Scanlon, B.R., Healy, R.W. and Cook, P.G. (2002). Choosing appropriate techniques for quantifying groundwater recharge. Hydrogeol. Jour., 10: 18–39.
11. Healy, W. and Cook, P.G. (2002). Using groundwater levels to estimate recharge. Hydrogeol. Jour., 10: 91–109.
12. De Vries, J.J. and Simmers, I. (2002). Groundwater recharge: an overview of processes and challenges. Hydrogeol. Jour., 10: 5–17.
13. Becker, M.W. (2006). Potential for satellite remote sensing of ground water. Ground Water, 44(2): 306–318.
14. Chatterjee, R. and Purohit, R. R., 2009. Estimation of replenishable groundwater resources of India and their status of utilization, Current Science, vol. 96, no. 12, pp. 1581-1591.

Websites

Japanese Landslide Society: http://www.tuat.ac.jp/~sabo/lj/
International Landslide Research Group: http://ilrg.gndci.pg.cnr.it/
NASA landslide site: http://earthobservatory.nasa.gov/Study /Landslide/
USGS landslide program: http://landslides.usgs.gov/index.html
FEMA Landslide fact sheet: http://www.fema.gov/hazards/landslides/landslif.shtm
Selection of the Dam Site of the Three Gorges Project:
http://www.ctgpc.com.cn/en/faq/01.php?NewsId=13196
USGS Engineering Geology: http://www.usgs.gov/science/science.php?type=theme&term=337
Rock mechanics: http://www.xs4all.nl/~hack/WORKHack/index.html
GRACE satellite data: http://grace.jpl.nasa.gov/data/mass/
Central Ground Water Board: cgwb.gov.in
Ground water Pollution using DRASTIC: http://csat.er.usgs.gov/statewide/layers/drastic.html
Remote Sensing Applications to Groundwater:
http://www.itc.nl/news_events/archive/general/unesco_publishes_new_manual.asp
Ground water exploration: http://geosun.sjsu.edu/paula/285/keil/index.htm

Dutch portal to international hydrology and water resources: http://www.hydrology.nl/
http://www.unesco.org/water/ihp/graphic/subjects+methods.shtml
Journal of Engineering Geology:
http://www.elsevier.com/wps/find/journaldescription.cws_home/503330/description#description
Journal of the International Consortium on Landslides, Landslides:
http://www.springer.com/new+%26+forthcoming+titles+(default)/journal/10346
Journal of Hydrology:
http://www.elsevier.com/wps/find/journaldescription.cws_home/503343/description#description
Hydrogeology Journal:
http://www.springer.com/earth+sciences+and+geography/hydrogeology/journal/10040

Syllabus for Semester-II

Urban & Regional Studies

(Optional)

2.4 Urban & Regional Studies

Code	Papers	Lectures*	Practical		Total Hrs.
			Lab Hrs.	Field Hrs.	
2.4.1	Fundamentals of Urban and Regional Planning	25	40	10	75
2.4.2	Urban and Regional Area Analysis	25	40	10	75
2.4.3	Urban Resources, Services and Facilities Analysis	25	40	10	75
2.4.4	Advanced Urban and Regional Studies	25	40	10	75
Total		100	160	40	300

*****Includes guest lectures & tutorials

2.4.1 Fundamentals of Urban and Regional Planning (Theory)

Units	Topics	Sub Topics
1	**Concepts of Settlement Planning**	Terminology in Urban planning; Town planning Practices in Developing Countries; Urban & Regional Planning Models; Urban Area delineation Rules; New Towns: planning and Development; Process of Preparation of Development/Master/Zonal plans; Norms in Urban planning and Building bye-laws; urban Housing, Demand & supply; Types of Housing.
2	**Image Interpretation of Urban Areas**	Basic Principles; basic reason for applications; factors governing interpretability; Elements of Image interpretation; Techniques of Interpretation; Sequence of activities; Convergence of evidence for urban areas analysis.
3	**Urban Land Use Planning**	Issues in urban land use mapping; Urban land use classification system; Rules of classifications; Various Scales; Accuracy assessment.
4	**Base Maps and Cadastral Maps for Urban Areas**	Characteristics of Base maps; Scale of base maps; base maps for regional/district planning; Photo-maps; Ortho-photo maps; cadastral mapping; Preparation of foot-print map; RS and GIS for Property tax assessment.

2.4.1 Fundamentals of Urban and Regional Planning (Practical)

Practical No.	Topics
Ex.1	Identification of Defined Urban objects
Ex.2	Interpretation of Urban objects
Ex.3	Interpretation of urban areas on different Scales
Ex.4	Development of working definition & delineation of urban areas
Ex.5	Interpretation and delineation of residential areas; Field verification
Ex.6	Development of Urban land use/ land cover classification system
Ex.7	Interpretation and mapping of urban land use/land cover; field verification
Ex.8	Visit to Survey of India

Suggested Readings

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2. www.globalchange.umich.edu
3. www.interenvironment.org/cipa/urbaniztion
4. http:en.wikipedia.org/wiki/photogrammetry
5. www.gim-international.com
6. www.itc.nl/library/
7. www.tuwien.ac.at

2.4.2 Geospatial Technologies in Urban Area Analysis (Theory)

Units	Topics	Sub Topics
1	**Urban Area Analysis**	Urban Sprawl: Definition, Types, Mapping and Consequences; Change Detection Techniques for Urban Growth Monitoring; Indices for Built-Up Area Extraction; Slums Identification and Mapping.
2	**Quantitative Techniques for Urban and Regional Analysis**	Statistical Techniques and Data Interpretation, Types of Data, Graphs and Charts; Spatial Metrics; Urban Development Indicators.
3	**Census Operation and Population Studies**	Census Operations, Basic Principles; Population Estimation through Remote Sensing, Updating of Population Data, Case Studies; Population Projection Techniques.
4	**Urban Growth Modelling**	Urban Growth Models, Basic Concepts and Prediction of Future Growth Pattern using CA-ANN, MCE-CA Models; Use of Night-Time Light Data in Urban Studies.
5	**3D Modeling and its Applications**	3D Modeling Techniques for Urban Surface Profiling: Digital and Satellite Photogrammetry, LiDAR (Airborne and Terrestrial), Close Range Photogrammetry; DEM/DSM Generation for Urban Areas, Modeling and Visualization, Concepts and Techniques of Space Use Mapping.

2.4.2 Geospatial Technologies in Urban Area Analysis (Practical)

Practical No.	Units	Topics Covered
1	URA- P1	• Indices for Built-Up Area Extraction • Urban Growth Monitoring • Field Verification
2	URA- P2	• Various Statistical Techniques of Data Analysis • Population Projections
3	URA- P3	• Population Estimation using Geospatial Techniques • Urban Growth Modelling
4	URA- P4	• Generation of DEM • Demonstration of DGPS/GNSS for Field Data Collection • Demonstration on 3D Modeling of Urban Areas • Space Use Mapping

Suggested Readings:

Books and Reports

1. Lillesand, T.M. and Kiefer, R.W. (2009): Remote Sensing and Image Interpretation, John Wiley and Sons, New York.
2. UNCHS (1982). Survey of Slums and Squatter Settlements. Development Studies Series, Vol.1, Tycooly International, Dublin.
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11. Maithani, Sandeep (2014), Neural Networks Based Simulation of Land Cover Scenarios in Doon valley, India", Geocarto International,. DOI: 10.1080/10106049.2014.927535, Impact factor: 0.897.
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2. www.casa.ncl.ac.uk
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4. www.gim-international.com
5. www.unhabitat.org
6. www.unep.org
7. www.itc.nl/library/

2.4.3 Urban Resources, Services & Facilities Analysis (Theory)

Units	Topics	Sub Topics
1	**Urban Infrastructure and Services**	Geospatial Technologies for Urban Utility Mapping, Mobile Mapping and Mobile Apps for Facilities Mapping; Urban Water Supply.
2	**Network Analysis for Urban Infrastructure and Services**	Service Area Analysis, Optimum Path Finding, OD Matrix, Location-Allocation of Urban Services, AM/FM, LBS.
3	**Urban Resources Studies**	Definitions and Concept of Urban Resources, Classification and Spatial Distribution of Resources; Geospatial Technologies for Urban Heritage and Conservation.
4	**Energy resources**	Renewable and Non-Renewable Energy Resources, Use of Geospatial Data for Solar and Hydro (In Hills) Energy Potential, Power GIS.
5	**Urban Hazard & Risk Assessment**	Basic Concepts, Urban Geomorphology for Hazard Identification, Multi-Hazards, Risk and Vulnerability Assessment, Urban Hydrology and Flood Modeling.

2.4.3 Urban Resources, Services & Facilities Analysis (Practical)

Practical No.	Units	Topics Covered
1	**URS-P1**	• Facility Mapping and Buffer Analysis • Mobile App for Asset Mapping and GIS Analysis • Demonstration on Ground Penetrating Radar • Field Visit
2	**URS-P2**	• Network Analysis • Solar Energy Potential Assessment
3	**URS-P3**	• Urban Runoff • Seismic Hazard Mapping • Analysis and Risk Assessment • Field Verification

Suggested Readings:

Books and Reports

1. Jackson, C. I. (1977). Human Settlement and Energy. Pergamon.
2. Huang, Zhengdong (2003). Data Integration for Urban Transport Planning, Ph. D. Thesis, Utrecht
3. University, The Netherlands.
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14. Weston, C. J.V. Montoya, L. et.al. (2001): Multi-Hazard Risk Assessment using GIS in Urban Areas: A Case study for the city of Turrialba, Costa Rica, ITC, Netherlands

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4. Kumar, P., Kunwar, S. and Garg, V., 2017. Hydropower Sites Investigation and Sensitivity Analysis of Assessed Potential Using Geospatial Inputs. In Development of Water Resources in India (pp. 499-522). Springer, Cham.
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7. Maithani, Sandeep, and Sokhi, B.S. (2001), Developing Social Infrastructure Indicators for Dehradun Municipal area. GIS Development, Vol. 5, Issue12, pp. 23-25.
8. Maithani, Sandeep, and Sokhi, B.S. (2004), RADIUS: A methodology for Earthquake Hazard Assessment in Urban Areas in a GIS Environment, Case Study Dehradun Municipal Area. Journal of Institute of Town Planners (ITPI), Vol. 1, No.3, pp. 55-64.

9. Sardar A Patil, Sonal Khobrgade, Shweta Khandelwal, Harpreet Singh, Asfa Siddiqui (2015), "An estimation of solar energy potential using point solar radiation tool in Arc GIS: A case study of College of Engineering Pune", International Journal of Applied Research, Vol 1(9), pg. 890-897
10. Tiwari, K.N., Kumar, P., Sebastian, M. and Pal, D.K., 1991. Hydrologic modelling for runoff determination: Remote sensing techniques. International Journal of Water Resources Development, 7(3), pp.178-184.
11. Utrick, Joseph B. (Ed.): Energy and buildings, Efficiency, Air Quality and Conservation. New Science, New York.

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2.4.4 AUR: Advanced Urban and Regional Studies (Theory)

Units	Topics	Sub Topics
1	**Advanced Techniques for Urban Area Characterization**	Applications of Hyperspectral and Microwave Remote Sensing Data for Built-Up Area, Urban Features and Material Characterization, Etc.
2	**Urban Environment**	Urban Open Spaces and Green Spaces; Solid Waste Management at Macro and Micro Level; Urban Pollution Studies.
3	**Urban Climate**	Urban Climate: Factors Affecting Urban Climate, Impact of Urban Surfaces, Diseases and Human Health; Thermal Images for Assessment of Urban Heat Island and other microclimatic problems.
4	**Urban Governance**	e-Tools and Services for Urban Governance, Municipal GIS, RS and GIS for Property Tax Assessment; Tourism Resources
5	**Emerging Concepts and Trends in Urban and Regional Planning**	Urban and Regional Information Systems, Open Source Data Servers & Web Portals, Concepts and Components of Smart Cities, Role of Geospatial Technologies in Smart Cities Planning, Challenges and Potential.

2.4.4AUR: Advanced Urban and Regional Studies (Practical)

Practical No.	Units	Topics Covered
1	**AUR-P1**	• Built-Up and Non-Built-Up Area Extraction using Microwave Data • Urban Material Spectra Generation Using Hyperspectral Data
2	**AUR-P2**	• Urban Green Space Assessment • Solid Waste Management • Urban Pollution Survey, Mapping and Analysis
3	**AUR-P3**	• Land Surface Temperature Map Generation and Urban Heat Island
4	**AUR-P4**	• Property Taxation • Data Download and Visualization using Open Source Data Servers & Web Portals

Suggested Readings

Books and Reports

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2. Barrile, V., Billota, G.(2008). An Application of Remote Sensing: Object-oriented Analysis of Satellite data. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science. Vol.XXXVII, Part B8, Beijing, 2008.
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5. Haykin, S. (1999). Neural Networks: A Comprehensive Foundation. Prentice Hall, New Jersey.
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8. Kumar, S. (2004). Neural Networks: A Classroom Approach. Tata -McGraw-Hill, New Delhi.
9. Lo, C.P. and Quattrochi, D.L. (2003): Land use and Land cover change, Urban Heat Island
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19. White, R. and Engelean, G. (1997). Cellular automata and fractal urban form: a cellular modelling approach to the evaluation of urban land use pattern. Environment and Planning, B 25: 1175 - 1199.
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2. www.microsoft.com/virtual-earth
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4. www.gim-international.com
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6. www.unhabitat.org; www.usgs.gov.usa

Syllabus for Semester-II

Marine and Atmospheric Science

(Optional)

2.5 Marine and Atmospheric Science

Code	Papers	Lecture * (hrs.)	Practical		Total Hrs.
			Lab Hrs.	Field Hrs.	
2.5.1	Coastal Processes and Marine Ecology	25	40	10	75
2.5.2	Atmosphere and Ocean Dynamics	25	40	10	75
2.5.3	Satellite Oceanography	25	40	10	75
2.5.4	Satellite Meteorology	25	40	10	75
	Total	100	160	40	300

*Lecture includes guest lectures & tutorials

2.5.1 Remote Sensing Applications in the Coastal Processes and Marine Ecology (Theory)

Units	Topics	Sub Topics
1	**Elements of Coastal Geomorphology and visual interpretation of satellite image**	Classification of coasts, primary coasts, secondary coasts, coasts formed by biological activity; beaches, beach scarp, berm, sand spit, sea cave, sea cliff, delta; landforms due to erosional and depositional activities. Visual interpretation of coastal landforms
2	**Remote sensing application for coastal land form and bathymetry**	Remote sensing application for the study of shore line configuration, temporal coastal landforms analysis and shoreline changes: sedimentation, erosional and depositional processes. Principle of retrieval of coastal bathymetry from remote sensing observations: optical, and SAR data.
3	**Coastal Dynamics and processes**	Coastal and estuarine dynamics, near shore circulation pattern. Multi-temporal remote sensing analysis for coastal erosion/accretion estimation. Erosion preventive structures
4	**Fundamentals of Marine Ecology**	Elements of oceanic eco-system, Bio-pyramids pelagic, non-pelagic, benthos, Beach and sub-tidal ecology, Coastal dune ecosystem, coastal wetlands, salt marshes and mangroves, coral, coastal aquaculture and fisheries, coastal eutrophication.
5	**Remote sensing for coastal hazards**	Coastal hazards such as storms, storm surges, tsunami, sea-level rise, salt water intrusion into coastal aquifer, Tropical Cyclone.

2.5.1 Remote Sensing Applications in the Coastal Processes and Marine Ecology (Practical)

Practical No.	Practical
EX. CPME 1	Visual image interpretation for identification and delineation of coastal landforms
EX. CPME 2	Coastal landform analysis and mapping shoreline changes
EX. CPME 3	Coastal ecological component mapping and monitoring using satellite data (Coral reef, Mangrove).
EX. CPME 4	Productivity estimation
EX. CPME 5	Coastal bathymetry from RS data

Suggested Readings

1. Principles of Geomorphology, 1969, William D. Thornbury, John Wiley & Sons, Inc. 1-594.

2. Physical Geology, 1985, Author Holmes, Elsevier Science Publishers. Ltd. 1-259.

3. Marine Biology, An Ecological Approach, 1982, James W. Nybakken, Harper & Row, Publishers, New York.
4. Remote Sensing Applications in Marine Science and Technology, 1982, Edited by A.P.Cracknell, Dorderecht: D. Reidel.

5. Duncan M. FitzGerald, 2003, Beaches and Coasts**,** Blackwell Publishing, 448 p.

6. Colin David Woodroffe, 2002, Coasts: Form, Process, and Evolution, Cambridge University Press, 638 p.

7. F. John. Vernberg, Winona B. Vernberg**,** 2001**,** The Coastal Zone: Past, Present, and Future**,** Univ of South Carolina Press, 191 p.

2.5.2 Atmosphere and Ocean Dynamics (Theory)

Units	Topics	Sub Topics
1	**Introduction to physics of atmosphere and ocean: Part (a)**	Atmosphere structure and composition (major and trace gases, greenhouse gases, pollutant gases); electromagnetic radiation; energy balance.
2	**Introduction to physics of atmosphere and ocean: Part (b)**	Atmospheric circulation: Hadley cell, Ferrel cell, Polar cell, Trade winds, Jet streams. Ocean structure and composition; radiation and heat budget
3	**Governing Equations: atmosphere and ocean**	Equations of motion: Equation of continuity, momentum equation. Equations in a rotating frame, gravity waves etc., Hydrostatic approximation, Potential Temperature, Lapse rate.
4	**Tropical dynamics**	Basic concepts of tropical dynamics, Observed Structure of Large-Scale Tropical Circulations, Scale Analysis of Large-Scale Tropical Motions, Rossby number, Geo-strophic balance, cyclostrophic balance.
5	**Large scale Tropical phenomenon**	Introduction to Monsoon: Interannual,intra-seasonal variability, El-Nino and La-Nina (ENSO)

2.5.2 Atmosphere and Ocean Dynamics (Practical)

Practical No.	Practical
EX. AOD 1	Distribution of air pollutants based on observations
EX. AOD 2	Case study/ Practical on atmospheric Dynamics
EX. AOD 3	Case study/ Practical on Ocean Dynamics
EX. AOD 4	Analysis of inter-annual variability of monsoon based on observations

Suggested Readings

1. Atmospheric and ocean fluid dynamics, 2006, Geoffrey K. Vallis, Cambridge University Press.
2. An introduction to dynamic meteorology 2004, James R. Holton, Elesevier Academic Press.
3. Handbook of atmospheric science, 2003. C.N. Hewitt and Andrea V. Jackson, Blackwell publishing.
4. Descriptive Physical Oceanography, 1992. G. L. Pickard & W. J. Emery. Pergamon Press.
5. Atmosphere and Ocean Dynamics, 1982. A. Gill, Academic Press Inc.
6. Geophysical Fluid Dynamics, 1977. J. Pedlosky, Springer Verlag.
7. Introduction to Physical Oceanography, R. H. Stewart, http://oceanworld.tamu.edu (online book).

2.5.3 Satellite Oceanography (Theory)

Units	Topics	Sub Topics
1	**Ocean Physics**	Fundamental radiometric quantities; interaction of electro-magnetic radiation with ocean: absorption, emission, reflection, scattering and transmission; subsurface diffused reflectance and beam attenuation coefficient
2		Introduction to infrared scanning radiometers, Passive microwave radiometers: principle of passive microwave radiometry; retrieval of temperature. Applications of remotely sensed salinity and wind speed for oceanographic studies.
3		Wave spectrum, wind speed and oil slicks study from remote sensing data.
4		Retrieval of sea surface winds; Application of altimeter data for oceanographic studies.
5	**Ocean Biology**	Visible wavelength ocean-color sensors: introduction to color sensors on past and present satellites; principle of retrieval of phytoplankton concentration, suspended sediment concentration, yellow substance, diffused attenuation coefficient of ocean water from optical sensors.

2.5.3 Satellite Oceanography (Practical)

Practical No.	Practical
EX. SO 1	Computation of In-situ underwater optical data: water quality retrieval Algorithms from In-situ optical measurements and Application of remotely sensed Ocean Colour data.
EX. SO 2	Retrieval and analysis of Sea Surface Temperature (SST) from thermal/microwave sensor data.
EX. SO 3	Applications of altimeter for ocean studies
EX. SO 4	Applications of scatterometer observations for ocean studies

Suggested Readings

1. An Introduction to Ocean Remote Sensing, 2004, S. Martin, Cambridge University Press.
2. Introduction to Satellite Oceanography, 1985, G.A.Maul, Martinus Nijhoff Publishers, Dordrecht.
3. Satellite Oceanography, 1985, I.S.Robinson, Ellis Horwood, New York.
4. Remote Sensing Applications in Marine Science and Technology, 1982, Edited by A.P. Cracknell, Dorderecht: D. Reidel.

Marine Optics, 1976, N.G. Jerlov, Elsevier, Amsterdam.

Theory and Applications of Optical Remote Sensing, 1989, Edited by Ghassem Asrar, John Wiley & Sons, New York.

2.5.4 Satellite Meteorology (Theory)

Units	Topics	Sub Topics
1	**Image interpretation**	Introduction to meteorological satellites, meteorological satellite image interpretation based on visible, infrared and water vapor imageries for various meteorological phenomena such as various type of clouds, tropical cyclone, cold fronts, Fog etc.
2	**Physical meteorology**	Introduction to physical meteorology, applications of satellite data for the study of trace gases, temperature and humidity.
3	**Mesoscale meteorology**	Introduction of mesoscale meteorology, applications of satellite data for the mesoscale meteorological phenomenon (extreme rainfall events), spatial temporal characteristics of extreme rainfall events.
4	**Atmospheric aerosols and radiation budget**	Atmospheric Aerosol theory, applications of satellite data for aerosol studies, concept of Aeronet. Solar constant and top of the atmosphere radiation budget estimation.
5	**Numerical weather prediction**	Introduction to numerical prediction models, applications of satellite data sets in NWP models for the study of various meteorological processes.

2.5.4 Satellite Meteorology (Practical)

Practical No.	Practical
EX. SM 1	Satellite image interpretation for meteorological phenomena.
EX. SM 2	Analysis of atmospheric temperature, humidity and Ozone using satellite data
EX. SM 3	Analysis of extreme rainfall events using satellite data
EX. SM 4	Analysis of Aerosol optical depth based on satellite data
EX. SM 5	Applications of satellite data for the study of cyclone.

Suggested Readings

1. Satellite Meteorology an Introduction, 1995 Stanley Q. Kidder and Thomas H. Vonder Haar, Academic Press.
2. An Introduction to Ocean Remote Sensing, 2004, S. Martin, Cambridge University Press.
3. Introduction to Satellite Oceanography, 1985, G.A.Maul, Martinus Nijhoff Publishers, Dordrecht.
4. Satellite Oceanography, 1985, I.S.Robinson, Ellis Horwood, New York.

Syllabus for Semester-II

Water Resources

(Optional)

2.6 Water Resources

Code	Papers	Lecture * Hrs.	Practical		Total Hrs.
			Lab Hrs.	Field Hrs.	
2.6.1	Water Resources Assessment	25	40	10	75
2.6.2	Watershed Analysis and Planning	25	40	10	75
2.6.3	Water Resources Development	25	40	10	75
2.6.4	Water Resources Management	25	40	10	75
	Total	100	160	40	300

*includes guest lectures & tutorials

2.6.1 Water Resources Assessment (Theory)

Units	Topics	Sub Topics
1	**Basic Hydrology & Remote Sensing of Surface Water**	Introduction of hydrological cycle and its components (Precipitation, Interception, Infiltration, ET, Runoff etc.), concept of the basin/watershed, overview of remote sensing and GIS applications in hydrology, water availability and use in river basins hydrograph analysis, unit hydrograph, base flow separation, S-curve derivation, Synthetic Unit hydrograph and IUH, Flood hydrograph Spectral signature of water, surface water mapping, causes of water pollution, Overview of remote sensing applications in limnology (study of inland waters - lakes, reservoirs, rivers, streams, etc)
2	**Quantification of Hydrological Elements - I**	Precipitation: statistical analysis of precipitation data, spatial analysis of precipitation using GIS, Precipitation (rainfall and snow) retrieval using satellite data. Interception: components of interception, role of remote sensing in estimation of interception. Infiltration: quantification of infiltration.
3	**Quantification of Hydrological Elements - II**	Soil moisture: Soil moisture at local and global scale, soil moisture retrieval using satellite data. Evapotranspiration: factors affecting evapotranspiration (ET), energy balance components, evapotranspiration estimation using satellite data.
4	**Snow cover area mapping and snow melt runoff modeling**	Spectral signature of snow, snow cover & Glacier mapping and monitoring, snow parameter retrieval using optical and microwave data, snow & Glacier melt runoff modeling
5	**Hydrological Modelling**	Hydrologic modelling - introduction and type of models: empirical, lumped, distributed and physical based models, Water balance, river flow measurement, flow routing; and calibration and validation of models Space Based Water Level and Discharge Estimation, Rating Curve Water balance computation

2.6.1 Water Resources Assessment (Practical)

Practical No.	Topics
1	Statistical and spatial analysis of precipitation data using RS-GIS techniques
	Derivation of unit hydrograph, S-hydrograph and synthetic unit hydrograph
	Surface water body mapping and water quality analysis
2 & 3	Rainfall retrieval using satellite data
	Estimation of interception using remote sensing
	Estimation of soil moisture using remote sensing
	Estimation of evapotranspiration (ET) using remote sensing data
4	Snow cover area mapping and snow melt runoff modeling
5	Estimation of surface runoff using SCS method
	Estimation of climatic water balance components
Field	Hydrological data collection in a watershed/Demo field based instrument: water quality kit, spectroradiometer, current meter, soil moisture (Theta Probe)

Suggested Readings

Books And Reports

1. Bala Krishnan P. "Issues in Water Resources Development and Management & the role of Remote Sensing", Technical Report ISRO-NNRMS-TR-67-86, NNRMS, ISRS, India.
2. Beven, K.J. (2001). "Rainfall-runoff modelling: the primer". John Wiley and Sons, UK.
3. Chow V.T., Maidment D.R. and Mays L.W. (1988). "Applied Hydrology", McGraw-Hill, New York.
4. Engman E.T. and Gurney R.J (1991). "Remote sensing in Hydrology", Chapman & Hall, London.
5. Levizzani V., Bauer P. and Joseph Turk F. (eds.) (2007). "Measuring Precipitation from space EURAINSAT and the Future", Published by Springer, P.O. Box 173300, AA Dordrecht, The Netherlands.
6. Maidment D.R. (ed.) (1993). "Handbook of Hydrology", McGraw-Hill.
7. Michaelides S. (ed.) (2008). "Precipitation: Advances in Measurement, Estimation and Prediction". Published by Springer-Verlag, Berlin, Heidelberg.
8. Rees W. G. (2006). "Remote Sensing of Snow and Ice." Published by CRC Press, Taylor and Francis Group.
9. Schultz G.A. and Engman E.T. (2000). "Remote Sensing in Hydrology and Water Management" Springer-Verlag, Berlin, Germany
10. Singh P. and Singh V.P. (2001). "Snow and Glacier hydrology". Kluwer Academic Publishers, Dordrecht, The Netherlands.
11. Subramanya, K. (2008). "Engineering Hydrology". 3rd Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, India.
12. US Department of Agriculture (1972). "Soil Conservation Service", National Engineering Handbook, Section 4, Hydrology, US Govt. Printing Office, Washington, DC, USA.

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1. Bastiaanssen W.G.M., Menenti M., Feddes R.A. and Holtslag A.A.M. (1998). "A remote sensing surface energy balance algorithm for land (SEBAL) 1. Formulation, 2. Validation". Journal of Hydrology, 212-213, pp. 198–229.

2. Clifford, D. (2010). "Global estimates of snow water equivalent from passive microwave instruments: history, challenges and future developments". International Journal of Remote Sensing, 31(14), pp. 3707-3726.
3. Dozier, J. (1989). "Spectral signature of Alpine snow cover from the Landsat Thematic Mapper". Remote Sensing of Environment 28, pp. 9–22.
4. Dubois, P., van Zyl J. and Engman E. (1995). "Measuring Soil Moisture with Imaging Radars," IEEE Trans. Geosc and Rem. Sens., 33, pp. 915-926.
5. Guha, A. and V. Lakshmi (2004). "Use of the Scanning Multichannel Microwave Radiometer (SMMR) to Retrieve Soil Moisture and Surface Temperature over the Central United States." IEEE Transaction on Geoscience and Remote Sensing, vol. 42.
6. Han, L. and Rundquist, D.C. (1996). "Spectral Characterization of Suspended Sediments Generated Form Two Textures Classes of Clay Soil", International Journal of Remote Sensing, 17, pp. 643-649.
7. Hong Y., Alder R.F., Hossain F., Curtis S. and Huffman G.J. (2007). "A first approach to global runoff simulation using rainfall estimation". Water Resources Research, 43, W08502, doi:10.1029/2006WR005739.
8. Kumar V., Jain S.K. and Singh Y. (2010). "Analysis of long-term rainfall trends in India." Hydrological Sciences Journal, 55(4), 484-496.
9. Tang Q., Durand M., Lettenmaier D. and Hong Y. (2010). "Satellite-based observations of hydrological processes." International Journal of Remote Sensing, 31(14), 3661-3667.
10. Schmugge T.J., Kustas, W.P., Ritchie J.C., Jackson, T.J. and Rango Al. (2002). Remote sensing in hydrology. Advances in Water Resources, 25, 1367-1385.
11. Yuan W., Liu S., Yu G., Bonnefond J.M., Chen J., Davis K., Desai A.R., Goldstein A.H., Gianelle D., Rossi F., Suyker A.E. and Verma, S.B. (2010). "Global estimates of evapotranspiration and gross primary production based on MODIS and global meteorology data." Remote Sensing of Environment, 114, 1416-1431.
12. Thakur, P.K., Nikam, B.R., Garg, V., Aggarwal, S.P., Chouksey, A., Dhote, P. and Ghosh, S. (2017). Hydrological Parameters Estimation using Remote Sensing and GIS for Indian Region - A Review. Proc. Natl. Acad. Sci., India, Sect. A Physical Sciences, 87(4):641–659. https://doi.org/10.1007/s40010-017-0440-z.
13. Thakur, P.K., Garg, V., Nikam, B.R., Chouksey, A. and Aggarwal, S.P. (2017). Remote sensing of snow, glaciers and ice in Indian Himalayan region and parts of Arctic and Antarctica: Current status, advances and future prospects. Proc. Natl. Acad. Sci., India, Sect. A Physical Sciences, 87(4):593–616. https://doi.org/10.1007/s40010-017-0437-7.
14. Thakur, P.K., Chouksey, A., Aggarwal, S.P. and Kumar A.S. (2017). Polar Ice Sheet and Glacier Studies – Indian Efforts in last Five Years. Proc Indian Natn Sci Acad 83(2): 415-425, DOI: 10.16943/ptinsa/2017/48946.
15. Nikam, B.R., Garg, V., Gupta, P.K., Thakur, P.K., Kumar, A.S., Chouksey, A., Aggarwal, S.P., Dhote P. and Purohit, S. (2017). Satellite-based mapping and monitoring of heavy snowfall in North Western Himalaya and its hydrologic consequences, Current science, 113(12): 2328-2334.
16. Garg, V., Kumar, A.S., Aggarwal, S.P., Kumar, V., Dhote, P.R., Thakur, P.K., Nikam, B.R., Sambare, R.S., Siddiqui, A., Muduli, P.R. and Rastogi, G. (2017). Spectral similarity approach for mapping turbidity of an inland waterbody. Journal of Hydrology, 550: 527–537.
17. Thakur, P.K., Chouksey, A., Aggarwal, S.P. and Kumar A.S. (2017). Polar Ice Sheet and Glacier Studies – Indian Efforts in last Five Years. Proc Indian Natn Sci Acad 83(2): 415-425, DOI: 10.16943/ptinsa/2017/48946.
18. Danodia, A., Patel, N. R., Chol, C. W., Nikam, B. R. and Sehgal, V. K. (2017). Application of S-SEBI model to map crop evapotranspiration using Landsat-8 OLI data over Western Uttar Pradesh region of India. Geocarto International, doi: 10.1080/10106049.2017.1374473.
19. Thakur, P. K., Aggarwal, S.P., Arun, G., Sood, S., Kumar, A.S., Snehmani, Dobhal, D.P. (2016). Estimation of snow cover area, snow physical properties and glacier classification in parts of Western Himalayas using C-band SAR data. Springer's Journal of the Indian Society of Remote Sensing (JISRS), June 2017, 45(3), pp 525–539, DOI: 10.1007/s12524-016-0609-y.

20. Aggarwal, S.P., Thakur, P.K., Nikam, B.R. and Garg, V. (2014). Integrated approach for snowmelt run-off estimation using temperature index model, remote sensing and GIS. Current Science, 106 (3), 397-407.
21. Nikam, B. R., Garg, V., Sachan, P. K., Thakur P. K. and Aggarwal S. P. (2014). Comparative Evaluation of Different Potential Evapotranspiration Estimation Approaches. International Journal of Research in Engineering and Technology, 3 (6), 544:552.
22. Thakur, P.K., Garg, P.K., Aggarwal, S.P., Garg, R.D. and Snehmani (2013). Snow Cover Area Mapping Using Synthetic Aperture Radar in Manali watershed of Beas River in the Northwest Himalayas. Journal of the Indian Society of Remote Sensing (JISRS), DOI: 10.1007/s12524-012-0236-1.
23. Garg, V., Nikam, B.R., Thakur, P.K. and Aggarwal, S.P. (2013). Assessment of the effect of slope on runoff potential of a watershed using NRCS-CN Method. International Journal of Hydrology Science and Technology, 3(2), 141–159.
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25. Thakur, P.K., Garg R.D. and Garg, P.K. (2012b). Snow wetness and density estimation using space based synthetic aperture radar data. i-Manager's Journal on Civil Engineering, 2(l): 10-20. December 2011 - February 2012.
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27. Aggarwal, S.P., Garg, V., Gupta, P.K., Nikam, B.R., Thakur, P.K. and Roy P.S. (2013). Runoff potential assessment over Indian landmass: A macro-scale hydrological modeling approach. Current Science, 104(7), 950-959.

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2. http://www.chikyu.ac.jp/precip/
3. http://clic.npolar.no/
4. http://www.cwc.nic.in/
5. http://ladsweb.nascom.nasa.gov/data/
6. http://www.itc.nl/WRS
7. http://www.iirs-nrsc.gov.in/index.php
8. http://www.india-wris.nrsc.gov.in/
9. http://www.imd.gov.in/

2.6.2 Watershed Analysis and Planning (Theory)

Units	Topics	Sub Topics
1	**Watershed Terrain Indices and its Hydrology**	DEM derivatives: Slope, Aspect, flow direction, flow accumulation, Drainage network extraction, watershed delineation using DEM, terrain Indices, morphological analysis of watershed and Geomorphic Instantaneous Unit Hydrograph (GIUH); watershed characteristics, watershed hydrology and factors influencing the watershed hydrology
2	**Soil Erosion Processes and Modeling**	Soil erosion types and its physical processes, erosion area mapping using satellite data, soil erosion and sediment yield modeling using empirical and process based models (USLE,RUSLE,MMF,WEPP etc.).
3	**Watershed Prioritization and Conservation Planning**	Problems in watershed, Use of high resolution data for watershed Resource mapping, concepts of watershed prioritization, RS and GIS approach for prioritization of watersheds, objectives of watershed management and conservation planning, role of remote sensing and GIS in watershed conservation planning,
4	**Integrated Watershed Management**	Integrated watershed management and action plans, Impact of watershed conservation plan on hydrology and soil Erosion, economic evaluation of watershed conservation measures.
5	**Urban Watershed Hydrology**	Basics of urban hydrology, role of RS-GIS in urban hydrological process, urban hydrological and water distribution system modeling.

2.6.2 Watershed Analysis and Planning (Practical)

Practical No.	Topics
1	Watershed characterization and morphometric analysis
2	Soil erosion modeling using USLE & RUSLE
	Soil erosion modeling using revised MMF model
3	Watershed prioritization
4	Geospatial database creation & watershed conservation planning
5	Urban hydrological modeling (TR55, SWMM, EPANET)
Field	Watershed Conservation structures Demonstration

Books and Reports

1. Gregory K.J., Walling D.E. (1973). "Drainage Basin Form and Process: A Geomorphological approach", Edward Arnold Ltd., U.K.
2. Isobel W. H. (2009). "Integrated watershed management: principles and practice" John Wiley and Sons, U.K.
3. Maidment D.R., (2002). "Arc Hydro: GIS for Water Resources", ESRI Press, Redlands CA, USA.
4. Murty V.V.N. (1985). "Land and Water Management engineering", Kallyani Publishers, New Delhi.
5. Mutreja K.N. (1990). "Applied Hydrology", Tata McGraw Hill Publishing Company Ltd., New Delhi.
6. Pimentel David (1993). "World Soil Erosion and Conservation" (Edited), Cambridge University Press, U.K.
7. Rodda J. C. (1976). Facets of Hydrology (Edited), John Wiley & Sons, U.K.
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11. Osman A, Robert J. H. (2003). "Urban hydrology, hydraulics, and storm water quality: engineering applications and computer modeling". John Wiley and Sons, Technology & Engineering.
12. Wilson J.P and Gallant J.C. (eds.)(2000). "Terrain Analysis - Principles and applications". John Wiley &sons, New York, USA.
13. Tomislav Hengl and Reuter H.I. (eds.) (2009). "Geomorphometry - Concepts, Software, Applications". Elsevier, Oxford, UK.

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14. Gregory E. T., Filippo Catani, Andrea Rinaldo and Rafael L. B. (2001). "Statistical analysis of drainage density from digital terrain data". Geomorphology 36, pp. 187–202.
15. Manoj K. Jain, Mishra K. Surendra and Shah R. B. (2010). "Estimation of sediment yield and areas vulnerable to soil erosion and deposition in a Himalayan watershed using GIS." Special section: Himalayan Bio-Geo databases–I. Current Science, 98(2).
16. Manoj Kumar Jain and Debjyoti Das (2010). "Estimation of sediment yield and areas of soil erosion and deposition for watershed prioritization using GIS and remote sensing". Water Resources Management, Volume 24 (10), pp. 2091-2112.
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20. Renard K.G., Foster G.R., Weesies G.A. and Porter J.P. (1991). "RUSLE - Revised Universal Soil Loss Equation. J Soil Water Conserv 46(1), pp. 30–33.
21. Sharma K. Arun and Thakur K. Praveen (2007). "Quantitative assessment of sustainability of proposed watershed development plans for Kharod watershed, western India"; Journal of Indian Society of Remote Sensing (JISRS), 35(3), pp. 231-241.
22. Shrimalil S. S., Aggarwal S. P. and Samral J. S. (2001). "Prioritizing erosion-prone areas in hills using remote sensing and GIS - a case study of the Sukhna Lake catchment, Northern India". ITC Journal, JAG, 3(1), pp. 54-60.
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1) www.watermissionmp.com/
2) http://nrdms.gov.in/watershed_mgmt.asp
3) www.hydrocad.net/tr-55.htm
4) www.dolr.nic.in/iwmp_main.htm www.icimod.org/
5) http://www.unep.or.jp/ietc/publications/freshwater/watershed_manual/index.asp

2.6.3 Water Resources Development (Theory)

Units	Topics	Sub Topics
1	**Site Suitability for Water Resources Projects**	Types of water resources projects, database creation and site suitability for a) Water Harvesting Structures (WHS), database required and decision rules (IMSD, FAO guidelines), b) water mills and c) for hydro power projects using RS-GIS
2	**Environmental Impact Assessment**	Project cycle, role of remote sensing in project planning, environmental benefits from the water resources projects, environmental losses and remedial measures of the water resources projects. Remote sensing and GIS in EIA of water resources projects. Causes of water-logging, Effects of water-logging, Mapping & Monitoring of waterlogged and saline soil, Management of waterlogged areas, Role of remote sensing in monitoring and management of waterlogged areas.
3	**Reservoir Sedimentation**	Process of reservoir sedimentation, Suspended sediments & bed load, Spectral characteristics of suspended sediments, Methods of reservoir sedimentation rate, Conventional hydrographic survey, Reservoir Area-Capacity curves, Remote sensing techniques for updating of Area–Capacity curves, Sedimentation rate through remote sensing techniques.
4	**Irrigation Infrastructure Development**	Concept of irrigation command area development, mapping of irrigation command area using RS-GIS, Infrastructure mapping and canal alignment using high resolution RS Data,
5	**Groundwater targeting and modelling**	Groundwater system, groundwater potential zoning, basics of groundwater hydraulics, groundwater modelling in GIS environment. Integrated Surface and groundwater modelling.

2.6.3 Water Resources Development (Practical)

Practical No.	Topics
1	Identification of suitable sites for WHS
	Site suitability for hydro power projects using RS-GIS
2	EIA of river valley projects
	Mapping and monitoring of waterlogged and saline areas using RS & GIS
3	Monitoring of reservoir sedimentation
	Area capacity curve updation using RS & GIS
4	Irrigation command area (infrastructure & crop) mapping using temporal satellite data
5	Ground water targeting using RS-GIS
	Ground water modeling using MODFLOW
Field	Visit to Irrigation command Area/Cross drainage structures

Suggested Readings

Books and Reports

1. Bastiaanssen, W. G. M., D. J. Molden, S. Thiruvengadachari, A. A. M. F. R. Smit, L. Mutuwatte, and G. Jayasinghe. (1999). "Remote sensing and hydrologic models for performance assessment in Sirsa Irrigation Circle, India". Research Report 27. International Water Management Institute, Colombo, Sri Lanka.
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2. Bowander B. and Ravi C. (1983). "Water logging in Sri Ram Sagar Irrigation Project". Journal of Water Res. Dept., 1(3), pp. 157-171.
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4. Raju P.V., Sesha Sai, M.V.R. and Roy P.S. (2008). "In-season time series analysis of Resourcesat-1 AWiFS data for estimating irrigation water requirement". International Journal of Applied Earth Observation and Geo-information, 10, pp. 220–228.
5. Ritchie J.T. 1972. "A model for predicting evaporation from a row crop with incomplete cover", Water Resources Res., 8(5), pp. 1204-1213.
6. Ray S.S., Dadhwal V.K. and Navalgund R.R. (2000b). "Performance evaluation of an irrigation command area using remote sensing: a case study of Mahi command area, Gujarat, India". Agricultural Water Management, 56, pp. 81–91.

7. Ray S.S., Dadhwal V.K., (2001). "Estimation of crop evapotranspiration of irrigation command area using remote sensing and GIS". Agric. Water Manage. 49 (3), 239–249.
8. D Sethi G.K., Chaudhary B.S., Goyal S.K. and Thakur P.K. (2010). "Assessment of groundwater quality for irrigation use in Yamuna Nagar District, India: A GIS approach," Environmental Pollution Control Journal, 13(3), pp. 47-48, 53-56.
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10. Kumar, P., Thakur, P.K., Bansod, B.K.S. and Debnath, S.K. (2017). Groundwater: a regional resource and a regional Governance. Environ Dev Sustain, 18 pages, DOI 10.1007/s10668-017-9931-y.
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2. www.iwmi.cgiar.org/
3. www.icid.org/
4. http://envfor.nic.in/divisions/iass/iass.html
5. http://mowr.gov.in/
6. www.fao.org/landandwater/aglw/cropwater/training.stm
7. http://www.waterlog.info/
8. http://www.groundwater.org/
9. http://water.usgs.gov/ogw/
10. http://cgwb.gov.in/
11. http://www.pmwin.net/index.htm
12. www.waterandfood.org/gga/
13. http://www.nrsc.gov.in/
14. http://ddws.nic.in/
15. http://www.isro.org/
16. http://www.esa.int/esaLP/LPsmos.html

2.6.4 Water Resources Management (Theory)

Units	Topics	Sub Topics
1	**Irrigation Water Management**	Estimation of crop water requirement, irrigation scheduling, performance indicators, performance evaluation of irrigation Projects, conjunctive use of surface and ground water.
2	**Flood Hydrology, Damage Assessment and Risk Zone Mapping**	Introduction to flood hydrology, flood flow estimation and routing, introduction to hydrological models & 1D, 2D hydrodynamic models, river basin characteristics in upland, flood plain and deltaic areas, high resolution terrain and flood plain mapping, flood inundation mapping and modeling, dam break and GLOF modeling, flood damage assessment and flood hazard zoning and flood risk zone mapping using remote sensing and GIS techniques.
3	**Drought Monitoring & Assessment**	Types of droughts, drought indices, assessment of meteorological, hydrological and agricultural drought, role of remote sensing in drought studies. Precipitation and NDVI relationships, Drought assessment and monitoring programmes.
4	**Climate Change and Water Resources**	Concepts of climate change. trend analysis of hydro-meteorological parameters, EO systems for climate change studies, climate change scenarios, scaling issues, dynamic and statistical downscaling, Ice-sheet & Sea-ice dynamics, glacier retreat and glacial lake mapping, impact of climate change on water resources.
5	**Integrated Water Resources Management (IWRM)**	Integrated Water Resources Management (IWRM), decision support system (DSS) for water resources. Role of remote sensing in IWRM and developing DSS.

2.6.4 Water Resources Management (Practical)

Practical No.	Topics
1	Estimation of Crop water requirement
	Performance evaluation of irrigation command area using RS & GIS
2	Water level estimation using altimeters and Flood peak flow estimation
	Hydrologic modeling and flood flow estimation using hydrodynamic models
	Mapping of flood inundation area, damage assessment & Risk Mapping
3	Drought assessment using remote sensing approach
4	Trend analysis of hydro-meteorological parameters.
	Glacier retreat mapping and hydrological modeling for climate change scenarios
5	Use of open source water resources portal for IWRM
Field	Visit to Local dams and flood prone areas

Suggested Readings

Books and Reports

1. Ministry of Agriculture (1972). "Hand book of Hydrology," Govt. of India, New Delhi.
2. National Remote Sensing Agency, (1995), "Integrated Mission of Sustainable Development technical guide lines," Department of Space, Govt. of India.
3. MacArthur R.C., Neill C.R., Hall B.R., Galay V.J. and Shvidchenko A.B. (2008). "Overview of Sedimentation Engineering". In: Garcia, M.H. (Ed.) Sedimentation engineering: processes, measurement, modelling, and practice, ASCE Manuals and Reports on Engineering Practice No. 110, 1-20, ASCE, Virginia, USA.
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5. Meijerink A.M.J., de Brouwer J.A.M., Mannaerts C.M. and Valenzuela C.R. (1994). "Introduction to the use of geographic information systems for practical hydrology". IHP - IV M 2.3. ITC Publication 23, ITC, Enschede, The Netherlands.
6. Sorooshian Soroosh; Hsu Kuo-lin; Coppola Erika; Tomassetti; Verdecchia Marco and Visconti Guido (eds) (2009). "Hydrological Modeling and the Water Cycle: Coupling the Atmospheric and Hydrological Models". Springer Science.
7. Verma H.N., Tiwari K.N. (1995). "Current status and Prospects of Rainwater Harvesting, Indian National Committee on Hydrology, Roorkee, India.
8. Knight P.G. (ed) (2006). "Glacier Science and environmental change". Blackwell publishing, Oxford, UK.

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2. Anon (1991). "Integrated Approach to Flood Disaster Management and Rural Area Development" Water Resources Journal, ESCAP/UN, Bangkok, Thailand, pp 106.
3. Gosain A. K., Sandhya Rao and Debajit Basuray (2006). "Climate change impact assessment on hydrology of Indian river basins", Current Science, 90 (3), pp. 346-353.
4. Jain S.K., Singh P. and Seth S.M. (2002). "Assessment of sedimentation in Bhakra Reservoir in the Western Himalayan region using remotely sensed data". Hydrological Sciences Journal, 47(2), pp. 203-212.
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6. Mall, R.K., Bhatla, R. and Pandey, S. N. (2007). "Water resources in India and impact of climate change". Jalvigyan Sameeksha, 22, pp. 157-176.
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8. Xing Ma, Jianchu Xu, Yi Luo, Aggarwal, S.P. and Jiatong Li. (2009). "Response of hydrological processes to land-cover and climate changes in Kejie watershed, south-west China". Hydrological Processes, published online in Wiley Inter Science (www.interscience.wiley.com) DOI: 10.1002/hyp.7233.
9. Krishan, R., Chandrakar, A., Nikam, B. R., Pingale, S. M. and Khare, D. (2017). Long Term Rainfall Data Analysis over Eastern Ganga Canal Command Area. Indian Journal of Soil Conservation, 45 (3), 338-347.
10. Padhee, S., Nikam, B. R., Dutta, S. and Aggarwal S. P. (2017) Using satellite based soil moisture to detect and monitor spatiotemporal traces of agricultural drought over Bundelkhand region of India. GIScience Remote Sensing, 54(2), 144-166. doi: 10.1080/15481603.2017.1286725.

11. Garg, V., Aggarwal, S.P., Nikam, B.R. and Thakur, P.K. (2013). Hypothetical Scenario Based Impact Assessment of Climate Change on Runoff Potential of a Basin. ISH Journal of Hydraulic Engineering, 19(3), 244-249.
12. Thakur, P.K., Maiti, S., Kingma, N.C., Prasad, V.H., Aggarwal, S.P. and Bhardwaj, A. (2012). Estimation of structural vulnerability for flooding using geospatial tools in the rural area of Orissa, India. Natural Hazards, 61(2): 501-520, DOI 10.1007/s11069-011-9932-3.
13. Rajan, S., Nikam, B.R., Aggarwal, S. P. and Garg, V. (2014). Statistical Downscaling of GCM Output and Generation of Future Hydrological Scenario for Ganga Basin, India. International Journal of Scientific Engineering and Technology, (ISSN: 2277-1581), Vol. 3 (Special Issue), 121-130.
14. Thakur, P.K., Ghosh, S., Garg, V., Aggarwal, S. P., Saha, S.K., Sharma, R. and Bhattacharyya, S. (2015). SARAL/AltiKa waveform analysis to monitor inland water levels: A case study of Maithon Reservoir, Jharkhand, India. Marine Geodesy. (Available Online, DOI:10.1080/01490419.2015.1039680)
15. Thakur, P.K, Aggarwal, S., Aggarwal, S.P., and Jain, S.K. (2016). One dimensional hydrodynamic modeling of GLOF and impact on hydropower projects in Dhauliganga River using remote sensing and GIS applications, Springer's Natural Hazards Journal, pp. 1-19, DOI 10.1007/s11069-016-2363-4.
16. Ghosh, S., Thakur, P.K., Sharma, R., Nandy, S., Garg, V., Amarnath, G., Bhattacharyya, S. (2017). The potential applications of satellite altimetry with SARAL/AltiKa for Indian inland waters. Proceedings of the National Academy of Sciences, India Section A: Physical Sciences, 87(4), 661-677.
17. Mohan, S., Nikam, B.R., Aggarwal, S. P., Thakur, P. K., Krishna Murthy, Y. V. N. and Kingma, N. (2017). Evaluation of Adaptive Filters for Speckle Reduction in RISAT-1 Data for Flood Mapping. Asian Journal of Geoinformatics, 17(2), 12-24.
18. Aggarwal S., Rai S.C., Thakur P.K. and Emmer A. (2017), Inventory and recently increasing GLOF susceptibility of glacial lakes in Sikkim, Eastern Himalaya. Geomorphology, 295: 39–54.
19. Sharad Kumar Jain, Pankaj Mani, Sanjay K. Jain, Pavithra Prakash, Vijay P. Singh, Desiree Tullos, Sanjay Kumar, S. P. Agarwal & A. P. Dimri (2018): A Brief review of flood forecasting techniques and their applications, International Journal of River Basin Management, DOI: 10.1080/15715124.2017.1411920.
20. Rahman, M. R. and Thakur P. K. (2017). Detecting, mapping and analysing of flood water propagation using synthetic aperture radar (SAR) satellite data and GIS: A case study from the Kendrapara District of Orissa State of India. The Egyptian Journal of Remote Sensing and Space Sciences, https://doi.org/10.1016/j.ejrs.2017.10.002.

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2) http://www.indiawaterportal.org/node/10500
3) http://www.unesco-ihe.org/
4) http://www.flo-2d.com/
5) http://www.hec.usace.army.mil/
6) http://www.dhigroup.com/
7) http://saarc-sdmc.nic.in/drought.asp
8) http://www.nidm.gov.in/Drought.asp
9) http://www.rainwaterharvesting.org/crisis/Drought.htm
10) http://www.unep.org/climatechange/
11) http://www.ipcc.ch/
12) http://www.glc.org/wateruse/wrmdss.html
13) http://waterwiki.net/index.php/IWRM
14) http://nwda.gov.in/
15) http://nsidc.org/glaciers/
16) http://www.nasa.gov/
17) http://www.ce.utexas.edu/prof/maidment/gishydro/home.html
18) http://www.drought.unl.edu/dm/monitor.html

Syllabus for Semester-II

Satellite Image Analysis and Photogrammetry

(Optional)

2.7 Satellite Image Analysis and Photogrammetry

Code	Papers	Lectures* Hrs.	Practical		Total Hrs.
			Lab Hrs.	Field Hrs.	
2.7.1	Remote Sensing- II	25	40	10	75
2.7.2	Image Processing II	25	40	10	75
2.7.3	Digital Photogrammetry and Mapping	25	40	10	75
2.7.4	Surface Generation techniques	25	40	10	75
Total		100	160	40	300

*includes guest lectures & tutorials

2.7.1 Remote Sensing- II (Theory)

Units	Topics	Sub Topics
1	**Data pre-processing**	• Noise characterization, noise & smile effects and illumination effects in Hyperspectral data • SAR data pre-processing
2	**Radiometric and Atmospheric Corrections for hyperspectral and thermal data**	• Basic Concepts of radiative transfer theory, Overview of Atmospheric Correction models. Relative & absolute atmospheric calibration. • Atmospheric correction process for Multispectral and Hyperspectral Sensors and retrieval of surface reflectance • Thermal data pre-processing
3	**Hyperspectral Remote Sensing**	• Noise and data dimensionality reduction using PCA and MNF, ICA etc., end member extraction, Spectral library creation, Hyperspectral Feature extraction techniques – Spectral Angle Mapper (SAM), Spectral Feature Fitting (SFF), Linear Spectral Un-mixing (LSU), and Mixture Tuned Matched Filtering (MTMF) constrained energy minimization, cross correlograms, Hyperspectral indices • UAV hyperspectral remote sensing
4	**Thermal Remote Sensing**	• Space based thermal imaging systems (Operational and future). Retrieval of geo-physical parameters using thermal sensors (emissivity, surface Temperature, radiation heat budget) • UAV thermal remote sensing
5	**Polarimetric SAR Remote Sensing**	• Fundamentals of Polarimetric SAR Remote Sensing, Stokes Vector, The Stokes criterion, Polarimetric Scattering, Scattering Matrix, Lexicographic Feature Vector, Pauli Spin Matrix Basis & Feature Vector, Second order derivatives of Scattering Matrix, Covariance Matrix, and Coherency Matrix • Overview of PolSAR decomposition model • UAV SAR remote sensing

2.7.1 Remote Sensing- II (Practical)

Practical No.	Topics
EX RS 1	Radiative transfer modeling using atmospheric parameters
EX RS 2	Atmospheric correction of Multispectral and Hyperspectral data data
EX RS 3	Hyperspectral Data Dimensionality reduction using different algorithms, comparison and end member selection
EX RS 4	Ground spectra collection
EX RS 5	Spectral library generation, classification of Hyper-spectral image and accuracy assessment
EX RS 6	Retrieval of geophysical parameters using thermal sensors (albedo, emissivity, surface temperature etc.)
EX RS 7	Polarimetric SAR data processing

Suggested Readings

Books and Reports

1. Elachi, C. (1987). Introduction to the Physics and Techniques of Remote Sensing, Wiley Interscience.
2. Freek van der Meer, Steven M. de Jong, (2001). Imaging Spectrometry Basic Principles and Prospective Applications. Kluwer Academic Publisher, Dordrecht, the Netherlands.
3. Pramod K. Varshney, Manoj K. Arora, (2004). Advanced Image Processing Techniques for Remotely Sensed Hyperspectral Data, Springer. ISBN: 3540216685.
4. 4. Asrar, G., (1989). Introduction in Theory and Application of Optical remote sensing. (Asrar. G. Ed), John Wiley & Sons.
5. 5. Shunlin Liang, (2005). Quantitative Remote Sensing of Land surfaces. John Wiley & Sons.

Additional Readings

1. Tsang L., Kong J.A., Shin R.T. (1985).Theory of Remote Sensing.
2. Kalacska M., Arturo G. (2008). "Hyper-spectral remote sensing of tropical Forests", CRC press.
3. Quattrochi D.A., Luvall, (2000). "Thermal Remote Sensing in Land Surface process" CRC Press,

Journals Articles

1. Tran Thi VAN, Le Van Trung, Hoang Thai Lan, Vietnam, "Application of Thermal Remote Sensing in Study on Surface Temperature Distribution of Ho Chi Minh City", 7th FIG Regional Conference Spatial Data Serving People: Land Governance and the Environment – Building the Capacity Hanoi, Vietnam, 19-22.\,2009.

2. Bo-Cai Gao, Marcos J. Montes, Curtiss O. Davis, Alexander F.H. Goetz, 2009. Atmospheric correction algorithms for Hyperspectral Remote Sensing data of land and ocean. Remote sensing of environment 113 (2009) S17–S24

2.7.2 Image Processing II (Theory)

Units	Topics	Sub Topics
1	**Change detection**	• Strategy for change detection, Data pre-processing for change detection (Geometric and radiometric) and change detection algorithms: Image difference, PCA, change vector analysis and based on classification
2	**ANN & Fuzzy classifiers**	• Introduction to Artificial Neural Networks, back propagation training algorithms, ANN classifiers • Advanced Classifiers - Introduction to Fuzzy Theory, Fuzzy Classification and, membership function
3	**Image Texture**	• Texture Analysis for Remote Sensing Data- First Order, Second Order Texture Parameters, Gray Level co-Occurrence Matrix
4	**Image Segmentation and Object Oriented Classification**	• Image Segmentation- Basic concepts; Segmentation algorithm- edge based, thresholding, region based • Object Oriented Classification: Object vs. pixel-based classification, Advantage of object oriented classification, Multiresolution segmentation and classification, concept of scale, shape, smoothness, compactness
5	**Change detection**	• Automated Information Extraction- Intro (Need, Importance, Challenges) • Algorithms for point feature extraction • Algorithms for linear feature extraction • Algorithms for region extraction • Morphological operators

2.7.2 Image Processing II (Practicals)

Practical No.	Topics
EX. IP 1	Land use/Land Cover change detection
EX. IP 2	Image classification using Fuzzy supervised and unsupervised techniques
EX. IP 3	Image classification using Neural network
EX. IP 4	High-resolution image classification using segmentation and object oriented approach
EX. IP 5	Image Texture quantification and analysis
EX. IP 6	Automatic linear feature extraction
EX. IP 7	Automatic extraction of regions (Polygon/area features)

Suggested Readings

1. Richards John A& Xiuping Xia, 2006. Remote Sensing Digital Image Analysis: An Introduction.
2. Jensen John R. Introduction to Digital Image Processing: A Remote Sensing Perspective Prentice hall, New Jersey
3. Yu Hen Hu and Jenq_Neng Hwang, Handbook of Neural Network Signal Processing, CRC Press, 2001.
4. Patrick Henry Winston, Artificial Intelligence, AWL, 1999.
5. Adedeji B. Badiru and John Y. Cheung, Fuzzy Engineering Expert System with Neural Network Applications, 2002
6. Gerald Kaiser, 1994. A friendly guide to wavelets. Springer.
7. George J. Klir and Bo Yuan, 2009. Fuzzy sets and fuzzy logic – Theory and Applications, 2nd Edition, Phi Learning.
8. Riza C. Barkan and Sheldon L. Trubatch, 1997. Fuzzy Systems Design Principles- building Fuzzy If-Then Rule Bases.IEEE Computer Society Press ISBN: 0780311515
9. Patrick Henry Winston 1992. Artificial Intelligence (Third Edition) Addison-Wesley Longman Publishing Co., Inc
10. Simon Hyki, 1994. Neural Network – A Comprehensive foundation, MacMillan Publishing Company
11. Danilo P. Mandic, Jonathon A., 2002. Chambers Recurrent Neural Networks for Prediction. Online Publication
12. Zuranda JM, 1994. Introduction to Artificial Neural Network. Jaico Publishing House
13. Blackledge Jonathan M and Turner Martin, 2001. J. Image Processing III: Mathematical Methods, Algorithms and Applications: Horwood Publishing Limited, England 2001. Xiv.

2.7.3 Digital Photogrammetry and Mapping (Theory)

Units	Topics	Sub Topics
1	**Geodesy and Surveying**	• Overview of conventional survey techniques (horizontal and vertical control, triangulation, traversing, leveling, GPS and Total Station surveying) • Data integration from different sources (GPS, Total Station, High-resolution satellites) for large-scale mapping • GNSS: Observables, Differential positioning techniques (concept and modes-post processing, real time processing), Augmentation systems (LAAS, WAAS, GAGAN, EGNOS, MSAS), IGS ephemeris products, static & kinematic method of surveying
2	**Satellite Photogrammetry**	• Mathematical Concepts for Satellite Photogrammetry • Collinearity and Co-planarity Conditions • Photogrammetric solution in Satellite Photogrammetry • Orbital Parameters; Orbital Modeling, Sensor Modeling and Intersection
3	**Sensor Models and Product Generation**	• Data Processing for stereo generation • Alternate Sensor Models - Rational Function Model /Rational Function coefficient: Image Matching Techniques, DEM generation (Regular, Irregular) and Ortho-rectification, feature extraction from photogrammetric products and mapping
4	**Digital Cartography**	• Geospatial Database organization, Data dissemination services: contemporary approaches, Geoportals (e.g. Google Earth and Bhuvan) • Digital Cartography, Web Cartography, 3D Simulation and Visualization, Digital earth models. Virtual Reality concepts in Digital Mapping
5	**Terrain Analysis**	• Digital surfaces(DTM, DSM, nDSM0, sources for DEM DTM types/forms and conversions • DEM derivatives (slope, aspect, stream extraction), Terrain analysis: Inter-visibility & indundation Analysis and Visualization

2.7.3 Digital Photogrammetry and Mapping (Practical)

Practical No.	Topics
EX DP 1	Use of Total Station for ground survey (large-scale mapping)
EX DP2	GCP collection using Multi frequency DGNSS (Familiarization)
EX DP3	Post-processing of GNSS data for GCP's
EX DP4 & 5	Data integration from different sources -GNSS, Total Station and high resolution satellites for large-scale mapping and cadastral surveys
EX DP6	Stereo model generation using Satellite images (physical sensor model), DEM and ortho-image generation and accuracy assessment
EX DP7	Stereo model generation using of Satellite images (RFM based, DEM and ortho-image generation and accuracy assessment
EX DP8	Feature extraction from Photogrammetric product
EX DP9	Digital cartography and Demo on Digital Earth models (Google Earth and Bhuvan).
Ex DP 10	View shed and inundation analysis using DEM

Suggested Readings

1. Toni Schenk: Digital Photogrammetry, Volume I., TerraScience.
2. Sanjib K. Ghosh, 1979: Analytical Photogrammetry, New York: Pergamon Press
3. Sanjib K. Ghosh. 2005. Fundamentals of computation Photogrammetry. Concept publishing, New Delhi.
4. Luhmann, Thomas, Robson, Stuart and Kyle, Stephen, 2007. Close Range Photogrammetry: Principles, Techniques and Applications. Wiley, 2007. 528. ISBN : 978047010633
5. Kasser Michel and Egles Yves, 2002. Digital Photogrammetry. London: Taylor and Francis, 2002. Xv,351p. ISBN: 0-748-40945-9.
6. Wolfgang Torge, W., Geodesy, 3rd edition
7. Robinson H,Arthur, Morrison Joel L and Muehrcke Phillip C "Elements of Cartography.--6th ed.--New York: John Wiley and Sons, Inc, 1995. 671p.
8. Slocum Terry A, 1999. Thematic Cartography and Visualization. New Jersey: Prentice-Hall Inc., 1999. 293p.
9. Kraak Menno-Jan and Ormelling Ferjan Cartography: Visualization of geospatial data.--2nd ed. --Harlow: Prentice Hall, 2003.ix, 205p.
10. Kraak Menno-Jan (Ed) and Brown Allan (Ed) Web Cartography: Developments and Prospects. --New York: Taylor and Francis, 2001. ix, 213p.

Additional Reading

11. Li,Zhilin, Chen,Jun and Baltsav,Emmanual, 2008. Advances in photogrammetry, Remote Sensing and Spatial Infomation Science: 2008 ISPRS Congress Book. / London: Taylor and Francis Group, xviii, 527p ISBN: 978041547805.
12. Cliff Greve and ASPRS Digital Photogrammetry: An Addendum to Manual of Photogrammetry

13. Mikhail Edward, bethel James and Mcglone J Chris Introduction to Modern Photogrammetry, John Wiley & sons Inc.
14. Kasser Michel and Egles Yves Digital Photogrammetry. Taylor & Francis. London & New York.
15. Schmidt Milton O and Rayner William Horace Fundamentals of Surveying, Van Nostrand Reinhold Company
16. Monimonier Mark S: Computer-assisted Cartography: Principles and Prospects.- New Jersey: Prentice-Hall, 1982. x, 214p.
17. Nag, Prithivish: Thematic Cartography and Remote Sensing.-- New Delhi: Concept Pub.,
18. Maceachren Alan M (Ed) and Taylor DR Fraser (Ed) Visualization in Modern Cartography.-- UK: Pergamon Press
19. Dodge, Martin (Ed), Mcderby, Mary (Ed) and Turner, Martin (Ed), 2008. Geographic Visualization: Concepts, Tools and Applications./ by -- England: John Wiley & Sons
20. Linder, Wilfried, 2009. Digital Photogrammetry: A Practical Course. 3rd ed.: Springer, 2009. Berlin. ISBN: 9783540927242.
21. Mikhail Edward M, Bethel James S and McGlone J Chris, 2001. Introduction to Modern Photogrammetry. New York: John Wiley and Sons, 2001. ix, 479p. ISBN : 0471309249.

2.7.4 Surface Generation Techniques (Theory)

Units	Topics	Sub Topics
1	**Introduction to digital surface generation**	• Challenges and issues in DSM generation, Limitations of photogrammetric height extraction and alternatives. Comparison of DEM extraction Techniques
2	**Close Range Photogrammetry**	• Principles of CRP, Data Acquisition, Camera Calibration, and Data Processing for surface Generation, case examples
3	**SAR Interferometry**	• Concept of Interference, Young's Double Slit Experiment for Constructive and Destructive Interference, Phase Information, SAR Interferometry, Types of RADAR Interferometry, Baseline, Critical Baseline, Altitude of Ambiguity, Synthetic Phase Generation, Interferogram Generation, Interferogram flattening, Coherence Generation, Phase Unwrapping, Interpretation of SAR Backscatter, Coherence & Interferogram, Height of the Effective Scattering Centre
4	**Advance techniques in SAR Interferometry**	• Concept of Differential SAR Interferometry (DInSAR); Two, Three and Four pass differential interferometry; Phase calculation of differential interferogram; Effect of ionospheric and tropospheric propagation of EM wave on Interferometric phase; Overview of persistent SAR interferometry (PSInSAR) and Applications
5	**LiDAR remote sensing**	• Laser Footprint, multiple return, Bathymetry LiDAR, full wave digitization; platforms of LiDAR; Components of a LiDAR system; LiDAR foot print geo-location; terrain product (DSM, nDSM, BEM, building) extraction from point data & LiDAR waveform • Terrestrial and UAV based Laser Scanning

2.7.4 Surface Generation Techniques (Practical)

Practical No.	Topics
EXSGT1	Close-range photogrammetry based 3D modelling
EXSGT2	Interferometric Processing of space borne SAR Data
EXSGT3	Field exercises for interferometric data interpretation
EXSGT4	LiDAR data Filtering: Intensity & Elevation based information (DEM, DSM) generation from LiDAR data and classification
EXSGT5	TLS data collection and processing

Suggested Readings

1. Jie Shan, Charle k .Toth, Topographic laser ranging and scanning: Principles and processing.
2. George Vosselman, Hans Gerd Maas, Airborne and Terrestrial laser scanning
3. George L. Heritage and Andrew R.G. Large,Laser Scanning for environmental sciences
4. Laby F.T.U., moore R.K., Fung A.K.,"Microwave Remote Sensing Active and passive" Vol.I, Addison-Wesley Pub. 1981.
5. Woodhouse I.H., "Introduction to Microwave remote Sensing", Taylor and Francis group, 2006.
6. Skolnik M., "Radar Handbook", Third edition, McGrawHill, 2008.
7. I.H. Woodhouse, Introduction to Microwave Remote Sensing, Taylor and Francis, Boca Raton, Florida, 2006.
8. F.M. Henderson and A.J. Lewis (Eds), Principles and Applications of Imaging Radar, Manual of Remote Sensing, 3rd ed, Volume 2, John Wiley and Sons, N.Y., 1998.
9. J-S Lee and E. Pottier, Polarimetric Radar Imaging: From Basics to Applications, CRC Press, Taylor and Francis, Boca Raton, Florida, 2009.
10. R. Hanssen, Radar interferometry: data interpretation and error analysis. Dordrecht, Boston: Kluwer Academic, 2001.
11. A. Ferretti, A. Monti-Guarnieri, C. Prati, and F. Rocca, InSAR Principles: Guidelines for SAR Interferometry Processing and Interpretation, Volume 19 of ESA technical memoranda, 1-3 vols. The Netherlands: ESA Publications, 2007.

Syllabus for Semester-II

Geoinformatics

(Optional)

2.8 Geoinformatics

Code	Papers	Lectures*	Practical		Total (Hrs.)
			Lab (Hrs.)	Assignment (Hrs.)	
2.8.1	Spatial Database Architectures & Modeling	25	35	15	75
2.8.2	Programming in Geodata Modeling	25	35	15	75
2.8.3	Web GIS and Geovisualisation	25	35	15	75
2.8.4	Spatial Data Quality and Geostatistics	25	35	15	75
Total		100	140	60	300

*includes guest lectures & tutorials

2.8.1 Spatial Database Architectures and Modeling (Theory)

Units	Topics	Sub Topics
1	**Basics of Spatial Databases**	Databases overview, Attribute data models, Spatial Databases, Spatial data types and structures, Basics of relational algebra, ER Model, Normalization
2	**Spatial Database Design**	Conceptual data modeling, Concepts of UML, Database design using UML, Spatial data topological relationship
3	**Spatial Database Storage & Retrieval**	Concepts of spatial data storage, spatial query languages using extended SQL, spatial query processing and optimization, Spatial Indexing
4	**Advances in Spatial Databases**	Introduction to spatial data mining and algorithms (case study demonstration), Web-enabled Spatial Database Systems, Overview of NoSQL for spatial data handling, Demonstration on IBIN and BIS web based GIS Portals
5	**Geospatial Modeling**	Spatial data modeling and its classification, spatial decision modeling concepts, spatial decision support systems, AHP based modeling with applications, Concepts of Agent-based modeling and its applications

2.8.1 Spatial Database Architectures and Modeling (Practical)

Practical No.	Topics	Sub Topics
1	**Basics of Spatial Databases**	Spatial database creation (spatial database creation in GIS: Personal Geodatabase, File Geodatabase and Enterprise Geodatabase using spatial database engine & PostgreSQL and PostGIS)
2	**Spatial Database Design**	Spatial database design using UML, spatial database schema creation
3	**Spatial Database Storage & Retrieval using PostgreSQL/PostGIS**	Shape file storage, spatial data types insertion and retrieval, spatial queries using extended SQL, Query optimization & index creation
4	**SQL Queries in PostgreSQL**	SQL Queries (data insertion, selection, updation, deletion), Defining Constraint, Mathematical operators, date/time operations, string operations, indexing, join operations and writing complex queries
5	**Geospatial Modeling**	Case studies on multi-criteria decision modeling (using AHP) & Agent-based modeling

Suggested Readings

Books:

1. Booch, G., Rumbaugh, J., and Jacobsen, I. (1999). The Unified Modeling Language User Guide. Addison-Wesley.
2. Date, C. J. (2003). An introduction to database systems. Addison Wesley.
3. Shekhar, S. and Chawla, S. (2003). Spatial Databases: A Tour. Prentice Hall.
4. Zelkowitz, M. V., Shaw, A. C., and Gannon, J. D. (1979). Principles of Software Engineering and Design. Prentice Hall.

2.8.2 Programming in Geodata Modeling (Theory)

Units	Topics	Sub Topics
1	**Basics of Programming Language**	Basic programming concepts: flowchart & algorithms, variables, expressions and statements, conditionals , iterations, functions and recursion
2	**Data structure and Object Oriented Programming**	Strings, Lists, Tuples, Dictionaries, Files, Objects & Classes, Methods, Inheritance
3	**Open Source programming APIs**	Matrices and linear algebra, Scientific plotting, Database connectivity, Imaging library
4	**Geo-Programming**	KML parsing API, Geodata abstraction library, Customizing open source GIS softwares

2.8.2 Programming in Geodata Modeling (Practical)

Practical No.	Topics	Sub Topics
1	**Basics of Programming Language**	Familiarization with Python IDE, Exercise on variables and functions, conditionals and iterations , flowchart
2	**Data structure and Object Oriented Programming**	Python strings and lists, tuples, dictionaries, files, object orientation
3	**Open Source programming APIs**	Exercises on Numpy, Matplotlib and Python imaging library , database connectivity
4	**Geo-Programming**	KML parsing, Python library "Shape" for basic & advanced spatial functions; plug-ins for QGIS

Suggested Readings

Books:

1. Downey, A. B. (2009). Python for Software Design: How to Think Like a Computer Scientist. Cambridge University Press.
2. Sherman, G. (2012). The Geospatial Desktop: Open Source GIS and Mapping. Locate Press.
3. Swaroop C. H. (2008). A Byte of Python. http://www.swaroopch.org/notes/Python.

Online Resources:

1. http://www.python.org/
2. http://pypi.python.org/pypi
3. http://www.pythonware.com/products/pil/
4. http://www.opengeospatial.org/standards/kml/
5. http://www.gdal.org/
6. NumPy User Guide Release 1.5.1 (http://docs.scipy.org/doc/numpy-1.5.x/numpy-user.pdf)
7. Python Imaging Library Overview 1.1.3 (http://www.pythonware.com/media/data/pil-handbook.pdf)
8. Matplotlib Release 1.0.0 (http://matplotlib.sourceforge.net/trunk-docs/Matplotlib.pdf)

2.8.3 Web GIS Technology and Geo-visualization (Theory)

Units	Topics	Sub Topics
1	**Internet Technology and Web GIS**	Basic Internet concepts, Networking Protocols, Client/Server Architecture, WebGIS concepts and its applications.
2	**Web Programming**	Creation of basic web site using HTML and CSS, Client-side scripting and Server-side scripting for web mapping.
3	**Distributed GIS**	Concepts of distributed GIS, Service Oriented Architecture (REST & SOAP Services), Interoperability and Standards.
4	**Web GI Services**	OGC Geospatial web service standards (OGC WMS, WFS and WPS), SDI and Metadata standards and cataloguing, GIS Servers (COT's and Open Source), Location Based Services, Overview of Cloud Computing & Crowdsourcing
5	**Geo-visualization**	Geo-visual exploration/analytics, different methods of visualization, multi-scale problem, web cartography, 3D topology, KML, Virtual Globes

2.8.3 Web GIS Technology and Geo-visualization (Practical)

Practical No.	Topics	Sub Topics
1	**Internet Technology and Web GIS**	Internet GIS Examples
2	**Web Programming**	Web designing using HTML and CSS, Client-side and Server-side Scripting using Javascript and PHP.
3	**Distributed GIS**	Open Source Geonetwork metadata cataloguing system, Demonstration and Hands-on Google Earth Engine
4	**Web GI Services**	Creation and Dissemination of OGC WMS, WFS and WPS Services using FOSS4G tools and web mapping using Open layer APIs, Demonstration on SWAMIS (System for Weather and Apadaa Management Information for SriLanka) Application
5	**Geo-visualization**	Visualization of 3D geospatial data using virtual globes, Creation and demonstration of 3D models using TRIVIM and SketchUp

Suggested Readings

Books:

1. Kraak, J.M., and Allan, B. (2001). Web Cartography: Developments and Prospects. Taylor & Franscis (Edition-1), London.
2. Kraak, M.J., and Ormeling, F. (2010). Cartography: Visualization of Spatial Data. Pearson- Harlow, England (3rd ed.).
3. Pinde Fu, and Jiulin S. (2011). Web GIS: Principles and Applications. ESRI Press, Redlands, California**.**
4. Scott, D. (2007). GIS for Web Developers: Adding Where to Your Web Applications. Pragmatic Bookshelf, China (Edition-1).

Additional Readings:

5. Gregory, M. N., Hagan, H., and Muller, H. (1997). Scientific Visualization: Overviews, Methodologies and Techniques, IEEE Computer Society.

Online Resources:

1. Adobe Dreamweaver tutorial (http://www.adobe.com/devnet/dreamweaver/articles/first_website_pt1.html)
2. Server-side Scripting Primer (http://www.w3schools.com/web/web_scripting.asp)
3. GEOG 585: Open Web Mapping https://courseware.e-education.psu.edu/courses/geog585/content/home.html
4. OGC Support and Configuration (http://mapserver.org/ogc/index.html)
5. UMN Mapserver (http://mapserver.org/)
6. Introduction to GeoServer (http://workshops.opengeo.org/geoserver-intro/)
7. ArcIMS (http://www.esri.com/software/arcgis/arcims/index.html)
8. GeoNetwork opensource (http://geonetwork-opensource.org/).
9. http://personal.cscs.ch/~mvalle/visualization/tools.html
10. http://www.bu.edu/tech/resersch/training/tutorials/introduction-to-scientific-Visualization-tutorial/
11. www.mgnet.org/~douglas/classes/cs521/scivis/SciVis2004.ppt

2.8.4 Spatial Data Quality and Geostatistics (Theory)

Units	Topics	Sub Topics
1	**Basic concepts of SDQ**	Concepts of SDQ, Concepts of probability and statistics, Exploratory data analysis, Principles of regression and least squares,
2	**Uncertainty Analysis**	Scales of measurements, Sources of uncertainty and types, Effects of rounding, Modifiable areal unit problem (MAUP), Scale and Zonation
3	**Error and Uncertainty Propagation**	Taylor series approximations, The uncertainty cascade, Error models, Error propagation, Taylor series and model uncertainty
4	**Spatial Sampling and Variogram Modeling**	Spatial Sampling Techniques, Spatio-temporal characteristics, Spatial pattern search, Isotropy, Anisotropy, Homogeneity, Spatial dependence function, Spatial correlation function, Semi-variogram (SV), Theoretical SV and Experimental SV construction,
5	**Geostatistical Interpolation Techniques**	Optimal Interpolation Techniques (Geostatistical and Kriging Methodologies: Simple Kriging, Ordinary Kriging, Universal Kriging, Block Kriging)

2.8.4 Spatial Data Quality and Geostatistics (Practical)

Practical No.	Topics
1	Introduction to R software, Exploratory data analysis, Probability and Statistics operations, Regression and least squares using R
2	Image generation at varied spatial resolutions, Spatial resolution vs. attribute uncertainty, Studying/ understanding Modifiable Areal Unit Problem (MAUP)
3	Exercise on Taylor series expansion, Error and uncertainty modeling and propagation
4	Spatial Samplings, Optimal Sampling Design, Auto-correlation, Variogram Modeling and Semi-variogram analysis
5	Spatial Sampling Modeling spatial structure from point samples, Predicting point samples, Assessing the quality of spatial predictions, Optimal Interpolation techniques (Geostatistical, Kriging Methodologies: Simple Kriging, Ordinary Kriging, Universal Kriging, Block Kriging)

Suggested Readings

Books:

1. Devillers, R. and Jeansoulin (2006). Fundamentals of Spatial Data Quality. ISTE Ltd, United States.
2. Draper, N. and Smith, H. (1981). Applied Regression Analysis. Wiley, New York.
3. Hengl, H. (2007). A Practical Guide to Geostatistical Mapping of Environmental Variables. European Commission, Italy.
4. Sen, Z. (2009). Spatial Modeling Principles in Earth Sciences. Springer.