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REGIONAL CENTRES FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION

(AFFILIATED TO THE UNITED NATIONS)

Remote sensing and the geographic information system

Education curriculum

United Nations

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Office for Outer Space Affairs

United Nations Office at Vienna

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Preface

All life on Earth depends on the thin layer of gas that surrounds the globe; it is called the atmosphere, taken from the Greek word *atmos* (vapour) and the Latin word *sphaera* (sphere). Remote sensing of the atmosphere attempts to quantify numerous variables: cloud coverage and identity, water vapour concentration and precipitation rate, wind speeds, atmospheric aerosol and trace gas concentrations, and even lightning in storms.

The term atmosphere has led to the creation of several other words to describe various divisions of the Earth's environmental systems:

- The hydrosphere, encompassing oceans, rivers, lakes and snow and ice on both land and sea;
- The biosphere, referring to the living things that inhabit the Earth, which for remote-sensing purposes primarily means land vegetation and oceanic phytoplankton;
- The geosphere, covering such areas as the Earth's radiation budget, the physical topography of the continents, geological processes that modify the land surface, the dynamic activity of volcanoes and the movement of the Earth's continental plates;
- The anthroposphere, meaning the influence of humanity on the surface of the Earth through structures and activity that have the potential to significantly alter the Earth's climate.

The primary processes that remote sensing seeks to measure in each of these spheres and the technical aspects of remote-sensing observations for each of these systems in terms of educational modules are described in the present publication.

Contents

Explanatory notes

The following abbreviations and acronyms appear in this publication:

AGNPS	agricultural non-point point source
AICRPDA	All India Coordinated Research Project on Dry Land Agriculture
ALTM	airborne laser terrain mapper
BR	biorichness
C++	object-oriented programming language
CCD	charge-coupled device
CGCP	coastal geomorphology and coastal processes
CME	coastal and marine ecology
CMI	crop moisture index
CS	current science
DI	disturbance index
DIP	digital image processing
DEM	digital elevation model
DTM	digital terrain modelling
EIA	environmental impact assessment
ET	evapotranspiration
FAO	Food and Agriculture Organization of the United Nations
FRIS	forest resource information system
GIS	geographic information system
GISO	GIS applications in oceanography
GPS	global positioning system
GRID	Global Resource Information Database
GSDI	global spatial data infrastructure
HEC	hydrologic engineering centre
IGBP	ISRO Geosphere Biosphere Programme
ICAR	Indian Council of Agricultural Research
ICORG	International Conference on Remote Sensing and GIS/GPS
IIRS	Indian Institute of Remote Sensing
INSAR	Interferometric Synthetic Aperture Radar
IRS	Indian Remote Sensing Satellite

ISO TC211	International Organization for standardization standards on geographic information/geomatics
ISRO	Indian Space Research Organization
ISRS	Indian Society of Remote Sensing
ITC	International Institute for Geo-information Science and Earth Observation
Landsat	Land Remote Sensing Satellite
Lidar	light detection and ranging
LIS	land information system
LISS II	linear imaging self scanner II
LISS III	linear imaging self scanner III
M^2S	modular multispectral scanner
MODFLOW	modular three-dimensional finite-difference groundwater flow model
MXL	maximum likelihood
NDVI	normalized difference index
NNRMS	National Natural Resources Management System
NPP	net primary productivity
PAN	panchromatic camera
RS	remote sensing
SAR	synthetic aperture radar
SF	space forum
SLAR	side-looking airborne radar
SO	satellite oceanography
SPOT	Satellite pour l'observation de la Terre
SST	sea surface temperature
TEO	The Earth Observer
TM	thematic mapper
TR	technical report
VB	visual basic
Vol.	volume

Introduction

Space science and technology education can be pursued at the elementary, secondary and university levels. In spacefaring nations, elements of space science and technology have been introduced into science curricula at those levels. Such an innovation has not taken place in many developing countries, partly because the benefits of space science and technology have not been appreciated enough and partly because the facilities and resources for teaching science and technology at educational institutions are not yet well developed. Education in space science and technology in developed countries has become highly interactive; the World Wide Web and other information technologies have become useful tools in education programmes at all levels.

The incorporation of elements of space science and technology into university-level science curricula can serve a dual purpose for developed and developing countries. It can enable all countries to take advantage of the benefits inherent in the new technologies, which, in many cases, are spin-offs from space science and technology. It can revitalize the educational system, introduce the concepts of high technology in a non-esoteric fashion and help create national capacities in science and technology in general. In that regard, Lewis Pyenson emphasized in his recent work entitled *Servants of Nature*[1] that:

"Both geographical decentralization and interdisciplinary innovation have become watchwords in academic science. Electronic information processing to some extent obviates the necessity for a scientist or scholar to reside at an ancient college of learning. Universities everywhere have adapted to new socio-economic conditions by expanding curricula. They have always responded in this way, although never as quickly as their critics would like. Measured and deliberate innovation is one of academia's heavy burdens. It is also a great strength. Emerging fields of knowledge become new scientific disciplines only after they have found a secure place in universities. We look to universities for an authoritative word about the latest innovations. New scientific ideas emerge in a variety of settings, but they become the common heritage of humanity only when processed by an institution for advanced instruction like the modern university."

There are many challenges in the teaching of science at university level, both in developing and developed countries, but the challenges are of a higher magnitude in developing countries. The general problem confronting science education is the inability of students to see or experience the phenomena being taught, which often leads to an inability to learn basic principles and to see the relationship between two or more concepts and their practical relevance to problems in real life. Added to those problems are a lack of skills in the relevant aspects of mathematics and in problem-solving strategies. There are also language problems in countries in which science is not taught in the national language(s). Over the years, developed countries have overcome most of the basic problems, except perhaps a psychological problem, namely that students may consider science to be a difficult subject. In developing countries, however, basic problems linger, exacerbated by the fact that there are not enough academically and professionally well-trained teachers.

Establishment of the regional centres for space science and technology education

The General Assembly, in its resolution 45/72 of 11 December 1990, endorsed the recommendation of the Working Group of the Whole of the Scientific and Technical Subcommittee, as endorsed by the Committee on the Peaceful Uses of Outer Space, that the United Nations should lead, with the active support of its specialized agencies and other international organizations, an international effort to establish regional centres for space science and technology education in existing national/regional educational institutions in the developing countries (A/AC.105/456, annex II, para. 4 (n)).

The General Assembly, in its resolution 50/27 of 6 December 1995, paragraph 30, also endorsed the recommendation of the Committee on the Peaceful Uses of Outer Space that those centres be established on the basis of affiliation to the United Nations as early as possible and that such affiliation would provide the centres with the necessary recognition and would strengthen the possibilities of attracting donors and of establishing academic relationships with national and international space-related institutions.

Regional centres have been established in India for Asia and the Pacific, in Morocco and Nigeria for Africa, in Brazil and Mexico for Latin America and the Caribbean and in Jordan for Western Asia, under the auspices of the Programme on Space Applications, implemented by the Office for Outer Space Affairs (A/AC.105/749). The objective of the centres is to enhance the capabilities of Member States, at the regional and international levels, in various disciplines of space science and technology that can advance their scientific, economic and social development. Each of the centres provides postgraduate education, research and application programmes with emphasis on remote sensing, satellite communications, satellite meteorology and space science for university educators and research and application scientists. All centres are implementing nine-month postgraduate courses (in remote sensing, satellite communications, meteorological satellite applications, and space and atmospheric sciences) based on model curricula that emanated from the United Nations/Spain Meeting of Experts on the Development of Education Curricula for the Regional Centres for Space Science and Technology Education, held in Granada, Spain, in 1995. Since 1995, these curricula (A/AC.105/649 and http://www.oosa.unvienna.org/SAP/centres/centres.htm) have been presented and discussed at regional and international educational meetings.

The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held in Vienna in July 1999, recommended that collaboration should be established between the regional centres and other national, regional and international organizations to strengthen components of their education curricula.[2] In its resolution 54/68 of 6 December 1999, the General Assembly endorsed the resolution of UNISPACE III entitled “The Space Millennium: Vienna Declaration on Space and Human Development”, in which action was recommended to ensure sustainable funding mechanisms for the regional centres.[3]

United Nations Expert Meeting on the Regional Centres for Space Science and Technology Education: Status and Future Developments

The Office for Outer Space Affairs of the Secretariat organized, in cooperation with the European Space Agency (ESA), the United Nations Expert Meeting on the Regional Centres for Space Science and Technology Education: Status and Future Development in Frascati, Italy, from 3 to 7 September 2001. The Meeting was hosted by the ESA European Space Research Institute in Frascati.

The Meeting reviewed the status of establishment and operation of the regional centres with a view to enhancing cooperation between the centres. The main objective of the Meeting was to review and update curricula at the university level and across cultures in four areas: remote sensing, satellite meteorology, satellite communications and space science. The Meeting considered that education varied significantly between countries and even between institutions within the same country which led to differences in space science and technology education curricula in terms of course content and modes of presentation. The Meeting noted that the model curricula (A/AC.105/649) had contributed to resolving such problems.

The Meeting established five working groups to focus on the following specific topics and respective education curriculum: (a) management issues of the centres; (b) remote sensing; (c) satellite meteorology; (d) satellite communications; and (e) space science. The working groups drew on the knowledge and expertise of participants, thereby taking into account the results of previous nine-month postgraduate courses, particularly those organized since 1996 at the Centre for Space Science and Technology Education in Asia and the Pacific and since 1998 at the African Centre for Space Science and Technology—in French Language and the African Regional Centre for Space Science and Technology Education—in English Language.

The Meeting, through its working groups, updated the four education curricula and drew up course syllabuses that differ from most of those available in literature and on the World Wide Web. They are based on physics, mathematics and engineering as taught in many universities around the world. They are not tailored to any specific space-related project or mission that may have been or will be executed by any specific institution.

Curriculum on remote sensing and the geographic information system

The present chapter contains the deliberations of the working group on remote sensing and the geographic information system, which was established during the United Nations Expert Meeting on the Regional Centres for Space Science and Technology Education: Status and Future Development, on a revised curriculum. The curriculum of the six courses that have been held at the Centre for Space Science and Technology Education in Asia and the Pacific and the academic performance evaluation are contained in annexes I and II, respectively.

Topics for the revised curriculum

The working group drew up indicative topics, which the regional centres may appropriately tune and structure the actual course by deciding on the depth/content of the topics. Centres may also fine-tune the topics to address issues related to the region). The topics are arranged under modules, as follows:

Module/ submodule	*Topics*
0	Introduction
	A one-week induction module for students on the culture, social, economic and developmental aspects of the host country and institutions, with brief lectures on overall general topics
1	Fundamentals and principles of remote sensing and GIS (2-3 months)
1.1	Principles of remote sensing
1.1.1	Overview of remote sensing technology: history and evolution
1.1.2	Electromagnetic radiation and its interaction with matter: Laws of radiation, electromagnetic spectrum and its characteristics, sources of electromagnetic radiation; propagation of electromagnetic energy: dispersion, scattering, absorption, refraction and reflection; interactions between electromagnetic radiation and matter in the atmosphere and on the Earth's surface (emission of radiation): emissivity, black body radiation, Stefan's law, Kirchoff's law, Wien's law, Planck's law; physical processes in the interaction of radiation and matter: properties of the atmosphere, constituents, contaminants, lapse rate, clouds, atmospheric sounding, scattering mechanisms, temporal variations; albedo, reflection, Snell's law, absorption, spectral signatures, photo-electric effect, insulation
1.1.3	Spectral characteristics of crops/vegetation, soils, water etc.
1.2	Remote sensing platforms, sensors and ground systems
1.2.1	Platforms
	General overview of airborne remote sensing: photography, imaging; advantages and applications
	Satellite remote sensing: classification by orbit, applications, advantages and disadvantages, type of observation, orbital dynamics
	Types of satellites: overview of Earth observation satellites; overview of optical infrared (IR) remote sensing sun-synchronous satellites; overview of polar platforms and meteorological satellites
	High-resolution satellites; radar satellites; other missions: hyper-spectral etc.
	Future satellite systems
1.2.2	Sensors

Module/ submodule	*Topics*
	Fundamentals of imaging technology: imaging/non-imaging, active/passive, advantages and disadvantages
	Concept of resolution: spatial, spectral, radiometric and temporal
	Aerial photography systems: photographic, historical, camera systems, film types, multispectral photography, airborne laser terrain mapper (ALTM)
	Scanners/imagers: frame camera systems, scanning systems, pushbroom scanners, spectrometers, charge-coupled device (CCD), thermal imagers
	Microwave sensors: principles of side-looking airborne radar (SLAR), synthetic aperture radar (SAR) and its characteristics
	Non-imaging sensors/systems: infrared radiometer, microwave radiometer, scatterometer, altimeter etc.
	Other sensors: hyperspectral, laser imaging etc.
1.2.3	Ground systems
	Data reception and pre-processing systems and their configurations
	Principles of data reception systems, data transmission and receive chains; recording; archival; pre-processing: radiometric and geometric corrections; types of satellite data products; value-added products
	Ground data collection and truthing; errors in image data and their correction
1.3	Image interpretation
1.3.1	Fundamentals of aerial photo interpretation
1.3.2	Principles of image interpretation of optical, thermal and microwave satellite data
1.4	Photogrammetry
1.4.1	Introduction to photogrammetry: aerial photography, photo interpretation, analogue photogrammetry, digital photogrammetry
1.4.2	Principles of accuracy assessment and error analysis
1.5	Digital image processing
1.5.1	Overview of programming languages: C++ (an object-oriented programming language), visual basic (VB), macro languages
1.5.2	Statistical concepts: average, median, mode, standard deviation, covariance matrix, eigenvalues, eigenvectors, principal component analysis etc.
1.5.3	Ground data for digital image processing
1.5.4	Elements of digital image processing and pre-processing: radiometric, geometric and atmospheric corrections

Module/ submodule	*Topics*
1.5.5	Image enhancement techniques: histograms, contrast stretching, transfer functions, histogram equalization, histogram specification
1.5.6	Filtering: low- and high-pass filters, ideal filter, Butterworth filter, exponential filter, trapezoidal filter etc., smoothing
1.5.7	Classification techniques: spectral distances, probabilities, error analysis, clustering, training areas, sampling methods, extrapolation; per-pixel classifier, Maximum likelihood (MXL)/Bayesian/ parallelepiped etc., classifiers, object-oriented classifier, Neural Networks (NN), textural, fractals
1.5.8	Accuracy assessment and error analysis
1.5.9	Image fusion techniques
1.5.10	Image segmentation and feature extraction techniques: knowledge-based techniques, artificial intelligence, fuzzy image concepts
1.5.11	Image transforms and wavelets
1.5.12	Stereo image processing techniques
1.5.13	High-resolution image analysis techniques
1.5.14	Principles of analysis of SAR data, SAR interferometry and differential-interferometric synthetic aperture radar (INSAR) techniques
1.5.15	Processing hyper-spectral, polarimetric, ALTM and other types of data
1.6	Image processing systems
1.6.1	Configuration, choice and selection
1.6.2	Integrated image analysis and GIS
1.7	Geographic information system
1.7.1	Characteristics and types of GIS data: types of data; concept of information
1.7.2	Maps and projections: principles of cartography, ellipsoids, cartographic projections, coordinate systems, types and scales; accuracy of maps
1.7.3	GPS concepts, techniques, systems and applications
1.7.4	GIS principles: concepts and principles of GIS: GIS models, GIS components, inputs to GIS; GIS database design and organization; integration in GIS, querying in GIS, GIS outputs and visualization, accuracy of data in GIS, GIS integration errors
1.7.5	3-dimensional GIS: representing 3rd dimension in GIS, 3-dimensional analysis and derivatives
1.7.6	Concepts of temporal GIS, decision support systems, GIS modelling, visualization techniques, virtual reality, mobile mapping, World Wide Web-GIS

Module/ submodule	*Topics*
1.7.7	Illustrations and overview of GIS applications
1.7.8	Spatial data infrastructures: metadata, search/access, data warehousing, data mining, standards, specific programmes of countries (United Nations Environment Programme (UNEP)/Global Resource Information Database (GRID), digital Earth, global spatial data infrastructure (GSDI), global mapping etc.); common standards: open GIS, ISO-TC211
2	Remote sensing applications (3-4 months)
2.1	Overview of remote sensing and GIS applications (1 month; common module for all streams)
2.1.1	Remote sensing and GIS applications for water resources; agriculture; urban; coastal and oceans; environment; forestry; ecology; geology; mapping and others
2.1.2	Earth processes
2.1.3	Satellite meteorology
2.1.4	Natural disasters
2.1.5	Sustainable development and carrying capacity
2.1.6	Environmental analysis, monitoring and management
2.1.7	Cost-benefit analysis
2.1.8	Project planning and execution
2.2	Thematic streams (2 or 3 months)
2.2.1	Review for project planning and execution for pilot project
3	Pilot project (3 months): pilot projects to be executed at the regional centre; the topics are chosen by the student, in consultation with his/her sponsoring organization and approved by the centre

Curriculum structure

The working group recommended the following breakdown of time for each module:

Module	*Topic*	*Duration*
1	Fundamentals of remote sensing and GIS	12 weeks, 400 hours
2	Remote sensing and GIS applications in natural resources surveys and environment	12 weeks, 400 hours
3	Project work, including ground data collection	12 weeks, 400 hours

The breakdown by module, submodule and type of activity is shown in the table.

Table
Duration of the course by type of activity

Module/ submodule	*Topic*	*Activity (hours)*				
		L	*T+P*	*F*	*Li+G*	*Total*
1	Fundamentals of remote sensing and GIS					
1.1	Remote sensing	20	40	10	5	75
1.2	Image interpretation and image analysis	40	95	10	5	150
1.3	Photogrammetry	20	40	10	5	75
1.4	Geoinformatics	30	50	15	5	100
	Subtotal	110	225	45	20	400
2	Remote sensing and GIS applications in natural resources surveys and environment					
2.1	Advances in remote sensing and GIS	5			1	6
2.2	Satellite meteorology	5			1	6
2.3	Earth processes	6			1	7
2.4	Sustainable development and integrated resource management	7			1	8
2.5	Natural disaster monitoring and management	6			1	7
2.6	Environmental analysis, monitoring, management and global issues	12	50		4	66
2.7	Remote sensing and GIS applications in thematic areas (elective in one of the following disciplines)	48	192	40	20	300
2.7.1	Agriculture and soils					
2.7.2	Forestry and ecology					
2.7.3	Geosciences					
2.7.4	Human settlements					
2.7.5	Water resources					
2.7.6	Marine sciences					
	Subtotal	89	242	40	29	400
3	Project work[a]					
3.1	Project planning		50			50
3.2	Pre-field interpretation and analysis		100			100
3.3	Field data collection			100		100
3.4	Field data analysis		50			50
3.5	Post-field interpretation and analysis report		100			100
	Subtotal		300	100		400
	Total	199	767	185	49	1 200

Note: L = lectures; T+P = tutorials and practical exercises;
F = field work; Li+G = library/guest lectures.

[a]In module 3, T+P consists of practical exercises only.

Notes

[1] L. Pyenson and S. Sheets-Pyenson, *Servants of Nature: a History of Scientific Institution, Enterprises, and Sensibilities* (New York, W. W. Norton and Company, 1999).

[2] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 9-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. II, sect. G, para. 220.

[3] Ibid., chap. I, resolution 1, para. 1 (e) (ii). The Declaration is also available on the home page of the Office for Outer Space Affairs (http://www.oosa.unvienna.org).

Annex I

Specifications for the curriculum of the first six courses

Module 1: Fundamentals of remote sensing and GIS

Six 9-month post-graduate courses in remote sensing and GIS have been held at the Centre for Space Science and Technology Education in Asia and the Pacific. The present annex outlines the curriculum for those courses.

The breakdown of module 1 by topic and activity is shown in table 1, followed by detailed lists of activities and suggested reading.

Table 1
Breakdown of module 1 by topic and activity

			Activity (hours)				
Submodule	*Topic*	*Code*	*Lectures*	*Tutorials and practical exercises*	*Field work*	*Library/ guest lectures*	*Total*
1.1	Remote sensing	RS	20	40	10	5	75
1.2	Image analysis	IA	40	95	10	5	150
1.3	Photogrammetry	PG	20	40	10	5	75
1.4	Geoinformatics	GE	30	50	15	5	100
	Total		110	225	45	20	400

Remote sensing

Lectures

Code	*Description*
RS 1	Definition and overview of remote sensing and remote sensing system
RS 2	History and evolution of remote sensing
RS 3 and 4	Electromagnetic radiation, terms and definitions, laws of radiation, electromagnetic spectrum, sources of electromagnetic radiation
RS 5	Interaction between electromagnetic radiation and matter, reflection, absorption and transmission
RS 6	Interactions between electromagnetic radiation and atmosphere, atmospheric windows
RS 7 and 8	Remote sensing systems: active and passive systems, imaging and non-imaging systems, resolution—spatial, spectral and temporal
RS 9	Orbits and platforms for Earth observation
RS 10	Earth observation satellites (Land Remote Sensing Satellite (Landsat), Satellite pour l'observation de la Terre (SPOT),

Code	*Description*
	Indian Remote Sensing Satellite (IRS)
RS 11	Sensors used in Earth observation satellites and their geometric and other characteristics
RS 12	Data reception, processing and generation of data products
RS 13 and 14	Principles of thermal remote sensing including its uses
RS 15 and 16	Principles of microwave remote sensing (imaging and non-imaging)
RS 17 and 18	Geometric and radiometric corrections and sources of errors in satellite data
RS 19	Ground truth data collection—use of radiometers and spectrophotometers etc.
RS 20	spectral reflectance and spectral signature for water, land and vegetation

Practical exercises and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.RS 1	Study of satellite image annotation (information) Landsat, SPOT and IRS	4	
EX.RS 2	Study of satellite data, tracing of drainage	5	
EX.RS 3	Study of satellite data, identification and mapping of different surface features	5	
EX.RS 4	Study and use of infrared—thermal radiation measuring instruments	5	
EX.RS 5	Interpretation of synthetic aperture radar data (from satellites) for land-use studies	5	
EX.RS 6	Study of ground data collection instruments, radiometers, spectrometers etc.	5	
EX.RS 7	Use and analysis of microdensitometer data for a given image	5	
EX.RS 8	Study of additive and subtractive colour principles	5	
EX.RS 9	Ground data collection in a given area with the help of radiometers and spectrometers		10

Suggested reading

American Society of Photogrammetry and Remote Sensing. Manual of remote sensing. v. I. and II. 2. ed. Falls Church, Virginia, 1983.

Campbell, J. B. Introduction to remote sensing. 2. ed. London, Taylor and Francis, 1996.

Curran, P. J. Principles of remote sensing. Essex, Longman Scientific and Technical Group, 1985.

Deekshatulu, B. L., and P. S. Roy. Human resource development in space technology applications. *Space forum* (Amsterdam) 5:239, 2000.

Kumar, M. Remote sensing. New Delhi, National Council for Educational Research and Training, 2001.

Lillesand, T. M., and R. W. Keifer. Remote sensing and image interpretation. 4. ed. New York, John Wiley and Sons, 2000.

Sabins, F. F. Remote sensing principles and interpretation. San Francisco, W. H. Freeman, 1987.

Image interpretation and analysis

Lectures

Code	*Description*
IA 1	Principles of visual interpretation of aerial photos and satellite imagery
IA 2	Recognition elements and interpretation keys for visual interpretation
IA 3	Techniques of visual interpretation
IA 4	Basic interpretation equipment
IA 5	Interpretation of aerial photos
IA 6	Interpretation of multispectral imagery
IA 7	Interpretation of thermal imagery
IA 8	Interpretation of side-looking airborne radar imagery
IA 9	Interpretation of synthetic aperture radar imagery
IA 10	Principles of data transfer and assessment of interpretation accuracy
IA 11	Introduction to digital image processing
IA 12	Fundamentals of computers and image processing systems
IA 13 and 14	Statistics: basic concepts
IA 15 and 16	Statistics: theory of probability
IA 17 and 18	Statistics: Bayesian theory
IA 19 and 20	Statistics: sampling techniques
IA 21	Fundamentals of image analysis and digital data format
IA 22 and 23	Fundamentals of image rectification and registration

Code	*Description*
IA 24	Image enhancement techniques
IA 25	Contrast stretching, edge enhancements and filtering
IA 26	Fourier space enhancements and spectral rationing
IA 27	Principal component analysis
IA 28	Intensity, hue and saturation transformation and image fusion techniques
IA 29	Texture analysis
IA 30	Principles of image classification and supervised classification
IA 31	Supervised classification
IA 32 and 33	Unsupervised classification
IA 34	Classification accuracy
IA 35	Digital elevation model
IA 36	Satellite stereo image generation
IA 37 and 38	Microwave data processing techniques
IA 39 and 40	Advanced topics in digital image processing

Practical exercises and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.IA 1	Identification of features on single vertical aerial photographs	2	
EX.IA 2	Tracing of details from stereopairs	2	
EX.IA 3	Study of given area in black/white, black/white infrared, colour infrared photographs	6	
EX.IA 4	Study of multispectral photographs using an additive colour viewer	4	
EX.IA 5	Study of satellite imagery (black/white) in different bands and visual interpretation	4	
EX.IA 6	Study of thermal images, interpretation of various features and drawing the isotherms	4	
EX.IA 7	Study of radar and synthetic aperture radar (microwave) imagery and interpretation of features	4	
EX.IA 8	Study of modular multispectral scanner (M^2S) imagery	4	

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.IA 9	Interpretation of cultural details from different satellite image data (IRS, SPOT, Landsat)	4	
EX.IA 10	Familiarization with image processing systems, start-up procedures	4	
EX.IA 11	Loading image data and display, identification of objects on video displays, display of histograms	4	
EX.IA 12	Image enhancement techniques: contrast enhancement, band rationing, edge enhancement, filtering, density slicing and transfer functions	12	
EX.IA 13	Image registration: image to map, image to image, image to user coordinates	8	
EX.IA 14	Image classification techniques: supervised and unsupervised	12	
EX.IA 15	Digital analysis of microwave data	4	
EX.IA 16	Digital analysis of stereo satellite data	6	
EX.IA 17	Ground data collection for training sets in image processing systems for classification of image		10

Suggested reading

American Society of Photogrammetry and Remote Sensing. Manual of remote sensing. v. I and II. 2. ed. Falls Church, Virginia, 1983.

Avery, T. E., and G. L. Berlin. Interpretation of aerial photographs. Minneapolis, Burgen, 1985.

Gonzalez, R. C., and R. E. Woods. Digital image processing. New York, Addison Wesley, 1983.

Jensen, J. R. Introductory digital image processing: a remote sensing perspective. 2. ed. Saddle River, New Jersey, Prentice Hall, 1996.

Lillesand, T. M., and R. W. Keifer. Remote sensing and image interpretation. 4. ed. New York, John Wiley and Sons, 2000.

Richards, J. A., and Jia Xiuping. Digital image analysis. 3. ed. New York, Springer, 1999.

Photogrammetry

Lectures

Code	*Description*
PG 1	Fundamentals of aerial photogrammetry
PG 2	Aerial cameras
PG 3	Processing of black/white, colour, black/white infrared, colour infrared films, film density and characteristic curves
PG 4	Aerial flight planning
PG 5	Basic geometric characteristics of aerial photographs
PG 6	Scale, ground coverage and resolution of aerial photos, tilt-and-relief displacement
PG 7	Stereo vision, stereomodel and stereoscopes
PG 8	Measurement of height from aerial photos, parallax and parallax measurement
PG 9	Satellite sensors for stereo coverage, along track/across track stereo scanning
PG 10 and 11	Principles of stereo photogrammetry
PG 12	Principles of satellite photogrammetry
PG 13	Principles of radargrammetry and synthetic aperture radar interferometry
PG 14 and 15	Plotting instruments (stereoplotters)
PG 16 and 17	Aerial triangulation, control and mapping
PG 18 and 19	Principles of digital photogrammetry
PG 20	principles of cartography and map making

Practical exercises and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.PG 1	Stereo test	2	
EX.PG 2	Orientation of stereo models under mirror stereoscopes	4	
EX.PG 3	Preparation of photo/line index and determination of photo scale	6	
EX.PG 4	Use of a parallax bar and determination of heights and slope	8	
EX.PG 5	Preparation of base map from toposheet	4	

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.PG 6	Orientation on stereoplotter and plotting of details	4	
EX.PG 7	Use of planimeters and optical reflecting projectors	4	
EX.PG 8	Study and use of theodolite and electronic distance measurement instruments	4	
EX.PG 9	Familiarization with digital photogrammetric systems	4	
EX.PG 10	Ground data collection and verification on aerial photos		10

Suggested reading

American Society of Photogrammetry and Remote Sensing. Photogrammetry. v. I and II. 2. ed. Falls Church, Virginia, 1983.

Kilford, W. Elementary air survey. 4. ed. London, Pitman Publishing, 1979.

Wolf, P. R. Elements of photogrammetry. New York, McGraw-Hill, 1974.

Geoinformatics

Lectures

Code	*Description*
GE 1	Introduction to GIS
GE 2	Hardware and software requirements of GIS
GE 3 and 4	Database structures and formats
GE 5	Vector data structures
GE 6	Raster data structures
GE 7	Data inputting, editing and topology in GIS
GE 8	Integration of spatial and non-spatial data
GE 9 and 10	Map projections and data transformations in GIS
GE 11 and 12	Spatial data analysis (vector-based)
GE 13 and 14	Spatial data analysis (faster-based)
GE 15	Digital elevation model (DEM) and its applications
GE 16	Remote sensing and GIS data integration
GE 17	Errors and accuracy evaluation in GIS (data quality and sources of errors)

Code	*Description*
GE 18 and 19	Network analysis in GIS
GE 20	Characteristics of large-area databases, global and regional
GE 21 and 22	Decision support systems
GE 23, 24	Overview of current GIS packages
GE 25, 26	Trends in geoinformatics
GE 27	Fundamental concepts of the global positioning system (GPS)
GE 28 and 29	Types of GPS, GPS satellites, constellation of GPS satellites
GE 30	Applications of GPS in resource surveys, mapping and navigation

Practical exercises and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.GE 1	Familiarization with GIS system software	4	
EX.GE 2	Data input (spatial data) digitization and scanning	4	
EX.GE 3	Data input: editing	4	
EX.GE 4	Data input (non-spatial data)	4	
EX.GE 5	Data linking between spatial and non-spatial data	4	
EX.GE 6	Database creation and registration	4	
EX.GE 7	DEM generation	4	
EX.GE 8	Analysis and modelling of data	8	
EX.GE 9	Output generation in GIS	4	
EX.GE 10	Familiarization with different types of GPS receivers	2	
EX.GE 11	Checking of existing map coordinates using single GPS	4	
EX.GE 12	Calculation of coordinates with differential GPS receiver	4	
EX.GE 13	Ground data collection: spatial and non-spatial data for analysis and modelling of a given area		10
EX.GE 14	Survey of a small area with the help of GPS receivers		5

Suggested reading

Burroughs, P. A. Geographical information systems for land resources assessment. Oxford, Clarendon Press, 1986.

Chou, Y. H. Exploring spatial analysis in geographical information systems. Santa Fe, New Mexico, Onward Press, 1997.

Laurini, R., and D. Thompson. Fundamentals of spatial information systems. London, Academic Press, 1992.

Longley, P. A., M. F. Goodchild, D. J. Maguire and D. W. Rhind. Geographical informatics systems. v. 1 and 2. 2. ed. New York, John Wiley, 1997.

Module 2: Remote sensing and GIS applications in natural resources surveys and environment

The breakdown of module 2, submodules 2.1 to 2.6, by topic and activity is shown in table 2, followed by detailed lists of activities and suggested reading. Separate tables and details on submodules 2.7.1 through 2.7.6 are shown later in the annex.

Table 2
Breakdown of module 2 by topic and activity

			Activity (hours)			
Sub-module	*Topic*	*Code*	*Lectures*	*Tutorials and practical exercises*	*Library/ guest lectures*	*Total*
2.1	Advance concepts of remote sensing and GIS	ARG	5	-	1	6
2.2	Satellite meteorology	SM	5	-	1	6
2.3	Earth processes	EP	6	-	1	7
2.4	Sustainable development and integrated resource management	SD	7	-	1	8
2.5	Natural disaster monitoring and management	ND	6	-	1	7
2.6	Environmental analysis, monitoring management and global issues	EA	12	50	4	66
	Total		41	50	9	100

Module 2 lectures

Code	*Description*
ARG 1 and 2	Advances in digital image processing (DIP) (image fusion, image segmentation etc.)
ARG 3	Advances in GIS technology (object-oriented GIS, GIS customization, web GIS etc.)
ARG 4	Imaging spectrometry and its application
ARG 5	New satellite sensors (laser; fluorescence spectroscopy) and their application
SM 1 and 2	Role of meteorological satellites and onboard systems in assessing cyclones/typhoons, rainfall, atmospheric humidity profile etc.
SM 3	Weather analysis, forecasting and modelling
SM 4	Satellite estimation of ocean colour, net primary productivity (NPP), aerosol over ocean
SM 5	Satellite agrometeorology
EP 1	Bio-geochemical cycles and role of RS
EP 2	Hydrological cycle and role of RS
EP 3	Greenhouse gases and their atmospheric chemistry
EP 4	Global warming and climatic change
EP 5	Indian Space Research Organization (ISRO) Geosphere Biosphere Programme (IGBP)
EP 6	Impacts of climatic change on terrestrial ecosystems
SD 1	Concepts of sustainable development and carrying capacity
SD 2	Integrated resource management for sustainable development, sustainable development models in different bioclimatic regions
SD 3	Watershed hydrology and integrated soil and conservation planning of watersheds
SD 4	Soil resource inventory and land evaluation for sustainable agricultural planning
SD 5	Integrated coastal zone management
SD 6	Urban resource planning—an integrated approach
SD 7	Wildlife habitat analysis and protected area management
ND 1 and 2	Geological disasters (landslides, earthquakes and volcanoes etc.)
ND 3 and 4	Droughts and floods
ND 5	Agricultural disasters (pests and diseases, desertification etc.)
ND 6	Forest fires

Code	*Description*
EA 1	Environment management problems, prospective, responses and socio-economic issues
EA 2 and 3	Biodiversity conservation and management
EA 4	Environmental information system
EA 5	Land, water and air pollution and their monitoring
EA 6	Impact of industrialization and anthrogenic influences on the environment
EA 7 and 8	Impacts of river valley project on the environment
EA 9 and 10	Environmental impact assessment
EA 11 and 12	Earth observation systems for global change studies

There were also 50 hours of hands-on exercises on DIP and GIS and project planning in module 2.

Suggested reading

Bent, D., and A. Young. Soil survey and land evaluation. London, George Allen and Unwin, 1989.

Ecangman, E. T., and R. J. Gurney. Remote sensing in hydrology. London, Chapman and Hall, 1991.

Heywood, V. H. Fundamental of ecology. Cambridge University Press, 1971.

Kidder, S. Q., and T. H. Vondar Harr. 1995, Satellite meteorology—an introduction. San Diego, Academic Press, 1995.

Singh, O. P., and D. C. Pande. Development planning: theory and practice. Nainital, Gyanodaya Prakashan, 1990.

Rao, U. R. Space technology for sustainable development. New Delhi, Tata McGraw-Hill, 1996.

Rao, U. R., M. G. Chandrasekhar and V. Jayaraman. Space and Agenda 21—caring for the planet Earth. Bangalore, Prism Books, 1995.

Toselli, F., ed. Application of remote sensing to agrometeorology. Dordrecht, Kluwer Academic Publishers, 1989.

Deekshatulu, B. L., and P. S. Roy. Human resource development in space technology applications. *Space forum* (Amsterdam) 5:239, 2000.

The breakdown of submodule 2.7.1 by topic and activity is shown in table 3, followed by a detailed list of activities and suggested reading.

Table 3
Remote sensing and GIS applications in agriculture and soils (submodule 2.7.1)

			Activity (hours)				
Sub-module	*Topic*	*Code*	*Lectures*	*Tutorials and practical exercises*	*Field work*	*Library/ guest lectures*	*Total*
2.7.1.1	Crop inventory and landuse	CL	12	48	10	5	75
2.7.1.2	Soil survey and mapping	SM	12	48	10	5	75
2.7.1.3	Agrometeorology and agricultural water management	AW	12	48	10	5	75
2.7.1.4	Land evaluation and soil conservation planning	LC	12	48	10	5	75
	Total		48	192	40	20	300

Crop inventory and land use (submodule 2.7.1.1)

Lectures

Code	*Description*	*No. of lectures*
CL 1	Background and introduction of remote sensing in agriculture	1
CL 2	Spectral characteristics of crops	1
CL 3	Landuse mapping and change analysis using remote sensing technique	1
CL 4	Principles of crop identification and acreage estimation using remote sensing technique	2
CL 5	Crop yield modelling using remote sensing	1
CL 6	Microwave remote sensing applications in crop inventory	1
CL 7	Crop condition/stress assessment using remote sensing technique	1
CL 8	GIS applications in crop inventory and land use analysis	1
CL 9	Use of hyperspectral remote sensing in crop inventory	1
CL 10	GIS applications in crop yield modelling	1
CL 11	Precision agriculture	1

Practical exercises/tutorials and fieldwork

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.CL 1	Agriculture land use mapping using aerospace data	9	
EX.CL 2	Agriculture land use mapping following digital techniques	6	
EX.CL 3	Ground truth collection for agriculture land use analysis (Fieldwork)		10
EX.CL 4	Crop identification, acreage estimation using digital techniques	5	
EX.CL 5	Demonstration of CAPEMAN Software for crop inventory	5	
EX.CL 6	Demonstration of Hyperspectral data (MOS Case Study)	3	(Guest faculty)
EX.CL 7	Crop stress assessment	6	
EX.CL 8	Creation of spatial and non-spatial database of land use and crop inventory using GIS	10	
EX.CL 9	Land use change and crop inventory analysis using GIS	7	

Suggested reading

Navalgund, R. R., J. S. Parihar, Ajai and P.P.N. Rao. Crop inventory using remotely sensed data. *Current science* (London) 61:162, 1991.

Steven, M. D. and J. A. Clark, eds. Applications of remote sensing in agriculture. London, Butterworths, 1990. 169.

Toselli, F., ed. Applications of remote sensing to agrometeorology. Dordrecht, Kluwer Academic Publishers, 1989.

Johansen, C. J. Precision farming: farming by the inch. *The Earth Observer* (Greenbelt, Maryland) 6:24, 1994.

Sharma, T., and R. R. Navalgund. Integrated use of remote sensing and GIS for crop yield modeling. In proceedings of the Symposium on Remote Sensing of Environment with Special Emphasis on Green Revolution. Indian Society of Remote Sensing, 1995.

Vibay, F. T. Microwave responses of vegetation. *Advances in space research* (Amsterdam) 1:55, 1990.

Web sites

http://www.SAA.NOAA.gov/

http://www.boku.ac.at/imp/agromet/agrar1.htm

http://www.apsru.gov.au

http://www.ciesin.org

http://edcwww.cr.usgs.gov/landdace

http://daac.gsfc.nasa.gov

http://eosweb.larc.nasa.gov

http://ghx.insfa.nasa.gov

Soil survey and mapping (submodule 2.7.1.2)

Lectures

Code	*Description*	*No. of lectures*
SM 1	Background and introduction of remote sensing in soil surveys	1
SM 2	Spectral characteristics of soils	1
SM 3	Physiographic analysis and soil mapping using aerial and satellite remote sensing data	2
SM 4	Soil information system	1
SM 5	Use of hyperspectral remote sensing in soil resource inventory	1
SM 6	Soil spatial variability	1
SM 7	Soil morphology and classification	3
SM 8	Digital image processing techniques for soil resource mapping	1
SM 9	Digital terrain modelling (DTM) for terrain slope, aspect and physiography analysis for soil mapping	1

Practical exercises/tutorials and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.SM 1	Physiographic analysis and soil mapping using aerospace data	10	
EX.SM 2	Soil morphology and classification	7	
EX.SM 3	Ground truth collection for physiographic analysis, soil classification and mapping and demonstration of spectro-radiometer for hyper spectral data analysis		10
EX.SM 4	Soil mapping and physiographic analysis using digital techniques	6	
EX.SM 5	Creation of spatial and non-spatial databases of physiography, soils, slope etc. using GIS	12	
EX.SM 6	Generation of DTM and slope, aspect and physiographic analysis using GIS	9	

References

Soil reflectance

Baumgardner, M. F., L. F. Silva, L. L. Biehl and E. R. Stoner. Reflectance properties of Soils. *Advancers in agronomy*. 38:1, 1985.

Ben-Dor, E., J. R. Irons and G. F. Epema. Soil reflectance. Remote sensing for Earth sciences: Manual of remote sensing, Rencz A. N., ed. 3. ed. 3:111. New York, John Wiley and Sons, 1998.

Condit, H. R. The spectral reflectance of American soils. *Photogrammetric engineering and remote sensing*. 36:955-966, 1970.

Mulders, M. A. Remote sensing in soil science. *Developments in Soil Science* (Amsterdam) 379, 1987.

Rao, B.R.M., *and others*. Spectral behavior of salt-affected soils. *International journal of remote sensing*. 16:2125, 1995.

Stoner, E. R, and M. F. Baumgardner. Characteristic variations in reflectance of surface soils. *Journal of the Soil Science Society of America*. 45:1161, 1981.

Soil survey and land evaluation

Burrough, P. A. Principles of geographical information systems for land resources assessment. New York, Oxford Univ. Press, 1986.

Dent, D., and A. Young. Soil survey and land evaluation. London, George Allen and Unwin, 1981.

Olson, G. W. Soils and the Environment. New York, Chapman and Hall, 1981.

Soil survey division staff. Soil survey manual. U.S.A. Department of Agriculture (Washington, D.C.) Handbook 18, 1993.

U.S.A. Department of Agriculture. Keys to soil taxonomy, 8. ed. Washington, D.C., Government Printing Office, 1998.

Web sites

http://www.statlab.iastate.edu:80/soils/soiltax/

http://www.research.umbc.edu/~tbenja1/leblon/module9.html

http://www.itc.nl/~rossiter/teach/SoL3_K5_links.html

http://www.itc.nl/~rossiter/research/rsrchs_s.html

http://wwwscas.cit.cornell.edu/landeval/le_notes/lecnot.htm

http://wwwscas.cit.cornell.edu/landeval/landeval.htm

Agrometeorology and agricultural water management (submodule 2.7.1.3)

Lectures

Code	*Description*	*No. of lectures*
AW 1	Fundamentals of agrometeorology and its importance in agriculture	1
AW 2	Satellite agrometeorology (evapotranspiration, albedo, insulation, rainfall etc.)	2
AW 3	Use of satellite remote sensing in land surface climatology	2
AW 4	Retrieval of agrometeorological parameters following advanced analysis of satellite data	1
AW 5	Soil moisture assessment using optical and microwave data	1
AW 6	Drought assessment and monitoring through remote sensing	1
AW 7	GIS applications in agro-climatic and agro-ecological zoning	1
AW 8	Regional water balance modelling	1
AW 9	GIS applications in agricultural water management	1
AW 10	Global climatic change and agriculture	1

Practical exercises/tutorials and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.AW 1	Irrigated and unirrigated crop land inventory using satellite data, and crop water requirement estimation using GIS	15	
EX.AW 2	Study on spectral characteristics of soil under varying moisture content using ground radiometer	6	
EX.AW 3	Ground truth collection for irrigated crop land inventory and drought management		10
EX.AW 4	Digital analysis for soil moisture, agrometeorological and drought assessment	12	
EX.AW 5	Creation of databases of agromet and terrain information and analysis of agro-ecological zonation following GIS	15	

References

Jensen, M. E., R. D. Burman and R. G. Allen, eds. Evapotranspiration and irrigation water requirements. *ASCE manual and reports on engineering practice* (Reston, Virginia) 70, 1994.

Stewert, J. B., E. T. Engman, R. A. Feddes and R. A. Ken. Scaling up in hydrology using remote sensing. New York, John Wiley and Sons, 1996.

Mavi, H. S. Introduction to agrometeorology. Oxford, IBH Publishing, 1994.

Mutreja, K. N. Applied hydrology. New Delhi, Tata McGraw-Hill, 1986. 314.

Perrier, A. Land surface processes: vegetation. Land surface processes in atmospheric general circulation models. New York, Cambridge University Press, 1982.

Sellers, P. J., S. I. Rassol and H. J. Bolle. A review of satellite data algorithm for studies of land surface. *Bulletin American Meteorological Society*. 71(10):1429, 1990.

Burman, R. D., R. H. Cuenca and A. Weiss. Techniques for estimating irrigation water. Advances in irrigation. v. 2. Hiller, D., ed. New York, Academic Press, 1983. 335.

Bausch, W. C. Remote sensing of crop coefficients for improving irrigation scheduling of corn. *Agriculture water management*. 27:55, 1995.

Doorenbos, J., and W. O. Pruitt. Guidelines for predicting crop water requirements. Irrigation and drainage paper No. 24. Rome, 64. Food and Agriculture Organization of the United Nations, 1997.

Seguin, B. Use of surface temperature in agrometeorology. Application of remote sensing to agrometeorology. F. Tosseli, ed. Dordrecht, Kluwer Academic Publications, 1989. 221.

Seguin, B., D. Coaranet and M. Guerif. Satellite thermal IR data applications in agricultural meteorology. *Advances in space research* (Amsterdam) 5:207, 1993.

Web sites

http://www.SAA.NOAA.gov/

http://www.boku.ac.at/imp/agromet/agrar1.htm

http://www.apsru.gov.au

http://www.ciesin.org

http://edcwww.cr.usgs.gov/landdace

http://daac.gsfc.nasa.gov

http://eosweb.larc.nasa.gov

http://ghx.insfa.nasa.gov

Land evaluation and soil conservation planning (submodule 2.7.1.4)

Lectures

Code	*Description*	*No. of lectures*
LC 1	Concept and approaches of land evaluation	3
LC 2	Identification and mapping of degraded lands	2
LC 3	Soil erosion modelling and hazard assessment	1
LC 4	Process-based soil erosion modelling	1
LC 5	Watershed analysis and prioritization	2
LC 6	Soil conservation planning	1
LC 7	Decision support system for land use planning	1
LC 8	Optimal land use planning for sustainable development	1

Practical exercises/tutorials and fieldwork

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.LC 1	Degraded land mapping using aerospace data	6	
EX.LC 2	Degraded land mapping by digital techniques	10	
EX.LC 3	Ground truth collection for watershed parameters and degraded lands		10
EX.LC 4	GIS applications for soil erosion inventory	10	
EX.LC 5	Land evaluation and suitability analysis	12	
EX.LC 6	Watershed analysis: prioritization and suggested soil conservation measures	10	

Suggested reading

Bocco, G., J. Palacio and C. R. Valenzuela. Gully erosion modeling using GIS and geomorphic knowledge. *ITC Journal*. 3:253, 1990.

Csillag, F., L. Pasztor and Biehl. Spectral band selection for the characterization of salinity status of soils. *Remote sensing of environment*. 43:231, 1993.

Dwivedi, R. S., and K. Sreenivas. Image transforms as a tool for the study of soil salinity and alkalinity dynamics. *International journal of remote sensing*. 19(14):605, 1998.

Melternicht, G., and J. A. Zinck. Spatial discrimination of salt and sodium affected soil, soil surfaces. *International journal of remote sensing*. 18(12):2571, 1997.

Natural resources management—a new perspective. Karale, R. L., ed. Bangalore, National Natural Resources Management System, 1992.

Verma, K. S., R. K. Saxena, A. K. Barthwal and S. N. Deshmukh. Remote sensing techniques for mapping salt affected soils. *International journal of remote sensing*. 15:1901, 1994.

The breakdown of submodule 2.7.2 by topic and activity is shown in table 4, followed by a detailed list of activities and suggested reading.

Table 4
Remote sensing and GIS applications in forestry and ecology (submodule 2.7.2)

			Activity (hours)				
Sub-module	*Topic*	*Code*	*Lectures*	*Practical exercises*	*Field work*	*Library/ guest lectures*	*Total*
2.7.2.1	Forest classification and mapping	FCM	12	48	10	5	75
2.7.2.2	Forest inventory	FI	12	48	10	5	75
2.7.2.3	Forest management	FM	12	48	10	5	75
2.7.2.4	Ecosystem analysis	EA	12	48	10	5	75
Total			48	192	40	20	300

Forest classification and mapping (submodule 2.7.2.1)

Lectures

Code	*Description*	*No. of lectures*
FCM 1	Aerial photo interpretation techniques	1
FCM 2	Forest mapping using aerial photographs	2
FCM 3	Spectral response of vegetation	1
FCM 4	Spectral indices for vegetation analysis	1
FCM 5	Satellite image interpretation (visual) for forest mapping	2
FCM 6	Satellite image interpretation (digital) for forest mapping including use of hyperspectral data	2
FCM 7	Forest change detection and monitoring	1
FCM 8	Forest disease detection	1
FCM 9	Microwave remote sensing of forests	1

Practical exercises and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.FCM 1	Forest mapping using air photos	6	3
EX.FCM 2	Measurement of spectral signatures of vegetation cover and their interpretation	3	1

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.FCM 3	Visual interpretation of satellite image for forest mapping	9	6
EX.FCM 4	Digital interpretation of satellite image for forest mapping	15	
EX.FCM 5	Forest change detection	9	
EX.FCM 6	Forest disease detection	6	

Suggested reading

American Society of Photogrammetry and Remote Sensing. Manual of Remote Sensing. v. I and II. 2. ed. Fall Church, Virginia, 1983.

Champion, H. G. Revised forest types of India. New Delhi, Government of India Publications, 1968.

Howarth, P. J., and C. M. Wicks. Procedure of change detection. *International journal of remote sensing*. 2:277, 1981.

Roy, P. S., *and others*. Tropical forest type mapping and monitoring using remote sensing. *International journal of remote sensing*. 12(11):2205, 1991.

Roy, P. S., K. P. Sharma and A. Jain. Stratification of density in dry deciduous forest using satellite remote sensing digital data: an approach based on spectral indices. *Journal of biosciences*. 21(5):723, 1996.

Singh, H., *and others*. Vegetation cover mapping using hybrid approach in digital classification. *Asian journal of geoinformatics*. 2(2):57, 2001.

Tomar, M. S., and A. R. Maslekar. Aerial photographs in land use and forest surveys. Dehradun, Jugal Kishore and Sons, 1974.

Forest inventory (submodule 2.7.2.2)

Lectures

Code	*Description*	*No. of lectures*
F 1	Principles of forest inventory	1
F 2	Forest sampling techniques	2
F 3	Growing stock mapping for preparation of management plans	2
F 4	Planning forest inventory	2
F 5	Modern data processing techniques	3
F 6	Fuelwood/fodder assessment in forests	1
F 7	Airborne light detection and ranging (LIDAR) for forest stand height estimation	1

Practical exercises and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.FI 1	Measurement of tree height and crown density on aerial photographs	10	4
EX.FI 2	Forest sampling techniques	8	6
EX.FI 3	Field data analysis	8	
EX.FI 4	Growing stock estimation	22	

Suggested reading

Chacko, V. J. A manual on sampling techniques for forest surveys. New Delhi, Government of India Publications, 1965.

Freese, F. Elementary forest sampling, Agriculture handbook No. 232. Washington, D.C., United States Department of Agriculture, 1962.

Vries, P. G. de. Sampling theory for forest sampling. Berlin, Springer-Verlag, 1986.

Hamilton, G. J. Forest mensuration handbook. Delhi, Periodical Expert Book Agency, 1992.

Loetsch, F., and K. E. Haller. Forest Inventory. Munich, BLV Verlag, 1973.

Forest management (submodule 2.7.2.3)

Lectures

Code	*Description*	*No. of lectures*
FM 1	Site suitability analysis for forestry	2
FM 2	Revision and updating of stock maps	2
FM 3	Sustainable forest management and joint forest management	2
FM 4	Fire-risk zoning	2
FM 5	Wasteland development planning	2
FM 6	Forest resource information system (FRIS)	2

Practical exercises and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.FM 1	Site suitability analysis for forestry	9	6
EX.FM 2	Revision and updating of stock maps	9	4
EX.FM 3	GIS database creation for forest management	30	

Suggested reading

Food and Agriculture Organization of the United Nations. Land evaluation for forestry. Rome, Food and Agriculture Organization of the United Nations, 1984.

Tomar, M. S. Use of aerial photographs in working plans. *Indian forester*. 102(2):98, 1979.

Singh, I. J., and P. S. Roy. Growing stock estimation through stratified random sampling. *Photonirvachak.* 18:29, 1990.

Kushwaha, S.P.S. Remote sensing for forest surveys and management. Proceedings. Varanasi, International Society for Tropical Ecology, 1987.

Roy, P. S. Tropical forest type mapping and monitoring using remote sensing. *International journal of remote sensing*. 12(11), 2205, 1991.

Ecosystem analysis (submodule 2.7.2.4)

Lectures

Code	*Description*	*No. of lectures*
EA 1	Landscape analysis and conservation ecology	3
EA 2	Biodiversity characterization	2
EA 3	Environmental impact assessment (EIA)	2
EA 4	Forest ecosystem analysis	2
EA 5	Grassland ecosystem analysis	1
EA 6	Wildlife habitat evaluation	1
EA 7	Carbon cycling and productivity analysis	1

Practical exercises and field work

Code	*Description*	*Practical exercises (hours)*	*Field work (hours)*
EX.EA 1	Landscape analysis	12	
EX.EA 2	Disturbance index and biorichness	15	
EX.EA 3	Forest vegetation analysis	10	4
EX.EA 4	Biomass estimation	11	6

Suggested reading

Odum, E. P. Fundamentals of ecology. Philadelphia, W. B. Saunders, 1976.

Ambasht, R. S., and N. K. Ambasht. A handbook of ecology. Varanasi, Students Friends and Company, 1996.

Forestry and Ecology Division. Manual on biodiversity characterization at landscape level using remote sensing and GIS. Dehradun, Indian Institute of Remote Sensing, 1999.

Roy, P. S., and S. Ravan, Biomass estimation using satellite remote sensing—an investigation on possible approaches for natural forest. *Journal of biosciences*. 21(4):535, 1996.

Porwal, M. C., P. S. Roy and V. Chellamuthu. Wildlife habitat analysis for 'sambar' (cervus unicolor) in Kanha National Park using remote sensing. *International journal of remote sensing*. 17(4):2683, 1996.

Roy, P. S., and S. Tomar. Biodiversity characterization at landscape level using geospatial modelling technique. Biological conservation, 95.

Roy, P. S., and S. Ravan. Landscape cover dynamics pattern in Meghalaya, *International journal of remote sensing.* 22(18):3813, 2001.

The breakdown of submodule 2.7.3 by topic and activity is shown in table 5, followed by a detailed list of activities and suggested reading.

Table 5
Remote sensing and GIS applications in geosciences (submodule 2.7.3)

		Activity (hours)				
Submodule	*Topic*	*Lectures*	*Tutorials and practical exercises*	*Field work*	*Library/ guest lectures*	*Total*
2.7.3.1	Remote sensing and GIS in geology	12	51	7	5	75
2.7.3.2	Remote sensing and GIS in geomorphology	12	51	7	5	75
2.7.3.3	Remote sensing and GIS in hydrogeology	12	51	7	5	75
2.7.3.4	Remote sensing and GIS in engineering geology	12	51	7	5	75
	Total	48	204	28	20	300

Principles of remote sensing in geology (submodule 2.7.3.1)

Lectures

Code	*Description*
L 1 and 2	Remote sensing in geology—an overview
L 3	Aerial photo/satellite image interpretation in lithological interpretation
L 4	Aerial photo/satellite image interpretation in structural analysis
L 5	Geological interpretation of thermal remote sensing data
L 6	Geological interpretation of microwave remote sensing data
L 7	Hyperspectral remote sensing for lithological mapping and mineral exploration

Code	*Description*
L 8	Organization and design of spatial/non-spatial geoscientific data under a GIS environment
L 9 and 10	Integration of geoscientific data under a GIS environment
L 11	Remote sensing and GIS in oil and mineral exploration
L 12	Remote sensing and GIS in mineral exploration and management
L 13 and 14	Principles of geostatistics and applications in geosciences

Practical exercises and field and other work

Code	*Description*
GE-P 1 to 6	Geological mapping using aerial photographs
GE-P 7 to 15	Geological mapping using satellite imagery
GE-P 16 to 21	Geological interpretation of microwave remote sensing data
GE-P 22 to 33	Geological applications of remote sensing data in mineral and oil exploration
GE-P 34 to 44	Digital image analysis and GIS in geosciences
	Library (3 hours)
	Field work: lithological and structural data collection (7 hours)
	Examination (7 hours)

Textbooks

Burrough, P. A. Principles of GIS for land resources assessment. Oxford, Claredin Press, 1986.

Gupta, R. P. Remote sensing geology. Berlin, Springer-Verlag, 1991.

Sabins, F. F., Jr. Remote sensing, principles and interpretation. 2. ed. San Francisco, W. H. Freeman, 1978.

Jenson, J. R. Introductory digital image processing. 2. ed. Englewood Cliffs, New Jersey, Prentice Hall, 1996.

Suggested reading

American Society of Photogrammetry and Remote Sensing. Manual of photographic interpretation, Washington, D.C., 1960.

American Society of Photogrammetry and Remote Sensing. Manual of remote sensing. v. I and II. 2. ed. Falls Church, Virginia, 1983.[a]

[a] See chapters 9 and 16, revised from the first edition of 1975.

Allan, T. D., ed. Satellite microwave remote sensing. Chichester, Ellis Horwood, 1983.

Drury, S. A. Image interpretation in geology. London, Allen and Unwin, 1987.

Goetz, A.F.H., B. N. Rock and L. C. Rowan. Remote sensing for exploration: an overview. *Bulletin of the Society of Economic Geologists*. v. 78. 4:573, 1983.

Halbouty, M. T. Application of Landsat imagery to petroleum and mineral exploration, *The American Association of Petroleum Geologists bulletin.* v. 60. 5:745-793, 1976.

Lueder, D. R. Aerial photographic interpretation—principles and applications. New York, McGraw-Hill, 1959.

Lillesand, T. M., and R. W. Kiefer. Remote sensing and image interpretation. 4. ed. New York, John Wiley and Sons, 2000.

Mekel, J.F.M. The use of aerial photographs and other images in geological mapping. ITC textbook of photo interpretation. v. VIII. Enschede, International Institute for Aerospace survey and Earth Sciences, 1970.

Miller, V. C. Photogeology. New York, McGraw-Hill, 1961.

Ray, R. G. Aerial photographs in geologic interpretation and mapping. US Geological Survey paper. 373:230, 1960.

Trevett, J. W. Imaging radar for resource surveys. London, Chapman and Hall, 1986.

Ulaby, F. T., R. K. Moore and A. K. Fung. Microwave remote sensing—fundamentals and radiometry. Reading, Massachusetts, Addison-Wesley, 1981.

Principles of remote sensing in geomorphology (submodule 2.7.3.2)

Lectures

Code	*Description*
L 1	Outlines of geomorphology—an overview
L 2 and 3	Landform analysis based on aerial satellite data interpretation
L 4	Drainage basin morphometry and slope analysis
L5 and 6	Remote sensing for geomorphological mapping, landform and terrain evaluation
L7 and 8	Morphostructure/morphotectonics/neotectonics
L 9 and 10	Integrated digital terrain evaluation using GIS
L 11 and 12	Land system analysis
L 13 and 14	Guest lecture

Practical exercises and field and other work

Code	*Description*
P 1 to 12	Geomorphological interpretation of aerial photos and satellite imagery for landform analysis
P 13 to 18	Drainage basin morphometry and slope analysis
P 19 to 27	Morphotectonics/neotectonics analysis
P 28 to 33	Remote sensing for geomorphological mapping
P 34 to 44	Integrated terrain evaluation using remote sensing—digital image analysis and GIS
	Library (3 hours)
	Field work: ground data collection on different landforms (7 hours)
	Examination (7 hours)

Textbooks

Cooke, R. U., and J. C. Doornkamp. Geomorphology in environmental management—a new introduction. Oxford, Clarendon Press, 1990.

Lueder, D. R. Aerial Photographic Interpretation—Principles and Applications. New York, McGraw-Hill, 1959.

Strahler, A. N. Modern physical geography. 3. ed. New York, John Wiley and Sons, 1978.

Townshend, J.R.G. Terrain analysis and remote sensing. London, George Allen and Unwin, 1981.

Suggested reading

American Society of Photogrammetry and Remote Sensing. Manual of remote sensing. v. I and II. 2 ed. Falls Church, Virginia, American Society of Photogrammetry and Remote Sensing, 1983.

Doornkamp, J. C., and C.A.M. King. Numerical analysis in Geomorphology—an introduction. London, Edward Arnold, 1971.

Demek, J., ed. Manual of detailed geomorphological mapping. Prague, Czechoslovak Academy of Sciences, 1972.

Fairbridge, R. W., ed. The encyclopedia of geomorphology. New York, Reinhold Book Corporation, 1968.

Horton, R. E. Erosional development of streams and their drainage basins: hydrophysical approach to quantitative morphology. *Bulletin of the Geological Society of America*. 56:275, 1945.

Hails, J. R., ed. Applied geomorphology. Amsterdam, Elsevier, 1977.

Leopold, L. B., *and others*. Fluvial processes in geomorphology. New Delhi, Eurasia Publishing House, 1964.

Machatshek, F. Geomorphology. Clayton, K. M., ed. Edinburgh, Oliver and Boyd, 1969.

Maguire, D. J., M. F. Goodchild and D. Rhind. Geographic information system, principles and applications. v. II. New York, John Wiley and Sons, 1993.

Ollier, C. D. Weathering. London, Longman, 1976.

Thornbury, W. D. Principles of geomorphology. New York and London, John Wiley and Sons, 1991.

Verstappen, H. Th. Fundamentals of photogeology/geomorphology. ITC textbook of photo interpretation. Delft, International Training Centre for Aerial Survey, 1963.

Verstappen, H. Th. Remote sensing in geomorphology. Amsterdam, Elsevier Scientific Publishing, 1977.

Way, D. S. Terrain analysis. Dowden, Pennsylvania, Hutchinson and Boss,1973.

Principles of remote sensing in hydrogeology (submodule 2.7.3.3)

Lectures

Code	*Description*
L 1 and 2	Principles of remote sensing in geohydrological mapping and groundwater exploration
L 3 and 4	Significance of geological mapping of rocks and structures and their hydrological properties in groundwater exploration
L 5	Significance of geomorphological mapping of different landforms and their hydrological properties in groundwater exploration
L 6 and 7	Remote Sensing and GIS in groundwater exploration and management in hard rock/unconsolidated material
L 8 and 9	GIS for groundwater modelling
L 10	Groundwater management, artificial recharge and rain water harvesting
L 11	Groundwater resources and estimation
L 12	Groundwater quality
L 13 and 14	Guest lecture

Practical exercises and field and other work

Code	*Description*
GH-P 1 to 9	Geologic and geomorphic interpretation of aerial photographs for groundwater exploration
GH-P 10 to 15	Geologic and geomorphic interpretation of satellite imagery for groundwater exploration

Code	*Description*
GH-P 16 to 31	Groundwater targeting in different terrain areas—unconsolidated, semi-consolidated and hard rock types
GH-P 32 to 44	Remote sensing and GIS for groundwater targeting and management
	Library (3 hours)
	Field work: ground truth collection for hydrogeomorphological conditions in different terrain conditions, water table/quality etc. (7 hours)
	Examination (7 hours)

Textbooks

Fetter, C. W. Applied hydrogeology. 2. ed. Columbus, Ohio, Charles E. Merrill, 1988.

Karanth, K. R. Groundwater assessment, development and management. New Delhi, Tata McGraw-Hill, 1987.

Ragunath, H. M. Groundwater. 2. ed. New Delhi, Wiley Eastern, 1990.

Todd, D. K. Groundwater hydrology. New York, John Wiley and Sons, 1959.

Suggested reading

American Society of Photogrammetry and Remote Sensing. Manual of photographic interpretation. Washington, D. C., 1960.

American Society of Photogrammetry and Remote Sensing. Manual of remote sensing. v. I and II. 2. ed. Falls Church, Virginia, 1983.

Davis, S. N., and R.J.M. De Wiest. Hydrogeology. New York, John Wiley and Sons, 1966.

Eaton F. M. Significance of carbonated in irrigation water. *Soil sciences*. v. 69. 1950.

Heath, R. C., and F. W. Trainer. Introduction to groundwater hydrology. New York, John Wiley and Sons, 1968.

Indian Standard Institution. Indian standard specification for drinking water. No. 10500. New Delhi, 1991.

Lueder, D. R. Aerial photographic interpretation—principles and applications. New York, McGraw-Hill, 1959.

Meijerink, A.M.J. Photo-interpretation in hydrology—geomorphic approach. Enschede, International Institute for Aerial Survey and Earth Sciences, 1970.

Nefedov, K. E. and T. A. Popova. Deciphering of groundwater from aerial photographs. New Delhi, Amerind Publishing, 1972.

Sabins, F. Jr. Remote sensing—principles and interpretation. San Francisco, W. H. Freeman, 1997.

World Health Organization. Guidelines for drinking water quality. v. 1. Recommendations. 2. ed. Geneva, 1993.

Remote sensing and GIS in engineering geology (submodule 2.7.3.4)

Lectures

Code	*Description*
L 1	Remote sensing for engineering geological studies
L 2 and 4	Remote sensing for construction material investigations and estimation of rock mass strength
L 4 and 5	Remote sensing for mapping of erosion and mass movement process
L 6	Remote sensing for highway alignment studies
L 7	Remote sensing for investigation of river valley projects
L 8 to 10	Remote sensing and GIS for natural hazard zonation and modelling
L 11 and 12	Application of interferometry for analysis of geological hazards
L 13 and 14	Guest lecture

Practical exercises and field and other work

Code	*Description*
P 1 to 12	Remote sensing for construction material investigations and estimations of rock mass strength
P 13 to 24	Remote sensing for erosion and mass movement processes
P 25 to 27	Remote sensing for highway alignment studies
P 28 to 30	Remote sensing for investigation of river valley projects
P 31 to 44	Remote sensing and GIS for geologic hazards
	Library (3 hours)
	Field work (7 hours)
	Examination (7 hours)

Textbooks

Anderson, M. G., and K. S. Richards, eds. Slope stability. New York, John Wiley and Sons, 1987.

Crozier, M. J. Landslides: causes, consequences and environment. London, Croons Helm, 1986.

Kennie, T.J.M., and M. C. Mathews. Remote sensing in civil engineering. New York, John Wiley and Sons, 1985.

Townshend, J.R.G., Terrain evaluation and remote sensing. Sydney, George Allen and Unwin, 1981.

Suggested reading

Babkov, V., and M. Zamakhayer. Highway engineering. Moscow, Mir, 1967.

Brundsden, D., and D. B. Prior. Slope instability. New York, John Wiley and Sons, 1984.

Burrough, P. A. Principles of geographic information system for land resource assessment. Oxford, Clarendon Press, 1986.

Carrara, A. Multivariate models for landslide hazard evaluation. *Mathematical geology*. v. 15. 1983.

Carrara, A. Landslide hazard mapping by statisticals methods: a “black box” model approach. Proceedings of the International Workshop on Natural Disasters in European-Mediterranean Countries, Perugia, Italy, 27 June-1 July 1988.

Davis, J. C. Statistics and data analysis in geology. New York, John Wiley and Sons, 1973.

Gee, M. D. Classification of landslide hazard zonation methods and a test of prediction capability. Proceedings of the Sixth International Symposium on Landslides. Christchurch, New Zealand, v. 2.

Krynine, D. P., and W. R. Judd. Principles of engineering geology and geotechniques. London, McGraw-Hill, 1957.

Legget, R. F. Geology and engineering. New York, McGraw-Hill, 1962.

Lueder, D. R. Aerial photographic interpretation—principles and applications. New York, McGraw-Hill, 1959.

Lahee, F. H. Field geology, New York, McGraw-Hill, 1952.

Hills, E. S. Outlines of structural geology. New York, John Wiley and Sons, 1953.

Woods, K. B. Highway engineering handbook. New York, McGraw-Hill, 1960.

Van Westen, C. J. Application of geographic information systems to landslide hazard zonation. Enschede, ITC Publication No. 15. International Institute for Aerospace Survey and Earth Sciences, 1993.

Massonnet, D., and K. L. Feigl. Radar interferometry and its application to changes in the Earth’s surface. *Reviews on heophysics*. 36(4):441, 1998.

Rocca F., C. Prati, and A. Ferretti. An overview of ERS-SAR Interferometry. Proceedings of the 3rd ERS Symposium. Paris, European Space Agency, 1997. SP-414:1.

The breakdown of submodule 2.7.4 by topic and activity is shown in table 6, followed by a detailed list of activities and suggested reading.

Table 6
Remote sensing and GIS applications in human settlement analysis (submodule 2.7.4)

		Activity (hours)				
Submodule	*Topic*	*Lectures*	*Tutorials and practical exercises*	*Field work*	*Library/ guest lectures*	*Total*
2.7.4.1	Remote sensing applications in urban and regional planning, mapping and analysis	12	48	10	5	75
2.7.4.2	Remote sensing applications in urban land use planning and monitoring of urban areas	12	48	10	5	75
2.7.4.3	Remote sensing applications in urban resources management, urban services and land evaluation	12	48	10	5	75
2.7.4.4	Remote sensing applications in physical planning of urban and regional environments	12	48	10	5	75
	Total	48	192	40	20	300

Urban and regional planning, mapping and analysis (submodule 2.7.4.1)

Lectures

Code	*Description*	*No. of lectures*
L 1	Remote sensing and its data products for urban/regional planning	1
L 2	Image interpretation, visual and digital image interpretation principles and techniques	2
L 3	Urban area interpretation and analysis using satellite imagery as well as aerial photographs	2
L 4	Remote sensing application in large-scale mapping for cadastral database and urban areas	1
L 5	High-resolution digital cadastral information	1
L 6	Residential area evaluation	
L 7	Methods of population estimation using remote sensing	1
L 8	Slum and squatter settlement detection, interpretation, delineation and analysis	1
L 9	Traffic and parking survey with aerial photographs	2

Practical exercises

Code	*Description*	*No. of lectures*
P 1	Identification of urban objects on aerial photographs of various scales	6
P 2	Urban area interpretation on satellite imagery	6
P 3	Urban area interpretation and analysis A. Residential area interpretation B. Traffic and parking surveys	12
P 4	Population estimation	12
P 5	Urban growth monitoring	6
P 6	Urban area object identification and ground data collection	6

Suggested reading

American Society of Photogrammetry and Remote Sensing. Manual of remote sensing. 2. ed. Falls Church, Virginia, 1983.

Avery, T. E., and G. L. Berlin. Interpretation of aerial photographs. 4. ed. Minneapolis, Burgen, 1985.

Jupenlatz, M. Cities in transformation. Hong Kong, University of Queensland Press, 1970.

Sundaram, K. V. Urban and regional planning in India. New Delhi, Vikas Publishing House, 1977.

Krishna Babu, P. Regional planning in India. Allahabad. Chugh Publications, 1988.

Kadiyali, L. R. Traffic engineering and transport planning. New Delhi, Khanna Publishers, 1978.

Lo, C. P. Applied remote sensing. Essex, Longman, 1986.

Adeniyi, P. O. An aerial photographic method for estimating urban population. Photogrammetric Engineering of Remote Sensing. v. 49. 4:545, 1983.

Branch, M. C. City planning and aerial information. Cambridge, Harvard University Press, 1971.

United Nations Centre for Human Settlements. Survey of slums and squatter settlements. Development studies series. v. 1. Dublin, Tycooly International, 1982.

GIM International. Cadastre in the 21st century. *GIM international*. v. 15. 1-7, 2001.

Urban land use planning and monitoring of urban areas (submodule 2.7.4.2)

Lectures

Code	*Description*	*No. of lectures*
L 1	Planning background, principles of urban area development planning and land use	2
L 2	Urban land use classification systems, interpretation, monitoring and change detection analysis using satellite imagery and aerial photographs	2
L 3	Urban land use mapping and analysis using satellite imagery and aerial photographs: advantage and limitation	1
L 4	Urban land use mapping and analysis using satellite imagery and aerial photographs: specific case studies	1
L 5	Role of small-format aerial photography in monitoring urban land use changes and development plans	1
L 6	Airborne laser terrain mapping for space use mapping	1
L 7	Urban land conservation using remote sensing	1
L 8	Urban information system for resources and integrated development planning with remote sensing inputs	2
L 9	Urban information management	1

Practical exercises

Code	*Description*	*No. of hours*
	Urban area classification	12
	Urban plan monitoring and change detection	12
	Urban area land use mapping and classification	12
	Urban area land use mapping and ground data collection for verification and updating	12

Suggested reading

Rhind, D., and R. Hudson. Landuse. New York, Methuen Publishers, 1980.

Lillesand, T. M., and R. W. Kiefer. Remote sensing and image interpretation. 2. ed. New York, John Wiley and Sons, 1987.

Sokhi, B. S., and S. M. Rashid. Remote sensing and urban environment. New Delhi, Manak Publishers, 1999.

Chapin, F. S., and E. I. Kelser. Urban land use planning. Chicago, University of Illinois, 1979.

Ratcliffe, J. An introduction to town and country planning. 2. ed. London, Hutchinson, 1976.

Gallion, A. B., and S. Eisner. The urban pattern. 4. ed. New Delhi, BS Publishers and Distributors, 1984.

American Society of Photogrammetry. Manual of remote sensing. 2. ed. Falls Church, Virginia, 1983.

Breese, G. Urbanization in newly developing countries. Englewood Cliffs, New Jersey, Prentice Hall, 1966.

Remote sensing applications in urban resources management, urban services and land evaluation (submodule 2.7.4.3)

Lectures

Code	*Description*	*No. of lectures*
L 1	Database design vector/raster and statistical analysis for urban/regional resources and land use planning (raster-based)	1
L 2	Database design vector/raster and statistical analysis for urban/regional resources and land use planning (vector-based)	2
L 3	Urban geomorphology for hazard identification	1
L 4	Land evaluation and suitability analysis with regard to urban development	2
L 5	Urban area mapping techniques including photo/orthophoto mapping	1
L 6	Digital ortho images	1
L 7	Urban trends in mapping and analysis using remote sensing/GIS/GPS	1
L 8	Urban environment, services and utility planning	2
L 9	Urban facility mapping	1

Practical exercises

Code	*Description*	*Total No. of hours*
P 1	Urban area mapping, zoning and classification	9
P 2	Urban area environment monitoring	9
P 3	Urban area planning—facility mapping	9
P 4	Urban area land suitability analysis and land evaluation	12
P 5	Urban area utility and services ground data collection	9

Suggested reading

Herbert, D. T, and R. J. Johnston. Geography and the urban environment. v. I-IV, New York, John Wiley and Sons, 1984.

Marsh, W. M. Environmental analysis for landuse and site planning. New York, McGraw-Hill, 1978.

Rubenstein, H. M. A guide to site and environmental planning. 2. ed. New York, John Wiley and Sons, 1980.

Ramesh, A. Resource geography. New Delhi, Heritage Publishers, 1984.

Mahavir. Modelling settlement patterns for metropolitan regions: inputs from remote sensing. ITC publication No. 35. Enschede, International Institute for Aerospace Survey and Earth Sciences, 1996.

Lynch, K., and G. Hack. Site planning. 3. ed. Cambridge, Massachusetts, MIT Press, 1985.

Erb, T. L., *and others*. Analysis of landfills with historic airphotos, photogrammetric engineering and remote sensing. v. 47. 9:1363, 1981.

Burrough, P. A. Principles of geographical information systems for land resource assessment. Oxford, Clarendon Press, 1986.

Saini, N. S. Urban and regional information system. New Delhi, School of Planning and Architecture, 1986.

Lo, C. P. Geographical applications of aerial remote sensing. New York, Craw, Russak and Co., 1978.

Rame Gowda, K. S. Urban and regional planning: principles and case studies. Mysore, Prasaranga, 1986.

Monnier, J. B. Digital orthophotos and facilities management. *GIM international*. v. 13. 5, 1999.

Remote sensing applications in physical planning of urban and regional environment (submodule 2.7.4.4)

Lectures

Code	*Description*	*No. of lectures*
L 1	Remote sensing applications in regional and district planning	1
L 2	Process of built form and environment: an integrated analysis using remote sensing techniques	1
L 3	Urban land use planning and land evaluation	1
L 4	Virtualizing of 3-D real world for urban design	1
L 5	Digital surface model	1
L 6	Route alignment	1
L 7	Modelling for urban environment impact analysis	1
L 8	Appraisal of development plan implementation	1
L 9	Human health and environment analysis	1

Code	*Description*	*No. of lectures*
L 10	Urban structure and transportation study	1
L 11	Incompatible land use vis-à-vis topography	1
L 12	Urban hazards and risk management	1

Practical exercises

Code	*Description*	*Total No. of hours*
EX. 1	Database creation for urban area analysis—creation of spatial databases	24
EX. 2	GIS/land information system (LIS) applications: - Utility planning - Urban growth monitoring - Land use planning - Developmental planning etc.	24

Suggested reading

White, R. R. Urban environmental management. New York, John Wiley and Sons, 1994.

Sokhi, B. S., and S. M. Rashid. Remote sensing of urban environment. New Delhi, Manak Publishers, 1999

Bandhu, D. Environmental management. New Delhi, Indian Environmental Society, 1981.

Singh, V. N. Spatial urban pattern and growth of urbanization. New Delhi, Inter-India Publications, 1986.

Rashid, S. M., ed. Remote sensing in geography. New Delhi, Manak Publications. 1993.

Johnson, J. H. Suburban growth: geographical process at the edge of the western city. London, John Wiley and Sons, 1974.

Mayer, H. M., and F. K. Clyde. Readings in urban geography. Allahabad, Castral Bank Depot, 1967.

Government of India. Report of National Commission on Urbanization. v. IV:93-301, 1988.

Jordan, L. Virtualising the 3-D real world. *GIM international.* V. 14. 4-7, 2000.

Holm, M. Automatic creation of mosaics and surface models, *GIM international.* v. 13, 5, 2000.

Krupnik, A. Dem from SPOT images. *GIM international*. v. 13, 5, 1999.

The breakdown of submodule 2.7.5 by topic and activity is shown in table 7, followed by a detailed list of activities and suggested reading.

Table 7
Remote sensing and GIS applications in marine sciences (submodule 2.7.5)

Sub-module	*Topic*	*Code*	*Activity (hours*				
			Lectures	*Tutorials and practical exercises*	*Field work*	*Library/ guest lectures*	*Total*
2.7.5.1	Remote sensing applications in the coastal geomorphology and coastal processes	CGCP	12	48	10	5	75
2.7.5.2	Remote sensing applications in coastal and marine ecology	CME	12	48	10	5	75
2.7.5.3	Satellite oceanography	SO	12	48	10	5	75
2.7.5.4	GIS applications in oceanography	GISO	12	48	10	5	75
	Total		48	192	40	20	300

Remote sensing applications in the coastal geomorphology and coastal processes (submodule 2.7.5.1)

Lectures

Code	*Description*	*No. of lectures*
CGCP 1	Fundamentals of submarine geology and geomorphology	2
CGCP 2	Coastal zone: definition, concepts and issues	1
CGCP 3	Elements of coastal geomorphology	2
CGCP 4	Temporal—spatial dynamics of coastal landforms, coastal landform analysis, shoreline changes etc.	2
CGCP 5	Principles of visual interpretation techniques in coastal geomorphology	2
CGCP 6	Principle of bathymetry and depth surveying and methods of retrieval of coastal bathymetry from visible remote sensing, SAR and lidar data.	2
CGCP 7	Fundamentals of wave tide, and circulation patterns	1

Practical exercises and tutorials

Code	*Description*	*No. of hours*
EX.CGCP 1	Satellite image interpretation for identification and delineation of coastal landforms	6
EX.CGCP 2	Coastal landform analysis and mapping shoreline changes	6
EX.CGCP 3	Digital image processing techniques in mapping coastal landforms	10

Code	*Description*	*No. of hours*
EX.CGCP 4	Digital image processing techniques as applied to coastal zone density measurements, circulation patterns, bathymetry, suspended sediment analysis etc.	26

References

Garrison, T. Essentials of oceanography. Boston, Wadsworth Publishing Company, 1995.

Thornbury, W. D. Principles of geomorphology. New York, John Wiley and Sons, 1969.

Holmes, A. Principles of physical geology. London, Thomas Nelson and Sons, 1944.

Cracknell, A. P. Selected topics of coastal zone color scanner data evaluation in remote sensing applications in marine science and technology. Dordrecht, D. Reidel, 1983.

Remote sensing applications in coastal and marine ecology (submodule 2.7.5.2)

Lectures

Code	*Description*	*No. of lectures*
CME 1	Fundamentals of marine ecology	2
CME 2	Remote sensing applications in coastal and marine ecology	2
CME 3	Remote sensing applications in bioresources mapping and monitoring (fisheries and aquaculture), quantitative estimation of chlorophyll using ocean colour data	2
CME 4	Principles of remote sensing of sea, satellite sensors and hyperspectral remote sensing for identification of coastal features	3
CME 5	Remote sensing applications in coastal wetland and monitoring	1
CME 6	Coastal ecosystem's mapping and monitoring, sea level change and impact on coastal ecosystem	2

Practical exercises and tutorials

Code	*Description*	*No. of hours*
EX.CME 1	Bioresources mapping and monitoring using satellite data (fisheries)	12
EX.CME 2	Wetland mapping using satellite data	12

Code	*Description*	*No. of hours*
EX.CME 3	Bioresources mapping and monitoring using satellite data (aquaculture)	12
EX.CME 4	Pollution monitoring	12

References

Nybakken, J. W. Marine biology, an ecological approach. New York, Harper and Row, 1982.

Cracknell, A. P. Remote sensing applications in marine science and technology. Dordrecht, D. Reidel,1982.

Barrow, C. J. Environmental management, principles and practices. London, Routledge, 1999.

Robinson, I. S. Satellite oceanography. New York, Ellis Horwood, 1985.

Satellite oceanography (submodule 2.7.5.3)

Lectures

Code	*Description*	*No. of lectures*
SO 1	Interaction of electromagnetic radiation with water and physics of infrared radiation and principles of passive radiometry	2
SO 2	Fundamentals of ocean optics and their utility in remote sensing of ocean colour	2
SO 3	Application of visible remote sensing data for water quality assessment and primary productivity estimation	4
SO 4	Application of remote sensing in sea surface temperature (SST) mapping	1
SO 9	Active microwave remote sensing of sea	1
SO 10	Estimation of wave, current and tide parameters by remote sensing	1
SO 11	Remote sensing applications in retrieval of wind data and air sea heat exchange	1

Practical exercises and tutorials

Code	*Description*	*No. of hours*
EX.SO 1	Sea surface temperature retrieval	10
EX.SO 2	Atmospheric correction to ocean colour data	8
EX.SO 3	SST mapping in ocean waters	10

Code	*Description*	*No. of hours*
EX.SO 4	Estimation of wind, wave, current and tide parameters	10
EX.SO 5	Coastal colour/pigment mapping and productivity estimation	10

References

Maul, G. A. Introduction to satellite oceanography. Dordrecht, Martinus Nijhoff, 1985.

Robinson, I. S. Satellite oceanography. New York, Ellis Horwood, 1985.

Cracknell, A. P. Remote sensing applications in marine science and technology. Dordrecht, D. Reidel, 1982.

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

Asrar, G. Theory and applications of optical remote sensing. New York, John Wiley and Sons, 1989.

GIS applications in oceanography (submodule 2.7.5.4)

Lectures

Code	*Description*	*No. of lectures*
GISO 1	GIS: concepts, models and information system and database design for coastal zone	2
GISO 2	GIS applications to integrated coastal geomorphology in temporal—spatial dynamics of coastal landforms	3
GISO 3	GIS applications to coastal bioresources monitoring and management	1
GISO 4	GIS applications in physical modelling of natural processes weather and climate analysis	1
GISO 5	GIS applications in physical modelling of natural processes coastal sedimentary processes	1
GISO 6	GIS applications in physical modelling of natural processes sea level rise, sea surface temperature and fishery forecasting, coastal pollution monitoring	3
GISO 7	Future sensor for coastal environment and oceanography	1

Practical exercises and tutorials

Code	*Description*	*No. of hours*
EX.GISO 1	Creation of spatial and non-spatial databases	12
EX.GISO 2	GIS applications: monitoring geomorphic changes/ shoreline changes	12

Code	*Description*	*No. of hours*
EX.GISO 3	GIS applications: bioresources monitoring	12
EX.GISO 4	GIS applications: sea surface temperature/fisheries	12

References

Cicin-Sain, B., and R. W. Knecht. Integrated coastal and ocean management concept and practices. Washington, D.C., Island Press, 1998.

Adalberto, V. Sea management: A theoretical approach. London, Elsevier, 1992.

Frankel, E. B. Ocean environmental management: a primer on the role of oceans and how to maintain their contributions to life on Earth. Saddle River, New Jersey, Prentice Hall, 1995.

Barrow, C. J. Environmental management, principles and practices. London, Routledge, 1999.

Sudarshana, R., *and others*. Subtle issue in coastal management. Dehdrdun: Indian Institute of Remote Sensing, 2000.

The breakdown of submodule 2.7.6 by topic and activity is shown in table 8, followed by a detailed list of activities and suggested reading.

Table 8
Remote sensing and GIS applications in water resources (submodule 2.7.6)

		Activity (hours)				
Submodule	*Topic*	*Lectures*	*Tutorials and practical exercises*	*Field work*	*Library/ guest lectures*	*Total*
2.7.6.1	Water resources assessment	12	48	10	5	75
2.7.6.2	Watershed characterization	12	48	10	5	75
2.7.6.3	Water resources development	12	48	10	5	75
2.7.6.4	Water resources management	12	48	10	5	75
	Total	48	192	40	20	300

Remote sensing applications in water resources assessment (submodule 2.7.6.1)

Lectures

Code	*Description*	*No. of lectures*
L 1 and 2	Principles of remote sensing in water resources assessment	2
L 3 and 4	Hydrologic elements and quantification through remote sensing: collection, transfer and processing of hydrological measurements	2

Code	*Description*	*No. of lectures*
L 5 and 6	Groundwater exploration in consolidated material or hard rock terrain	2
L 7 and 8	Groundwater exploration in unconsolidated material—alluvial terrain	2
L 9	Surface water inventory	1
L 10	spectral characteristics of water and water quality	1
L 11 and 12	Snow hydrology, snowmelt run-off modelling and glacier inventory	2

Practical exercises, tutorials and field work

Code	*Description*	*No. of hours*
P 1 and T 1	Interpretation of satellite imagery on different scales for water resources (aerial photographs, satellite imagery of linear imaging self scanner (LISS) III, thematic mapper (TM), LISS II, panchromatic data of the same area will be interpreted)	11 plus 1
P 2 and T 2	Groundwater targeting in different rock types (aerial photographs and satellite imagery will be used to target the groundwater body mapping)	11 plus 1
P 3 and T 3	Surface water bodies mapping (visual interpretation and digital image processing will be used for mapping of irrigation tanks, ponds, reservoirs, lakes etc.)	11 plus 1
P 4 and T 4	Quantification of hydrologic elements (various components of the hydrologic cycle will be determined/computed by using RS, GIS and mathematical models)	11 plus 1
FW 1	Spectral response of different water features	10

Suggested reading

American Society of Photogrammetry and Remote Sensing. Manual of remote sensing. v. II. Falls Church, Virginia, 1983.

Philip, S., and M. D. Shirley. Remote sensing: the quantitative approach. New York, McGraw-Hill, 1978.

Engman, E. T., and R. J. Gurney. Remote sensing in hydrology. London, Chapman and Hall, 1991.

Kennie, T.J.M., and M. C. Mattews. Remote sensing in civil engineering. New York, John Wiley and Sons, 1985.

Balakrishan, P. Issues in water resources development and management and the role of remote sensing. Technical report ISRO-NNRMS-TR-67-86. Bangalore, Indian Society of Remote Sensing, 1986.

Archer, D. R., *and others*. The potential of satellite remote sensing of snow over Great Britain in relation to cloud cover. *Nordic Hydrology* (Kongens Lyngby, Denmark) 25, 1994.

Brunengo, M. J. A method of modeling the frequency characteristics of daily snow amount for stochastic simulation of rain-on-snowmelt events. Proceedings of the Western Snow Conference. 58, 1990.

Singh, P., *and others*. Snow and glacier contribution in the Ganga river at Devprayag. National Institute of Hydrology, Roorkee, India, 1994.

Remote sensing applications in watershed characterization (submodule 2.7.6.2)

Lectures

Code	*Description*	*No. of lectures*
L 1	Watershed hydrology and physical processes in watershed	1
L 2	Principles of aerial photo/satellite image interpretation in lithological identification and structural analysis	1
L 3 and 4	Organization and design of spatial and non-spatial data in water resources engineering	2
L 5 and 6	Erosion, erodibility and sediment yield modelling and watershed prioritization	2
L 7 and 8	Watershed characterization and hydrological modelling	2
L 9 and 10	Watershed conservation planning	2
L 11 and 12	DEM applications in water resources	2

Practical exercises, tutorials and field work

Code	*Description*	*No. of hours*
P 1 and T 1	Database creation for water resources: spatial and non-spatial databases: spatial and non spatial data input, rectification and generation of thematic maps, which will serve as an input for further GIS analysis	11 plus 1
P 2 and T 2	Identification of erosion prone areas in watershed (aerial photographs and satellite imagery will be used; visual and digital techniques will be used to identify the erosion prone area)	11 plus 1
P 3 and T 3	DEM Applications in water resources (flow direction, flow accumulation, automatic sub-watershed delineation, etc.)	11 plus 1

Code	*Description*	*No. of hours*
P 4 and T4	Hydrologic modelling in GIS (capability of Hydrologic Engineering Centre (HEC) HEC-1 model and agricultural non-point source (AGNPS) model will be demonstrated)	11 plus 1
FW 2	Resource data collection in small watersheds	10

Suggested reading

Gregory, K. J., and D. E. Walling. Drainage basin form and process: a geomorphological approach. London, Edward Arnold, 1973.

Murty, V.V.N. Land and water management engineering. New Delhi, Kalyani, 1985.

Mutreja, K. N. Applied hydrology. New Delhi, Tata McGraw-Hill, 1990.

Pimentel, D. ed. World soil erosion and conservation. Cambridge, Cambridge University Press, 1993.

Rodda, J. C. Facets of hydrology. London, John Wiley and Sons, 1976.

Singh, G., *and others*. Manual of soil and water conservation practices. New Delhi, Oxford and IBH Publishing, 1990.

Chow, V. T., D.R. Maidmert and L. W. Mays. Applied hydrology. Singapore, McGraw-Hill, 1988.

Remote sensing applications in water resources development (submodule 2.7.6.3)

Lectures

Code	*Description*	*No. of lectures*
L 1 and 2	River valley project planning	2
L 3 and 4	Geoengineering considerations for investigation of hydel resources	2
L 5 and 6	River morphology	2
L 7 and 8	Mapping waterlogged and salinization areas in irrigation command	2
L 9	Evaluation water management in irrigation command areas	1
L 10 and 11	Irrigation water scheduling and conjunctive water use planning	2
L 12	Environmental impact assessment of water resource projects	1

Practical exercises, tutorials and field work

Code	*Description*	*No. of hours*
P 1 and T 1	Geo-engineering mapping for investigation of hydel resources (aerial photographs and satellite imagery (panchromatic camera (PAN data) will be used)	10 plus 1
P 2 and T 2	Geomorphological feature identification of rivers and deltas	10 plus 1
P 3 and T 3	Hydrologic soil grouping and irrigability classification (soil map will be reclassified to hydrologic soil grouping map using GIS)	10 plus 1
P 4 and T4	Irrigation command area mapping (multi-sensor, multi-date data will be used to map the irrigation command area)	10 plus 1
P 5 and T 5	Assessment of crop water requirements (various losses, namely evapotranspiration, percolation and conveyance losses, will be determined using RS and GIS to assess the crop water requirement)	3 plus 1
FW 3	Data collection for water resources development	10

Suggested reading

Doorenbos, J., and W. O. Pruitt. Guidelines for predicting crop water requirements. Irrigation and drainage paper No. 24. Rome, Food and Agriculture Organization of the United Nations, 1977.

Ministry of Irrigation. A guide for estimating irrigation water requirements. Technical series No. 2, rev. 144. New Delhi, Government of India, Ministry of Irrigation, Water Management Division, 1984.

Ministry of Irrigation. Groundwater estimation methodology. Report of the Groundwater Estimation Committee. New Delhi, Government of India, 1984.

Ritchie, J. T. A model for predicting evaporation from a row crop with incomplete cover. *Water resources research*. 8:5, 1972.

Veeranna, M. Groundwater resources and development potential of Karimnagar District, Andhra Pradesh. Central Ground Water Board, Ministry of Water Resources, Government of India, 1990.

Remote sensing applications in water resources management (submodule 2.7.6.4)

Lectures

Code	*Description*	*No. of lectures*
L 1 and 2	Groundwater modelling	2
L 3 and 4	Drought monitoring and evapotranspiration (ET) estimation using satellite data	2
L 5	Reservoir sedimentation	1

Code	*Description*	*No. of lectures*
L 6 and 7	Flood, risk zone mapping and damage assessment, application of microwave data in flood studies	2
L 8	Water balance	1
L 9 and 10	Site suitability analysis for water harvesting structures: a remote sensing and GIS approach	2
L 11 and 12	Integrated watershed management for sustainable development	2

Practical exercises, tutorials and field work

Code	*Description*	*No. of hours*
P 1 and T 1	Ground water modelling (the modular three-dimensional finite-difference groundwater flow model (MODFLOW) will be demonstrated for determining the groundwater depth; GIS layers will also be created)	11 plus 1
P 2 and T 2	Drought monitoring, ET estimation (generation of various indices, namely the normalized difference index (NDVI), crop moisture index (CMI) etc.; these indices will be generated for multi-date data to monitor drought)	11 plus 1
P 3 and T 3	Water balance (various components of the water balance equation will be determined using RS and GIS)	11 plus 1
P 4 and T4	GIS data analysis for flood risk zoning (various statistical models with a specific return period will be used in conjunction with a digital elevation model for flood risk zone mapping)	11 plus 1
FW 4	Data collection for watershed management	10

Suggested reading

Bonham-Carter, G. F. Geographic information systems for geoscientists: Modelling with GIS. Kidlington, Pergamon Press, 1994.

Laurini, R., and D. Thompson. Fundamentals of spatial information systems. Apic series No. 37. New York, Academic Press, 1994.

Meijerink, A.M.J., *and others*. Introduction to the use of geographic information systems for practical hydrology. Paris, United Nations Educational, Scientific and Cultural Organization, 1994.

Goel, R. K. Tutorial on GIS basics (preconference). Ahmedabad, Indian Society of Geoinformatics, 1996.

de Brouder, J.A.M. Flood study in the Meghna-Dhonagoda polder, Bangladesh. Paper presented to the 15th Asian Conference on Remote Sensing, Bangalore, India, 17-23 November 1994.

Economic and Social Commission for Asia and the Pacific. Integrated approach to flood disaster management and rural area development. *Water resources journal*. Bangkok, 1991

Durga Rao, K.H.V., P.L.N. Raju and P. Sharma. Application of GIS in flood alarming and flood hazard area zoning. Proceedings of the International Conference on Operationalisation of Remote Sensing, 16-20 August 1999. Enschede, International Institute for Aerial Survey and Earth Sciences, 1999.

Durga Rao, K.H.V., V. Hariprasad and P. S. Roy. A suitable site for water harvesting: technology of remote sensing and GIS. Making water everybody's business. Aggarwal, A., S. Narain and I. Khurana, eds. New Delhi, Center for Science and Environment.

Mahamood, V., and K.H.V. Durga Rao. Groundwater modelling using remote sensing and GIS: a case study of Visakhapatnam, India. Proceedings of the International Conference on Remote Sensing and GIS/GPS. v. I, 162. Hyderabad, India, 1-4 December 2000.

Government of India. Handbook of hydrology. New Delhi, Ministry of Agriculture, 1972.

National Remote Sensing Agency. Integrated mission for sustainable development: technical guidelines. Department of Space, Government of India, 1975.

Thornthwait, C. W and J. R. Mather. Instructions and tables for computing potential evapotranspiration and the water balance. Publications in climatology. v. 10, Centerton, New Jersey, 1957.

Vijayalakshami, K., K.P.R. Vittal and R. P. Singh. Water harvesting and reuse. Decade of dryland agriculture research in India (1971-1980). Hyderabad, All India Coordinated Research Project for Dryland Agriculture, Council of Agriculture Research, 1987.

Module 3: Project work, including ground data collection

The stages of project work by topic and activity is shown in table 9, followed by a detailed list of activities.

Table 9
Pilot project

		Activity (hours)		
Submodule	*Topic*	*Practical exercises*	*Field work*	*Total*
3.1	Project planning	50	--	50
3.2	Prefield interpretation and analysis	100	--	100
3.3	Field data collection	--	100	100
3.4	Field data analysis	50	--	50
3.5	Post field interpretation and analysis	100	--	100
	Total	300	100	400

Activities

Project planning: definition of problem, data requirement (remote sensing, collateral and other), approach, method of analysis and interpretation.

Interpretation and analysis of remote data: preparation of outputs/maps/ generation of statistics etc.

Field data collection: checking of outputs; modifications.

Final interpretation and analysis of data, ground data finalization of maps and outputs report.

Annex II

Academic performance evaluation

The points given for each activity are shown below.

		Points			
Code	*Topic*	*Theory*	*Practical exercises*	*Tutorials*	*Total*
Module 1					
1.1	Remote sensing	50	30	20	100
1.2	Photogrammetry	50	30	20	100
1.3	Image analysis	100	60	40	200
1.4	Geoinfomatics	100	60	40	200
	Subtotal				600
Module 2					
2.1 to 2.6	Environmental analysis and management (common)	200			200
2.7	RS and GIS applications in thematic areas (optional) (two papers)				
	Paper 1	100	70	30	200
	Paper 2	100	70	30	200
	Subtotal				600
Module 3					
3.1	Project planning				50
3.2	Field data collection				150
3.3	Analysis of RS data and GIS analysis				150
3.4	Final analysis, outputs and report				150
3.5	Seminar preparation and presentation				100
	Subtotal				600
	Total				1 800

Grades will be given as follows:

A+ (distinction)	75% or more
A (first class)	less than 75% to 60%
B (pass)	less than 60% to 50%