

**Asamblea General**

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**Comisión sobre la Utilización del Espacio
Ultraterrestre con Fines Pacíficos****Centros regionales de formación en ciencia y tecnología
espaciales (afiliados a las Naciones Unidas)****Programa de estudios sobre las aplicaciones de la teleobservación
y el sistema de información geográfica****Índice**

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I. Introducción

1. Toda la vida en la Tierra depende de una tenue capa de gas que rodea el planeta; se trata de la atmósfera, un nombre que proviene de la palabra griega *atmós* (vapor) y la palabra latina *sphaera* (esfera). Mediante la teleobservación de la atmósfera se intenta cuantificar numerosas variables: la cobertura de las nubes y sus características, la concentración del vapor de agua y la tasa de precipitación, la velocidad del viento, las concentraciones de aerosoles y oligogases en la atmósfera, e incluso las descargas eléctricas durante las tormentas.
2. El término atmósfera ha hecho que surjan varias palabras más para describir diversas divisiones de los sistemas ambientales de la Tierra:
 - La hidrosfera, que abarca los océanos, los ríos y los lagos, así como la nieve y el hielo tanto en tierra como en el mar;
 - La biosfera, es decir, los seres vivientes que habitan la Tierra, lo que significa sobre todo, a efectos de la teleobservación, la vegetación terrestre y el fitoplancton oceánico;
 - La geosfera, que abarca ámbitos como el balance de radiación de la Tierra, la topografía física de los continentes, los procesos geológicos que modifican la superficie del terreno, la actividad dinámica de los volcanes y el movimiento de las placas continentales de la Tierra;
 - La antroposfera, o sea, la influencia de la humanidad en la superficie de la Tierra mediante estructuras y actividades que puedan causar importantes alteraciones del clima del planeta.
3. En el capítulo siguiente se describen, en función de módulos de enseñanza, los principales procesos que se intenta medir con la teleobservación en cada una de esas esferas y los aspectos técnicos de la teleobservación en relación con cada uno de esos sistemas.

II. Deliberaciones del grupo de trabajo sobre teleobservación y el sistema de información geográfica

4. La Oficina de Asuntos del Espacio Ultraterrestre, en cooperación con la Agencia Espacial Europea, organizó la Reunión de expertos de las Naciones Unidas sobre los centros regionales de formación en ciencia y tecnología espaciales: situación actual y evolución futura, que se celebró en Frascati (Italia) del 3 al 7 de septiembre de 2001. Uno de los principales objetivos de la Reunión fue examinar y actualizar los programas de estudios de los centros regionales en cuatro esferas: teleobservación; meteorología satelital; telecomunicaciones por satélite; y ciencias espaciales. En el presente informe figuran las deliberaciones del grupo de trabajo sobre teleobservación y el sistema de información geográfica acerca de un programa de estudios revisado.
5. El programa de estudios de los seis cursos que se han celebrado en el Centro de Formación en Ciencia y Tecnología Espaciales para Asia y el Pacífico y la evaluación del rendimiento académico figuran en los anexos I y II, respectivamente. El anexo III contiene las notas explicativas del programa de estudios.

A. Recomendaciones generales

6. Dado el alcance actual de los centros de formación en ciencia y tecnología espaciales, es necesario orientar sus actividades para que abarquen lo siguiente:

- a) La formación en dos programas distintos:
 - i) Programas básicos de formación de nueve meses de duración que conduzcan a la obtención de un diploma del centro regional;
 - ii) Programas avanzados de 12 meses de duración que conduzcan a la obtención de una licenciatura;
- b) Capacitación: capacitación de corta duración y personalizada (la duración dependerá del tipo de capacitación);
- c) Investigación: proyectos de investigación concretos;
- d) Consultoría, sobre todo en combinación con proyectos en la región de que se trate.

7. Habida cuenta de lo que antecede, en el proyecto de objetivos de los centros regionales (adaptados del documento A/AC.105/649, pág.1) se debería recalcar que los centros regionales tienen que ofrecer a sus participantes en todos los programas, en cuanto a formación, investigaciones y experiencia relativa a las aplicaciones, la más alta calidad posible. En consecuencia, el objetivo principal de los centros regionales es desarrollar las aptitudes y los conocimientos de los docentes universitarios y los científicos especializados en investigaciones o aplicaciones, mediante un gran rigor en la teoría, las investigaciones, las aplicaciones, los ejercicios sobre el terreno, los proyectos experimentales y las consultas relativas a los aspectos de la ciencia y la tecnología espaciales que puedan fomentar el desarrollo social y económico en los países de la región.

8. Se debería alentar a los centros regionales a establecer entre sí redes con las que apoyen y complementen su capacidad, en particular mediante intercambios de personal y estudiantes, enlaces entre redes de antiguos alumnos, intercambios de información y material didáctico y la participación en comités consultivos.

9. Dado el surgimiento de la globalización y de alianzas comerciales, los centros regionales y sus respectivos órganos rectores podrían estudiar la posibilidad de que el sector privado y las organizaciones no gubernamentales participen también y podrían buscar su cooperación en la preparación de material didáctico y la prestación de apoyo docente, así como podrían invitar a conferencistas de la industria y las organizaciones no gubernamentales.

10. Los centros deberían establecer un proceso de evaluación de los estudiantes que sea estricto y sistemático, clasificar a los estudiantes de acuerdo con su rendimiento y otorgar solamente un certificado de asistencia, pero no un diploma, a los estudiantes que no logren plenamente los objetivos de formación de los centros regionales.

11. En el caso de los programas que ofrecen los centros regionales para obtener un diploma al cabo de nueve meses o títulos más avanzados, se debería alentar a los centros a que concierten acuerdos de cooperación con las universidades o instituciones pertinentes de su región. Se debería permitir el ingreso en los

programas de formación en los centros sólo a los poseedores de un título universitario en ciencias (que se obtiene en general tras cuatro años de estudios universitarios de pregrado), o su equivalente (de acuerdo con el sistema de enseñanza de cada región) o un título más alto.

12. Los programas de estudios recomendados para el programa de nueve meses figuran *infra* en términos generales. Sin embargo, los propios centros regionales pueden determinar la estructura de los cursos y la profundidad o el contenido de cada tema, teniendo presente el tiempo disponible. El módulo relacionado con las nociones fundamentales de la teleobservación y el sistema de información geográfica (SIG) duraría, según se prevé, de dos a tres meses; cada centro regional puede decidir acerca de su hincapié y profundidad. El módulo sobre las aplicaciones de la teleobservación y el SIG duraría de tres a cuatro meses y aproximadamente un mes se dedicaría a un submódulo relacionado con un panorama general (común a todos los itinerarios) y unos dos meses se dedicarían a un itinerario temático (sobre el que decidiría el centro respectivo). El módulo relativo al proyecto experimental duraría tres meses.

13. Otro programa avanzado de 12 meses de duración consistiría en un proyecto que los participantes ejecutarían en su país de origen, con el apoyo comprometido de un organismo patrocinador. Después de completar el proyecto, los participantes presentarían una tesis a los centros regionales, que tendrían que concertar un acuerdo de cooperación con una universidad para conceder una licenciatura. El requisito previo para participar en el programa sería contar con el diploma del curso de nueve meses, además de otros requisitos concretos de idoneidad que puedan aplicarse.

14. Los centros regionales se deben esforzar por dividir el programa de estudios en módulos, a fin de que ello pueda ayudarlos a estructurar en forma apropiada cursos de corta duración o cursos especializados sobre los mismos temas y con el mismo material didáctico. Ello es muy importante para uniformar los programas de estudios en el futuro.

15. Es también muy importante evaluar cómo los estudiantes han aplicado sus conocimientos después de haber recibido un diploma o una licenciatura y es recomendable que los centros regionales reciban informes breves de los estudiantes o los organismos patrocinadores y preparen sistemáticamente informes de evaluación de su desempeño.

B. Temas del programa de estudios revisado

16. El grupo de trabajo estableció a título indicativo algunos temas que los centros regionales podrían perfeccionar y estructurar en forma apropiada para los cursos, además de decidir sobre la profundidad y el contenido de los temas. Quizá también deseen adecuar los temas a los problemas relacionados con su respectiva región. Los temas están ordenados sobre la base de los siguientes módulos:

<i>Módulo/ submódulo</i>	<i>Tema</i>
0	Introducción Un módulo de orientación para los estudiantes, de una semana de duración, sobre la cultura y los aspectos sociales, económicos y de desarrollo del país anfitrión y sus instituciones, incluidas lecciones breves sobre temas generales
1	Nociones fundamentales y principios de la teleobservación y el SIG (de dos a tres meses)
1.1	Principios de la teleobservación
1.1.1	Panorama general de la tecnología de la teleobservación: historia y evolución
1.1.2	La radiación electromagnética y su interacción con la materia: las leyes de la radiación, el espectro electromagnético y sus características, las fuentes de la radiación electromagnética; propagación de la energía electromagnética: difusión, dispersión, absorción, refracción y reflexión; interacciones entre la radiación electromagnética y la materia en la atmósfera y la superficie de la Tierra (emisiones de radiación): emisividad, radiación de cuerpos negros, ley de Stefan, ley de Kirchhoff, ley de Wien, ley de Planck; procesos físicos en la interacción entre la radiación y la materia: propiedades de la atmósfera, elementos constitutivos, contaminantes, gradiente térmico vertical, nubes, sondeo atmosférico, mecanismos de dispersión, variaciones temporales; albedo, reflexión, ley de Snell, absorción, firmas espectrales, efecto fotoeléctrico, aislamiento
1.1.3	Características espectrales de los cultivos y la vegetación, los suelos y el agua, entre otras cosas
1.2	Plataformas, sensores y sistemas terrestres de teleobservación
1.2.1	Plataformas Panorama general de la teleobservación aérea: fotografía, formación de imágenes; ventajas y aplicaciones Teleobservación por satélite: clasificación por órbita, aplicaciones, ventajas y desventajas, tipo de observación, dinámica orbital Tipos de satélites: panorama general de los satélites de observación de la Tierra; panorama general de los satélites heliosincrónicos de teleobservación del infrarrojo óptico; panorama general de las plataformas polares y los satélites meteorológicos Satélites de alta resolución; satélites de radar; otras misiones: por ejemplo, hiperespectrales Futuros sistemas de satélites
1.2.2	Sensores

<i>Módulo/ submódulo</i>	<i>Tema</i>
	Nociones fundamentales de la tecnología de la formación de imágenes: formación de imágenes/no formación de imágenes, activa/pasiva, ventajas y desventajas
	El concepto de resolución: espacial, espectral, radiométrica y temporal
	Sistemas de aerofotografía: fotográficos, históricos, sistemas de cámaras, tipos de película, fotografía multispectral, dispositivos cartográficos láser aerotransportados (ALTM)
	Analizadores de barrido/imaginizadores: sistemas de cámara de fotogramas, sistemas de análisis de barrido, analizadores de barrido de matriz de líneas, espectrómetros, dispositivos de acoplamiento de cargas (CCD), imaginizadores térmicos
	Sensores de microondas: principios del radar aerotransportado de banda lateral (SLAR), el radar de abertura sintética (RAS) y sus características
	Sensores/sistemas que no forman imágenes: radiómetro de infrarrojos, radiómetro de microondas, dispersómetro y altímetro, entre otros
	Otros sensores: hiperspectrales, formación de imágenes por láser y otros
1.2.3	Sistemas terrestres
	Sistemas de recepción y preprocesamiento de datos y sus configuraciones
	Principios de los sistemas de recepción de datos, cadenas transmisoras y receptoras de datos; grabación; archivo; preprocesamiento: correcciones radiométricas y geométricas; tipos de productos de datos satelitales; productos de valor añadido
	Recogida y comprobación de datos sobre la realidad del terreno; errores en los datos de imágenes y su corrección
1.3	Interpretación de imágenes
1.3.1	Nociones fundamentales de interpretación aerofotográfica
1.3.2	Principios de interpretación de imágenes de datos satelitales ópticos, térmicos y de microondas
1.4	Fotogrametría
1.4.1	Introducción a la fotogrametría: aerofotografía, interpretación fotográfica, fotogrametría analógica, fotogrametría digital
1.4.2	Principios de evaluación de la exactitud y análisis de errores
1.5	Procesamiento digital de imágenes

<i>Módulo/ submódulo</i>	<i>Tema</i>
1.5.1	Reseña de lenguajes de programación: C++ (lenguaje de programación orientado a objetos), visual básico (VB), lenguajes de macros
1.5.2	Conceptos estadísticos: promedio, mediana, moda, desviación característica, matriz de covarianzas, raíces características, vectores característicos, análisis de componentes principales, etc.
1.5.3	Realidad del terreno para el procesamiento digital de imágenes
1.5.4	Elementos de procesamiento y preprocesamiento digital de imágenes: correcciones radiométricas, geométricas y atmosféricas
1.5.5	Técnicas de realce de imágenes: histogramas, estiramiento de contrastes, funciones de transferencia, igualación de histogramas, especificación de histogramas
1.5.6	Filtrado: filtros de paso bajo y de paso alto, filtro ideal, filtro Butterworth, filtro exponencial, filtro trapezoidal, etc., suavización
1.5.7	Técnicas de clasificación: distancias espectrales, probabilidades, análisis de errores, conglomeración, áreas de aprendizaje, métodos de muestreo, extrapolación; clasificador por píxeles, clasificadores de probabilidad máxima (MXL)/bayesianos/paralelepípedo, etc., clasificador orientado a objetos, redes neurales, granulometría, fractales
1.5.8	Evaluación de la exactitud y análisis de errores
1.5.9	Técnicas de fusión de imágenes
1.5.10	Técnicas de segmentación y extracción de características de imágenes: técnicas basadas en el conocimiento, inteligencia artificial, conceptos de imágenes difusas
1.5.11	Transformaciones y trenes de ondas de imágenes
1.5.12	Técnicas de procesamiento de imágenes en estéreo
1.5.13	Técnicas de análisis de imágenes de alta resolución
1.5.14	Principios de análisis de datos de radar de pequeña abertura, interferometría de radar de pequeña abertura y técnicas diferenciales-interferométricas de radar de pequeña abertura (INSAR)
1.5.15	Procesamiento de datos hiperespectrales, polarimétricos, dispositivos cartográficos láser aerotransportados (ALTM) y otros tipos de datos
1.6	Sistemas de procesamiento de imágenes
1.6.1	Configuración, opción y selección
1.6.2	Análisis integrado de imágenes y SIG
1.7	Sistema de información geográfica

<i>Módulo/ submódulo</i>	<i>Tema</i>
1.7.1	Características y tipos de datos de SIG: tipos de datos; concepto de la información
1.7.2	Mapas y proyecciones: principios de cartografía, elipsoides, proyecciones cartográficas, sistemas, tipos y escalas de coordenadas; exactitud de los mapas
1.7.3	Conceptos, técnicas, sistemas y aplicaciones del GPS
1.7.4	Principios de SIG: conceptos y principios de SIG: modelos de SIG, componentes de SIG, insumos a SIG; diseño y organización de bases de datos de SIG; integración en SIG, consultas en SIG, productos y visualización de SIG, exactitud de los datos en SIG, errores de integración en SIG
1.7.5	SIG tridimensional: representación de la tercera dimensión en SIG, análisis y derivadas tridimensionales
1.7.6	Conceptos de SIG temporal, sistemas de apoyo de decisiones, modelización de SIG, técnicas de visualización, realidad virtual, cartografía móvil, SIG en la World Wide Web
1.7.7	Ilustraciones y panorama general de las aplicaciones de SIG
1.7.8	Infraestructura de datos espaciales: metadatos, búsqueda/acceso, almacenamiento de datos, explotación de datos, normas, programas específicos de países (Programa de las Naciones Unidas para el Medio Ambiente (PNUMA)/Base de Datos sobre Recursos Mundiales (GRID), infraestructura digital de la Tierra, infraestructura mundial de datos espaciales (GSDI), cartografía mundial, etc.); normas comunes: SIG, ISO-TC211
2	Aplicaciones de la teleobservación (3 a 4 meses)
2.1	Panorama general de las aplicaciones de la teleobservación y los SIG (1 mes; módulo común para todos los itinerarios)
2.1.1	Aplicaciones de la teleobservación y los SIG para los recursos hídricos; la agricultura; el urbanismo; costas y océanos; medio ambiente; silvicultura; ecología; geología; cartografía y otras materias
2.1.2	Procesos de la Tierra
2.1.3	Meteorología satelital
2.1.4	Desastres naturales
2.1.5	Desarrollo sostenible y capacidad de sustentación
2.1.6	Análisis, vigilancia y gestión ambientales
2.1.7	Análisis de rentabilidad
2.1.8	Planificación y ejecución de proyectos
2.2	Itinerarios temáticos (2 a 3 meses)

<i>Módulo/ submódulo</i>	<i>Tema</i>
2.2.1	Examen de planificación de proyectos y ejecución de proyectos experimentales
3	Proyectos experimentales que se han de ejecutar en el centro regional; el estudiante, en consulta con su organización patrocinadora y con la aprobación del centro, escoge los temas

C. Estructura del plan de estudios

17. El grupo de trabajo recomendó que se adoptara la siguiente división del tiempo en cada módulo:

<i>Módulo</i>	<i>Tema</i>	<i>Duración</i>
1	Nociones fundamentales de teleobservación y SIG	12 semanas, 400 horas
2	Aplicaciones de la teleobservación y los SIG en los estudios de los recursos naturales y el medio ambiente	12 semanas, 400 horas
3	Labor de proyecto, comprendida la recogida de datos sobre la realidad del terreno	12 semanas, 400 horas

18. En el siguiente cuadro se indica la división por módulo, submódulo y tipo de actividad.

Cuadro
Duración del curso por tipo de actividad

<i>Módulo/ submódulo</i>	<i>Tema</i>	<i>Actividad (horas)</i>				<i>Total</i>
		<i>CM</i>	<i>CD+EP</i>	<i>TST</i>	<i>B+CI</i>	
1	Nociones fundamentales de teleobservación y SIG					
1.1	Teleobservación	20	40	10	5	75
1.2	Interpretación de imágenes y análisis de imágenes	40	95	10	5	150
1.3	Fotogrametría	20	40	10	5	75
1.4	Geoinformática	<u>30</u>	<u>50</u>	<u>15</u>	<u>5</u>	<u>100</u>
	Total parcial	110	225	45	20	400

Módulo/ submódulo	Tema	Actividad (horas)				
		CM	CD+EP	TST	B+CI	Total
2	Aplicaciones de la teleobservación y los SIG en los estudios de los recursos naturales y en el medio ambiente					
2.1	Progresos de la teleobservación y los SIG	5			1	6
2.2	Meteorología satelital	5			1	6
2.3	Procesos de la Tierra	6			1	7
2.4	Desarrollo sostenible y gestión integrada de los recursos	7			1	8
2.5	Vigilancia y gestión de desastres naturales	6			1	7
2.6	Análisis, vigilancia y gestión del medio ambiente y cuestiones globales conexas	12	50		4	66
2.7	Aplicaciones de la teleobservación y los SIG en esferas temáticas (electivo en una de las siguientes disciplinas)	48	192	40	20	300
2.7.1	Agricultura y edafología					
2.7.2	Silvicultura y ecología					
2.7.3	Geociencias					
2.7.4	Asentamientos humanos					
2.7.5	Recursos hídricos					
2.7.6	Ciencias marinas					
	Total parcial	89	242	40	29	400
3	Labor de proyectos ^a					
3.1	Planificación de proyectos		50			50
3.2	Interpretación y análisis previos a la labor sobre el terreno		100			100
3.3	Recogida de datos sobre el terreno			100		100
3.4	Análisis de datos sobre el terreno		50			50
3.5	Informe de interpretación y análisis posterior a la labor sobre el terreno		100			100
	Total parcial		300	100		400
	Total	199	767	185	49	1 200

Nota: CM= clases magistrales; CD+EP= clases dirigidas y ejercicios prácticos;

TST = trabajo sobre el terreno; B+CI = biblioteca/clases de profesores invitados;

^aEn el módulo 3, CD + EP consta únicamente de ejercicios prácticos.

Annex I

Specifications for the curriculum of the first six courses

A. Module 1: Fundamentals of remote sensing and GIS

1. 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.

2. 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

Submodule	Topic	Code	Lectures	Activity (hours)			Total
				Tutorials and practical exercises	Field work	Library/guest lectures	
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	<u>30</u>	<u>50</u>	<u>15</u>	<u>5</u>	<u>100</u>
	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), Indian Remote Sensing Satellite (IRS))

<i>Code</i>	<i>Description</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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.

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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

<i>Code</i>	<i>Description</i>
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

<i>Code</i>	<i>Description</i>
IA 21	Fundamentals of image analysis and digital data format
IA 22 and 23	Fundamentals of image rectification and registration
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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	

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
EX.IA 8	Study of modular multispectral scanner (M ² S) imagery	4	
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**

<i>Code</i>	<i>Description</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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	

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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

<i>Code</i>	<i>Description</i>
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 (raster-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)

<i>Code</i>	<i>Description</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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.

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

3. 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

<i>Sub-module</i>	<i>Topic</i>	<i>Code</i>	<i>Activity (hours)</i>			<i>Total</i>
			<i>Lectures</i>	<i>Tutorials and practical exercises</i>	<i>Library/guest lectures</i>	
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	<u>12</u>	<u>50</u>	<u>4</u>	<u>66</u>
	Total		41	50	9	100

Module 2 lectures

<i>Code</i>	<i>Description</i>
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

<i>Code</i>	<i>Description</i>
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 anthropogenic 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

4. 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.

5. 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)

Sub-module	Topic	Code	Activity (hours)				Total
			Lectures	Tutorials and practical exercises	Field work	Library/guest lectures	
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	<u>12</u>	<u>48</u>	<u>10</u>	<u>5</u>	<u>75</u>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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.

Websites

<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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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	

Reference

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.

Websites

<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/landeal/le_notes/lecnot.htm

<http://wwwscas.cit.cornell.edu/landeal/landeal.htm>

Agrometeorology and agricultural water management (submodule 2.7.1.3)**Lectures**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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.
- Stewart, 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. Rasool 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.

Websites

<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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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.

6. 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)

Sub-module	Topic	Code	Activity (hours)				Total
			Lectures	Practical exercises	Field work	Library/guest lectures	
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	<u>12</u>	<u>48</u>	<u>10</u>	<u>5</u>	<u>75</u>
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

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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
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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>Practical exercises (hours)</i>	<i>Field work (hours)</i>
EX.EA 1	Landscape analysis	12	
EX.EA 2	Disturbance index and bio richness	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.

7. 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)

<i>Submodule</i>	<i>Topic</i>	<i>Activity (hours)</i>				<i>Total</i>
		<i>Lectures</i>	<i>Tutorials and practical exercises</i>	<i>Field work</i>	<i>Library/guest lectures</i>	
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	<u>12</u>	<u>51</u>	<u>7</u>	<u>5</u>	<u>75</u>
Total		48	204	28	20	300

Principles of remote sensing in geology (submodule 2.7.3.1)**Lectures**

<i>Code</i>	<i>Description</i>
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
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

<i>Code</i>	<i>Description</i>
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)

Text books

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, 1983.¹

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.

¹ See chapters 9 and 16, revised from the first edition of 1975.

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

<i>Code</i>	<i>Description</i>
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

<i>Code</i>	<i>Description</i>
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

<i>Code</i>	<i>Description</i>
	Library (3 hours)
	Field work: ground data collection on different landforms (7 hours)
	Examination (7 hours)

Text books

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

<i>Code</i>	<i>Description</i>
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

<i>Code</i>	<i>Description</i>
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
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

<i>Code</i>	<i>Description</i>
	Library (3 hours)
	Field work: ground truth collection for hydrogeomorphological conditions in different terrain conditions, water table/quality etc. (7 hours)
	Examination (7 hours)

Text books

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 readings

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**

<i>Code</i>	<i>Description</i>
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

<i>Code</i>	<i>Description</i>
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)

Text books

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.
- Brundsdon, 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 statistical 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 geophysics*. 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.
8. 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)**

<i>Submodule</i>	<i>Topic</i>	<i>Activity (hours)</i>				<i>Total</i>
		<i>Lectures</i>	<i>Tutorials and practical exercises</i>	<i>Field work</i>	<i>Library/guest lectures</i>	
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	<u>12</u>	<u>48</u>	<u>10</u>	<u>5</u>	<u>75</u>
Total		48	192	40	20	300

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

Lectures

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>No. of hours</i>
	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

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>Total No. of hours</i>
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 readings

- 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, Crow, 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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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
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

<i>Code</i>	<i>Description</i>	<i>Total No. of hours</i>
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.

9. 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)				Total
			Lectures	Tutorials and practical exercises	Field work	Library/guest lectures	
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

<i>Code</i>	<i>Description</i>	<i>No. of hours</i>
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
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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

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

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>No. of hours</i>
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
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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>No. of hours</i>
EX.GISO 1	Creation of spatial and non-spatial databases	12
EX.GISO 2	GIS applications: monitoring geomorphic changes/ shoreline changes	12
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. Dehldrund: Indian Institute of Remote Sensing, 2000.

10. 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)

<i>Submodule</i>	<i>Topic</i>	<i>Activity (hours)</i>				<i>Total</i>
		<i>Lectures</i>	<i>Tutorials and practical exercises</i>	<i>Field work</i>	<i>Library/guest lectures</i>	
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	<u>12</u>	<u>48</u>	<u>10</u>	<u>5</u>	<u>75</u>
Total		48	192	40	20	300

**Remote sensing applications in water resources assessment
(submodule 2.7.6.1)**
Lectures

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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
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

<i>Code</i>	<i>Description</i>	<i>No. of hours</i>
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 readings

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. Matthews. Remote sensing in civil engineering. New York, John Wiley and Sons, 1985.

Balakrishnan, 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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>No. of hours</i>
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
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. Maidment and L. W. Mays. Applied hydrology. Singapore, McGraw-Hill, 1988.

Remote sensing applications in water resources development (submodule 2.7.6.3)**Lectures**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
L 1 and 2	River valley project planning	2
L 3 and 4	Geoengineering considerations for investigation of hydrel resources	2
L 5 and 6	River morphology	2
L 7 and 8	Mapping waterlogged and salinization areas in irrigation command	2

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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

<i>Code</i>	<i>Description</i>	<i>No. of hours</i>
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 T 4	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**

<i>Code</i>	<i>Description</i>	<i>No. of lectures</i>
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
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

<i>Code</i>	<i>Description</i>	<i>No. of hours</i>
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 T 4	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.

Thorntwait, 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.

C. Module 3: Project work, including ground data collection

11. 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

Submodule	Topic	Activity (hours)		
		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

1. 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	Geoinformatics	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

2. 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%

Annex III

Explanatory notes for the curriculum

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 ² S	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