

# Contents

<i>Preface</i>	v
<i>Acknowledgements</i>	viii
<i>List of Colour Plates</i>	xvii

## Part I Remote Sensing and Image Analysis

<b>1. Concept of Remote Sensing</b>	<b>3</b>
1.1 Introduction	3
1.2 Distance of Remote Sensing	3
1.3 Definition of Remote Sensing	4
1.4 Remote Sensing: Art and/or Science	5
1.5 Data	5
1.6 Remote Sensing Process	7
1.7 Source of Energy	8
1.8 Interaction with Atmosphere	18
1.9 Interaction with Target	22
1.10 Interaction with the Atmosphere Again	26
1.11 Recording of Energy by Sensor	27
1.12 Transmission, Reception, and Processing	28
1.13 Interpretation and Analysis	29
1.14 Applications of Remote Sensing	34
1.15 Advantages of Remote Sensing	35
1.16 Limitations of Remote Sensing	35
1.17 Ideal Remote Sensing System	36
<i>Exercises</i>	37
<b>2. Remote Sensing Platforms and Sensor Characteristics</b>	<b>38</b>
2.1 Introduction	38
2.2 Characteristics of Images	38
2.3 Remote Sensing Platforms	40
2.4 Passive and Active Remote Sensing	42

2.7	Image Referencing System	56	
	<i>Exercises</i>	63	
<b>3.</b>	<b>History of Remote Sensing and Indian Space Program</b>		<b>64</b>
3.1	Introduction	64	
3.2	The Early Age	65	
3.3	The Middle Age	67	
3.4	The Modern Age or Space Age	68	
3.5	Indian Space Program	73	
	<i>Exercises</i>	97	
<b>4.</b>	<b>Photographic Imaging</b>		<b>98</b>
4.1	Introduction	98	
4.2	Camera Systems	99	
4.3	Filter	104	
4.4	Film	107	
4.5	Vantage Point	113	
4.6	Ideal Time and Atmosphere for Aerial Remote Sensing	116	
	<i>Exercises</i>	117	
<b>5.</b>	<b>Digital Imaging</b>		<b>118</b>
5.1	Introduction	118	
5.2	Digital Image	119	
5.3	Sensor	121	
5.4	PAN/Multispectral Imaging	127	
5.5	Hyper-spectral Imaging	147	
5.6	Imaging by Digital Aerial Cameras	150	
5.7	Thermal Imaging	151	
5.8	Other Sensors	156	
	<i>Exercises</i>	163	
<b>6.</b>	<b>Microwave Remote Sensing</b>		<b>164</b>
6.1	Introduction	164	
6.2	Passive Microwave Remote Sensing	164	
6.3	Active Microwave Remote Sensing	165	
6.4	Radar Imaging	166	
6.5	Airborne Versus Space-Borne Radars	178	
6.6	Radar Systems	179	
6.7	Passive Microwave Radiometer	180	
	<i>Exercises</i>	182	
<b>7.</b>	<b>Ground-truth Data and Global Positioning System</b>		<b>183</b>
7.1	Introduction	183	
7.2	Requirements of Ground-Truth Data	184	
7.3	Instruments for Ground Truthing	185	
7.4	Parameters of Ground Truthing	188	

7.5	Factors of Spectral Measurement	190	
7.6	Global Navigation Satellite System	192	
	<i>Exercises</i>	212	
<b>8.</b>	<b>Photogrammetry</b>		<b>214</b>
8.1	Introduction	214	
8.2	Development of Photogrammetry	215	
8.3	Classification of Photogrammetry	218	
8.4	Photogrammetric Process	219	
8.5	Acquisition of Imagery and its Support Data	219	
8.6	Orientation and Triangulation	233	
8.7	Stereo Model Compilation	241	
8.8	Stereoscopic 3D Viewing	241	
8.9	Stereoscopic Measurement	244	
8.10	DTM/DEM Generation	248	
8.11	Contour Map Generation	249	
8.12	Orthorectification	249	
8.13	3D Feature Extraction	251	
8.14	3D Scene Modelling	252	
8.15	Photogrammetry and LIDAR	252	
8.16	Radargrammetry	255	
8.17	Limitations of Photogrammetry	256	
	<i>Exercises</i>	256	
<b>9.</b>	<b>Visual Image Interpretation</b>		<b>258</b>
9.1	Introduction	258	
9.2	Information Extraction by Human and Computer	258	
9.3	Remote Sensing Data Products	264	
9.4	Metadata of Photographic products	265	
9.5	Image Interpretation	267	
9.6	Elements of Visual Image Interpretation	268	
9.7	Interpretation Keys	277	
9.8	Generation of Thematic Maps	278	
9.9	Thermal Image Interpretation	289	
9.10	Radar Image Interpretation	293	
	<i>Exercises</i>	302	
<b>10.</b>	<b>Digital Image Processing</b>		<b>303</b>
10.1	Introduction	303	
10.2	Categorization of Image Processing	304	
10.3	Image Processing Systems	306	
10.4	Digital Image	307	
10.5	Media for Digital Data Recording, Storage, and Distribution	307	

10.6	Data Formats of Digital Image	308	
10.7	Metadata of Digital Image	309	
10.8	Display of Digital Image	310	
10.9	Pre-processing	311	
10.10	Image Enhancement	323	
10.11	Image Transformation	340	
10.12	Image Classification	353	
	<i>Exercises</i>	372	
<b>11.</b>	<b>Data Integration, Analysis, and Presentation</b>		<b>373</b>
11.1	Introduction	373	
11.2	Multi-Approach to Image Analysis	374	
11.3	Multisensor, Multiplatform, and Multiresolution Images	374	
11.4	Multispectral Images	376	
11.5	Multitemporal/Multiseasonal Images	377	
11.6	Multistage, Multiplatform, Multiscale, and Multiresolution Images	378	
11.7	Multisource Data	379	
11.8	Integration with GIS	380	
11.9	Presentation	381	
	<i>Exercises</i>	381	
<b>12.</b>	<b>Applications of Remote Sensing</b>		<b>383</b>
12.1	Introduction	383	
12.2	Land Cover and Land Use	383	
12.3	Agriculture	389	
12.4	Forestry	392	
12.5	Geology	398	
12.6	Geomorphology	401	
12.7	Hydrology	403	
12.8	Mapping	406	
12.9	Oceans and Coastal Monitoring	410	
12.10	Monitoring of Atmospheric Constituents	420	
	<i>Exercises</i>	421	

## Part II

### Geographic Information Systems and Geospatial Analysis

<b>13.</b>	<b>Concept of Geographic Information Systems</b>		<b>425</b>
13.1	Introduction	425	
13.2	Definitions of GIS	427	
13.3	Key Components of GIS	428	
13.4	GIS—An Integration of Spatial and Attribute Information	430	
13.5	GIS—Three Views of Information System	431	
13.6	GIS—A Knowledge Hub	432	

13.7	GIS—A Set of Interrelated Subsystems	437	
13.8	GIS—An Information Infrastructure	438	
13.9	Origin of GIS	440	
	<i>Exercises</i>	442	
<b>14.</b>	<b>Functions and Advantages of GIS</b>		<b>443</b>
14.1	Introduction	443	
14.2	Functions of GIS	443	
14.3	Application Areas of GIS	444	
14.4	Advantages of GIS	447	
14.5	Uses of GIS	452	
14.6	Limitations of GIS	454	
	<i>Exercises</i>	454	
<b>15.</b>	<b>Spatial Data Model</b>		<b>455</b>
15.1	Introduction	455	
15.2	Spatial, Thematic, and Temporal Dimensions of Geographic Data	455	
15.3	Spatial Entity	456	
15.4	Spatial Data Model	457	
15.5	File Formats of Spatial Data	474	
	<i>Exercises</i>	476	
<b>16.</b>	<b>Attribute Data Management and Metadata Concept</b>		<b>477</b>
16.1	Introduction	477	
16.2	Concept of Database and DBMS	477	
16.3	Advantages of DBMS	481	
16.4	Functions of DBMS	481	
16.5	File and Data Access	482	
16.6	Data Models	484	
16.7	Data Models in GIS	488	
16.8	Concept of SQL	490	
16.9	Concept of Metadata	490	
	<i>Exercises</i>	496	
<b>17.</b>	<b>Process of GIS</b>		<b>498</b>
17.1	Introduction	498	
17.2	Data Capture	498	
17.3	Data Sources	499	
17.4	Data Encoding Methods	501	
17.5	Linking of Spatial and Attribute Data	517	
17.6	Organizing Data for Analysis	518	
	<i>Exercises</i>	519	
<b>18.</b>	<b>Geospatial Analysis</b>		<b>520</b>
18.1	Introduction	520	

18.2	Geospatial Data Analysis	520	
18.3	Integration and Modelling of Spatial Data	521	
18.4	Geospatial Data Analysis Methods	521	
18.5	Database Query	522	
18.6	Geospatial Measurements	526	
18.7	Overlay Operations	528	
18.8	Network Analysis	531	
18.9	Surface Analysis	533	
18.10	Geovisualization	538	
	<i>Exercises</i>	549	
<b>19.</b>	<b>Planning, Implementation, and Management of GIS</b>		<b>551</b>
19.1	Introduction	551	
19.2	Planning of Project	551	
19.3	Implementation of Project	556	
19.4	Management of Project	558	
19.5	Keys for Successful GIS	560	
19.6	Reasons for Unsuccessful GIS	562	
	<i>Exercises</i>	562	
<b>20.</b>	<b>Modern Trends of GIS</b>		<b>563</b>
20.1	Introduction	563	
20.2	Local to Global Concept in GIS	564	
20.3	Increase in Dimensions in GIS	564	
20.4	Linear to Non-linear Techniques in GIS	564	
20.5	Development in Relation between Geometry and Algebra in GIS	565	
20.6	Development of Common Techniques in GIS	565	
20.7	Integration of GIS and Remote Sensing	566	
20.8	Integration of GIS and Multimedia	566	
20.9	3D GIS	572	
20.10	Integration of 3D GIS and Web GIS	575	
20.11	4D GIS and Real-time GIS	577	
20.12	Mobile GIS	578	
20.13	Collaborative GIS (CGIS)	581	
	<i>Exercises</i>	582	
	Appendix A Concept of Map, Coordinate Systems, and Projection		583
	Appendix B Concept on Mathematical Topics		604
	Acronyms and Glossary		629
	Bibliography		669
	Index		676