

REMOTE SENSING RESEARCH IN INDIA : TRENDS AND PROSPECTS

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INTRODUCTION

In recent years, there has been a shift in the environmental research from local/regional to national/global level. This is being focused on the scale and extent of human activities which induce global changes, threatening the geosphere-biosphere sustainability. This requires attention towards understanding spatial change of human activity and the environment, its process and effects, its monitoring and forecasting, the development of information system and the application of new areas of science, i.e. remote sensing and GIS technology (Deekshatulu and Jairam, 1991, Deekshatulu and Rajan, 1984, Singh, 1990, Singh, 1991; Singh, 1992).

The environmental problems are essentially multidimensional and multi-tiered in character. Till recently, scientists from various disciplines approached these problems in a fragmented and independent manner. There is a need to provide update and reliable environmental information within earthwatch and provide the necessary data integration technology to transform the monitored data into useful information to address environmental issues at global, national, and local level (Singh, 1990).

However, policy makers and environmental managers are not getting the information they

need for the sustainable management of environmental resources. Traditionally, information needed for environmental research and management has come from the earth's environment. As conventional ground methods (Brandenberger and Ghosh, 1991) of resource surveys are mostly incapable, there is a need for remote sensing application for monitoring dynamic character and up-to-date position of natural resources (Agarwal, 1984). Recently, space observation through remote sensing (Madhavan Unni and Roy, 1979) has emerged as an extremely powerful tool to detect and monitor such environmental changes and challenges. (Singh, 1991). This provides ability to cover the globe with the uniform instrumental system that integrates data into large scale measurements.

The development of modern data-gathering techniques and computer assisted cartography opens new possibilities of data storage and exchange. The combined use of Geographic Information Systems (GIS), and digital image processing provide better prospects of environmental monitoring and forecasting over wider areas within limited time-span. It would be easy to develop predictive model capabilities in order to achieve effective public policy in years to come. This has direct implications for national development.

HISTORICAL DEVELOPMENT OF REMOTE SENSING ACTIVITIES

On global scale, digital cartography or computer assisted cartography came into existence in 1964 when Bickmore and Boyle displayed prototype of the Oxford system of automated cartography. However real development had taken place in 1967 when Digital Cartography Unit was established under Natural Environmental Research Council. In India, digital cartography came to be a reality in the eighties.

Since last two decades, India has relentlessly pursued her ambitious space programme. With the launching of her own satellites, India has earned a coveted place in the exclusive space club. Realising the growing importance and indispensability of remote sensing, the Indian Space Research Organisation (ISRO) was set-up in 1969 in Bangalore to steer India's space endeavour. An earth station of NRSA, Department of Space, operationalised in 1979 has greatly augmented the data flow systems.

Indian Remote Sensing Satellite (IRS-1A) was launched on March 17, 1988. Since then IRS-1A has so far successfully provided considerable progress towards country's remote sensing needs. For utilisation of Indian satellite data, the Department of Space has set up five Regional Remote Sensing Service Centres (RRSSCS) at Bangalore, Dehradun, Jodhpur, Kharagpur and Nagpur. The main objective of the project is to provide regional services and training, primarily digital image processing facility and expertise to the users of the region. These centres will also provide support services and software development to conduct regional and national level projects. Subsequently, remote sensing centres have also been established at the state level. About 21 state governments have already set-up State Remote Sensing Applica-

tion Centres. A few such centres are located at Lucknow, Patna, Gauhati, Ahmedabad, Bhubaneswar, Jaipur, Madras, Bombay and Thiruvantapuram.

Realising the immense importance of remote sensing in resource survey and environmental management, many scientists working at central and state government departments, universities and research institutes are being trained in various application areas. In India, many centres and institutions offer training and education programme in the country (Table 1, 2 and 3).

APPLICATION OF REMOTE SENSING

The satellite remote sensing plays an effective role in natural resource inventory, desertification and drought monitoring, geological, geomorphological and environmental hazard mapping (NNRMS, etc.). It provides vast scope to explore and analyse resources of underdeveloped regions. Scientists are making use of the features of different bands : near infra-red and middle infra-red to detect plants, blue, green, near and middle infra-red for soil, and radar waves for hydrological studies.

GEOMORPHOLOGY AND GEOSYSTEM STUDY

The most frequent applied area of remote sensing in India is the study of earth's sub-surface and surface features (Deekshatulu and Kamat, 1984; Murthy *et al*, 1982; Singh *et. al*, 1988). Aerial photographs are the effective tool for the geological (Bhan and Krishnuni, 1984; Babu and Singh, 1982; Bhattacharjee *et al*, 1980), geomorphological, relief and hydrological studies and land use mapping. Geomorphic units have been identified based on interpretation of the aerial photographs (Murthy, *et. al*. 1980; Raghavswamy and Vaidyanathan, 1988) and the Survey of India topo-sheets and the landset imageries

in the Pali district (Vats, 1987), Jodhpur District (Singh, 1983), Luni basin (Dhabriya, 1984), and Tripura state (Bhattacharya, 1980). These geomorphic units (Srinivasan and Gopal, 1982) have different physical potential and provide a sound base for land use planning.

Based on aerial photographs, a study of Hiran catchment (Jabalpur district) highlights the physical and hydrological characteristics of the area, using quantitative analysis (Singh, 1985) for land resource development and management (Rakshit, 1980). Series Level Soil Map project was started in Hasdo subwatershed in Jangir tahsil of Bilaspur district to prepare a series level soil map on 1:15,000 scale. Finally, conception of a stereoscopic model and morphometric interpretation for slope and erosion phases were established.

Based on irrigation, cropping pattern and physical attributes namely watersheds, slope, landforms, lithology, soils, land use and hydromorphic units (Muley and Nayak, 1983), the land suitability of agricultural use are identified (Rudhviraju and Vaidyanathan, 1980; Rao and Vaidyanathan, 1981; Rao, 1985).

An integrated resource survey aimed at making a comprehensive survey of land and water resources in Idukki district of Kerala was carried out jointly by the SAC of ISRO and the Kerala State Land Board. About 270 maps on 1:15,000 scale, have been prepared on land use, geomorphology and structural geology. This enabled the planners to come out with a comprehensive plan for the region.

The National Remote Sensing Agency carried out a survey for soil association mapping, land degradation and ground water exploration to aid drought relief in Bundelkhand region of Uttar Pradesh. On the basis of maps prepared, further geophysical exploration was taken up to suggest areas suitable for tube-wells and dug-wells, etc.

Drought monitoring is an important aspect of satellite monitoring in Maharashtra state. The study for the period 1986-1989 provides invaluable database to study inter annual biomass production, agro-climatic zoning and rain-use efficiency in addition to its use in drought monitoring. In the year 1986, the NRSA completed the survey and mapping of wastelands in India using landsat satellite data. The study utilises the 190 Landsat' MSS FCC images to map on 1:1 million scale and estimates the gross area and types of waste lands.

The Himalaya (Kawosa, 1988; Singh, 1991, and 1992) have an important place in the life of North India. To study the vegetation, soil and drainage basins, a total number of 126 images in bands of 5 and 7 were acquired covering the entire Himalayan region in different seasons of the year on the basis of which broad land use types were delineated, of course with more emphasis on the forest vegetation.

GEOLOGY AND MINERAL RESOURCES

A pilot project on Geological Information System was initiated by Geological Survey of India (GSI) working on new projects—project Singhbhum and project Bhusampada (on lines similar to project "Vasundhara") in eastern and Northern region, respectively. Some of its achievements have been in delineating the bauxite-capped plateaus in the eastern Ghats of Andhra Pradesh and Orissa and location of buried deposits of calcareous nodules in the alluvial tracts of Uttar Pradesh and desert terrain of Rajasthan. Similarly, airborne multi-spectral scanner data (Subrahmanyam, 1983) are being used in locating zones of geothermal energy like hot springs, hot spots, etc. Another aerial survey of geology of Maner-Godavari valley (Andhra Pradesh) was conducted covering an area of 2900 km². Photo interpretation helped in delineating formation boundaries on the basis of photo recog-

nitiation elements, tones and textures, etc. (Perumal and Thillaigovindrajan, 1980). Construction of 56.58 m. high composite dam across the Tapi river, downstream of its confluence to the Sipra Nadi was studied extensively through aerial photography of 200 km² area. The scale chosen was 1:60,000 and the focus was to examine the geologic and geomorphic structure of the proposed dam-site. LANDSAT imageries of precambrian hardrock and desert terrains of Rajasthan were visually analysed and compared with ground data compiled on similar scale to determine their potentiality for regional geological interpretation (Gadekar, 1981) and feasibility of preparing small scale geological and tectonic maps of the region.

HYDROLOGY AND WATER RESOURCES

The first category of ongoing projects comprise ground water potential zone mapping, national drought monitoring, prioritization of watershed in the Brahmaputra basin (Krishnauni and Duara, 1980) and flood plain management for major river basins (Dhanju, 1980). Other projects refer to water management in command area, environmental studies of major river valley projects. Snow-belt run-off model development, microwave remote sensing, digital terrain models, etc. Sensing water is done mainly through infrared scanning for instance warm water emits more energy thus appearing brighter than cool water and it becomes easy to record the temperature of water bodies. In India, remote sensing is used for monitoring the aspects such as measurement of evapotranspiration, measurement of water surface roughness, rainfall distribution and infiltration pattern, ground water discharge, identification of subaqueous features of large lakes and reservoirs, salt content of water and light absorption.

Aerial photographs are utilized to get information regarding regional water storage, season

and long term fluctuations of lake and river surface aerial extent, assessment of underground (Seelan, 1982) and soil moisture, flood coverage and damage, etc. Water pollution can also be detected by the interpretation of aerial photographs (Verma, 1986, 1988, Sharma and Sinha, 1983).

The weather satellite imagery is used to monitor ice and snow cover conditions providing important inputs for water management and flood prediction. The central water commission (CWC) has deployed in DCPs in the Yamuna catchment area for flood forecasting. Even within a week the inundated areas can be mapped. Nine such flood maps were already prepared for the Brahmaputra and the Godavari basins between June and September.

Conventional aerial photographs and topographic sheets do not lend an adequate support for effective mapping of dynamic relief features, e.g. in case of flood plain. For quick appraisal of the dynamic nature of flood plain, it is necessary to use remote sensing data either in the visual interpretation or digital data for correct estimates (Vaidyanathan, 1983).

The potential of ground water has been investigated with reference to the geomorphic units, and relevant geological aspects. The occurrence and potential has been evaluated for the five major geomorphic units as river-built plain, broad valleys with infilled sediments, narrow valleys, active pediment, and piedmont zone which have been recognised and delineated on aerial photographs and landsat imagery. Several abandoned channels provide good aquifers for the accumulation of sub-surface water. Other structural features, e.g. fracture and faults can be identified also (Krishna Bhagavan and Ramana Rao, 1985).

The emerging technique of image Bathymetry is very useful in the areas of mobile sea bed and in the studies of coastal erosion where no

recent hydrographic surveys are available. With the help of image Bathymetry, coastal features (Sharma, 1980) and depths coastline, low water line reefs and islands, are delineated particularly using observed spectral reflectance by the sensors as recorded in Landsat Imagery specially in bands 4 and 5 (Prakash and Jha, 1986). Another study describes the lineaments in the coastal area of Goa identified on aerial photographs (Wagle, 1982).

ATMOSPHERE AND METEOROLOGY

The multipurpose INSAT sends information half-hourly, in the infrared band, and imageries of the weather systems over India and adjoining areas. This gives vital information for a detailed monitoring of the weather and an accurate forecasting. It also relays information sent by 100 unmanned Data Collection Platforms (DCPS). These DCPS have been installed in remote and uninhabited areas from where they keep transmitting meteorological data. The regular reception of the imageries of data has vastly improved weather forecasting.

Our country is ravaged by severe cyclonic storms in the east coast. In the cyclone-prone areas of coastal Andhra Pradesh and Tamil Nadu, 100 disaster warning systems (DWSs) have been installed. When a cyclone is detected heading for the coast, the satellite relays a signal from the Area Cyclone warning centre in Madras to DWSs in the villages in its path. The DWSs emit a siren which warns the villagers to head for shelters. The ideal case in witness, regarding the usefulness of remote sensing in forecasting cyclones, is the timely warning of impending cyclone in coastal Andhra Pradesh in May 1990. If the warning had not sounded, the damage could have been devastating. Similarly, flood forecasting has become much more easier. The Satellite Microwave Radiometer (SAMIR) has been functioning to provide water vapor content of atmosphere, rainfall rate over oceanic regions,

and surface winds over oceans. Abnormal composition of atmosphere, cloud cover and location of depressions, can be detected well in time.

FOREST MONITORING

India's forest areas (Tiwari and Singh, 1990, Singh, 1991) have been decreasing rapidly, and a system of continuous operational monitoring is necessary. A system of sampling should also be developed (Singh, 1986). Coloured infra-red aerial photography helps to assess the annual occurrence of losses especially in the less accessible areas. Fire can be detected by thermal scanners.

It is through remote sensing that the actual forest cover of India was known through findings of satellite data analysis in India as highlighted by Rao (1991). The country has 20 percent of land area under forest cover, of which only 10.88 per cent forms the closed forests of adequate density. In the last 40 years, as much as 4.32 million ha of forest land has been lost, 0.7 million ha encroached upon and the rest subjected to shifting cultivation. Deforestation has increased because of large-scale consumption of fuelwood. Each year Bangalore consumes 0.4 million tonne of fuel wood which is equivalent to 5000 ha of forests. The cattle carrying capacity of forests for grazing is 90 million head against the 400 million cattle population (Rao, 1991).

The first attempt to categorise forest cover types by computer analysis of Landsat digital data was done in 1978 for Nagaland. In this study, a colour-coded categorised map delineated the broad forest cover types. Similar studies in Mizoram and Andhra Pradesh were also conducted. In a study conducted by NRSA, the satellite digital covering of entire Periyar-Thodupuzha drainage basin was analysed. Multistage approach is being adopted by the Indian Remote Sensing which gives informa-

tion like timber volume using stratification of imageries obtained from space. Apart from forest land classification, stock mapping and volume estimation, remote sensing is also used for damage assessment and fire detection which is a common feature of Indian forests.

Use of aerial photographs or other imageries is to complement and improve or reduce field work rather than absolutely replacing it. The Forest Survey of India prepared forest cover type and land-use maps on 1:50,000 and 1:63360 scale by interpreting medium to small scale panchromatic aerial photographs for about 4,20,000 km² in India. The main application of remote sensing in forest management has been for timber harvest planning and monitoring logging and deforestation. The Forest Survey of India (FSI) has also suggested establishing about 30 industries relating to pulp and paper mills, plywood, saw mills, fiber board, hard board and newsprint, based on the results of forest inventory using aerial photo interpretation. This project was applied extensively in central India, Kerala, Andhra Pradesh and Manipur.

LAND USE / LAND COVER MAPPING

Using IRS-LISS - 1 data in 274 districts through visual interpretation and 168 selected districts through digital techniques, agro-climatic zones of India are being analysed. For the first time, two season satellite data both for Kharif and Rabi are used to precisely estimate the agricultural land (Murphy, *et al* 1984) in Kharif and rabi season. Landsat data has been used intensively for land use mapping (Gautam and Narayan, 1983; Kalara, 1991; Manchanda, *et al*, 1983; Seelan, *et al* 1983; Singh, 1991). Recently under this programme one of the projects refers to changes on land use because of urban spread (Pant and Singh, 1991), while another project emphasises industrialization in Ahme-

dabad-Vapi region.

The salient features of the programme are crop acreage and production estimation, watershed prioritization, command area, crop inventory, surface water monitoring for rabi crops, etc. The recent action plan includes preparation of remote sensing methodology manuals and crop acreage and production estimation for multiple dry land crop regions. Area under wheat is relayed by the season even before it is harvested in the states of Punjab, Haryana, western Utter Pradesh and parts of Madhya Pradesh and Rajasthan. The Department of space is also working on ways to accurately forecast crop yields from a variety of remotely sensed parameters (Venugopal, *et al* 1991).

DEVELOPMENT OF GEOGRAPHIC INFORMATION SYSTEMS

Of course, internationally, the research on GIS started in the early sixties, however in India, it is the recent phenomenon (Singh, 1990, 1991). It is also sometimes known as Land Information System or Environment Information System. The preparatory stage of GIS (1978-1980) began with the theoretical approach followed by software development, setting up research groups and organising some regional experimental researches and training programme (Singh, 1992).

NATIONAL NATURAL RESOURCES MANAGEMENT SYSTEM (NNRMS)

The NNRMS project was started in 1988 by the Department of Space to adopt a holistic approach to rational management of natural resources of the country. A few current project include launching IRS-IC and ID with incorporation of multi-spectral sensor and panchromatic camera with better than 10 metre resolution, crop acreage of production estimation using colour infrared photographs, agri-

cultural drought monitoring and assessments, saline and alkaline soil mapping, fish catch potential zones using sea surface temperature (SST), detail survey of the Brahmaputra and the Ganga estuaries, establishment of a remote sensing centre in North-Eastern region, etc. This undertook the task of preparing forest type mapping and monitoring in Baratang forest division (Andaman Island). The NNRMS is actively engaged in generation of integrated data. Their analysis through ARC/INFO system display geographic data in digital form and dissemination of information system.

REMOTE SENSING : CHALLENGES AND THE TASK AHEAD

The comprehensive space research programme for the future integrates satellite remote sensing within six areas of studies of the land : ice and atmosphere, theoretical and modelling studies, and laboratory - based analytical programme. These six measurements are necessary for local surface sampling and validation of satellite remote sensing data. Space use technology requires instrumental development like multi-channel imaging spectrometers, SAR, Lidar, Laser altimeter, Radar and high resolution images. By around 1996, the new generation of satellite like polar orbiting platforms will provide impetus to such activities. The atmosphere and land-observation satellites should be enhanced with higher spatial and temporal resolution and microwave remote sensing programme. The future programme should address problems relating to data continuity, access, acquisition and information systems. Like other countries, it is being realised that remote sensing by itself could not satisfy all information requirements of applications and that it should be supplemented with data from various sources, thus GIS is started as warehouse of remote sensing data merging with georeferenced data sets. A comprehensive study for national standard

for the exchange of digital geo-referenced information should be initiated. The multi-disciplinary information systems, i.e. NNRMS of the Department of space and NRDMS of the Department of Science and Technology need to be extended. A state and district level natural resource management should also be created to optimally utilise the resources.

Apart from establishing National Data Centre, national data archives should also be promoted. It is also essential that data can be freely exchanged among scientists in different institutions. National data sets include administrative and natural boundaries, elevation, slope, soils and soil degradation, vegetation and vegetation index, population, cultivation intensity, roads and railways, hydrology and watersheds, protected areas, livestock ecosystems, temperature and rainfall, evaporation and windspeed, etc.

Future application will focus on digital terrain models, digital cartographic data base, NRIS/ GIS, etc. There is an urgent need to develop a strategy to improve the existing 10 x 10 km Digital Elevation Model using national data sets. The IGBP-DIS suggests that substantial effort is required in the pre-processes of the data sets (radiometric calibration, atmospheric correction, geometric correction and temporal compositing) with several aspects requiring additional research before standard procedures can be established.

Coping with global change scenarios, pilot studies should concentrate on land cover, vegetation index, inter comparison study of surface temperature and data directory study. World-wide experience shows that remote sensing and GIS can be very effective tools for problems of natural resource management when carefully evaluated and applied within an appropriate conceptual framework. The new age of micro-computers and increased potential for information exchange would aid

in assembling these new programmes like developed countries through the next decade and into, the next century.

A detailed land capability classification should be conducted using remote sensing and GIS technology, especially for the highlands and the Himalaya region prone to land degradation to be used for the formulation of integrated land use plan. The arid zone monitoring includes agricultural improvement and desertification study. There is a need to prepare national atlas of desertification containing regional /local case studies. Data on vegetation index may also be used from NOAA weather satellites. India should join in worldwide initiatives to have first 8-km resolution global data sets of AVHRR products and subsequently 1-km data base.

A creation of biosphere reserves which is considered as restored polygon in different biogeographic regions, is one of the important programmes of Government of India. UNSECO-MAB initiated programme as an integral part of a wide spectrum of complementary and transverse scale observations from Man-on-the ground to geosynchronous satellites and polar orbital platforms. Such a vast task can be largely assisted by recent advances in computer-based GIS. In the wildlife census, the fish counts, migratory bird numbering, their resting spots, etc. could be photographed through thermal infra-red light imagery, this would provide a considerable management input to the protected areas and biodiversity.

As we move into the 21st century, the increasing gap between water supply and water demand will cause complex problems for human needs. In order to assess inland water resources and increase our understanding of the dynamics of the hydrological and biogeochemical cycles, the applications of remote sensing need to be refined and enhanced at local, regional and global scales. Some promising hydrological remote sensing research areas are the measurements of evapotranspiration, soil moisture, snow run-off and erosion, etc.

India is one of the largest coastline country and derives substantial socio-economic benefits from its coastal marine resources. The sustainable benefits require considerable improvement from application of remote sensing to improve both utilization and management of these resources.

Links between the scientific communities and the space agencies need to be improved. Close collaboration between academic institutions and central/state government departments will further improve remote sensing education. Various remote sensing sources should also be extended at various levels with suitable syllabuses in disciplines like geosciences, hydrology, marine science, agriculture, urban planning and engineering, etc. Young scientists will require appropriate training in GIS technology, access to data preferably free of charge and opportunities for regional and inter-regional collaboration.

APPENDIX - I

Educational Institutes offering Post-Graduate Programmes

<i>Name of Institute</i>	<i>Course</i>
1. Anna University, Madras	M. Tech. (<i>Remote Sensing</i>)
2. Roorkee University, Roorkee	M. E. Civil Engineering (<i>Remote Sensing & Photogrametry</i>)

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| 3. | Indian Inst. of Technology,
Kanpur | M. Tech. Civil Engineering
(<i>Remote Sensing</i>) |
| 4. | Indian Inst. of Technology,
Bombay | M. Tech. Civil Engineering
(<i>Remote Sensing</i>)
M. Tech. Computer Science
(<i>Image Processing</i>) |
| 5. | Aligarh Muslim University | M. Tech. (<i>Remote Sensing Applications</i>) |
| 6. | Jamia Millia Islamia | M. A./M. Sc. Geography (<i>Remote Sensing</i>) |
| 7. | B.H.Birla Science & Tech.
Centre Jaipur. | M. Tech. (<i>Remote Sensing</i>) |
| 8. | Andhra University, Waltair | M. Tech. (<i>Remote Sensing</i>) |
| 9. | University of Delhi, Delhi | M.A./M.Phil. Geography
(<i>Remote Sensing & GIS</i>) |
| 10. | Indian School of Mines, Dhanabad | |
| 11. | School of Planning
and Architecture, New Delhi. | |
| 12. | Bhartidasan University. | |

APPENDIX - II

Remote Sensing Training Centres

1. National Remote Sensing Agency, Hyderabad.
2. Indian Institute of Remote Sensing, Dehradun
3. Institute of Remote Sensing (IRS), Anna University, Madras
4. Centre of Studies in Resource Engineering, IIT, Bombay.
5. Regional Remote Sensing Service Centre at Bangalore, Dehradun, Jodhpur, Nagpur and Kharagpur.
6. Space Application Centre, Ahmedabad
7. Geological Survey of India, Training Institute, Hyderabad.
8. Forest Survey of India, Dehradun
9. National Institute of Oceanography, Goa.
10. National Bureau of Soil Survey & Land use Planning, Nagpur/Bangalore
11. Survey Training Institute, Hyderabad.

APPENDIX - III

Remote Sensing Data Utilisation Facilities

Organisations/Institutions that have visual interpretation equipment facilities like stereoscope, illuminating magnifier, sketch master, additive colour viewer, large format optical enlarger, micro densitometer etc. :

University of Bombay

All India Soil and Land use Survey (AIS & LUS - DAC), Delhi.

Centre Arid Zone Research Institute (CAZRI-ICAR), Jodhpur.

Central Ground Water Board (CGWB-MOWR), Lucknow & Hyderabad.

Centre for Earth Science Studies, Trivandrum.

Department of Mines & Geology, Madras.

Directorate of Town & Country Planning, Madras.

Geological Survey of India (GSI-DOM), Jaipur.

National Institute of Hydrology (NIH), Roorkee.

National Natural Resources Management System (NNRMS-DOS), Bangalore.

State Government Departments such as Birla Institute of Scientific Research, Jaipur.

The State Remote Sensing Applications Centres such as Gujarat State Remote Sensing Application Centre, Vadodara, Kerala State Landuse Board, Trivand MP Council of Science and Technology, Bhopal, and Orissa Remote Sensing Application Centre, Bhubaneswar.

Organisations/institutions that have facilities for interpretation and some precision mapping instruments like room transferscope, stereoroom, transferscope, avopret, stereoplotters, etc.

Atomic Minerals Division (AMOD-DAE), Hyderabad.

Academic Institutions such as Indian Institute of Technology (IIT), Kanpur; Indian Institute of Technology (IIT), Kharagpur and Madras University.

Geological Survey of India (GISI-MOS & M), Calcutta.

Indian Institute of Remote Sensing (IIRS), Dehradun of Department of Space.

National Remote Sensing Agency (NSRA), Hyderabad.

Oil & Natural Gas Commission (ONGC-MOP & NG), Dehradun.

Survey of India (SOI-DST), Dehradun & Chandigarh.

Space Application Centre (SAC), Ahmedabad.

State Remote Sensing Centres - Such as Institute of Remote Sensing (IRS-AU), Madras, Remote Sensing Application Centre (RSAG-UP), Lucknow, State Departments such as Directorate of Mines & Geology, Bhubneswar, Maharashtra Research Institute, Nasik.

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