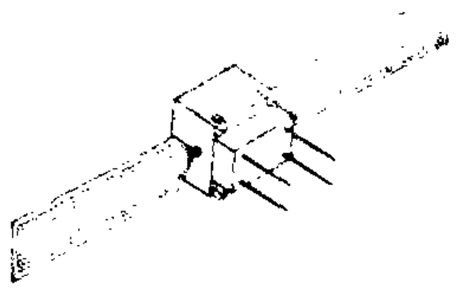

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Remote Sensing for National Development

Infrastructure in India for Analysis of Remotely Sensed Data

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ABSTRACT: *Towards realising the goals of National Natural Resources Management System (NNRMS), conceptualised as an integrated resources management system, the first step has been to establish indigenous space and ground segments. While the space segment consists of operationalisation of the IRS Series of satellites, appropriate data reception, dissemination and analysis facilities/infrastructure form the ground segment. This paper highlights the achievement made in the establishment of data analysis facility in the country.*

INTRODUCTION

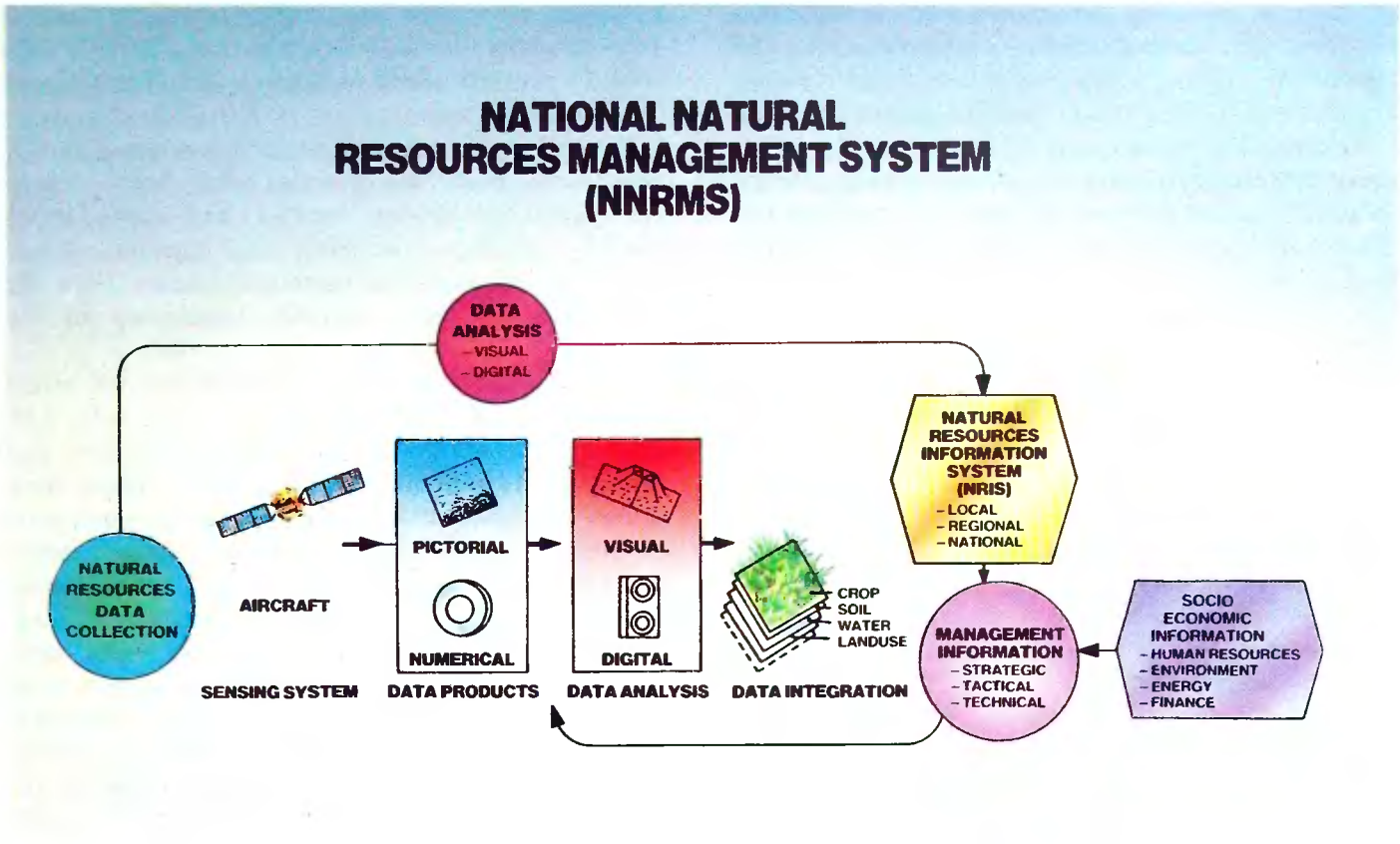
The National Natural Resources Management System (NNRMS) is conceptualised as an integrated resource management system to aid towards optimum management of the natural resources. Ensuring an indigenous base for appropriate space and ground segments, with basic data analysis facilities for the utilisation of satellite-based remote sensing technology, has been the first step in this direction. The successful launch and operationalisation of IRS-1A spacecraft in 1988 was a major milestone in the establishment of indigenous space segment. The data reception facilities at Shadnagar near Hyderabad operated by National Remote Sensing Agency ensures the continuous availability of satellite data to the user community from IRS-1A as well as contemporary satellites such as Landsat and NOAA.

The facilities for data analysis and interpretation form another major component of the remote sensing infrastructure. In this paper an attempt is made to briefly summarise the facilities available with the Central and State governments as well as academic institutions for analysis and interpretation of remotely sensed data for various applications.

DATA ANALYSIS METHODS AND AIDS

Analysis of data or image interpretation, as is commonly called, is defined as the art of examining images for the purpose of identifying objects or surface features and deducing their properties. Interpreters study remotely sensed data and attempt, through logical processes, in detecting, identifying, classifying, measuring and evaluating the significance of physical and cultural objects, their patterns and spatial relationships. Image interpretation can be attempted either by visual or digital techniques of analysis.

Visual interpretation is the identification of objects/classification manually by an analyst from the hard copy photographic prints/diapositives. The fundamental photo elements and the image characteristics seen on image which aid in visual interpretation are (i) tone or colour, (ii) size, (iii) shape, (iv) texture, (v) pattern, (vi) location, (vii) association, (viii) shadow, and (ix) aspect. Based on these image characteristics, a visual interpretation key is evolved for each of the thematic classes, which enables an interpreter, with basic knowledge and interpretation skill, to identify different categories of objects on the satellite imagery. The photogrammetric techniques enable quantitative assessment of terrain features such as location, distance, extent, height, etc., using relatively simple equipment and geometric concepts for obtaining precise maps, and measurements, through the use of sophisticated in-



strumentation and complex computational techniques.

Some of the commonly available visual interpretation aids are:

(i) Optical Reflecting Projector, which produces reduced and enlarged line diagrams/pictures of 5:1 and 1:5 ratio from hard copy images.

(ii) Optical Pantograph, which generates reduced and enlarged images with geometric rectification and distortion correction for aerial photographs and satellite images.

(iii) Optical reflecting enlargers, such as PROCOM which provide magnification upto 76 times with a provision of capturing enlarged images through a camera attachment.

(iv) Digital Planimeter, which provides areal estimates of any land use category for the thematic maps.

(v) Zoom Transferoscope, which facilitates generation of input image by ensuring the removal of tilt and diagonal distortions with respect to standard-base map, from aerial, satellite pictures and line maps.

(vi) Mirror Stereoscope, which provides a 3D perspective to categorise better terrain characteristics for proper delineation of landforms, height and slope estimation.

An alternative method for data analysis is through the computer assisted image analysis procedure of spectral pattern recognition by using the inherently digital nature of remotely sensed data. A typical spectral pattern recognition procedure comprises three distinct steps, viz. (i) compiling an interpretation key, by developing numerically the spectral attributes for each feature/type of interest, called training sets, (ii) comparing each pixel in the image with each category in the numerical interpretation key, and (iii) assigning the name of the category it resembles, known as classification. After the entire data set has been categorised, the results are presented in the form of a map.

By dealing with the image data quantitatively, the spectral information in virtually any number of bands can be fully evaluated. Additionally, correct radiometry and maximum resolution of the remotely sensed data favoured by digital techniques facilitate consistent results. For applications involving interpretation of spectrally discriminable features over large areas, spectral pattern recognition techniques provide a cost-effective means of data analysis as compared to the visual interpretation process which is labour intensive and therefore, expensive for large area inventories.

However, just as humans are limited in their ability to interpret spectral patterns, computers are limited in their ability to evaluate spatial patterns. Therefore, visual and numerical techniques are complementary in nature, and careful consideration must

be given in selecting the approach (or combination of approaches) fitting specific applications. A wide assortment of image processing techniques for application to various fields are presently available. Contextual, syntactic and layered classifiers are some of the innovative approaches, which provide additional image elements, such as association, shape and effective local reference, in digital domain akin to visual interpretation. New hardware and software concepts, characterised by fast data throughput enable users to handle large volumes of data interactively.

Various levels of digital image analysis systems (DIAS) are available ranging from Super-mini/Mini computer-based system to PC-based systems. These Systems provide capability to take inputs in the form of Computer Compatible Tapes (CCTs), Cartridge Tapes (CT), Floppies and maps, and analyse the data using various techniques such as enhancements, classification, rectification, etc., and produce hard copy output in the form of high precision films/paper.

The capabilities of DIAS have been further enhanced in recent times with the addition of Geographic Information System (GIS). GIS facilitates integration of data from various sources, such as maps, aerial photographs, satellite images, socio-economic data and other tabular statements into a format that allows the data to be compared and interrelated for extraction of information to make decisions about the real world. It is also possible to use known relationships to model geographically the outcome of a set of conditions. A number of GIS packages are available commercially on different computer platforms ranging from Super-mini Computer to PC Systems.

INFRASTRUCTURE/FACILITIES

Potential capabilities of Remote Sensing were recognised even as early as in the late seventies and early eighties and facilities for both visual and digital analyses were established at the National Remote Sensing Agency (NRSA), Hyderabad and Space Applications Centre (SAC), Ahmedabad. These Systems were based on PDP-11 and VAX-11/780 Computers.

Towards providing appropriate facilities of digital analysis and interpretation for the users in the country, five Regional Remote Sensing Service Centres (RRSSCs) have been set up by the Department of Space in collaboration with major user departments. The RRSSCs are located at Bangalore, Dehra Dun, Jodhpur, Kharagpur and Nagpur. These facilities are set up around a VAX-11/780 computer system with image processing functions. Multi-user terminals have been provided to facilitate several users to utilise the facilities at a time. The RRSSCs are also provided with indigenous Intelligent Image Graphics Terminals.

The philosophy adopted for infrastructure development has been to energise the user departments/agencies at the central and state levels towards identifying the basic requirements and provide essential technical support/assistance from the Department of Space towards setting up of the facilities.

Extensive facilities are available, either for visual interpretation or for digital analysis or for both, with various Central/State government organisations and academic institutions. As many as 21 States have already set up state level remote sensing application centres as part of NNRMS activities. These Centres are essentially equipped with visual interpretation facilities, such as stereoscope, illuminating magnifier, additive colour viewer and large format optical enlargers. Facilities for interpretation, and some precision mapping instruments like zoom transferoscope, stereo zoom transferoscope, aviopret, stereoplotters are available with major survey organisations and institutions in the States. In addition, a few States such as Tamil Nadu and Uttar Pradesh, Punjab, Haryana, Orissa and Madhya Pradesh have digital analysis facilities. Other State Remote Sensing Centres are in favour of setting up digital analysis facilities.

Central Government Departments like National Institute of Oceanography, Goa; Oil & Natural Gas Commission, Dehra Dun; National Forest Data Management Centre, Dehra Dun; Central Water Commission, Delhi; Geological Survey of India; National Bureau of Soil Survey and Land Use Planning, Nagpur; National Thematic Mapping Organisation, Calcutta; All India Soil and Land Use Survey Organisation, New Delhi, and several others, as indicated in table 1, are equipped with visual and digital interpretation equipments.

Figure 1 depicts the geographic distribution of remote sensing data utilisation facilities in the country. The details on the visual, digital and GIS facilities available at State/Central/Academic Institutions are given in table 1.

FUTURE PLANS

The ultimate goal of NNRMS is to establish a National Resources Information System (NRIS) to meet the needs of decision making at a (i) Strategic level, where policies are framed, (ii) Tactical level, where policies are converted into implementation programmes, and (iii) Technical/Operational level, where the

actual implementation takes place in order to facilitate optimal exploitation of the various natural resources in the country. While Remote Sensing derived information on all the natural resources such as forests, crops, wastelands, land use, minerals, water resources, soils, topography, terrain conditions will be contained in the information system, the socio-economic indicators will be added to the information in the form of GIS. The Information System thus evolved, is planned to be built around the existing systems by adding strength/capability. Notable amongst these are National Informatics Centre's DISNIC and Computerised Information System Project (CRISP), and National (Natural) Resources Data Management System (NRDMS).

The operational remote sensing programme is now

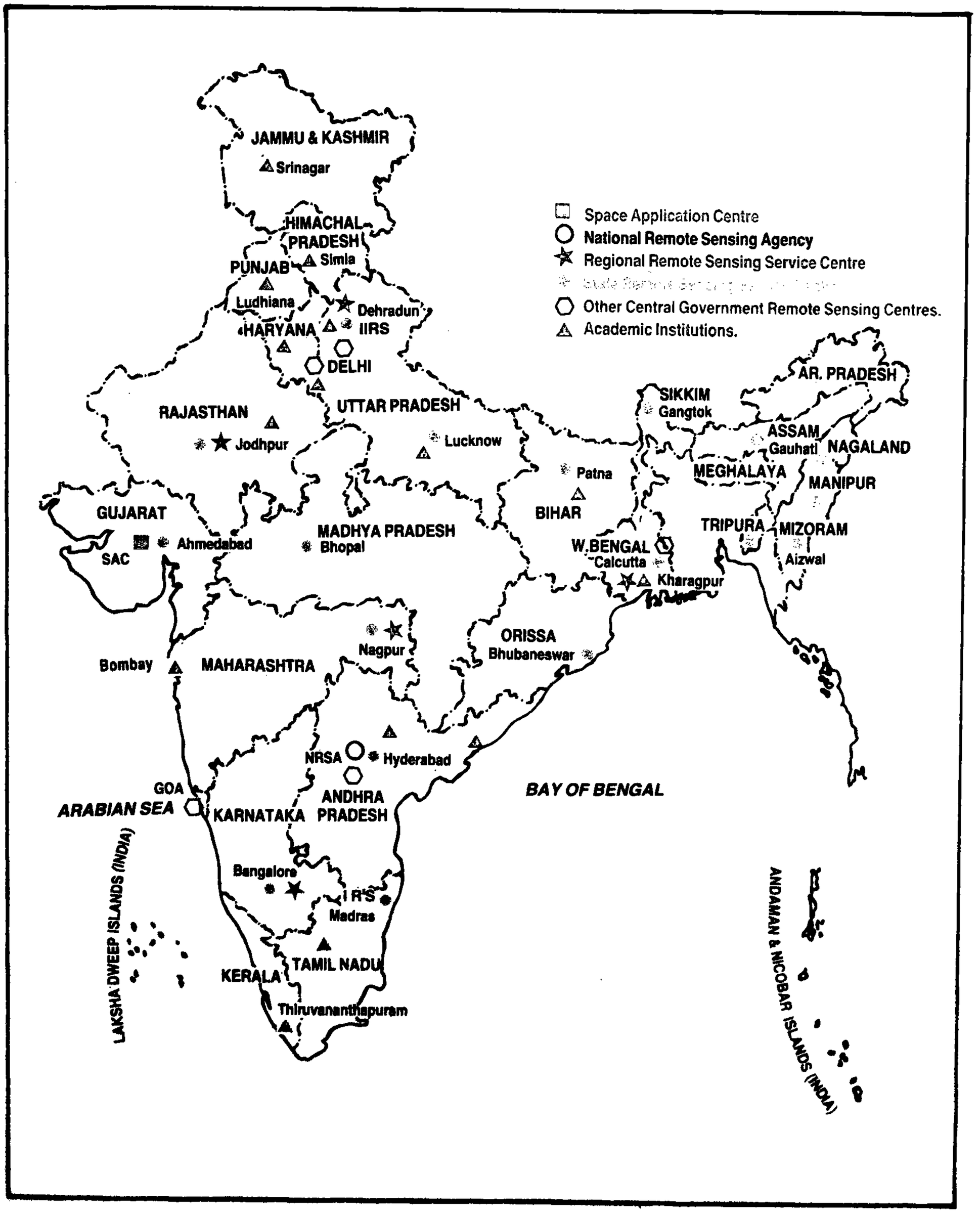


Figure 1. Remote Sensing Facilities in India

well poised to reach even greater heights, through the series of satellites planned to be launched following IRS-1A, to ensure data services to the users, on a continued and assured basis. A great deal of indigenous development, both in space and ground segments as well as in application areas have provided wide ranging opportunities for the application scientists at the various work centres for furthering the scope of utilisation of remote sensing technology for the benefit of the country.

Table 1. RS data analysis and GIS facilities available with the different organisations

Sl. No.	Organisation	Facilities Available		
		Visual	Digital	GIS
DOS Centres				
1.	Space Applications Centre, ISRO, Ahmedabad	Yes	Yes	Yes
2.	National Remote Sensing Agency, Hyderabad	Yes	Yes	Yes
3.	Regional Remote Sensing Service Centres			
	(i) Bangalore	Yes	Yes	Yes
	(ii) Dehra Dun	Yes	Yes	Yes
	(iii) Jodhpur	Yes	Yes	Yes
	(iv) Nagpur	Yes	Yes	Yes
	(v) Kharagpur	Yes	Yes	Yes
4.	Indian Institute of Remote Sensing (IIRS), Dehra Dun	Yes	Yes	Yes
State Centres				
1.	Assam Remote Sensing Applications Centre, Guwahati	Yes	No	No
2.	Andhra Pradesh State Remote Sensing Applications Centre, Hyderabad	Yes	No	No,
3.	Bihar Remote Sensing Applications Centre, Patna	Yes	No	No
4.	Gujarat State Remote Sensing Organisation, Vadodara	Yes	No	No
5.	Himachal Pradesh Remote Sensing Cell, Shimla	Yes	Yes	No
6.	Haryana State Remote Sensing Applications Centre, Hissar	Yes	Yes	No
7.	Institute of Remote Sensing, Madras	Yes	Yes	No
8.	Jammu & Kashmir RSAM, Srinagar	Yes	No	No
9.	Karnataka State Remote Sensing Technology Utilisation Centre, Bangalore	Yes	No	No
10.	Kerala State Land use Board, Thiruvananthapuram	Yes	No	No
11.	Maharashtra Remote Sensing Centre, Nagpur	Yes	No	No
12.	Mizoram Council of ST & E, Aizawl	Yes	No	No
13.	Madhya Pradesh Remote Sensing Applications Centre, Bhopal	Yes	Yes	No
14.	Manipur State Remote Sensing Centre, Imphal	Yes	No	No
15.	Orissa Remote Sensing Applications Centre, Bhubaneshwar	Yes	Yes	No
16.	Punjab Remote Sensing Centre, Ludhiana	Yes	Yes	No
17.	Planning & Co-ordination Dept., Nagaland, Kohima	Yes	No	No
18.	Rajasthan State Remote Sensing Applications Centre, Jodhpur	Yes	No	No
19.	Sikkim RSAC, Gangtok	Yes	No	No
20.	West Bengal Science & Technology Dept., Calcutta	Yes	No	No
21.	U. P. State Remote Sensing Application Centre, Lucknow	Yes	Yes	No
Other Central Govt. Depts.				
1.	Air-borne Mineral Survey & Exploration Wing, GSI, Bangalore	Yes	No	No

Sl. No.	Organisation	Facilities Available		
		Visual	Digital	GIS
2.	Central Water Commission, New Delhi	Yes	No	No
3.	Central Arid Zone Research Institute, Jodhpur	Yes	No	No
4.	Central Marine Fisheries Research Institute, Kochi	Yes	No	No
5.	Centre for Earth Science Studies, Thiruvananthapuram	Yes	No	No
6.	Forest Survey of India, Dehra Dun	Yes	Yes	No
7.	Locust Warning Organisation, Jodhpur	Yes	No	No
8.	National Institute of Oceanography, Dona Paula, Goa	Yes	Yes	No
9.	Remote Sensing Laboratory, ONGC, Dehra Dun	Yes	Yes	No
10.	All India Soil and Land Use Survey, New Delhi	Yes	Yes	No
11.	National Bureau of Soil Survey and Land Use Planning, Nagpur	Yes	No	Yes
12.	National Thematic Mapping Organisation, Calcutta	Yes	No	No
13.	Atomic Minerals Division, Hyderabad/ Nagpur	Yes	No	No
14.	National Environmental Engineering Research Institute, Nagpur	Yes	No	No
Academic Sector				
1.	Centre for Studies in Resources Engg. IIT, Bombay	Yes	Yes	Yes
2.	IIT, Kharagpur	Yes	Yes	No
3.	IIT, Kanpur	Yes	Yes	No
4.	Dept. of Geo-engineering, Andhra University, Waltair	Yes	No	No
5.	National Institute of Hydrology, Roorkee	Yes	No	No
6.	B. M. Birla Science & Technology Centre, Jaipur	Yes	No	No
7.	Jamia Millia Islamia, New Delhi	Yes	No	No
8.	Roorkee University, Roorkee	Yes	Yes	No
9.	Bharathidasan University, Tiruchchirappalli	Yes	No	No
10.	Regional Engineering College, Warrangal	Yes	No	No