SPACE TECHNOLOGY FOR DISASTER MONITORING AND MITIGATION IN INDIA

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ABSTRACT

In recent years, a number of major disasters (like natural, technological, or ecological) have made the global community aware of the immense losses of human lives and productive resources that are caused regularly by such calamities. With diverse geographical environment, population distribution, and level of economic development, the occurrence of multi-facet disasters in India including floods (caused the largest property damage), droughts (affects the most number of people), earthquakes (claimed the most lives), and cyclones (frequent disasters), etc., have increased manifold. During 1990s - the International Decade for Natural Disaster Reduction (IDNDR), an attempt should be made to strengthen scientific investigation towards disaster monitoring and mitigation activities. Efficient disaster monitoring and mitigation plans requires effective information systems which can utilize remote sensing and Geographic Information System Technology. The report highlights the use of space technology for disaster studies in India. The task is to harmonise the available information from various sources i. e. field work, aerial photographs, and satellite imagery with existing data sets as well as maps so that the resultant synthesis becomes campatible with the National Data Base Management Systems. The remote sensing and GIS application for disaster reduction strategies comprise disaster preparedness, hazard zone mapping, forecasting systems, risk assessment, and warning systems, etc.

Key words: Disaster monitoring, flood, drought, cyclone, earthquake, remote sensing, GIS, forecasting, hazard risk, early warning and mitigation plan.

International Center for Disaster-Mitigation Engineering

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APPENDICES

LIST OF ABBREVIATIONS

AVHRR	Advanced Very High Resolution Radiometer
CGWB	Central Ground Water Board
CODAPS	Coastal Ocean Design and Prediction System
COSTED	Committee of Science and Technology for Developing Countries
CWC	Central Water Commission
DCP	Data Collection Platform
DOD	Department of Ocean Development
DRDA	German Space Agency
DWC	Disasters Warning Center
EMS	Environmental Monitoring Society
ERS	Earth Resources Satellite
FCC	False Color Composite
FSI	Forest Survey of India
GIS	Geographic Information System
GPS	Global Positioning System
GSI	Geological Survey of India
IDNDR	International Decade for Natural Disaster Reduction
IGBP-DIS	International Geosphere - Biosphere Programme - Data and Information System
IGU	International Geographical Union
IIRS	Indian Institute of Remote Sensing
IIT	Indian Institute of Technology
IMD	Indian Meteorological Department
INCEDE	International Center for Disaster - Mitigation Engineering
INSAT	Indian National Satellite
IRS	Indian Remote Sensing Satellite
ISRO	Indian Space Research Organisation
LIS	Land Information System
MAB	Man and the Biosphere
MSS	Multi Spectral Scanner
NADAMS	National Agricultural Drought Assessment and Management System
NAGI	National Association of Geographers, India
NASA	National Aeronautics and Space Administration(USA)
NGRI	National Geophysical Research Institute
NGSI	National Geographical Society of India
NNRMS	National Natural Resources Management System
NOAA	National Oceanic and Atmospheric Administration(USA)
NRDMS	Natural Resources Data Management System
NRSA	National Remote Sensing Agency
RRSSC	Regional Remote Sensing Service Center
SAC	Space Application Center
SAMIR	Satellite Microwave Radiometer
SAR	Synthetic Aperture Radar
STC	Scientific and Technical Committee
VHRR	Very High Resolution Radiometer
VLBI	Very Long Baseline Interferometry

1. 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 and mechanism of natural disasters which threaten the geosphere-biosphere sustainability. This requires attention towards understanding of spatial change by 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, 1991, 1992, 1993).

The environmental hazards are essentially multi-dimensional and multi-tiered in character. Till recently, scientists from various disciplines approached to examine 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 issues relating to disaster monitoring and mitigation at global, national, and local level (Singh, 1990; IGBP,1988) (Figure 1).

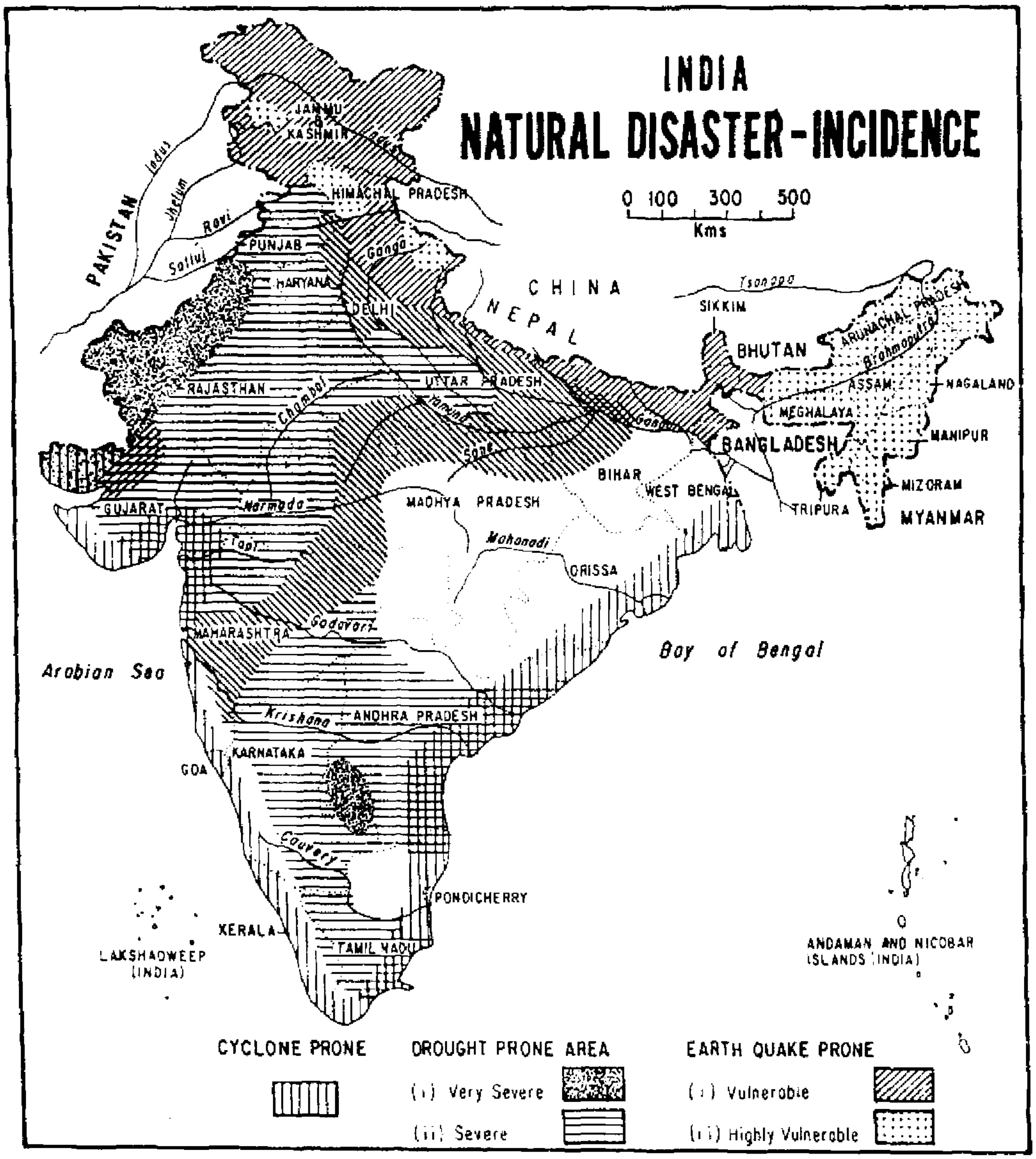


Figure 1: Natural Disaster - Incidence of India
(Source: Ministry of Agriculture)

2. DISASTER MITIGATION AND ENVIRONMENT

The Scientific and Technical Committee (STC) of International Decade for Natural Disaster Reduction (IDNDR) identified following actions to be undertaken as part of disaster reduction strategy:

a. Identification of hazard zones and hazard assessment.
b. Vulnerability and risk assessment, cost/ benefit analysis.
c. Awareness at level of decision and policy-makers.
d. Monitoring, prediction and warning.
e. Long-term prevention measures, including non-structural and structural measures.
f. Short-term protective measures and preparedness.
g. Early- intervention measures.

In above context, the application of space technology has great potential for implementing a disaster mitigation plan. With the new technological innovation of hazard monitoring and warning equipment, such as digitization, telemetry and satellite telecommunication systems, the monitoring and prediction systems got strengthened. This is further supplemented by timely and comprehensive data from space and other sources especially in the environmental and meteorological fields.

However, policy makers and environmental managers are not getting the information they need for the disaster management and environmental planning. Traditionally, information needed for environmental research and management has come from the earth's environment. As conventional ground methods (Brandenberges and Ghosh, 1991) of resource surveys are mostly incapable to cope with rapidly changing environment, 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 a uniform instrumental system that integrates data into large scale measurements (Deekshatulu, 1991, 1992; Karasudhi et al., 1987).

3. SPACE TECHNOLOGY AND DISASTER MONITORING AND MITIGATION

The space systems and their remote sensing applications have provided new possibilities to focus attention on various disasters both man-made and natural. The space technology plays an effective role in the monitoring of disasters to assist the level of preparedness and to minimise the loss of life.

The development of modern data-gathering techniques and computer assisted cartography give new impetus of data storage and exchange. Subsequently, 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 in national development. Many new initiatives (like International Center for Disaster-Mitigation Engineering (INCEDE)) are being introduced by various agencies to develop innovative projects that have a substantial disaster reduction potential (Katayama et al.,1992). The German Space Agency (DARA) is initiating pilot projects in India and Mali. NASA and the Italian Space Agency also organised workshops on the application of space technologies to disaster management and prevention. Many projects are already in operation at global level. This is a strong need to integrate space technology and ground networks for monitoring and forecasting purposes. This includes Geographic Information System (GIS), Image Processing, Expert Systems, Global Positioning Systems (GPS), Spatial Database Management System and visualization with user-friendly interfaces. A combination of GPS and GIS would be effective in risk assessment and mitigation of disasters, and would be helpful for constructing a model of an early warning system (Table 1).

TABLE 1: THEMATIC CONTENT THROUGH IMAGE PROCESSING

Parameter	Application	Spatial Frequency	Temporal Frequency
Soil			
types	Geochemistry, agriculture, forestry	30m	Annual
moisture	Hydrology, geochemistry	30m - 10km	Weekly
erosion	Agriculture, geochemistry	30m	Annual
carbon, nitrogen	Geochemistry	30m	Monthly
permafrost	Bioclimatology	30m	Annual
Surface temperature			
land	Bioclimatology	1km	12h
inland waters	Pollution, climatology	30m	12h
ocean	Climatology	1 - 4km	12h
ice	Climatology	1km	Daily
Vegetation			
types	Resource analysis	30m	Annual
	Geochemistry,bioclimatology	1km	Weekly
composition	Resource analysis	30m	Weekly
condition	Geochemistry, bioclimatology	1km	Weekly
Land use	Demography, planning Resource analysis	10 - 30m	Annual
Snow	Hydrology	1km	Weekly
Radiation (SW, LW)	Climatology, hydrology	1km	Daily
Precipitation	Climatology, hydrology	1km	Daily
Phytoplankton	Fisheries, biogeochemistry	1 - 4km	2 days
Turbidity	Pollution, erosion, geochemistry	30m - 1km	2 days
Surface elevation			
land	Geomorphology, hydrology, ecology	10 - 30m	10 years
ocean	Oceanography	25km	2 days
Rock mineralogy	Geology, pedology	30m	10 years

Some important earth surface parameters that can be measured remotely, and required spatial and temporal sampling frequencies for various applications (from Maguire D. J., 1991).

Some of these capabilities (e.g. satellite communications and storm tracking) are already available, others (e.g. flood and fire mapping, drought monitoring) are beginning to be used operationally while still others (e.g., mobile communications, landslide forecasts) are just being developed (Walter, 1992).

4. HISTORICAL DEVELOPMENT OF REMOTE SENSING

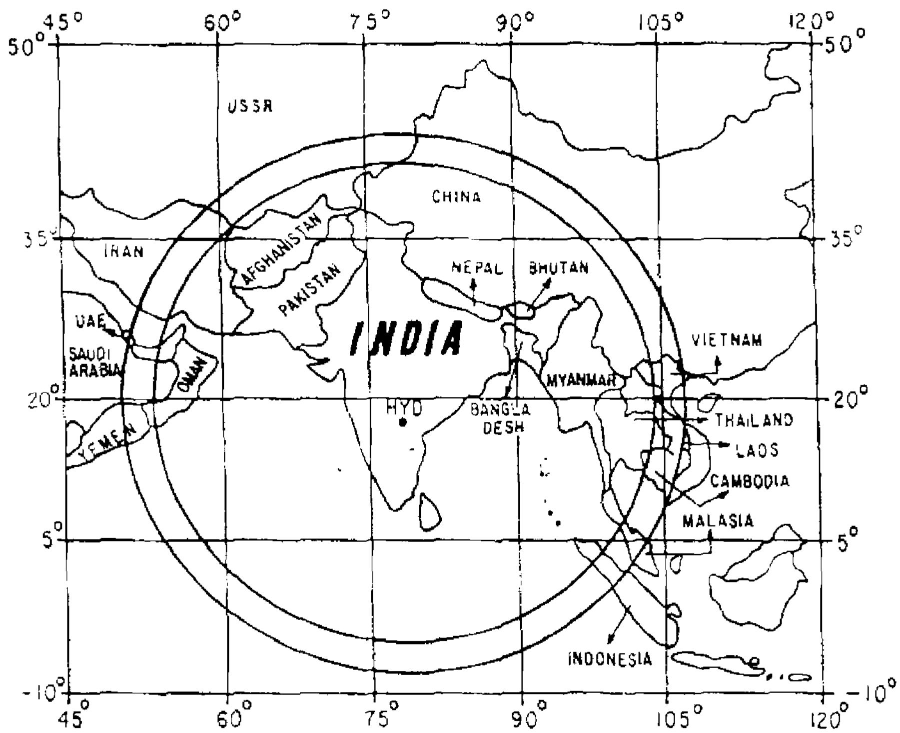
On global scale, digital cartography or computer assisted cartography came into existence in 1964 when Bickmore and Boyle displayed prototype of the Oxford system of automated cartography. However real development had taken place in 1967 when Digital Cartography Unit was established under Natural Environmental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

During last two decades, India has relentlessly pursued an 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 endeavor. An earth station of the National Remote Sensing Agency (NRSA), Department of Space, operationalised in 1979, has greatly augmented the data flow systems (Chandrasekher et al., 1992).

Indian Remote Sensing Satellite (IRS-1A) was launched on March 17, 1988. Since then IRS-1A has successfully provided considerable information towards country's remote sensing needs. For utilisation of Indian satellite data, the Department of Space has set up five Regional Remote Sensing Service Centers (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 centers will also provide support services and software development to conduct regional and national level projects (Figure 2).

Subsequently, remote sensing centers have also been established at the State Level. Twenty one State Governments have already set- up State Remote Sensing Application Centers. A few such centers are located at Lucknow, Patna, Gauhati, Ahmedabad, Bhubaneshwar, Jaipur, Madras, Bombay and Thiruvantpuram (Table 2 and Figure 3).

COVERAGE OF IRS RECEIVING STATION FOR 2° & 5° ELEVATION



COUNTRIES COVERED BY THE INDIAN STATIONS

CATEGORY B

(COUNTRIES FULLY COVERED BY THE INDIAN IRS STATION)		(COUNTRIES PARTIALLY COVERED BY IRS STATION)
Pakistan	..	Iran (50 %)
Afghanistan	..	Saudi Arabhia (10 %)
Oman	..	Peoples Democratic Republic of Yemen (35%)
Srilanka	..	China (45 %)
Bangla Desh	.	Laos (95 %)
Nepal	.	Vietnam (50 %)
Myanmar		Malaysia (50 %)
Bhutan	.	Combodia (75 %)
Thailand	..	Indonesia (1 %)
United Arab Emirates	.	USSR (1 %)

Figure 2: Coverage of IRS Receiving Station for 2° and 5° Elevation (Source: Department of Space)

TABLE 2 IN-ORBIT REMOTE SENSING SATELLITES

Existing

Satellite	Spatial Res (m)	Spectral Bands	Swath (km)	Repetivity (Days)	Data Availability From
INSAT-1 (GSO)	VHRR VIS 2750 IR 11000	VIS, IR	India and Surroundings	Half-hourly	1B - 1983 1D - 1990
IRS - 1A	LISS-1 73.0 LISS-2 36.5	VIS, NIR	148	22	1A - 1988
IRS - 1B	LISS-1 73.0 LISS-2 36.5	VIS, NIR	148	11	1991

Future

IRS1C/1D	PAN 10.0 LISS-3 23.0 WIFS	VIS, NIR SWIR 189	70 141 774	24	1993-94/96-97
INSAT-IIA	VHRR VIS IR	VIS, IR 2000 8000	India and Surroundings	33 mins.	1992

Source : Based on Reports, Department of Space

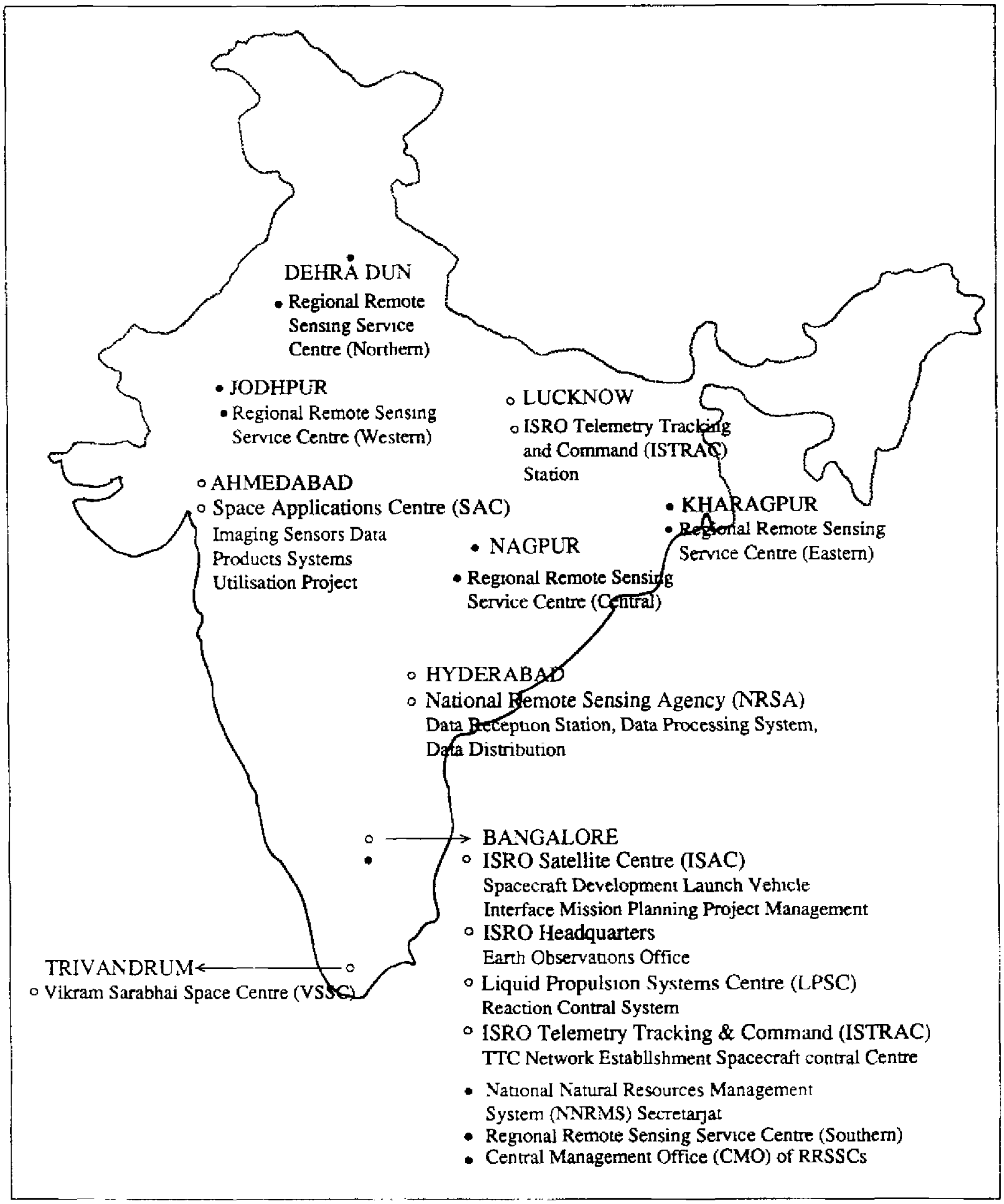


Figure 3: Major Work Centres for IRS-1A Mission
(Source: Department of Space)

5. REMOTE SENSING TECHNOLOGY AND DISASTER MITIGATION

India is considered as one of the highest disaster prone regions with about 85 per cent of the country prone to some type of disaster. In recent years remote sensing and GIS technology have been effectively used for disaster monitoring and mitigation. The Indian National Satellite System - INSAT is a unique multi-purpose system not only in its technical configuration but also in its utilization in the fields of meteorology, telecommunication and the broadcasting. The Very High Resolution Radiometer (VHRR) operating in visible and infrared bands provides cloud cover imagery which is an essential input for weather forecasting system, particularly during the monsoon and pre-monsoon periods. The remote sensing satellites also provides effective mechanism for monitoring various disasters and creating database on disaster impact, risk assessment and relief planning. Indian satellites and receiving stations generate extensive data which is used for disaster prone mapping, early warning, monitoring and mitigation of hazards i.e. droughts, floods, landslides, etc..

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 centers and institutions offer training and education programme in the country (Appendices 1-4).