Indian Earth Observations Satellites and Applications - Reaping Social Benefits

V.S. Hegde
Antrix Corporation Limited, Bangalore

1. Introduction

With humble beginning in early 60s, the Indian Space Programme has established its strong identity among contemporary space programmes of the world. During the past decades, simultaneously pursuing technology innovations, the Indian Space Research Organisation (ISRO), the flag-bearer of country's space programme, has launched over 70 spacecraft for a variety of applications such as observing earth resources, providing communications and location based services, and carrying out scientific studies of the earth system including planetary aspects.

Internationally, observing earth from space started with the image of the 'blue marble' taken in 1972 by the crew on Apollo 17. Since then, the capability to look at the earth from space, over the past 50 years, has fundamentally transformed peoples' view of the Plant Earth. Further, over time, it has advanced remarkably with quantitative measurements of the earth features and variables related to land, ocean and atmosphere. Imaging the earth from space has opened up new vistas in scientific and technological fields, as made possible miniaturising the mighty earth into synoptic domain. In the process, the satellite based observations led to new discoveries, transformed our understanding of the earth science, unfolded new opportunities of research, and provided important societal benefits by aiding in optimizing the decision making in developmental processes.

Keeping the momentum and pace with advanced nations, the Indian Earth Observations Programme, encompassing the space, ground and applications segments, has clearly demonstrated the various roles that Earth Observations could play in catalysing the developmental processes at different levels of administrative and societal hierarchy.

2. Evolution of the Indian Earth Observation (EO) Programme

In India, EO activities were initiated with the pioneering experiment on detection of coconut root-wilt disease carried out in 1970 using colour-infrared aerial photography obtained from a helicopter. This was the precursor to establishing operational remote sensing activity in the country. This was followed by many studies conducted using aerial data, and also data from the American Landsat series of satellites from 1972 onwards. The major experimental campaigns have been Agricultural Resources Inventory and Survey Experiment (ARISE), Mandya Crop

Inventory Experiment, Land use Studies of Idukki area and Integrated Resources Survey of Panchmahals, Gujarat. These studies were carried out by ISRO in association with different collaborating agencies.

2.1 The Experimental Phase

Concurrently, pursuing the technological quest in satellite building, ISRO successfully developed and launched experimental satellites - Bhaskara-1 in 1979 and Bhaskara-2 in 1981. These satellites, carrying an optical payload providing data at 1 km spatial resolution in two spectral bands and a microwave radiometer, were aimed at getting hands-on experience in satellite building, telemetry and tele-command operations, data reception and processing. The optical payload on board these satellites was slow a scan vidicon camera with capability to collect images in 0.54 to 0.66 and 0.75 to 0.85 micrometre bands, and passive microwave radiometer having 19, 22, 31 GHz channels.

The optical and microwave data collected from the Bhaskara I & II experimental satellites during 1976-82 provided valuable experience and insight into a number of aspects, such as sensor system definition and development, conceptualisation and implementation of a space platform, data reception and processing, data interpretation and utilization, and integration of remotely sensed data with conventional datasets for natural resources management. The capability to build operational satellites for remote sensing became clearly visible with the successful completion of the Bhaskara programme. Around this time, in 1978, a Joint Experiment Programme (JEP) was launched with intensive test sites in the country, for ground verification of space data, in close collaboration with user agencies; this lead to improved understanding of user requirements.

With this background, the Indian Space Programme leaped into development of national operational satellite-based remote sensing system in the 80s to ensure generation of spatial and temporal information on vital natural resources sectors such as Agriculture, Land, Water, Forestry and Geology. A unique institutional framework called 'National Natural Resources Management System' (NNRMS) was established in 1985 under the aegis of the union Planning Commission to steer the remote sensing applications in the country. The NNRMS framework helped in optimal integration of remote sensing inputs with conventional data; and, realised in a highly cost and time effective manner.

2.2 The Operational Era

Having gained experience through the foregoing, and in the quest to address the national developmental needs, the satellite based remote sensing system got firmly established in the country with the launch of the first operational Indian Remote

Sensing Satellite - IRS-1A in March 1988. This was followed by the launch of IRS-1B in August 1991. IRS-1A and 1B satellites were identical, and carried two types of cameras - LISS-I & II, with spatial resolutions of 72.5 and 36.25 m, respectively. IRS-P2 satellite with only LISS-II camera was added to this constellation by an indigenous launch in 1994. Both the LISS-I and LISS-II cameras ('LISS' meaning Linear Imaging Self-Scanner) provided highly useful data for a variety of natural resource management related studies.

With a large number of field-based campaigns carried out, predominantly over agricultural regions, for accuracy assessment; the need for improving the spatial resolution of remote sensing data was felt. As follow-on to the IRS-1A & 1B satellites, IRS 1C & 1D missions were planned with improved payloads such as a panchromatic (PAN) camera, LISS-III camera and a Wide Field Sensor (WiFS). The PAN camera operated in the 0.50 to 0.75 micrometre range with spatial resolution of ~5.8 m and a swath of ~70 km. The PAN camera was also the highest spatial resolution imager among the civilian space-based systems in the world at the time of launch of the IRS-1C satellite in 1995. Following, the four-band multi-spectral camera LISS-I/ LISS-II was modified into a four band multi-spectral LISS-III camera with inclusion of Short Wave Infra-Red (SWIR) band in place of blue band. Need for detection of moisture-stress in crops and snow-cloud discrimination were the driving forces for inclusion of the SWIR band. The spatial resolution of LISS-III was 23.5 m in green, red and NIR bands, and 70 m in SWIR band. IRS-1C incorporated enhanced capabilities in terms of spatial resolution, spectral bands, stereoscopic imaging, wider swath/ coverage and better revisit capability. The unique capabilities of IRS-1C were harnessed for a range of newer applications in different thematic areas. IRS-1D, identical to IRS-1C, was launched in September 1997, to maintain continuity of data services to the on-going projects and also to cater to newer initiatives.

While the availability of data from the operational remote sensing satellites starting from IRS-1A to IRS-1C/ 1D facilitated applications in the areas of agriculture, water resources, forestry, land use, coastal zone and cartography from regional scale to national scale; strong need was felt to design sensors for ocean observations, cartography and improved land applications.

The IRS-P3 satellite, launched in March 1996, provided good experience in studying the ocean colour using data from the MOS sensor, and helped in formulating the sensor specifications for IRS-P4 satellite, also known as Oceansat-1. The IRS-P4 (Oceansat-1), launched in May 1999, was the first Indian satellite with Ocean Colour Monitor (OCM) and Microwave Radiometer for ocean applications. The Oceansat-2, launched in 2009, carried a modified OCM and a Ku band Scatterometer to enable ocean wind vector measurements. It also carried a Radio Occultation Sounder instrument to make profile measurements of humidity and temperature. Of most recent, in February 2013, the SARAL, a joint ISRO-CNES satellite mission with Argos and a Ka-band altimeter for measurement of sea surface height and study of oceanic circulation, was launched.

In order to ensure the mission continuity for focussed on land observation, IRS P6/ Resourcesat-1 was developed and launched in 2003 with three cameras - LISS-IV, LISS-III and Advanced Wide Field Sensor (AWiFS). To utilize the full dynamic range of spectral data, a ten-bit radiometry was incorporated, particularly in the AWiFS sensor, which made the image features appear sharper. The Cartosat-1, launched in 2005, carrying a PAN camera with 2.5 m spatial resolution, was a state-of-the-art along-track stereo mission. Both Resourcesat-1 and Cartosat-1 provided valuable data, and have been much acclaimed missions globally. Many international ground stations have received data from these two satellites.

In the applications front, many national scale projects were initiated; to name a few, monitoring acreage and production forecasting of different crops at national level, snow cover monitoring of the entire Himalayas, coastal zone mapping/ monitoring, preparation of groundwater prospects maps, periodic land use/ cover mapping, and so on. Data from Cartosat-1 was used for generation of Digital Elevation/ Surface Models at 8 m posting for the entire country. Further, an important project called 'Space-based Information Support for Decentralized Planning' (SIS-DP) was initiated, to provide high-resolution thematic maps for facilitating planning at Panchayat level. The AWiFs data was extensively used by USA, and in Europe for crop monitoring.

Considering the importance of studying the earth system process in general, and to study the water cycle and energy exchanges in the tropics, the joint ISRO-CNES mission, 'Megha-Tropiques' satellite was launched in 2011. This satellite carried a conical-scanning microwave radiometer (MADRAS), multi-channel microwave humidity sounder (SAPHIR) and a radiation budget instrument (SCARAB). Megha-Tropiques formed a part of the Global Precipitation Measurement (GPM) satellite series - for carrying out rainfall measurements and related research as well as operational applications in the tropical region.

Focussing further on newer domains of space technology applications, and considering the hurdles faced by cloud cover in optical remote sensing, especially during the monsoon season; Imaging RADAR was considered necessary for the country. Accordingly, a C-band Synthetic Aperture Radar (SAR) was flown on board the Radar Imaging Satellite-1 (RISAT-1), in April 2012, for resource monitoring - particularly during the Kharif (June-September) season, flood monitoring and disaster management related applications.

On meteorology front too ISRO has made significant progress by way of building geostationary satellites for the purpose. 'Kalpana' was the first in the series of exclusive meteorological satellites built by ISRO, launched in September 2002. Kalpana carried a Very High Resolution Radiometer (VHRR) with water vapour and thermal channels with 8 km resolution, and visible channel with 2 km resolution. Following this, INSAT-3A, a multipurpose satellite was launched in April 2004 for providing telecommunications, television broadcasting, meteorological and search and rescue services. For meteorological observation in particular, INSAT–3A carried a three-channel Very High Resolution Radiometer (VHRR) and a Charge Coupled Device (CCD) camera operating in visible and SWIR bands at 1 km spatial resolution. To ensure enhanced meteorological observations, monitoring of land and ocean surfaces, generating vertical profile of the atmosphere in terms of temperature and humidity for weather forecasting and disaster warning, the 'INSAT-3D' was launched in July 2013 with improved 6-channel Imager and 19-channel Atmospheric Sounder.

Data from these satellites is regularly received, processed and disseminated to users for operational applications.

India is one of the few countries, which have end-to-end operational space programme, that are able to integrate the products and services emanating from space assets to address the developmental needs of the country. The Indian Space Programme, with INSAT, IRS and IRNSS (Indian Regional Navigation Satellite System - heading to become an operational constellation soon); the globally sought-after indigenous launchers - the PSLV and GSLV; and the host of illustrious applications and services; is one of the most cost-effective Space Programmes in the world, with a unique societal outreach.

3. Indian EO Satellites - addressing Thematic Areas

The Indian EO/ Remote Sensing satellite segment, developed in-tune with the overall goals of the Indian Space Programme, serves as a strong enabler of social transformation, a catalyst of economic development, a tool for enhancing quality of human resources, and a booster to address the national strategic needs. With these objectives, the Indian EO programme, over the years, has evolved from the initial broad-based missions to different discrete satellite series addressing thematic areas - viz., (i) the RESOURCESAT series - addressing agriculture in specific and integrated land & water resources management (this series includes the microwave satellites/ RISAT missions); (ii) CARTOSAT series - addressing detailed scale mapping & cadastral applications; and (iii) atmospheric/ ocean series - addressing land-atmosphere-ocean interactions & meteorology.

4. Earth Observations (EO) Applications in India - A few Examples

During the past decades, Indian Space Programme has made remarkable progress in building space infrastructure to accelerate various developmental processes, and harness the benefits of space for socio-economic development in the country. Since the early days of Remote Sensing with Landsat MSS data in the 70s, use of remote sensing for natural resources inventory & monitoring has come a long way in the country - graduating from demonstration phase to operational era, expanding scope to newer and newer areas over time. Today, remote sensing based actionable information/ products & services are supporting informed decision making in the country, in the areas of - food & water security, environment & eco-system management, cartography, ocean & atmospheric studies and disaster mitigation. The hallmark of the Indian EO programme is also the close cooperation between Government, Industry and Academia - forming a formidable EO triad.

In India, the space technology applications have helped in addressing the national developmental needs, and enabled creation of a comprehensive Spatial Data Infrastructure (SDI) as a national repository. Some examples of using such spatial data for management of natural resources, operationally, include: identifying environmentally degraded wastelands & reclaiming cultivable wastelands; identifying sources of drinking water - especially in hard-rock terrain, aw well as suitable sites/ zones for ground water recharge; watershed development in a holistic manner by linking livelihood system to soil & water conservation measures; irrigated/ command area management addressing issues like water-logging, salinity & alkalinity; assessment and forecasting of agricultural crop acreage & production; bio-diversity characterization at landscape level; and disaster management support for cyclone, flood, agricultural drought, landslides, forest-fire; etc. Following are some of the applications that highlight the use of EO data for societal benefits in the country.

4.1 Crop Forecasting

In globalised world, agricultural statistics is key information for taking crucial decisions related food security. Towards this, Ministry of Agriculture has been supporting a remote sensing based nationwide project called pre-harvest Crop Acreage and Production Estimation (CAPE) for providing in-season crop statistics with reasonable accuracy. Based on the experience gained through CAPE; ISRO has developed methodology for Forecasting Agricultural Output using Space, Agro-meteorology and Land-based Observations (FASAL), combining remote sensing, meteorology and econometrics for providing multiple in-season crop forecasting. This is one of the operational applications developed using remote sensing to provide forecasts of major crops with reasonable good accuracy well before the harvest. The effort has contributed to reducing the gaps between crop production and post-harvest technology, pricing and policy decisions. ISRO has also transferred the methodology of FASAL and National Agricultural Drought Monitoring Assessment Project to Mahalanobis National Crop Forecast Centre (MNCFC) of Ministry of Agriculture. Currently, MNCFC operationally provides multiple pre-harvest production forecasts of 8 crops, viz., Rice (kharif & rabi), wheat, rapeseed & mustard, potato, jute, sugarcane, cotton and sorghum (rabi) at National/ State/ District levels. The Centre also assesses the progress and severity of drought in the country towards facilitating better management of agriculture in drought prone/ affected regions.

4.2 Disaster Management Support (DMS)

DMS is another key application, which takes cognizance of the convergent technologies - satellite communication, satellite remote sensing and meteorology, towards timely delivery of operational products and services for disaster mitigation, during different phases of the disaster event. The unique capabilities of satellites providing comprehensive, synoptic and multi-temporal coverage of large areas at regular intervals with quick turnaround time has been valuable in disaster mitigation efforts. The sections below give the highlights of a few specific case studies.

Uttarakhand Flash Floods: Unprecedented heavy rainfall in parts of Uttarakhand during 16-17 June 2013 had led to flash floods and debris-flow, causing enormous destruction to life and property. Pre and post-flood satellite images were analysed and information on: (i) extent of damage to structures, roads, settlements etc., (ii) formation of new channels upstream of Kedarnath, and (iii) flow of debris from northern and north-eastern sides were provided to concerned State and Central Government Agencies in a timely manner for planning relief to the affected. Post disasters, about 2400 landslides were mapped in the disaster-affected area for implementing long-term mitigation measures.

Based on request from the State, 12 mobile satellite phones were provided to local administration in Uttarakhand for deployment in deep interior locations. About 1000 phone calls were made during the initial critical ten days. Five transportable satellite terminals (one mobile van and four fixed terminals) were established on crash basis, in the affected area, to facilitate videoconference, data & voice transfer for coordinating the rescue and relief activities.

Tropical Cyclone 'Phailin': Severe tropical cyclone Phailin (9-12 Oct 2013), a significant severe weather system, which hit the Odisha coast on 12 October 2013, was monitored extensively using India's advanced weather satellite INSAT-3D. The damage to human loss due to the cyclone "Phailin" in Bay of Bengal and the States of

Odisha, Jharkhand and Bihar was minimized due to satellite based timely early warning, and constant tracking of the cyclonic system.

High-resolution images and the sounder data from the satellite provided information on detailed structure of clouds near the centre of the tropical cyclone, cloud properties, rainfall distribution, etc., which helped in assessment of likely damage that could be caused due to the cyclonic winds. The track and intensity of the cyclone, as predicted, were disseminated through the MOSDAC website of ISRO.

Immediately after the cyclone hit, the State Government of Odisha was updated on the inundation due to floods in different rivers - at every 12 hours for the first three days, and then on daily basis; based on this, the State Administration could plan and implement the evacuation activities resulting in a very low casualty of human lives.

4.3 National Drinking Water Mission

In the last two decades, significant changes have taken place in the country in using groundwater for irrigation. Currently, about 60% of irrigated agriculture depends on groundwater sources; and close to 90% of rural domestic water supply is from groundwater. Remote Sensing data has proved its immense potential in identification of potable groundwater sources in terms of prospective locales, depth to water table & yield; and also, in identifying suitable zones/ sites for constructing recharge structures.

The project has been carried out in phases to cover the entire country; and the Groundwater Prospects Maps have been provided to respective State Agencies for using them in conjunction with hydro-geological and geophysical investigations for selecting suitable sites for drilling wells around needy habitations. The maps have also been used for locating site-specific recharge structures based on nature of underlying aquifer, site conditions, availability of water for recharge, etc.

Using these maps, over 300,000 bore wells have been drilled, across the country, with 90-95 % success rate; and over 9,000 recharge structures have been constructed.

Apart from these, a few States are using these maps in MGNREGA and Watershed Development Programmes of Ministry of Rural Development. In Gajra sub-watershed of Durg District, Chattisgarh, the Public Health Engineering Department (PHED) has constructed over 100 recharge structures of various types, such as percolation tank, stop dam, check dam, nala bund, etc.). Subsequently, it has been reported that, during 2002-2010, the water table in the area has come-up by 15 m on an average, and, at some places, even by 20 m.

4.4 Space-based Information Support for Decentralized Planning (SIS-DP)

Reliable information on land & water resources and their optimal management is vital in developmental planning. State level information repository comprising of natural resource database at 1:10,000 scale, coupled with stakeholder datasets and field- level information, helps in strengthening decentralized planning and decision making at grassroots level. In this regard, the recent initiative on 'Space based Information Support for Decentralized Planning' (SIS-DP) plays an important role in empowering the local bodies to prepare the action plans through a coordinated approach. For the 5 priority States (Andhra Pradesh, Assam, Haryana, Kerala and West Bengal), cadastral maps are also being integrated with the natural resources database. Taking advantage of the Information & Communication Technology (ICT), the information would be disseminated to grassroots through ISRO's Bhuvan Panchayat Geoportal.

4.5 Enhancing Area under Agriculture

About 16% of the country is characterized by wastelands, both cultivable and non-cultivable; and, reclamation of such lands is a must for enhancing agricultural productivity, improving ecology, and non-agricultural uses as well. Mapping and monitoring of wastelands for entire country has been carried out using remote sensing data at the behest of Ministry of Rural Development for planning and implementing various reclamation activities. The remote sensing based mapping and monitoring of wastelands has provided the estimate that the total wasteland area in the country is 46.72 mha (2009). Based on this information, Ministry of Rural Development has been planning and implementing wasteland development activities across the country. These efforts have also helped in diversification and intensification of agricultural activities especially in rain-fed areas.

4.6 Watershed Development

Watershed Development Programme is one of the major initiatives in the country towards conservation of soil & water in the rain-fed areas for enhancing agricultural production, providing livelihood security to rural people, besides halting the depletion of the natural resources. Space applications have been adapted to respond to integrated development of land and water resources, and assess/ monitor the improvements of the treated watershed.

The Integrated Mission for Sustainable Development (IMSD), carried out for 25% of country's geographical area, has significantly contributed towards implementing soil & water conservation measures in drought-prone and rain-fed areas. National Watershed Development Programme for Rainfed Areas (NWDPRA), watershed development activities in 100 watersheds spread across three States viz., Andhra

Pradesh (19), Uttar Pradesh (45) and Rajasthan (36), are being monitored using temporal satellite data (pre, first mid-term, second mid-term & post-treatment periods).

The Sujala Watershed Development Programme was implemented in 738 watersheds falling in 38 taluks distributed across seven drought-prone districts of Karnataka covering 5.12 lakh ha and encompassing about 1270 villages and 400,000 households. The project was assisted by World Bank to draw developmental plans at micro-watershed level using satellite data. Sujala was a community driven, participatory, holistic and integrated programme towards improving the production potential of degraded lands through land & water conservation measures and maximize the returns from per unit of land.

Combining of geospatial and conventional methods has resulted in arriving at a comprehensive Monitoring & Evaluation System to provide the up-to-date information at field level for tracking the project progress, outcome and impacts. The evidence-based monitoring and evaluation using top-down remote sensing and bottom-up participatory approach has helped decision makers to apply corrective measures and make appropriate policy changes, which resulted in positive impacts on the environment and socio-economic conditions. As outcome, various visible impacts were observed on ground, viz., improvement in cropping intensity by 12%, decrease in fallow lands by 10-15%; increase in irrigated crops by 8-14%; and improvement in crop yield by 6-15%. The project has received recognitions both at national and international levels, and become a role model in adopting innovations in the rural livelihood and watershed development programmes.

4.7 India-Water Resources Information Syastem (WRIS)

India-WRIS WebGIS provides a ‘single window’ solution for comprehensive, authoritative and consistent data & information on India’s water resources along with allied natural resources in a standardized national GIS framework (WGS-84 datum and LCC projection), with tools to search, access, visualize, understand and analyze the data for assessment, monitoring, planning, development, and finally, Integrated Water Resources Management (IWRM). ‘Watershed Atlas of India’ has been prepared using detailed-scale drainage network at 1:50,000 scale, Digital Elevation Model (DEM) and other ancillary data.

There are 27 basins, 101 sub-basins and 4566 watersheds in the country. The atlas depicts distribution of watersheds in basins and sub-basins along with their major water resource assets, hydrological observatories, terrain characteristics and rainfall variability, and land use/ land cover. It would serve as baseline information for water resources development and management in the country.

India-WRIS WebGIS Version 4.0 has been released. The portal contains 12 major information systems, 35 sub information systems, 95 spatial layers and a large number of attributes (> 700) with 5-100 years data of the country. The portal also provides 'Automatic Map' and 'Report Generation' facility. Based on the National Map Policy (2005) and data dissemination guidelines of Central Water Commission (CWC), the public domain version has been developed, which complies with both. The mapping of country level base layers like river network, canal network, water bodies, location of towns/ villages, road and railway network has been completed using recent IRS-P6 LISS-IV & Cartosat-1 merged data. The Version also contains 6 modules for data visualization and analysis viz., WRIS Info Discovery, WRIS Explorer, WRIS Connect, Share Success Story, Water Resources Planning & Management and Input Data Builder. Further, the newer software features added in this version include interactive mobile application, interactive live screen, text and data sharing tool and 2D-3D linked view. India-WRIS would be institutionalized at CWC following the establishment of National Water Informatics Centre (NWIC).

4.8 Web-enabled Information Systems

ISRO/ DOS has developed many Web-enabled Geospatial Information Systems viz., NNRMS Portal/ Natural Resource Data Base (NRDB) to visualize the spatial datasets generated under NNRMS programme; 'Bhuvan' for Indian Earth Observation Data Visualization; MOSDAC for Oceanography and meteorology data; BIS for Biodiversity Information; India-WRIS for water resources information; etc., to provide information services in the public domain. The ISRO data portal called "http://dataportal.isro.gov.in" provides unified access of all these databases to the user community. The services under ISRO data portal are organized under the category of Satellite Images, Land & Water, Ocean & Meteorology, Disaster Services and Planetary Science.

5. Future Perspectives

The future agenda of space applications is to further spread its wings to address developmental imperatives in various core sectors of the society with synergistic use of advanced communication, earth observation and navigation satellites; and, catalysing development of innovative applications and services towards sustainable development of natural resources, location-based services and smart governance for better decision-making, protection of environment & ecosystem, improved weather forecasting and near-real time support to disaster management.

The strategy of Indian EO programme is to ensure continuity and enhanced services to operational workhorse missions; plan newer missions by adapting and assimilating advances in technologies meeting user needs; innovative technology development both for on-board and ground systems for future missions; develop actionable EO products and services and address issues on access, affordability, timely delivery, user-friendly format and style; and work towards capacity building in user agencies and decision making bodies.

6. Conclusion

The above cited applications are just not unique concepts by themselves, but the synergy of a number of technologies, disciplines such as computers, communications, remote sensing, Geographical Information System (GIS), Global Positioning Systems (GPS), networking, etc. Today, India is rated as one amongst the 6 major space-faring nations with end-to-end capability in space technology. More than that, India has shown as to how the space technology and applications could be tailored to address the common problems faced by the society.

The underlying strategy adopted by the Indian Space Programme has essentially been building indigenous capability in this high-technology area, developing advanced systems using innovative technologies, setting up appropriate institutional arrangements in the country to adapt and absorb the innovative applications addressing the national developmental needs. The main objective has been to ultimately energize a social process to enhance the quality of human resources and empower the local community through seamless integration of space technology products and services into the societal fabric.

Thus, the Indian EO satellite programme, with strong focus on applications, mainly driven by nation's developmental priorities and with well-knit institutional framework, evolves innovative concepts to address the need of man and the society. With the emphasis shifting from the paradigm of working for the community to working with the community, the Indian EO programme aims to further penetrate to the last mile of social framework including poor and the marginalized sections. Further, the vision of Dr. Vikram Sarabhai, the father of Indian Space Programme, of building a self-reliant and indigenous Space Programme for the betterment of quality of life of the common people is being crystallized as demonstrated by the different applications directly reaching the common man.

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