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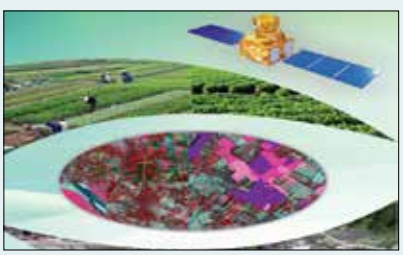

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Editorial

The intersection of space technology and rural progress in India is both vast and profound, offering solutions to challenges such as agricultural productivity, disaster management, rural education, and healthcare. Nation's space missions, such as Chandrayaan and Mangalyaan,are well known for their success in planetary exploration, the influence of space technology on the ground, particularly in rural development, is often overlooked.

Agriculture, the backbone of rural India, remains highly vulnerable to changing weather patterns, pests, and inadequate infrastructure. Space-based applications, such as satellite imaging, have revolutionized the ability to monitor crop health, water resources, and land use. These satellites provide crucial data for weather forecasting, drought prediction, and flood monitoring. Moreover, satellite imagery is used in precision farming techniques, helping farmers optimize the use of water, fertilizers, and pesticides.

Space technology plays a critical role in disaster preparedness, response, and recovery. During post-disaster recovery, satellite imagery helps assess the extent of damage and enables faster, more efficient delivery of aid and resources to affected areas. For instance, ISRO's "Bhuvan" portal offers high-resolution satellite images that can be used to assess flood damage and track recovery efforts.

Space technology also supports the development of critical rural infrastructure. ISRO's satellite-based mapping and Geographic Information Systems (GIS) are extensively used for planning rural infrastructure projects such as roads, irrigation systems, and electrification.

In rural India, access to quality education remains a persistent challenge. Space technology can play an essential role in bridging this gap by enabling satellite-based communication networks and e-learning platforms. The "EDUSAT" satellite, launched by ISRO, specifically targets the educational sector.

Access to healthcare services is another critical concern in rural India. Space technology offers innovative solutions to overcome geographical barriers. The "Telemedicine" programme, supported by ISRO, leverages satellite communication for providing healthcare consultations, diagnostic support, and medical education to rural areas.

The synergy between space technology and rural development in India is a promising and transformative force. By enabling real-time data collection, communication, and monitoring, space technology is bridging critical gaps in agriculture, healthcare, education, disaster management, and infrastructure development.

While challenges such as digital literacy, infrastructure limitations, and data accessibility remain, the integration of space technology into rural development initiatives holds immense potential for creating an inclusive and sustainable future.

The reason for choosing Space technology theme for this issue of Kurukshetra is to make our readers aware about the fast paced development achieved in this sector by India in recent years and the increasing role of this technology in governance and digitization in our country. Efforts have been made to provide real time and latest information about the role of space technology in agriculture and rural development which has the largest share in economy. ❑

ISRO's Role in Rural Development

Space technology has emerged as a transformative tool in rural development, offering innovative solutions to challenges in agriculture, water management, disaster preparedness, health, education, and infrastructure. There are several initiatives / projects, which are taken up by State and Central Government departments at micro and macro level to enrich the assets required in rural sector for the sustainable development through growth of agriculture.

* **Sudheer Kumar N**

Rural development is a critical component of the country's growth strategy, given that, in India, over 65% of its population resides in rural areas. Space technology has emerged as a transformative tool in this domain, offering innovative solutions to challenges in agriculture, water management, disaster preparedness, health, education, and infrastructure. Organizations like ISRO (Indian Space Research Organisation) and several government programmes leverage space-based applications to enhance the efficiency and reach of rural development initiatives. The satellite data and space applications contribute enormously for the sustainability of various domains.

Rural development applications are continuously focussing on water and land conservation through systematic planning and implementation of development plans in rural sector. Applications of geospatial solutions and their implementation in rural development sector provide customized near real time natural resources databases, tools for the analytics and drawing the water and land resources plans.

There are several initiatives / projects, which are taken up by State and Central Government departments at micro and macro level to enrich the assets required in rural sector for the sustainable development through growth of agriculture like Mahatma Gandhi National

* *The author is former Director, Capacity Building & Public Outreach (CBPO), ISRO Headquarters.*

Rural Employment Guarantee Act (MGNREGA), Accelerated Irrigation Benefit Programme (AIBP), Integrated Watershed Management Programme (IWMP) and On Farm Water Management (OFWM), National Health Resource Repository (NHRR) Project, Rural connectivity, which uses the latest remote sensing and GIS technologies in operational modes.

Rural health sanitation improvement programmes are also playing major role in sustainable development. Several projects are being executed for supporting Ministry of Rural Development and are useful for governance.

Agriculture and Food Security

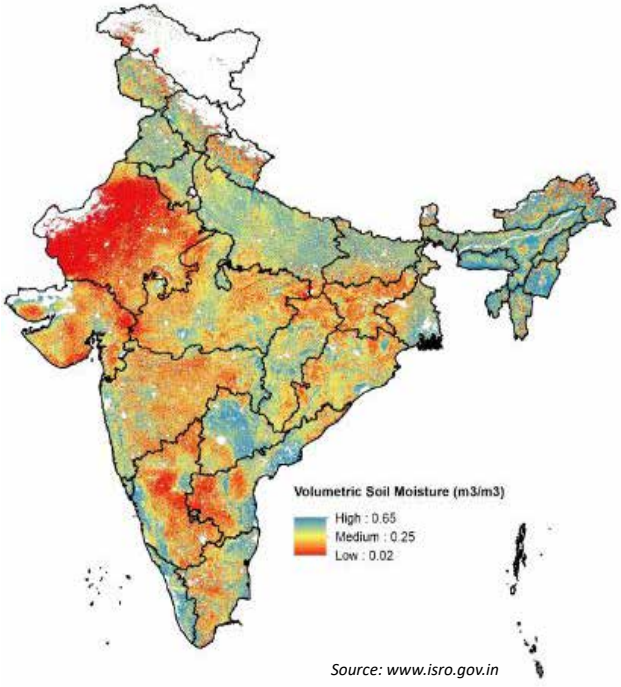
Agriculture in India holds a crucial place in the country's economy and society. As one of the largest agricultural economies in the world, India depends heavily on this sector for food security, employment, and economic development. Agriculture contributes approximately 18-20% of India's GDP. Despite a declining share in the GDP due to industrial and service sector growth, it remains vital for economic stability. India is the world's second-largest producer of rice and wheat and a leading producer of pulses. Initiatives like the Green Revolution in the 1960s boosted food grain production, making India self-sufficient in food. Agriculture accounts for about 12-15% of total exports from India.

Remote sensing satellites provide huge amount of data to assess the extent of crop for estimating the yield and analysing the productivity across various seasons and geographical regions. This facilitates planning the public distribution system and godowns for storing the food grains for ensuring the food security. It also enables the stakeholders to take decisions on the export potential of various agricultural products that are excess over domestic consumption.

The satellite imagery also provides crucial information about the crops affected by pest and its propagation to contain the extent of damage. It also provides the demand of fertilisers and pesticides based on the crops and timely distribution for effective application and control.

The land records mapping and asset tagging is very important for the farmers for regularising the loans and insurance claims in case of any calamity. The transactions will be more authenticated and secured using the satellite images to assess the extent of damage and substantiate the claims.

Satellite data is much useful in assessing the soil moisture and super-impose the soil fertility information for assessing the water demand and suggesting a



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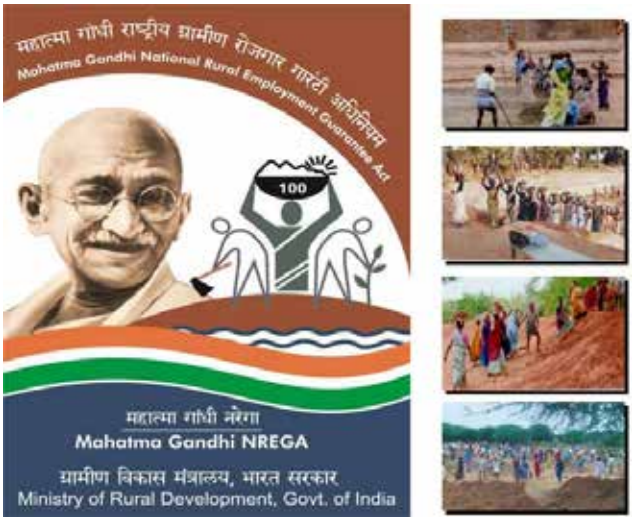
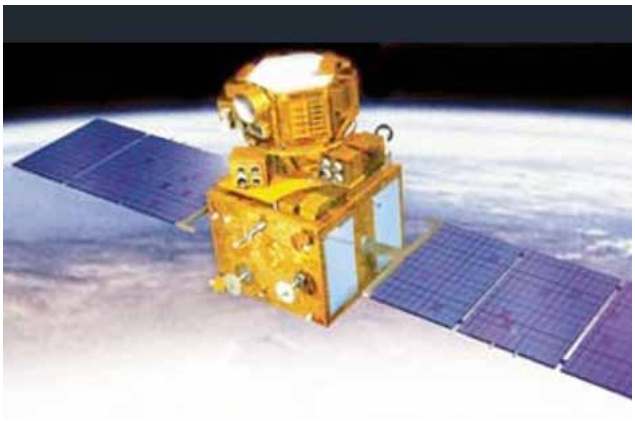


productive crop, that yields a balanced revenue for the farmers.

Majority of the farmers in India are in the small income groups and government supports them through various schemes such as *Pradhan Mantri Fasal Bima Yojana (PMFBY), Soil Health Card Scheme* etc. Satellite imagery is used to assess crop damage and determine insurance claims under this crop insurance programme, ensuring that farmers receive timely support in times of distress. The Soil Health Card provides farmers with information on soil health and fertility based on satellite and ground data. This helps them apply the right nutrients and improve productivity.

Horticulture

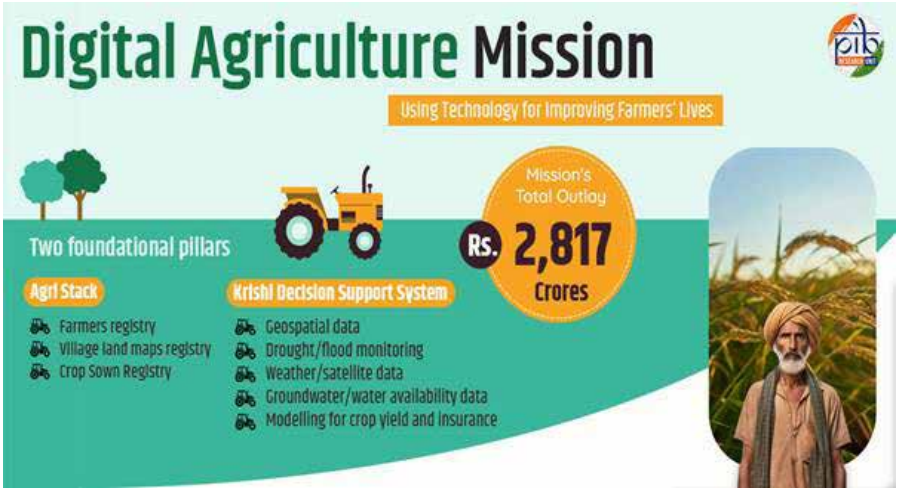
Another domain that contributes to the revenue is horticulture which includes vegetables, fruits, flowers, herbs and ornamental plants. Hyperspectral satellite data will be used to the extent of analysing stress and quality of leaves and monitoring the health of the plants. The production and yield of different seasonal fruits and vegetables play a vital role in the distribution system to



monitoring and control of the agriculture economy. This also leverages for proper planning of supply chain for a long term sustainability.

Aquaculture

Satellite imagery is increasingly being used in aquaculture to enhance productivity, sustainability, and environmental management. The remote sensing capabilities of satellites allow aquaculture practitioners to monitor and manage fish farms and aquatic ecosystems efficiently. Satellite images can help analyze water parameters such as chlorophyll concentration, turbidity, and temperature, which are crucial for site selection. Geographic data from satellites assists in identifying locations with optimal conditions for aquaculture based on factors like salinity, nutrient availability, and proximity to pollution sources. Thermal imaging from satellites helps track surface water temperatures, essential for fish and shrimp health. Satellites can detect sediment levels, indicating water clarity, which affects aquatic species' growth. By analyzing chlorophyll levels, satellites provide insights into plankton abundance, an important food source for some aquatic species. Satellite images can detect and monitor algal blooms, helping farmers mitigate risks of oxygen depletion and toxins affecting fish health. Continuous monitoring provides early warnings about blooms, allowing timely interventions. High-resolution satellite images can map aquaculture ponds, cages, and other infrastructure, ensuring proper spatial planning. Regular monitoring of aquaculture sites can track changes in water levels, vegetation, and infrastructure over time. Satellite data helps identify stressors like poor water quality or temperature fluctuations that could lead to disease outbreaks.



Digital Agriculture Mission

The Digital Agriculture Mission is designed as an umbrella scheme to support various digital agriculture initiatives. These include creating Digital Public Infrastructure (DPI), implementing the Digital General Crop Estimation Survey (DGCES), and supporting IT initiatives by the Central Government, State Governments, and Academic and Research Institutions.

The scheme is built on two foundational pillars:

- Agri Stack
- Krishi Decision Support System.

Additionally, the mission includes '*Soil Profile Mapping'* and aims to enable farmer-centric digital services to provide timely and reliable information for the agriculture sector.

The Krishi Decision Support System (DSS) will integrate remote sensing data on crops, soil, weather, and water resources into a comprehensive geospatial system.

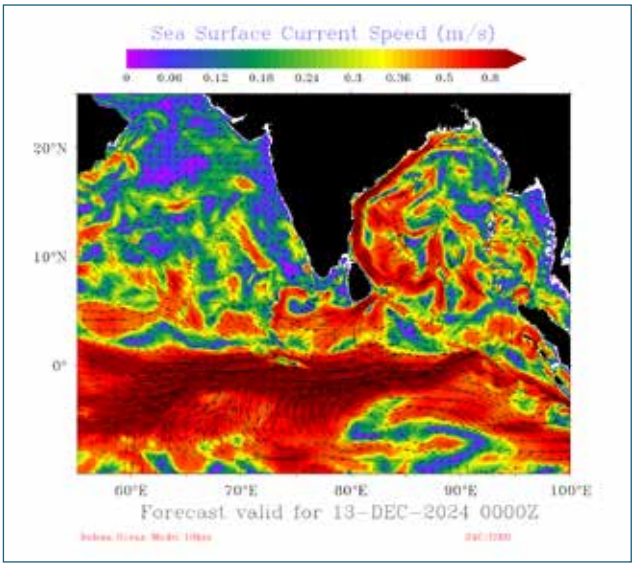
Water Resource Management

Satellite technology and data play a transformative role in water resource management by providing accurate, timely, and large-scale information about water availability, distribution, and quality. These tools aid in decision-making, planning, and sustainable management of water resources.

Mapping and Monitoring Water Bodies: Satellites can track the extent, volume, and seasonal variations of lakes, rivers, and reservoirs. High-resolution imagery maps the size of water bodies, helping assess storage capacities and trends. Multi-temporal satellite data reveals changes in water body extents due to climate variability, urbanization, or other factors. Satellite imagery assesses water clarity and sediment transport in rivers and reservoirs. Satellites detect groundwater depletion and recharge patterns. Satellite data helps in designing recharge structures and monitoring their effectiveness. Digital Elevation Models (DEMs) from satellites delineate watersheds and sub-basins.

Irrigation Management: Satellites provide data on vegetation health and evapotranspiration, optimizing irrigation schedules. Monitoring irrigated areas ensures efficient water allocation for agriculture. Satellites provide critical data on soil moisture levels, aiding drought forecasting.

Integrated Watershed Management Programme (IWMP) creates wide network of farm ponds, check dams and other soil conservation measures apart from supporting many other natural resource management actions. A geospatial data oriented Web GIS solution along with smart phone based application for achieving transparent and precise governance is developed and hosted on Bhuvan-IWMP. High resolution time series satellite images rendered in natural colour coupled with smartphone uploaded field inventory of activities are done under IWMP. With spatially explicit and detailed space based imaging of the watersheds for time periods



before the implementation of IWMP projects followed by post-implementation period, it is possible to watch the changes brought in due to activities duly validated by the near real time inventory of the field structures and activities.

8200 micro watershed projects to be monitored for five years. Utilisation smart phone application based geotagging of activities are being handled by State agencies. Visualization of assets brought in high level transparency that is acknowledged widely.

- Space technology facilitates mapping of water bodies, groundwater recharge zones, and watershed areas. This data is crucial for irrigation planning and drought mitigation.
- **Government Initiative**: Under the Jal Shakti Abhiyan, satellite data is used to monitor water conservation projects and rejuvenation of water bodies in rural areas.

Disaster Management and Preparedness

Flood Monitoring and Management

Flood Prediction and Early Warning: Real-time satellite data identifies areas at risk by monitoring rainfall, river discharge, and water levels.

Damage Assessment: Post-flood imagery maps inundated areas to evaluate the extent of damage and aid in recovery efforts.

- **National Agricultural Drought Assessment and Management System (NADAMS):** This initiative combines satellite data with meteorological data to assess drought conditions, providing timely information for farmers and policymakers to manage agricultural risk.
- **Early Warning Systems**: Satellites like INSAT provide timely weather updates and disaster alerts, reducing vulnerability to cyclones, floods, and droughts.
- **Post-Disaster Assessment**: High-resolution imagery aids in damage assessment and planning for relief operations.
- ISRO's Flood Early Warning System (FEWS) has been integrated into rural flood-prone areas, enhancing disaster preparedness.

Rural Connectivity, Employment and Infrastructure

To demonstrate the potential of satellite technology for development of rural areas, ISRO established Village Resource Centres (VRCs) on a pilot scale, in association with selected NGOs, Trusts and State Government Departments. VRCs have provided various space technology enabled services such as tele-healthcare, tele-education, natural resources information, advisories related to agriculture, career guidance to rural students, skill development and vocational training etc. About Rs 18 crore was spent for establishing 473 VRCs.

The Ministry of Rural Development is utilizing the Geographic Information System (GIS) for improvement in planning and implementation of projects. GIS planning is being used for Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and Pradhan Mantri Gram Sadak Yojana (PMGSY).

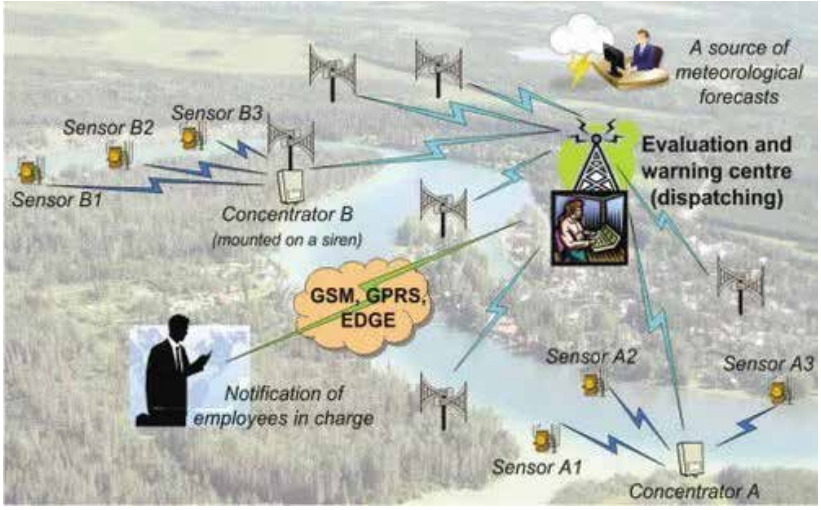
Healthcare and Education

- **Telemedicine**: ISRO's satellite-based telemedicine services bridge the healthcare gap in rural areas, enabling specialist consultations remotely.

Telemedicine initiative has been broadly divided into the following areas:

a. Providing Telemedicine Technology & Connectivity between remote/rural hospitals and Super Speciality Hospital for Teleconsultation & Treatment and Training of doctors & paramedics.

b. Providing the Technology & Connectivity for Continuing Medical Education (CME) between Medical Colleges & Post Graduate Medical Institutions/Hospitals.



c. Providing Technology & Connectivity for Mobile Telemedicine units for rural health camps especially in the areas of ophthalmology and community health.

d. Providing Technology and Connectivity for Disaster Management Support and Relief.

ISRO's Telemedicine pilot project was started in the year 2001 with the aim of introducing the Telemedicine facility to the grassroots level population as a part of 'proof of concept technology demonstration' programme.

• **eSanjeevani:** the National Telemedicine Service of MoHFW, Government of India has evolved into the world's largest documented telemedicine implementation in the primary healthcare.

For several decades, not only state-space agencies but also international organisations like the United Nations Office of Outer Space Affairs (UNOOSA) and United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) have also been promoting the use of space technologies for global health.

• **Tele-Education**: Initiatives like EDUSAT provide distance learning opportunities for rural students, improving access to quality education. ISRO's Tele-education programme provides satellite-based distance education services for bridging rural-urban divide and improve quality in education sector across the country.

Objectives :

- Supplementing curriculum based teaching
- E-learning through satellites
- Access to quality resourcepersons and education
- Taking education to every nook and corner of the country

Land and Property Management

- **Digital India Land Records Modernization Program (DILRMP)**:
  - Integrates satellite imagery for accurate mapping of land parcels, ensuring better land governance.
  - The *Bhoomi* initiative uses satellite imagery along with Ground Control Points (GCPs) to maintain accurate land records and streamline land transfer processes, thus promoting transparency in land dealings.
- **SVAMITVA Scheme**: Launched in 2020, this programme uses drones and geospatial technology to map rural land parcels, providing ownership records and resolving property disputes.

Bhuvan Panchayat

Bhuvan Panchayat portal is specifically designed to provide information and tools for utilisation on all the products and services developed under the National Natural Resources Management System (NNRMS) project called Space-based Information System for Decentralised Planning (SISDP). With an aim to support the geospatial data requirements for entire country at a large scale of 1:10k thematic products like LULC, Drainage, Settlements, Slope, Rail & Road along with collateral data

and high resolution satellite imagery base of 2.5m, the project has successfully completed two phases i.e. SISDP and SISDP-U by generating and disseminating generated datasets on Bhuvan Panchayat portal.

Bhuvan Panchayat presents a comprehensive information on the project, its activities, facilities to download the data directly as a shape file or use the data as OGC WMS/WMTS services thus facilitating all the users of different geospatial domains to integrate the data directly in their value added services or showcase as mashups / overlays in their existing value chains. A pan India seamless coverage of thematic data at this large scale of 1:10k scale is made available to support growing needs of g-governance, societal applications,

R&D activities in environment and land use studies and geospatial industry needs at absolutely no cost along with free access based on the governing policies as on date.

BharatNet

BharatNet, one of the biggest rural telecom projects in the world, implemented in a phased manner across all Gram Panchayats (approximately 2.5 lakh) in the country for providing non-discriminatory access to broadband connectivity to all the telecom service providers. Objective is to enable access providers like mobile operators, Internet Service Providers (ISPs), Cable TV operators and content providers to launch various services such as applications like e-health, e-education and e-governance in rural and remote India. Approved by Union Cabinet on 25.10.2011, the project is being executed by a Special Purpose Vehicle (SPV) namely Bharat Broadband Network Limited (BBNL). Till Oct end, 2024, under BharatNet Phase-I and Phase-II; 2,14,283 GPs are service ready.

i. **Objectives**: BharatNet aims to provide high-speed broadband to over 2.5 lakh Gram Panchayats (GPs) across India using optical fiber, enabling access to e-governance, e-health, e-education, and other digital services. Its last-mile connectivity extends broadband access to households, schools, hospitals, and other public institutions.

ii. **Implementation**: The project has progressed through phases:

- Phase I (completed in 2017) covered over 1.25 lakh Gram Panchayats.
- Phase II: GPs are to be connected through multiple implementing models like State-led Model, Private Sector Model and CPSU Model, along with Last Mile connectivity in GPs through Wi-Fi or any other suitable broadband technology. ❑

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Space Technologies : Transforming Rural India

Wide applications of space-based technologies in agriculture sector and rural development are transforming Indian villages into economically viable units and growth engines. Space technology is capable of serving the remote villages transcending geographical boundaries. Government is also focusing on capacity.

***Dr. Jagdeep Saxena**

Father of Indian space programme, Dr. Vikram A. Sarabhai, had a dream and vision to harness space sciences for societal benefits, national development and welfare of human race. The Indian Space Research Organization (ISRO), as the national apex body for space R&D, is relentlessly striving to live up to his vision and developing indigenous capabilities in achieving it. So far, India has developed a plethora of advanced space technologies and tools that are contributing in various operational domains of national development. Among various development verticals, agriculture and rural development are key beneficiaries due to their vast canvas and large number of potential tasks suitable for space-based interventions. Monitoring of crop growth, estimation of acreage and yield, monitoring and management of natural resources, disaster management and agro-advisories are some of the prominent areas where space technologies have revolutionized the processes and products. Incidentally,

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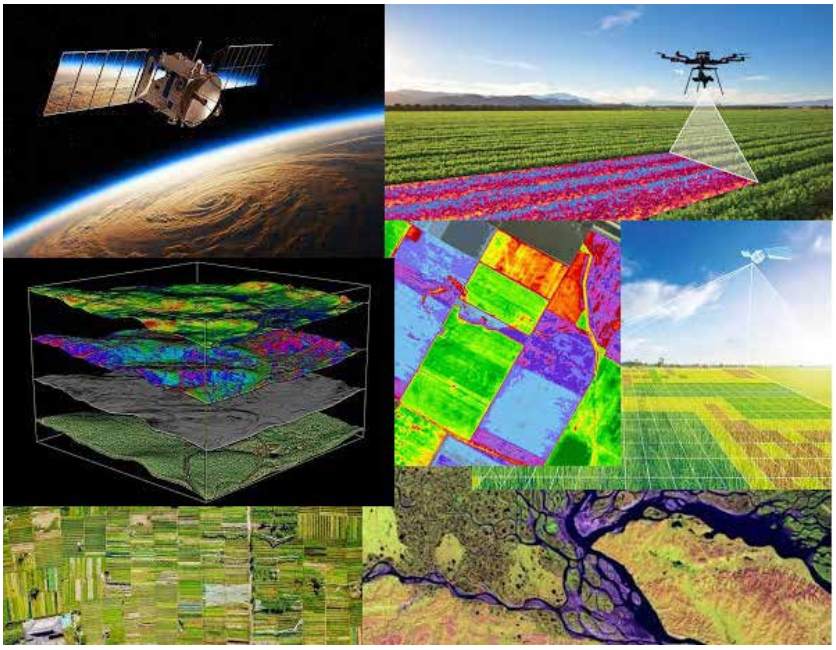
of National Natural Resources Management System in the country. Two major ISRO centres, viz., National Remote Sensing Centre, Hyderabad and Space Application Centre, Ahmedabad spearhead development of all such applications and implementation initiatives. Further, Ministry of Agriculture and Farmers Welfare established a dedicated Mahalanobis National Crop Forecast Centre (MNCFC) in New Delhi for application of remote sensing technologies in various activities/tasks of agriculture. The Centre implements various such projects in collaboration with ISRO. FASAL (Forecasting Agricultural output using Space, Agrometeorology and Land based observations) is a flagship project for forecasting the acreage and production of crops through integration of inputs from remote sensing, weather-based models and field observations. Nine crops, namely, jute, kharif rice, rabi rice, cotton, rapeseed & mustard, rabi sorghum, wheat, rabi pulses and sugarcane are covered under the project. Pre-harvest multiple in-season forecasts are issued for national, district and local levels. Project CHAMAN (Coordinated Horticulture Assessment and Management using geoiNformatics) mainly focused upon area assessment and production forecasting of major horticultural crops for better horticultural management and planning. In addition, project

the first practical application of a space technique (remote sensing) in India was in the field of agriculture, wherein early detection of coconut wilt disease in Kerala was possible using air-borne infrared cameras. Space technologies have value-added efficiency, transparency and pace in implementation of several vital schemes aiming rural development. Since the start of journey in the late 1960s, there has been a lot of improvement in the capabilities of the space technologies, particularly with reference to their application in agriculture sector. In addition to installations of remote sensing and communication satellites, India has now thematic satellites, such as ResourceSat & RISAT (Water and Land), Cartosat (Cartography), Oceansat (Oceanography and Atmosphere) and INSAT (Meteorology). Currently, India is one of the major providers of the earth observation data in the world, meeting the needs of many applications of relevance to natural resource management.

Remote Sensing: A Tool for all Seasons

Application of remote sensing (RS) data in agriculture sector started soon after the launch of first remote sensing satellite IRS-1A in 1988. An experimental project, the Crop Acreage and Production Estimation (CAPE) was initiated to provide district and state level pre-harvest acreage and production forecasts. Based on the experience of CAPE, various RS application projects at national, state and local levels are being carried out under the aegis



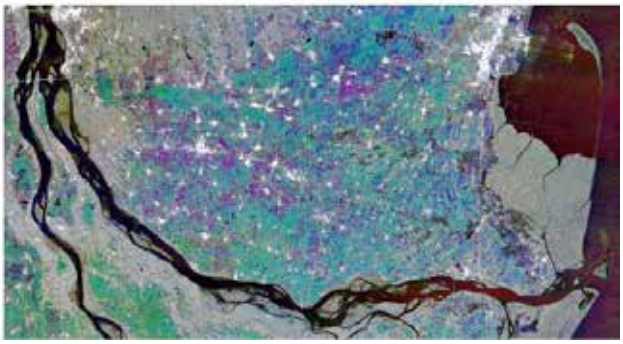
envisages creating a digital inventory of horticultural zones in the country and mapping the area and output of horticultural crops in identified states. Integration of RS data with GIS and field surveys helped in developing scientific methodology for crop identification, yield estimation, pest-disease identification etc. in collaboration with related agencies.

NADAMS (National Agricultural Drought Assessment and Monitoring System) is a very critical project for Indian agriculture as it helps prevent losses due to abnormal weather conditions. Developed by National Remote Sensing Centre, Hyderabad, it provides near-real time information regarding the prevalence, persistence and severity levels of the agricultural drought at state, district and sub-district levels. Project covers 17 drought-prone states, and uses rainfall datasets, district-wise soil moisture models and remote sensing derived vegetation indices for issue of drought warnings. After careful computation, analysis and study, drought warnings are issued from the datasets of June, July and August months in the form of 'normal', 'alert' and 'watch'. Whereas, drought declaration is done after incorporation of the datasets during September and October months in the form of 'mild', 'moderate' and 'severe' category. Large number of beneficiary farmers under Pradhan Mantri Fasal Bima Yojana (PMFBY) are getting quick and hassle-free claims due to application of RS data in the process. PMFBY envisages to provide the insurance cover and to meet the financial needs of the farmers when the crops get destroyed by various natural calamities and incidence of pests and diseases. As per revised guidelines and protocols, the RS data from satellites and UAV (Unmanned Aerial Vehicles or Drones) are now used for area and yield estimations, loss assessment, risk zoning etc. The applicable Remote Assessment (RA) -based approaches have greatly slashed time-period for settlement of claims, and also reduced cases of disputes considerably. Further, nowadays, analysing the information from crop calendars, weather forecast and remote sensing datasets by using machine learning/artificial intelligence, it is possible to estimate accurate crop yield in specific fields. Remote sensing has also been extensively used for planning purposes like site suitability, evaluation of different crops and cropping systems, sustainability of the cropping systems over a region, water resources development, wasteland management and even possibility of crop expansion in certain regions. Hyperspectral remote sensing, Internet of Things, state-of-art sensors, high speed data processing and intelligent systems are bringing a completely new dimension in the capabilities of remote sensing applications.

Soil, Water and Advisories

Space based Earth observation is a powerful tool to meet the demand for timely and accurate land cover information over large areas. Data on land cover is a critical input for weather and climate prediction, and also linked with the availability of food, fuel, timber, fiber and shelter resources for human populations. The spacetool used for land use/land cover studies are mainly optical sensors from satellites

RISAT-1 MRS (view of Paddy crop area - temporal data integrated)



Resourcesat 1, 2 and 2A, and the sensors used are at a scale of 1:2,50,000, 1:50,000 and 1:10,000. Similarly, for wasteland mapping sensors are used on 1:50,000 scale. This space-based service is used for mapping of land use and land cover across the country, and it encompasses all states and union territories. The datasets thus generated are used for planning of land resources upto village and taluka level. The data is also utilized to identify the kharif, rabi and zaid crop lands along with areas under double or triple crops. Departments dealing with rural management utilize the data for human settlement, generally of smaller agriculture, allied sectors and non-commercial activities. Data from IRS satellites along with Landsat-TM and SPOT (Earth Observation satellites) are often used for land degradation studies to identify and quantify the gully lands, water logged, saline areas, ravine land and shifting cultivation areas against the traditional field survey. Satellite data are also useful for direct detection of both wind and water erosion processes and their consequences by identifying erosion features and eroded areas. Some specific satellite sensors generate data on the top soil (5-10 cm depth) moisture content, where active roots of most crop plants are present.

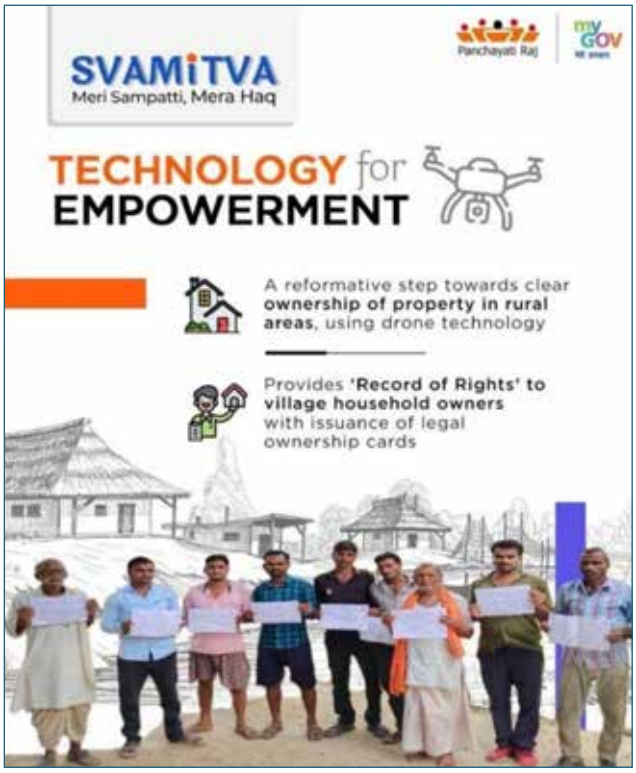
ISRO has developed various products and services of remote sensing satellites towards improved management of water resources in the country. The real-time information on various aspects of water utilization help manage resources effectively and efficiently. Other than remote sensing, data from Earth observation satellites and GIS is also integrated for better management of water resources, which includes surface water harvesting, adoption of latest irrigation practices, inter-basin transfer, water shed management and sustainable use of surface and ground water. The services of various remote sensing satellites starting from IRS series further to Resourcesat 1, 2, 2A and Cartosat 1, 2, 2S, 3 etc. were improved to provide a variety of applications like real-time monitoring, hydrological modeling, infrastructure planning, mapping and monitoring, information systems and decision support systems and so on. Such datasets are generated for entire country including Indian river catchment areas in transboundary region. RS data is a reliable and cost-effective tool for managing extreme water conditions such as flood and drought. During monsoon season, a constant watch is kept on the flood situation across the country and all possible satellite data are procured over flood affected areas. This helps and facilitates deployment of resources, and relief and rescue operations. Satellite data is also used for generation of flood hazard zone maps for planning non-structural flood management measure. Operation of India Water Resources Information System gets technical back-up from satellite data and Earth Observation System. Natural disasters, such as cyclones, landslides, forest, fires, etc. are regularly monitored and tracked to facilitate relief and rescue operations and further planning.

Weather based crop advisories enable farmers to take informed decisions on various crop management practices leading to higher yields and increased income.

To cater to this critical need of farming community, India Meteorological Department (IMD) runs an operational Agrometeorological Advisory Services, commonly called Gramin Krishi Mausam Sewa (GKMS), in collaboration with various agricultural institutions. INSAT Meteorological Data Processing System of IMD receives meteorological satellite data and imageries of INSAT for processing and analysis. INSAT satellites carrying meteorological payloads and geostationary meteorological satellites support weather forecasting services with supplying technical inputs. Presently, agromet advisories are prepared and released on every Tuesday and Friday for all the agriculturally important districts (over 700) and around 3,100 blocks by the 130 Agromet Field Units and 199 District Agromet Units. Along with the biweekly bulletins, daily weather forecast and nowcast informations are also disseminated to the farmers by IMD network. Print, electronic and social media along with mobile apps are also used for wider dissemination of agromet advisories.

Transforming Rural Lives

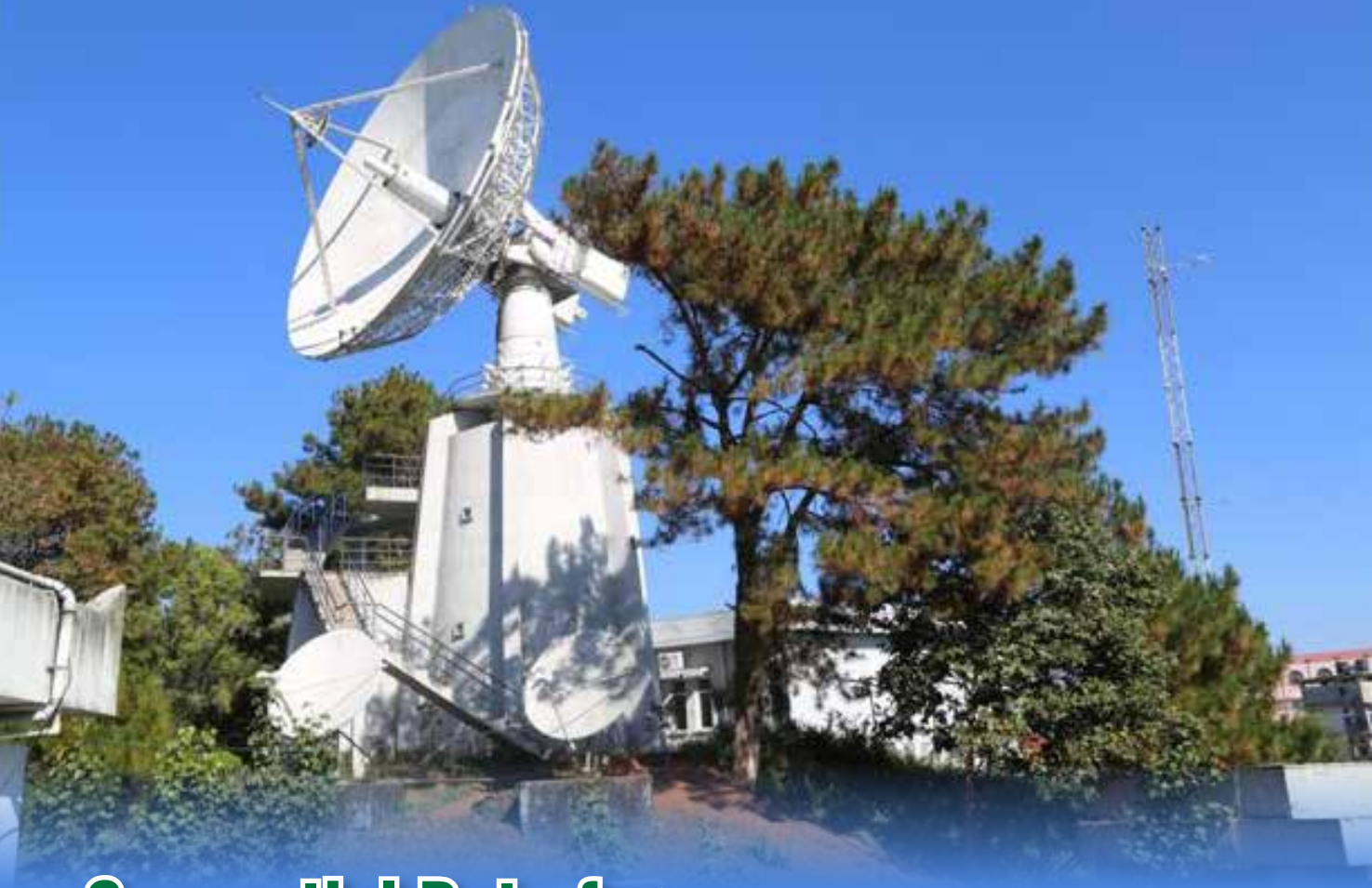
Development of rural areas plays a pivotal role in the overall development strategy of the country, and is also an integrated component of the growth and poverty alleviation schemes of the Government. In many such schemes, space technologies are contributing their bit in effective implementation and outreach, and better management of resources. Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) is a flagship scheme of the Government in which space technologies are adding transparency and efficiency. Remote Sensing (RS) and Geographical Information System (GIS) are serving as an effective tool to collect, store and analyze MGNREGA assets, such as watersheds, farm ponds, check dams, road layers, irrigation channels etc. GIS maps all the generated assets along with information for visualization and proper decision making. MGNREGA GIS Solution, called GeoMGNREGA, provides a single and integrated view of asset information system across rural India. This involves photo geotagging of



completed assets by the use of mobile application. NRSC, Hyderabad has developed mobile application and the web portal for displaying assets. GeoMGNREGA Bhuvan portal (e-Governance) acts as a gateway to facilitate and coordinate the sharing of geospatial data between various stakeholder agencies. GIS enabled portal maintains, processes, stores, distributes and improves the utilization of geospatial data for planners, decision makers and public. Recently, Ministry of Rural Development has entered into an agreement with IIT, Delhi for leveraging ground and space-based geospatial technologies to monitor and manage MGNREGA assets under BhuPRAHARI project. This initiative is expected to modernize the way rural development projects are planned, monitored and executed, ensuring accountability and optimizing resource allocation.

The SVAMITVA (Survey of Villages and Mapping with Improvised Technology in Village Areas) scheme aims to provide integrated property validation solution to rural India. Space-based geographical technologies play a central role in this scheme by leveraging cutting-edge drone surveys and GIS mapping technology for issue of Government recognized SVAMITVA property cards to genuine land owners. This integration of space-based technology ensures a more transparent and efficient land administration system, fostering socio-economic uplift in rural areas. Large scale mapping by using technologically advanced drones with cameras and sensors helps capturing high-resolution images and creating accurate maps. Drone survey has been completed in over three lakh villages and over 1,35,000 property cards have been distributed to land owners. Pushing-up the use of space-based technologies in rural development, Government has recently launched two Geoportals developed by ISRO. These geospatial tools are meant for visualisation and planning to provide high resolution satellite imageries of 1:10,000 scale for different locations across the country. The first one, Bhuvan Panchayat (Ver.4.0) geoportal is an online geospatial data and services platform to support integration of space-based information into governance up to Gram Panchayat level. It also supports 'Space based Information Support for Decentralised Planning' project to serve all sectors of national development. The second geoportal, National Database for Emergency Management (Ver.5.0) will provide space-based inputs on national disasters and aids disaster risk reduction in India as well as neighbouring countries. Satellite data and geospatial technologies are also used for Digital India Land Records Programme to optimize use of land resources. A 'Unique Land Parcel Identification Number' (ULPIN), commonly called Bhu-Aadhar, is being issued to plot owners across the country. Effective and transparent implementation of watershed development component of 'Pradhan Mantri Krishi Sinchayee Yojana' and mapping for 'Pradhan Mantri Gram Sadak Yojana' is facilitated by space-based technologies.

Wide applications of space-based technologies in agriculture sector and rural development are transforming Indian villages into economically viable units and growth engines. Space technology is capable of serving the remote villages transcending geographical boundaries. Government is also focusing on capacity building at Panchayat level to use space-based inputs and services. Once enriched with the technical knowledge, many issues related to land use or reclamation of wastelands, agriculture, horticulture, water harvesting, etc. specific to local environment can be addressed at local level. Meanwhile, Indian space community is striving to evolve new techniques and tools towards transforming rural India. Indian policy-planners and decision makers have rightfully carried forward the vision of Dr. Vikram A. Sarabhai, who believed that development in space will have a multifaceted impact on life of common citizens. ❑



Geospatial Data for Rural Resource Management

The geospatial platforms and projects developed by ISRO have given a new direction to Indian rural resource management, planning and disaster response mechanisms. These initiatives aim to promote transparency, resource management, and sustainable development, thereby enabling empowerment and sustainable development in rural areas.

* **Dr. Nimish Kapoor**

Geoportals developed by the Indian Space Research Organisation (ISRO) have emerged as a key player in rural development and disaster management in India. In particular, platforms such as Bhuvan Panchayat and the National Database for Emergency Management (NDEM) are empowering resource management, planning and disaster response mechanisms in rural areas. Through Bhuvan Panchayat, gram panchayats are getting access to high-quality satellite images and geospatial data, enabling them to implement their development works in a science-based manner. At the same time, the NDEM provides a robust geospatial database for effective decision-making and resource management during emergencies. These initiatives

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aim to promote transparency, accountability and sustainable development of governance in rural areas of India, which, combined with Digital India and other developmental schemes, are contributing to the overall development of the country.

Space-based Geoportal for Rural Development - Bhuvan Panchayat

Recently, an important geoportal developed by ISRO - Bhuvan Panchayat (version 4.0) has been launched in the country. The aim of these initiatives is to improve governance and decision-making by using space-based information in the field of geospatial database monitoring and rural development.

To empower the development of Gram Panchayats in India, a special geoportal - Bhuvan Panchayat has been launched by the Government of India and ISRO, which aims to assist in planning, monitoring and management of resources at the Gram Panchayat level through geospatial information and high-quality satellite images. It helps in monitoring land use, forest cover, water resources, and urban development. It helps in visualization and analysis of satellite data. The main objective of this initiative is to provide scientific satellite-imaging information to every Gram Panchayat, so that they can better implement their local development works.

Under this initiative, ISRO, in collaboration with various state governments and Panchayat Raj Institutions, has generated satellite-based data that will assist panchayats in matters of resource management, water and land use, socio-economic scenarios and primary health-education. The data collected by it can be used by the Gram Panchayats to prepare plans based on the information and monitor them.

The latest version 4.0 is equipped with more advanced features to maximize the benefits of rural development projects. Bhuvan Panchayat Geoportal (version 4.0) has been developed as an online platform that helps in the use and integration of space-based information for governance and research initiatives at the Gram Panchayat level. This platform has been developed by the National Remote Sensing Centre, which is capable of sharing, analyzing and visualizing web map service data products at 1:10,000 scale under the Space-based Information Support for Decentralized Planning (SIS-DP) project. 1:10,000 scale means that a distance of one centimetre on the map is equal to 100 metres in real life.

The platform uses web technologies, which enable it to work seamlessly across platforms and devices, and provides a seamless interface experience for users. With the availability of real-time data and analytics, the platform promotes transparency and accountability of rural projects. This enables effective use of resources and prevention of corruption. The Bhuvan Panchayat platform provides comprehensive data that supports holistic planning for various sectors such as agriculture, water resources, infrastructure, and social services. This holistic approach ensures that rural development is coherent and sustainable.

Gram Panchayats can accurately assess the status of their areas through Bhuvan Panchayat and make better use of local resources. This makes their plans more accurate and effective. Geospatial data from Bhuvan Panchayat can be used to manage water, land, and other natural resources, ensuring balanced and sustainable use of resources.

Bhuvan Panchayat (version 4.0) is playing a vital role in the development of rural India as an effective geospatial platform. It empowers local administration, ensures better management of resources, and makes citizens partners in governance. Also, it promotes transparency and accountability in monitoring developmental activities, thereby facilitating holistic and sustainable development in rural areas.

National Database for Emergency Management (NDEM) for Disaster Management

The recently launched National Database for Emergency Management (NDEM version 5.0) is a landmark initiative developed by ISRO with the objective of providing geospatial data and decision support tools for emergency management. Version 5.0 of NDEM provides enhanced features to further strengthen India's disaster preparedness and response mechanism.

NDEM is based on a structured, multi-level database that helps in situation assessment and effective decision-making during disaster or emergency situations for the entire country. It is a national level geoportal which is location-based. NDEM combines the data with Decision Support System (DSS) tools and services obtained from disaster forecasting organizations. It covers various phases of all natural disasters in the country and helps in effective Disaster Risk Reduction (DRR). Additionally, NDEM acts as a disaster recovery and data provider node, providing data to the Integrated Control Room for Emergency Response.

NDEM manages all phases of disaster management – preparedness, prevention, response and rehabilitation. Due to this holistic approach, loss of life and property is minimized during disasters. The portal provides real-time data and forecast analysis, which are critical for timely decision making in emergency situations. This helps in effectively utilizing resources and reducing the impact of disasters. NDEM facilitates end-to-end coordination among various government and non-government agencies involved in disaster management. NDEM educates communities about potential risks and preparedness measures so that they become more capable to deal with emergency situations.

NDEM version 5.0 is an important step to strengthen and make the disaster management process in India more effective. It promotes holistic disaster management, coordination, and community resilience, as well as helps in making timely decisions, which can reduce the impact of disasters. This version of NDEM further strengthens India's disaster preparedness and response mechanism, making India more capable to deal with the impact of natural disasters.

Space-based Information Support for Decentralized Planning at Panchayat Level Project (SIS-DP)

ISRO, in collaboration with National Remote Sensing Centre and State Remote Sensing Centres, has launched Space-based Information Support for Decentralized Planning (SIS-DP) Project at Panchayat Level. This innovative initiative has been taken with the aim of strengthening local self-governance and empowering Panchayati Raj Institutions.

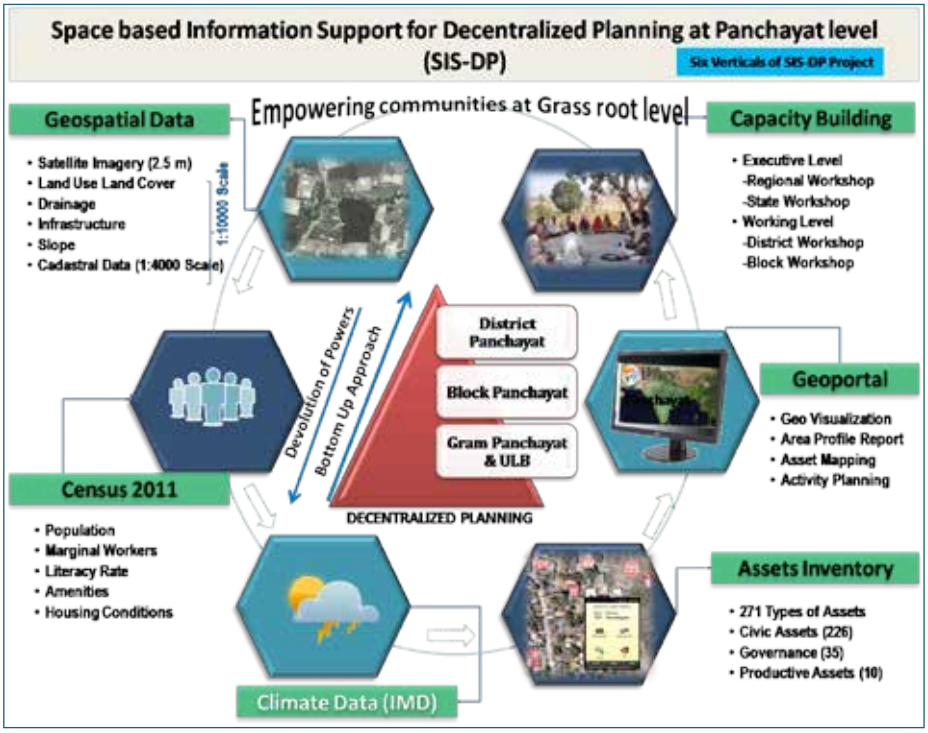
The project aims to improve the planning process at the Panchayat level through space-based data, analytical tools and geospatial products. Using high-resolution satellite imagery and Geospatial Information System (GIS) platforms, the initiative is helping to create a robust database for planning and governance, so that decisions are based on accurate and up-to-date geospatial data.

The key objectives of the SIS-DP project are to facilitate decentralized planning, promote transparency and improve governance at the Panchayat level. The work associated with this project is explained in the following points:

- **Preparation of satellite imagery maps for decentralized planning:** The project is preparing high-resolution orthorectified satellite maps for the entire country. These maps serve as the fundamentals for planning at the Panchayat level.
- **Preparation of thematic and base layers:** The project is working on topics such as land use/land cover, drainage, settlements, transport network, slopes and angles. Additionally, agricultural land records are being vectorized and geo-referenced to provide more detailed data.
- **Creation of Centralized Databank:** A centralized databank is being created which will include satellite imagery maps, thematic layers, slope maps, and other non-spatial data (such as census data, climate data, and village level data). All these data are being made available on a GIS platform so that they are easily accessible for planning.
- **Development of Web Portal for Panchayati Raj Institutions and stakeholders:** The project will develop a comprehensive web portal which will be accessible to Panchayati Raj Institutions and other stakeholders. This portal will become a tool for decentralized planning, governance, citizen outreach, and data dissemination.
- **Capacity Building for stakeholders:** An important component of the project is the capacity building of Panchayat members and stakeholders to enable them to effectively use space based information in decentralized planning and governance.

The SIS-DP project is being implemented in two phases. In the first phase, a national mosaic (a large collection of remote sensing data, which are stitched together to produce a detailed and accurate map) of high-resolution ortho products and digital elevation models obtained from Cartosat-1 and Resourcesat satellites was prepared.

Thematic layers and supporting data required for planning were also added in this phase. Thematic layers refer to different types of thematic data (such as land use, drainage, settlements, road network etc.), and supporting data is synonymous with other information that is helpful in planning and decision making, such as maps, geography and meteorological information. In the first phase, a detailed and accurate map was prepared using satellite images and data, which will be helpful for further planning and development work.



In the second phase, the scope of the project will be expanded to update geospatial data with the latest high-resolution satellite data and integrate geospatial data

analysis to create ready-to-use geospatial products and services. These services will be provided through a geoportal at the Gram Panchayat level - Bhuvan Panchayat, which will act as a central hub for access and management of geospatial data.

The Space-based Information Support for Decentralized Planning (SIS-DP) project is a transformational initiative at Panchayat level aimed at enhancing the effectiveness of local governance and planning by using satellite data and geospatial tools. It will not only improve the quality of decision-making at the Panchayat level but also empower Panchayati Raj Institutions and citizens by providing them with the information required for sustainable development.

Digital India Land Records Modernization Programme (DILRMP)

Indian Space Research Organisation (ISRO) has a significant contribution in the Digital India Land Records Modernization Programme (DILRMP). The DILRMP programme, run by the Ministry of Rural Development and Department of Land Resources, is supported by ISRO through its geospatial technical expertise, satellite imaging, and remote sensing.

ISRO's role is crucial in the modernization of land records at the national level. Its contribution under the Digital India Land Records Modernization Programme (DILRMP), formerly known as National Land Records Modernization Programme (NLRMP), is to improve the quality, transparency, and accessibility of land related information. It facilitates access to accurate land data for government departments and citizens.

The objective of DILRMP is to develop a modern, holistic and transparent land records management system to create an integrated land information management system. The objectives of the programme include improving land information (real-time information), optimising the use of land resources, benefiting land owners and potential users, aiding policy and planning, reducing land disputes, and checking fraudulent and benami transactions. The government has approved the extension of DILRMP for 5 years (from 2021-22 to 2025-26). Two new components have been added to the programme: (i) consent-based integration of Aadhaar numbers with land records database, (ii) computerization of revenue courts and integrating them with land records.

ISRO provides high-resolution satellite imagery and geospatial data, which are useful for mapping land records. These images are used to update and digitize

cadastral maps, which are essential for accurate land record management. These imageries help create a digital map of land boundaries.

This programme plays a vital role in geo-referencing traditional paper cadastral maps (Bhoomi maps). Geo-referencing involves aligning these paper maps with geographic coordinates using satellite-based positioning. This process is essential for integrating traditional land records with digital databases. Bhuvan Geoportal is integrated with DILRMP to increase accessibility of land data, map areas in digital format, and detect any changes in land use or boundaries.

ISRO's satellite technology is used to identify plots earmarked for single ownership or single use, so that land record management includes accurate geographic information. This process prevents problems like land disputes and encroachments.

95% of land records of rural India now digitized

ISRO has played a vital role in digitization of land records and land management. High-resolution images and geographic mapping provided by ISRO satellites have made it possible to accurately determine land boundaries, resolve ownership disputes and improve the accuracy of surveys. ISRO satellite technology has contributed to making the land management system more effective and equitable.

In a landmark achievement, about 95% of land records of rural India have been digitized, revolutionizing the management of land ownership and transforming the lives of millions of people. This historic step is an important part of the Digital India Land Records Modernization Programme (DILRMP), which is a major step towards transparency, efficiency and empowerment.

Digitization of land records is playing a vital role in the development of rural India. It is helping solve longstanding problems like complex paperwork, ownership disputes and fraud. Union Rural Development Minister Shri Shivraj Singh Chouhan recently emphasised the importance of this progress, and explained how digital records simplify land management and reduce the burden on courts, thereby speeding up the dispute resolution process.

With land ownership information now readily available online, rural households are enjoying greater security and convenience in land transactions than ever before. Disadvantaged communities are particularly benefiting from this change, as they gain better access to land rights. The integration of geographic mapping

has improved the accuracy of surveys, helping in disaster response and fair compensation during land acquisition.

The programme has so far completed digitisation of 95% of land records, digitization of 68.02% of cadastral maps, and integration of 87% of sub-registrar offices with land records, creating a more systematic, transparent and accessible land governance system.

This transformation is laying a strong foundation towards building a more equitable and just society. By making land records clear and accessible, it is being ensured that rural communities can confidently claim their land rights, thereby promoting economic growth and stability. This milestone not only strengthens rural land governance, but also ensures that every individual can actively participate in the progress of the nation.

Digitization of Land Records: Improving Transparency, Better Management and Development

ISRO's satellite technology and remote sensing data play a vital role in digitization of land records, ensuring accurate survey of land, geo-referencing and transparency, and helping resolve land disputes.

The Government of India has initiated the process of digitization of land records in 6.26 lakh villages, which is an important milestone in the efforts to make land ownership secure, transparent and accessible. This digitization aims to improve the land management system and solve various land related problems. Importance of Digitization of Land Records:

Land Disputes: More than 60% of litigation in India is related to land. Digitization can reduce these disputes.

Encroachment and Benami Properties: Digitization of land records will help in controlling encroachment and benami properties.

Inefficiency of manual processes: Digitization of land records will eliminate manual processes, thereby increasing efficiency.

Precise survey and planning: Transparency is being brought in land records through geospatial mapping, which will ensure equitable access to vulnerable sections.

Boosting agricultural credit: Clear ownership of land will ease the supply of agricultural credit, giving farmers access to capital.

Other benefits: Better targeted delivery of agricultural subsidies, timely compensation for land acquisition or disasters, and increased GDP.

ISRO satellites involved in digitization of land records and land survey work

Cartosat satellites: Cartosat-1, Cartosat-2, and its subsequent versions, such as Cartosat-3, provide high-resolution images, which are essential for determining the exact boundaries and use of land. These satellites are helpful in generating geospatial data, which accurately document the actual shape and boundaries of land. Cartosat satellites are also used in geo-referencing and thematic mapping.

ResourceSat Satellites: Resourcesat-1, Resourcesat-2, and Resourcesat-2A satellites provide important information about land use, environment, water resources, and agricultural activities. Data obtained from these satellites is used to obtain information such as

land use change, agricultural production, and drainage, which helps in digitizing land records and making land management accurate.

The data obtained through these satellites provide geospatial data required for valuation, determination of land use and rights, and development plans. With the help of these satellites, land records can be digitized in a more accurate, transparent, and effective manner.

Through the 73rd and 74th Amendments of the Constitution of India, Panchayati Raj Institutions have got greater autonomy in their rights and jurisdiction. This initiative has been launched with the aim of making Panchayati Raj Institutions more efficient and effective so that they can make better decisions at the local level by using spatial data and satellite technology and bring transparency in governance.

Navigation Signal System (NavIC), which is an Indian satellite-based navigation system, will also be used to provide location based services to Gram Panchayats. Through this, information about the correct location and necessary data for local development plans will be available in an accurate and timely manner.

Through Bhuvan-Panchayat Geoportal, state governments and panchayats will be empowered and will get an opportunity to effectively implement government schemes and development works under Digital India. The platform will reach around 2.56 lakh Gram Panchayats, providing the technology and information required to improve the quality of life in rural areas. This initiative is streamlining the implementation, monitoring and resource management of schemes by Panchayat Raj Institutions using satellite technology and digital information to create holistic and sustainable strategies for rural development. This initiative is an important step under the Digital India programme of the Government of India, which will technologically empower rural India and ensure its holistic development.

These geospatial platforms and projects developed by ISRO have given a new direction to Indian rural resource management, planning and disaster response mechanisms. These initiatives aim to promote transparency, resource management, and sustainable development, thereby enabling empowerment and sustainable development in rural areas. Through Bhuvan Panchayat, Gram Panchayats can now implement more scientific and data-supported schemes, while NDEM helps in making quick and effective decisions in disaster management. ISRO's role in DILRMP has improved digitization and transparency of land records, leading to better services to Indian rural society. ISRO has made significant contributions to resource management, governance and disaster response for rural areas of India, which will ensure more empowered, transparent and sustainable rural development in future. ❑

Space Technologies : Bridging the Rural - Urban Gap

Space technology has revolutionized sectors like agriculture, disaster management, communication, and environmental monitoring, enhancing efficiency, and literacy. Through satellite-based services and remote sensing, space advancements have become essential tools for rural development and societal well-being.

*** Dr. Manish Mohan Gore**

Space technologies have played a pivotal role in transforming India across various sectors, driving progress and self-reliance. Spearheaded by the Indian Space Research Organisation (ISRO), India's advancements in space technologies have revolutionized communication, agriculture, disaster management, education, and environmental monitoring.

Communication satellites like GSAT have bridged the digital divide, enabling connectivity even in rural areas. They facilitate telemedicine, e-learning, and digital governance, ensuring inclusive development. In agriculture, satellites like RISAT provide real-time data for crop monitoring, soil analysis, and weather prediction, empowering farmers with actionable insights to enhance productivity.

** The author is a Scientist with CSIR-National Institute of Science Communication and Policy Research, and Editor of the popular science magazine 'Vigyan Pragati'*

Space technology is committed to the service of rural population

Space technologies have also bolstered disaster management. Satellites monitor cyclones, floods, and earthquakes, enabling early warnings and timely relief efforts. Navigation systems like Navigation with Indian Constellation (NavIC) aid in precision navigation, supporting sectors like transport and defence.

Moreover, India's space missions, such as *Chandrayaan* and *Mangalyaan*, have not only advanced scientific research but also fostered national pride and international collaboration. These initiatives underline India's capabilities in cost-effective and innovative space exploration.

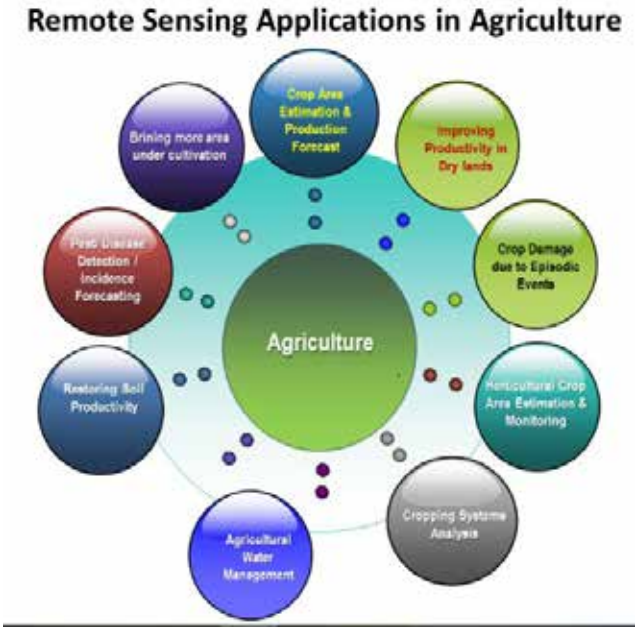
By leveraging space technologies, India continues to address pressing socio-economic challenges, empowering its citizens and contributing to sustainable development. The nation's commitment to harnessing space for the betterment of humanity underscores its vision of "space technology in the service of the common man."

Applications of Space technologies in Agricultural sector

Space technology has become a powerful tool for transforming Indian agriculture, a sector vital to the country's economy and food security. With its vast expanse of cultivable land and diverse agro-climatic zones, India leverages satellite technology and geospatial data to modernize farming practices, enhance productivity, and mitigate risks.

Crop Monitoring and Yield Estimation

Remote sensing satellites, such as those from the ISRO, provide high-resolution images to monitor crop health and growth stages. This enables early detection of pest infestations, nutrient deficiencies, and water stress. Satellite-derived data helps in estimating crop yields, allowing better planning for procurement, storage, and distribution.



Satellite-derived data helps in estimating crop yields

Soil Health and Land Use Planning

Satellite imagery is instrumental in mapping soil types, moisture content, and fertility levels. This data is crucial for precision agriculture, enabling farmers to use inputs like fertilizers and water judiciously. Additionally, geospatial information supports land use planning, identifying areas suitable for specific crops and improving overall land productivity.

Irrigation Management

Space technology plays a pivotal role in optimizing water resources, especially in water-scarce regions. Satellites help track groundwater levels and surface water availability. The data aids in designing efficient irrigation systems and monitoring their performance, ensuring sustainable water use in agriculture.

Crop Insurance and Risk Assessment

Satellite imagery facilitates the assessment of crop damage due to natural calamities, ensuring fair and

transparent crop insurance settlements. This reduces delays and disputes, offering financial stability to farmers.

Agricultural Advisory Services

Space-based data feeds into platforms like Kisan Call Centers and mobile apps like KisanSabha app, providing real-time advisories on best practices, pest control, and market prices. This empowers farmers with actionable knowledge. India's integration of space technology into agriculture has significantly enhanced efficiency, sustainability, and resilience. By fostering precision farming, improving resource management, and mitigating risks, these advancements promise a brighter future for Indian agriculture. Expanding the reach of such technologies to small and marginal farmers will be key to unlocking their full potential.

Village Resource Centres

ISRO and Department of Space has launched the Village Resource Centres (VRC) programme in collaboration with Non-Government Organisations and state/central agencies with the objective to provide the space based services directly to the rural areas of the country. VRCs have conducted more than 6500 programmes to address the sectors such as agriculture/horticulture development, fisheries development, livestock development, water resources, Tele-healthcare, women empowerment, computer literacy, micro credit, micro finance, and skill development for livelihood support. These activities have benefitted a number of people of rural community so far.

A glimpse of Village Resource Centre

Radio Stations to create awareness

Radio is a very effective medium to disseminate information to the rural areas and creating awareness among rural population. INSAT (Indian National Satellite System) based radio stations provide reliable programme channels for rural development. At present, 326 All India Radio (AIR) stations have been equipped with receive terminals which specifically create awareness among rural people.

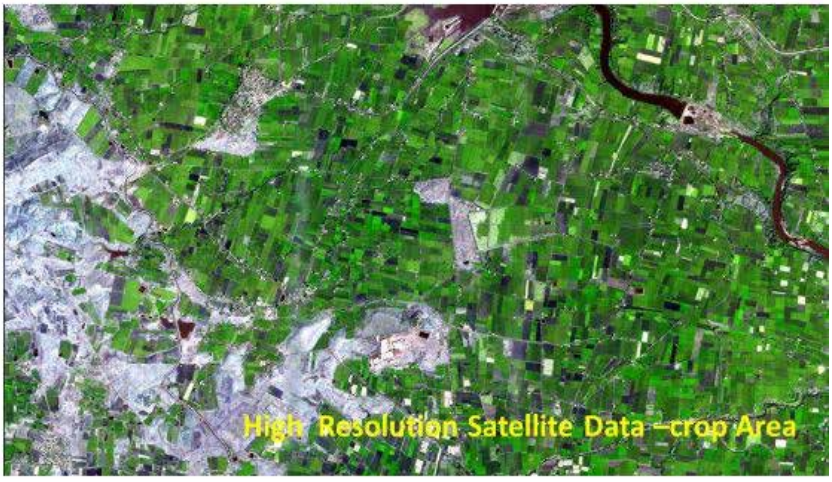
How Space technologies are useful in disaster management?

Space technologies play a vital role in disaster management by providing timely and accurate information for preparedness, response, and recovery efforts. Satellites equipped with remote sensing and Earth observation capabilities monitor environmental changes, detect potential hazards, and assess disaster impacts. For instance, weather satellites track hurricanes, cyclones, and floods, enabling early warnings and evacuation planning.

During disasters, satellite imagery helps map affected areas, identify inaccessible zones, and guide rescue operations. It also facilitates damage assessment, allowing authorities to allocate resources efficiently. GPS technology assists in coordinating relief efforts and locating survivors, while satellite communication ensures connectivity in rural areas where ground networks are disrupted.

Space-based systems are particularly valuable for monitoring large-scale events like wildfires, droughts, and earthquakes. They enable real-time data collection,

Cartosat-2E Crop Image



which aids in predicting disasters and mitigating risks. For instance, satellites can detect temperature anomalies or land deformations, signaling potential volcanic eruptions or landslides.

Space technologies and environmental monitoring for rural development

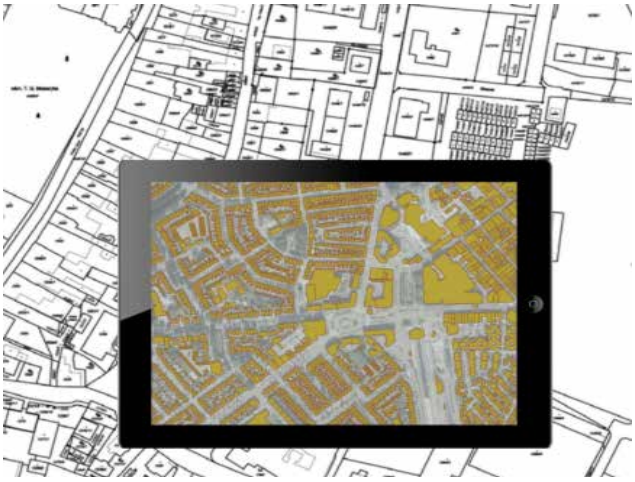
Space technologies play a pivotal role in advancing rural development by providing critical tools for environmental monitoring and resource management. Satellite imagery and remote sensing enable accurate assessment of natural resources, such as soil quality, water availability, and vegetation health. This data supports informed decision-making for agriculture, forestry, and land-use planning, fostering sustainable development in rural areas.

One significant application is precision agriculture, where satellite data guides farmers in optimizing crop yields. By monitoring soil moisture, pest outbreaks, and weather patterns, farmers can reduce waste and improve productivity. Similarly, satellites help track deforestation and land degradation, enabling timely interventions to protect biodiversity and restore ecosystems.

Space-based technologies also enhance disaster management, especially in rural areas prone to floods, droughts, and cyclones. Real-time satellite data aids in early warning systems, minimizing loss of life and property. For example, remote sensing helps identify flood-prone regions, allowing authorities to plan infrastructure and evacuation strategies.

Furthermore, rural communities benefit from satellite communication technologies that bridge the digital divide. High-speed internet via satellites connects remote areas to educational resources, telemedicine, and e-governance services. This connectivity fosters social and economic inclusion, empowering rural populations.

Telemedicine is one of the unique applications of Space Technology for rural development benefit. ISRO Telemedicine programme started in 2001 has been instrumental in connecting remote/rural/ medical college hospitals and Mobile Units through the Indian satellites to major specialty hospitals in cities and small towns. ISRO Telemedicine network covers various rural parts of the country including Jammu & Kashmir, Ladakh, Andaman & Nicobar Islands, Lakshadweep Islands, North Eastern States and other mainland states. Many tribal districts of



Chhattisgarh, West Bengal, Odisha, Kerala, Karnataka, Punjab, Andhra Pradesh, Maharashtra, Jharkhand and Rajasthan are covered under Telemedicine network of ISRO.

By integrating space technologies with grassroots efforts, rural development becomes more resilient and sustainable. From improving agricultural practices to protecting natural resources, space-driven environmental monitoring is a cornerstone of progress in rural areas, enhancing livelihoods while safeguarding the planet.

Satellite based weather prediction technology for India's rural upliftment

Satellite-based weather prediction technology plays a transformative role in uplifting India's rural landscape. With over 60% of the population relying on agriculture for their livelihood, timely and accurate weather forecasts are crucial for farmers to plan their activities and mitigate risks caused by unpredictable climate patterns.

Satellites such as INSAT-3D and Megha-Tropiques, developed by the Indian Space Research Organisation, provide real-time data on weather conditions, rainfall, temperature, and soil moisture. This data, coupled with advanced predictive algorithms, enables precise forecasting, helping farmers make informed decisions about sowing, irrigation, and harvesting. Early warnings of cyclones, droughts, or floods empower rural communities to take proactive measures, reducing crop losses and protecting livestock.

In addition to agriculture, satellite-based weather predictions enhance water resource management in rural areas. Reservoir operations, groundwater recharge planning, and efficient irrigation systems benefit from accurate rainfall and hydrological forecasts, ensuring better water availability during critical periods.

This technology also aids rural infrastructure planning, particularly in constructing weather-resilient roads, housing, and storage facilities. Furthermore, satellite data contributes to improving disaster response strategies, ensuring quicker evacuation and relief efforts in rural regions prone to extreme weather events.

Government initiatives like the Gramin Krishi Mausam Sewa (GKMS) leverage satellite data to deliver localized weather information and advisories via SMS, mobile apps, and community radios, ensuring the last-mile connectivity to farmers. Collaboration between ISRO, agricultural research bodies, and rural development programmes amplifies the impact of this technology.

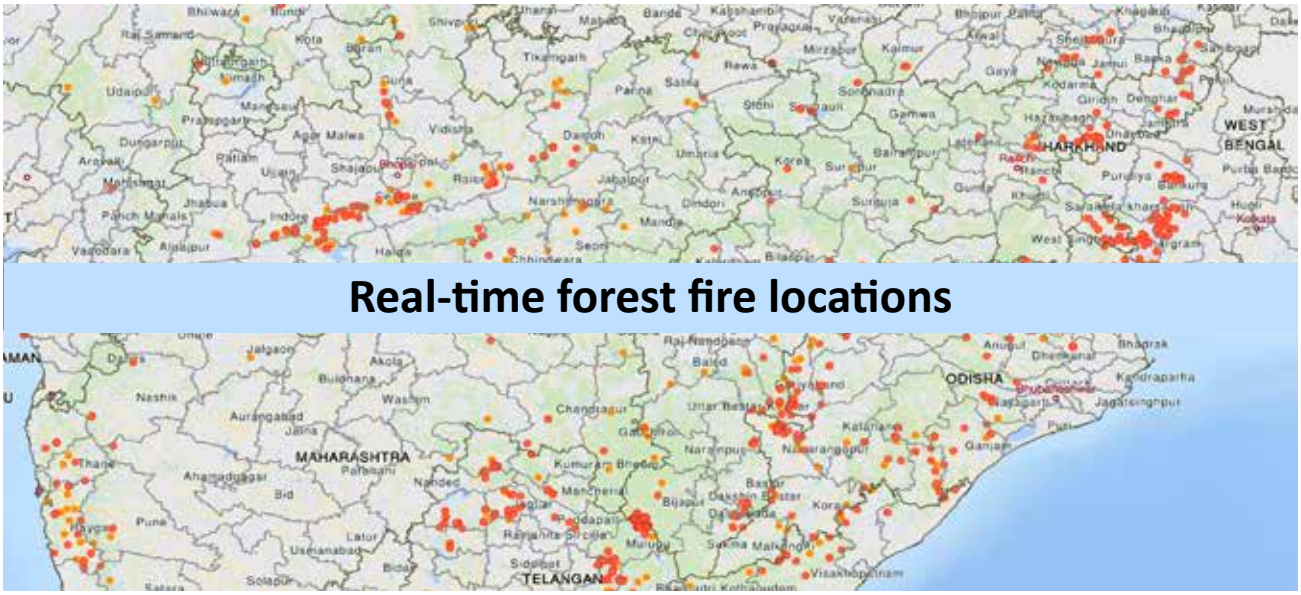
Satellite-based weather prediction, therefore, not only boosts agricultural productivity but also fosters sustainable rural development. It reduces vulnerability, promotes economic stability, and empowers rural India to thrive in an era of climate uncertainty.

Geospatial based solutions for flood, drought, landslide and forest fire in rural areas

Rural India faces a significant vulnerability to natural disasters like floods, droughts, landslides, and forest fires due to its varied topography and climatic conditions. Geospatial technologies, including Geographic Information Systems (GIS), remote sensing, and satellite imagery, play a pivotal role in developing efficient, scalable, and data-driven solutions to mitigate these challenges.

Flood Management

India is one of the most flood prone countries in the world. 23 of the 36 states and union territories in India are subject to floods covering above 40 million



Real-time forest fire locations

hectares of land. Geospatial solutions provide real-time flood forecasting and monitoring through satellite imagery and hydrological modelling. By analyzing river basins, rainfall patterns, and water levels, authorities can predict flood-prone areas and issue early warnings. Floodplain mapping using GIS helps identify high-risk zones, enabling rural communities to plan better land use and infrastructure placement. Drones and aerial surveys also aid in assessing flood damages and coordinating relief operations efficiently.

Flood Mapping through Geospatial Technique

Drought Mitigation

Around 70% of the country is drought prone. For drought-prone areas, remote sensing technologies monitor soil moisture levels, vegetation health, and rainfall deficits. Satellite-derived indices like the Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) are used to assess drought severity and guide crop planning. These tools help policymakers implement water conservation strategies, optimize irrigation, and plan for drought-resilient crops. Community-level GIS tools can map water resources and support groundwater recharge initiatives.

Landslide Risk Reduction

In hilly terrains, GIS and remote sensing are instrumental in landslide hazard zonation. These tools analyze factors like slope stability, soil composition, vegetation cover, and rainfall patterns to identify areas at risk. Real-time monitoring with internet of things (IoT) sensors and geospatial data enables early warning systems, giving residents time to evacuate. Moreover, geospatial analysis aids in designing proper drainage systems and reinforcing vulnerable slopes to minimize landslide occurrences.

Forest Fire Management

Forest fires are a growing concern, especially in rural and forested areas. Satellite-based monitoring systems like MODIS and VIIRS provide near real-time detection of active fires and assess their spread. GIS helps map high-risk areas by analyzing temperature, wind patterns, and vegetation density. These insights enable proactive fire prevention measures, such as controlled burns and the creation of firebreaks. During a fire, geospatial tools facilitate resource allocation and monitoring efforts for containment.

By integrating geospatial technologies into disaster management frameworks, rural India can better anticipate, prepare for, and mitigate the impacts of natural disasters. Empowering local communities with access to geospatial data and training fosters resilience and sustainable development, ensuring their safety and well-being amidst environmental uncertainties.

In this way, we see that space technology has revolutionized sectors like agriculture, disaster management, communication, and environmental monitoring, enhancing efficiency, and literacy. Through satellite-based services and remote sensing, space advancements have become essential tools for rural development and societal well-being, showcasing the broad and transformative impact of space innovations on everyday life of rural communities. ❑

Reimagining the Future of Learning: Educating on Space Technology

As India aspires to become a global leader in the space economy, there is an urgent need to strengthen education on space technologies, empowering students and the workforce to harness its potential effectively. To achieve this vision, India must prioritize investments in education and capacity-building initiatives.

***Shalender Sharma**
****Arushi Mathur**

Space technology has become an indispensable tool in addressing some of the most pressing challenges faced by humanity. The United Nations Office for Outer Space Affairs (UNOOSA) has introduced Space4SDGs emphasising on the importance of application of space technology for advancing towards a sustainable future. Further, this has been linked to all the 17 SDGs including Quality Education and Decent Work and Economic Growth. Space technologies are envisioned to support quality education through high-speed internet connectivity to support digital learning, electronic attendance marking and monitoring systems, and remote learning opportunities across geographically diverse regions. Additionally, its contribution to the global economy

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in several sectors including banking, monitoring agriculture practices, climate-resilience, and disaster risk reduction, and improving service delivery and communications will be instrumental in promoting GDP growth as well as development.

As per the World Economic Forum's report, the global space economy is expected to reach $1.8 trillion by 2035, this is an increase from $630 billion in the year 2023, having an AAGR of 9%, more than the global GDP growth projections. Similarly, India's space economy is also geared up, in fact it will outpace the global growth. It is expected to reach $77 billion by 2030 at a CARG of 26%. As the global demand for space-based solutions grows, investment in education and research in this field has become vital for fostering further innovation in areas such as early warning systems, promoting high-tech jobs and preparing the young generations for the future.

Integrating information on space technology and its applications into school curriculum can inspire young minds to pursue innovative solutions and make informed decisions at the time of identifying career trajectory or higher education degrees. By teaching students about how space technology aids renewable energy mapping or enhances urban planning, education systems can cultivate a generation of leaders equipped to address pressing global issues.

On one hand, the demand for use of space technology for enhancing education quality has significantly grown especially post Covid-19 pandemic via digital learning solutions for students, teachers and education officials and deployment of cost-effective satellite communication systems such as VSAT in low-resource and poor connectivity areas. Complementing this, it is equally important to work towards quality education and dissemination on Space Technology to equip young learners on relevant trends, best practices,

innovations across countries and future prospects in this sector.

Geospatial data can support education management, similarly, Geographical Information Systems can help improving equity and efficiency in resource management and infrastructure in education systems. School siting has been used to foster diversity and reduce inequality of opportunity. Many Indian States have used Geospatial technology to increase access to primary education in the neighbourhood and addressing the challenges of school opening. The technology is also supporting consolidation of schools in sparsely populated areas.

Global perspective

The growing need for sustainability has spurred an emerging global demand for skilled professionals who can leverage space technology to support sustainable development goals. According to UNOOSA, the space economy is worth 1.5% of global GDP and more than 10% of the GDP in advanced economies is underpinned by satellite data, services and applications including everyday use of satellite imagery, communication and navigation. UNESCO reports suggest that the space economy could generate $1.8 trillion in global growth by 2035.

The global space economy is poised for significant growth, driven by increasing digital capabilities and international collaboration. Global practices

emphasize experiential learning. NASA, for instance, has demonstrated the transformative potential of its technologies in classrooms, using tools like augmented reality (AR) to make complex space concepts more accessible and engaging.

Such immersive educational approaches can inspire students to pursue STEM careers while equipping them with practical problem-solving skills.

Japan has made significant strides in space education through its Japan Aerospace Exploration Agency (JAXA) which runs educational outreach programmes, including school visits, hands-on workshops, and interactive exhibits, allowing students to engage with space technologies. The JAXA Space Education Program offers school children and young adults opportunities to participate in astronaut training simulations and satellite design projects. Japan also encourages students to engage in research by supporting academic partnerships with universities and institutions globally.

Aside from this, the UAE Space Science Program actively involves students in space projects and competitions, including satellite design and space exploration, and the country has announced plans for the first Arab astronaut programme. The European Space Agency (ESA) also has a strong presence in promoting space education across Europe. Through programmes like Space in Schools, ESA provides resources such as satellite data for teachers to integrate into their lessons, enabling students to engage with real-world space applications. ESA also organizes space-themed competitions where students can design and launch small satellites or participate in hands-on space exploration projects.

However, the UNESCO GEM Report 2023 highlights persistent inequities in technological access, especially in rural regions. Bridging these gaps through satellite-based internet and affordable digital platforms can democratize access to space education.

Opportunities in India

According to the Indian Space Policy 2023, the key strategies include the need to promote space-related education and innovation, support space-sector start-ups, and increase awareness on space activities. Sensitization and capacity building initiatives will need to be directed towards promoting Research and Development in space sector and educating to nurture scientific temperament in the society.

In nations like India, the contributions of organizations such as ISRO have not only strengthened infrastructure but also inspired the next generation of scientists and engineers. The Young Scientist Program (YUVIKA) encourages students to explore space science

by providing a platform for them to engage in space-related activities like satellite building and mission planning. ISRO also collaborates with schools and universities to promote STEM education and offers internships and scholarships for students pursuing careers in space science and technology.

Another initiative towards enabling education in this area has been through the UN affiliated Centre For Space Science And Technology Education In Asia And The Pacific, hosted in India. The Centre offers short term courses and programmes ranging from Remote Sensing and Geographic Information System to Satellite Communications, Space and Atmospheric Science, Global Navigation Satellite Systems, and so on.

The aforementioned initiatives put India on a pedestal and enhance opportunity to strengthen education systems and make the learners ready to contribute to design, development, and application of space technologies.

Opportunities for strengthening quality education on space technology:

- **Access to Informative material and outreach programmes** on latest space technologies, trends and patterns, emerging needs, global competition and innovative exhibits, exhibits on Indian missions like Chandrayaan, Mangalyaan, and Gaganyaan, policy and ethical considerations, AI and robotics in space technology for monitoring and so on. The

first step is thus, to bridge information gap amongst students and youth and more importantly, ensure equitable access of information to all through print media, digital media, podcasts, YouTube, documentaries, and other social media channels.

- **Integration of Projects on R&D in space tech** especially in secondary and senior secondary grades. This may include initiatives like model satellite projects, designing space experiments, research papers or studying planetary science. This can inspire curiosity and scientific thinking from an early age. Such projects will need to be linked to the curriculum and textbook topics for effective implementation. Further, linkage with important topics such as climate change and disaster risk reduction and response, GIS mapping, Indian economy, and natural resource management for sustainable development may be useful in keeping this topic relevant and interrelated to mandatory subjects.
- **Skill oriented curriculum-** Introduce optional/add on courses in satellite design, AI, programming for space applications, robotics, and data analysis. ISRO's focus on satellite technology offers a base for designing skill-oriented programmes at schools and universities.
- **Improved Collaboration** between ISRO and private entities can amplify educational outreach. Programs like SpaceKidz and ISRO's IN-SPACe (Indian National Space Promotion and Authorization Center) can provide mentorship to young innovators with potential projects. International collaborations and partnerships can promote opportunities for scholarships, knowledge exchange and participation in student exchange programmes and camps.
- **Capacity augmentation** of teachers and educators- this may be the most critical pre-requisite to achieve the objective of improved education on space technologies. Teachers, being at the centre of any education reform, will need to be well equipped via specialized training to integrate basic examples of space technology into their teaching. Collaborate with ISRO and universities for workshops. Alternatively, attendance of teachers and coordination to arrange for expert speakers would also be a catalyst in driving change.
- **Promotion of start-up ecosystem**- Encourage students to develop entrepreneurial ideas by creating innovation hubs in schools, organizing competitions and providing necessary support for career guidance and counselling to enable them to make informed decisions.
- **Improving Access in Rural Areas**- Use ISRO's satellites to deliver e-learning content to rural and remote areas. Initiatives like EDUSAT can bridge the rural-urban gap in access to resources. Additionally, organizing space education camps and mobile exhibitions can

be beneficial in inspiring students in rural areas. These could showcase space applications in farming, weather forecasting, and disaster management.

Challenges

Potential challenges in this area include:

Limited openness to learning about space technologies- Space careers are often perceived as niche or not relevant to all students, and many students remain unaware of the broad applications of space technologies in industries like agriculture, disaster management, and telecommunications. To overcome these challenges, focused outreach, strategic investments, and systemic reforms are essential to make space education accessible, engaging, and future-ready.

Limited capacities of educators- Many teachers and educators lack the technical knowledge and pedagogical skills required to deliver advanced concepts like satellite systems, remote sensing, or space exploration effectively or even introduce basic examples while delivering their lessons. This, along with poor perception and motivation of educators towards the subject, can hamper learning.

Resistance to change in terms of integration in curriculum- curricular focus in Indian education is often

exam-oriented, prioritizing rote learning over practical, interdisciplinary approaches essential for space technology. Space education, being multidisciplinary, demands integration across subjects like physics, chemistry, geography, and computer science, which may require significant curricular reforms.

Socio-economic disparities and remote regions- while space technology can greatly benefit in rural development, agricultural practices and similar engagements, the reluctance to invest in educating youth due to preoccupation with other jobs to fend for the family, and poor internet connectivity poses a significant barrier. This will call for strategic behavioural change and provision to have learning resources and outreach up to the last mile and ensure that no one is left behind.

Conclusion

Space technology plays a transformative role in shaping the future of science, economy, and sustainable development. Its applications extend beyond exploration to critical domains such as agriculture, disaster management, climate monitoring, and telecommunications. As India aspires to become a global leader in the space economy, there is an urgent need to strengthen education on space technologies, empowering students and the workforce to harness its potential effectively. Educating youth about space technology is not just about cultivating curiosity but also about equipping them with skills to solve real-world problems and drive innovation in diverse fields.

To achieve this vision, India must prioritize investments in education and capacity-building initiatives. By integrating space-related topics into school and university curricula, emphasizing interdisciplinary learning, and fostering research and development projects, we can ensure that students gain both theoretical knowledge and practical skills. The Indian Space Policy 2023 offers a strategic framework

to enhance the space sector's contribution to the national economy. To realize its goals, the policy must be complemented by strong educational initiatives and robust public-private partnerships, ensuring access to resources for all, including those in rural and underserved regions.

India has much to learn from global practices. Countries like the United States, Japan, and members of the European Union have demonstrated the importance of early exposure to space sciences, teacher training programmes, and collaborations between academia, government, and private players. Adopting similar approaches, while tailoring them to India's unique socioeconomic landscape, can foster innovation and inclusivity in space education.

Furthermore, the effective use of space-generated data and information must be emphasized. Teaching students to interpret and apply satellite data in areas like environmental monitoring and urban planning can make education more relevant and impactful. Capacity-building programmes for educators, rural outreach initiatives, and entrepreneurial support can ensure a well-rounded strategy.

In conclusion, building a strong foundation in space technology education is essential for India's advancement as a global space power. By investing in education, policy implementation, and fostering a scientific temperament, the nation can inspire the next generation of space scientists, engineers, and entrepreneurs, contributing not only to technological progress but also to sustainable development and global leadership. ❑

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Mobile Apps for Fishermen

When fisherman in India go to sea in India, often they cross the International Maritime boundary during their fishing routines. To prevent such trespassings ISRO has developed the following apps for fisherman:

The MapmyIndiaNavIC Message Receiver App

This app alerts the fishers against putting out to sea during adverse weather conditions and recall those who are still at sea or have gone beyond the international maritime boundary.

The app also aids fisherman convenience. The app works completely offline and showcases areas for potential fishing (tuna or normal). It also provides waypoint navigation from the fisher's current position to the selected area of potential fishing.

Through INCOIS (Indian National Centre for Ocean Information Services), the app also provides emergency messages for incoming adverse weather conditions – cyclones, tidal waves, high tide etc

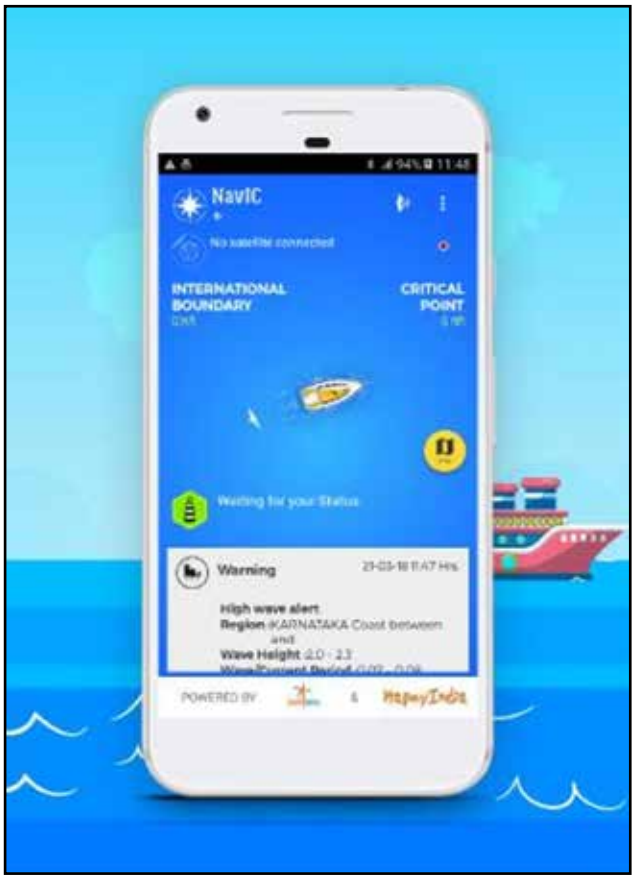
- Checking live location of the fisherman on the map
- Current position of the fisherman from the international maritime boundary
- Audio visual alert in case the fisherman is about to cross the international maritime boundary
- Provision to receive emergency messages - high tide wave, cyclone, etc. from INCOIS
- Location for potential fishing zones - tuna or normal
- Way point navigation from current location to selected potential fishing zone
- App works completely offline

Link to download: Google Play Store -> MapmyIndiaNavIC

Nabhmitra network & app for real time tracking of the sub-20 m boats

Nabhmitra is a national maximum segment size

(MSS) network implemented for real time tracking of the sub-20 m boats going into deep sea for fishing. It also supports two-way short messaging services wherein fishermen can send his distress or custom message to the User Agency through an Android application in his phone. The network also supports broadcasts of any weather alert or emergency warning in various modes, which can be received on the Fisherman app. The App is connected to MSS satellite terminal and offers all services in conjunction with the Satellite Terminal. A variant of this App is also available for the Boat Owners to track their assets and communicate with their employee or boat pilots.



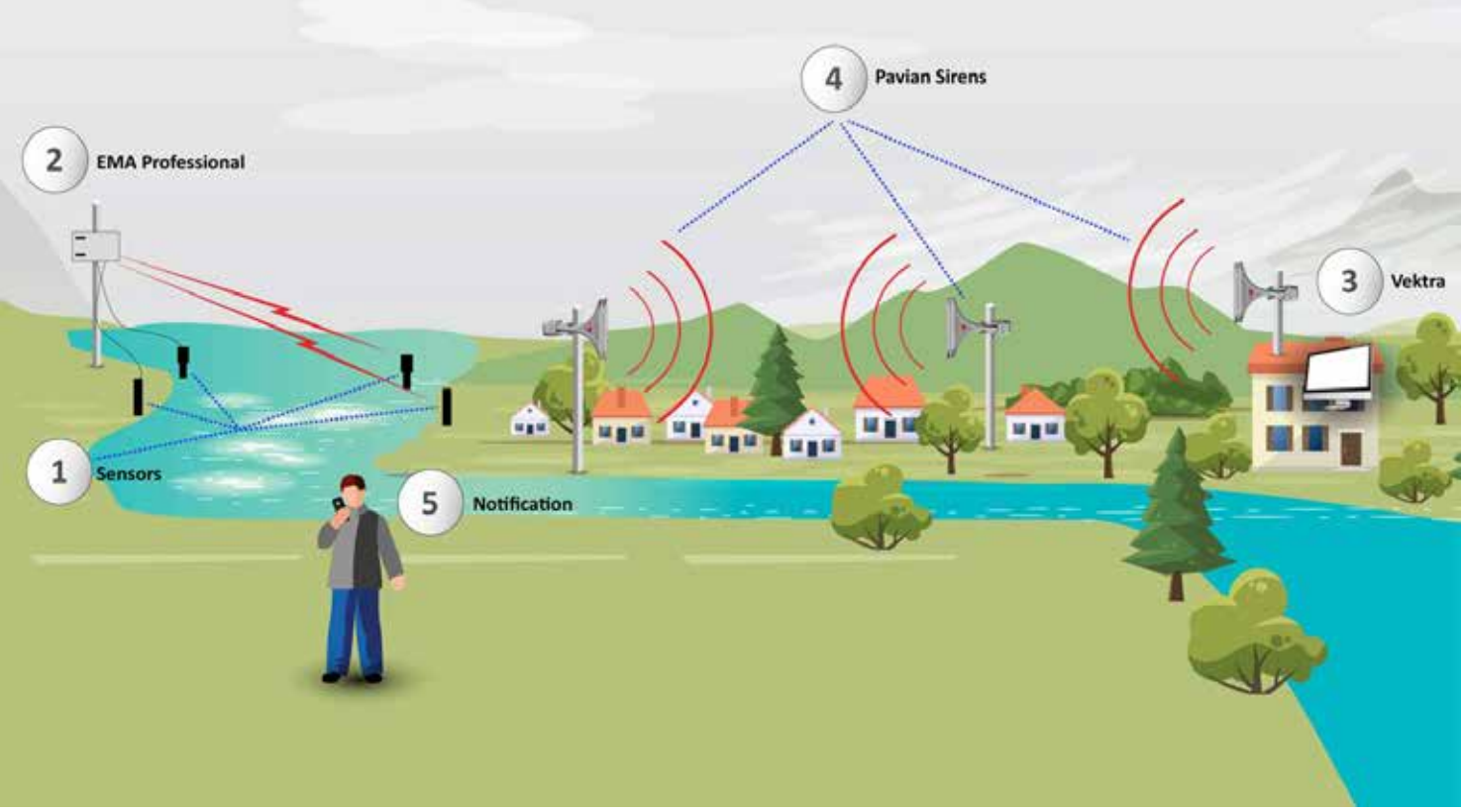
As this App works in conjunction with the MSS terminal, it is distributed by the concerned Nodal agency on Terminal registration.

Sagarmitra SAR emergency messaging app

Sagarmitra is an operational Satcom network developed for emergency messaging by fisherman for Search and Rescue (SAR) operation by Indian Coast Guard on manual activation. Sagarmitra app is an android app developed for fisherman which connects to the sitcom terminal through Bluetooth interface and provides user interface for sending and receiving emergency messages. It allows them to send their emergencies in case of any distress and displays the acknowledgments to the emergencies received from central control station (hub). This network also supports broadcasts of any weather alert, Potential Fishing Zone (PFZ) or emergency warning in various modes, which can be received on the app.

As this network is developed for a specific Nodal agency and the app works in conjunction with the Distress alert transmitter- Second Generation terminal, hence it is distributed by the agency on registration. ❑

Source: www.isro.gov.in



Satellite-Based Early Warning Systems for Drought and Flood Management

Exploiting satellite technology offers transformative solutions by providing precise data for monitoring, early warning and risk mitigation. Indian and global satellite programmes, combined with collaborative efforts, enhance disaster preparedness and sustainable agricultural practices. By facilitating community-centric approaches and aligning policies with satellite-based insights, India can effectively mitigate the effects of natural disasters.

***Sheikh Amjid**
****Subhash Chand**

Droughts and floods severely affect rural agriculture, threatening food security and farmer livelihoods. Droughts reduce crop yields, deplete water resources, and weaken livestock, while floods destroy crops, degrade soil, and damage infrastructure. These disasters disrupt agricultural productivity and economic stability in rural areas. Addressing their impact requires effective management strategies, including satellite-based monitoring, early warning systems, and sustainable agricultural practices, to protect rural communities and enhance resilience against climate-induced challenges.

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Droughts

Drought is a temporary reduction in water or moisture availability significantly below normal levels for a specific period. It is a climatic anomaly caused by sub-normal rainfall, erratic distribution, higher water demands, or a combination of these factors. Droughts are extreme hydrologic events that result in acute water shortages, persisting long enough to adversely impact humans, vegetation, animals and ecosystems across large areas. Meteorologists define drought as the absence of rainfall, while agriculturists view it as insufficient soil moisture in the crop root zone to sustain growth and productivity.

Drought is broadly categorized into meteorological, hydrological, agricultural and socioeconomic types based on its criteria and effects. Rainfed areas, particularly drylands, are more vulnerable to drought. In recent decades, monsoon patterns have become increasingly unpredictable, causing previously unaffected regions to experience mild to severe drought conditions. For crops and vegetation, drought induces moisture stress when evapotranspiration exceeds soil moisture availability. In India, agricultural drought occurs when annual rainfall falls below 50–75% of the normal southwest monsoon rains. Delayed monsoon onset, early withdrawal, or prolonged dry spells between heavy rains are common triggers of drought in Indian agriculture.

In India, they significantly affect:

Crop Yields: Insufficient water during critical crop growth phases reduces agricultural productivity,

threatening food security and causing significant economic losses for farmers.

Livelihoods: Persistent droughts lead to reduced income for farmers, pushing them into debt and forcing rural families to migrate for survival.

Livestock: Scarce fodder and water during droughts weaken livestock health, lowering their productivity and adding to rural economic challenges.

Water Resources: Over-reliance on groundwater during droughts depletes aquifers, creating long-term water scarcity and unsustainable agricultural practices.

Floods, often caused by excessive rainfall or overflowing rivers, pose immediate and long-term challenges:

Crop Destruction: Floodwaters submerge standing crops, causing complete agricultural losses and devastating rural farming communities.

Soil Degradation: Nutrient-rich topsoil is eroded by floods, reducing fertility and making land less productive for future cultivation.

Infrastructure Damage: Floods destroy essential rural infrastructure, including irrigation systems, storage facilities and roads, disrupting the agricultural supply chain.

Health Hazards: Stagnant floodwater creates breeding grounds for diseases, threatening the health and well-being of rural populations.

The Role of Satellite Imagery in Early Warning Systems

Satellites equipped with advanced sensors capture data on various Earth parameters. This data, processed and analyzed using Geographic Information Systems (GIS), provides invaluable insights into:

- **Rainfall Patterns:** Satellite imagery monitors precipitation levels and spatial distribution, offering precise data for weather forecasting, flood risk management and agricultural planning in vulnerable rural areas.
- **Soil Moisture:** Satellites estimate soil water content, enabling farmers to plan irrigation schedules effectively, reduce water wastage and adapt to drought conditions for sustainable agriculture.
- **River Levels:** Satellite altimetry tracks river flow and monitors rising water levels, aiding in flood risk assessment and disaster preparedness in flood-prone regions.
- **Vegetation Health:** Remote sensing analyzes vegetation conditions, using indices like NDVI to assess crop stress, detect drought-affected areas and guide timely interventions.

Key Satellites and Programs

- **Indian Satellites:** INSAT, RISAT and Cartosat, developed by ISRO, provide critical data for monitoring weather patterns, soil conditions and disaster-prone areas to support agricultural and disaster management efforts.
- **Global Initiatives:** Programs like Sentinel (ESA) and Landsat (NASA) complement Indian satellite data, offering global perspectives and enhanced imagery for more comprehensive applications in rural development.
- **Collaborative Efforts:** Partnerships with organizations such as FAO and WMO integrate satellite data globally, ensuring efficient analysis, better disaster response and enhanced agricultural planning strategies.

Drought Management through Satellite Technology

Monitoring and Assessment

- **Rainfall Anomalies:** Satellites identify deviations in precipitation levels, helping predict and address drought risks by monitoring rainfall distribution and intensity patterns.
- **Soil Moisture Mapping:** Tools like SMAP provide precise, real-time soil moisture data, enabling better water management and informed agricultural decisions during droughts.
- **Vegetation Indices:** NDVI and EVI measure crop health and stress, offering insights into water scarcity impacts and guiding adaptive agricultural practices.

Early Warning Systems

- **Seasonal Forecasting:** Predicting drought risks based on long-term climatic trends helps farmers and policymakers prepare for potential water shortages.
- **Dynamic Monitoring:** Regular satellite updates allow timely interventions, such as supplemental irrigation and shifting planting schedules, to minimize crop losses.
- **Community Alerts:** Warnings shared via mobile apps, SMS and local media empower rural communities to implement drought preparedness measures effectively.

Mitigation Strategies

- **Water Resource Management:** Satellite-guided resource mapping prioritizes water use, promoting efficient irrigation, rainwater harvesting and groundwater replenishment to ensure sustainability during droughts and enhance long-term agricultural resilience.
- **Crop Diversification:** Encouraging drought-resistant and short-duration crops reduces vulnerability to climate extremes, ensuring steady income and food security for farmers in rural areas affected by water scarcity.
- **Government Schemes:** Integrating satellite-based insights into initiatives like PMKSY and MGNREGA improves water conservation, infrastructure development and sustainable agricultural practices, mitigating the impact of droughts on rural livelihoods.

Flood Management through Satellite Technology

Flood Risk Assessment

- **Rainfall Intensity:** Satellites monitor heavy rainfall patterns, enabling authorities to anticipate potential floods and initiate timely disaster mitigation strategies.
- **River Monitoring:** Satellite altimetry tracks river water levels, providing early warnings for regions prone to flooding and guiding risk management.
- **Floodplain Mapping:** Identifying high-risk flood-prone areas through satellite imagery allows targeted resource allocation and preventive measures.

Early Warning Systems

- **Real-Time Alerts:** Satellite systems deliver timely flood predictions and alerts, minimizing risks to life, property and agriculture in vulnerable regions.
- **Hydrological Models:** Integrating satellite data with local ground observations enhances accuracy in flood forecasts and improves response strategies.
- **Community Preparedness:** Training rural communities in interpreting flood warnings and implementing evacuation plans reduces disaster-related casualties and losses.

Mitigation Strategies

- **Structural Measures:** Satellite imagery assists in designing and constructing embankments, reservoirs and drainage systems to control flooding effectively.
- **Non-Structural Measures:** Promoting afforestation, land use planning and community engagement reduces flood impact by mitigating environmental degradation.
- **Relief and Recovery:** Satellite-guided mapping aids rescue operations, resource distribution and efficient post-flood rehabilitation, minimizing recovery time for rural communities.

Challenges and Limitations

- **Data Accessibility:** Ensuring timely and affordable access to satellite data for local authorities and farmers.
- **Infrastructure Gaps:** Building ground stations and communication networks in rural areas.

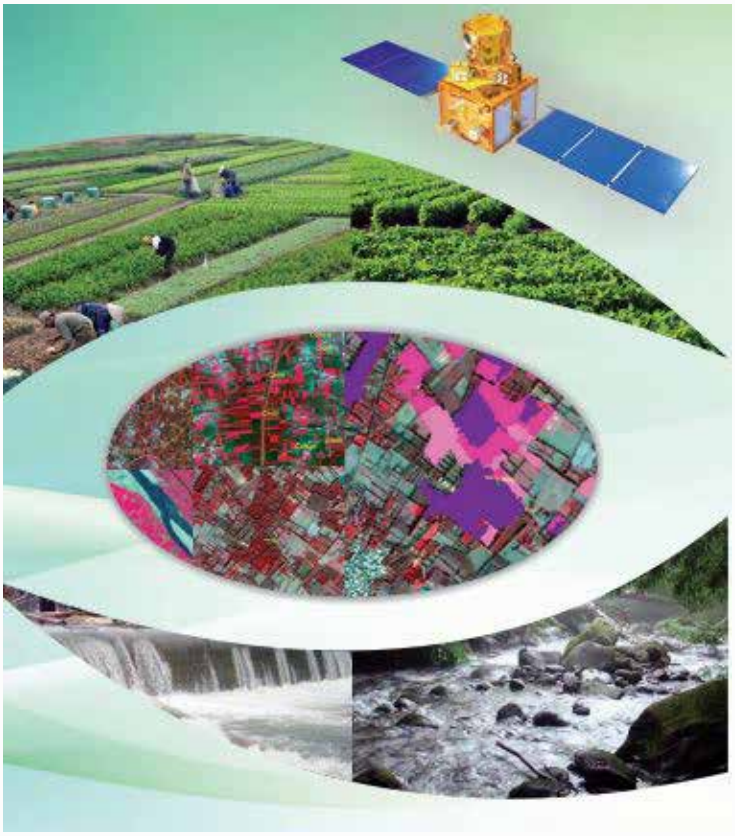
- **Awareness and Training:** Educating stakeholders on using satellite-based insights effectively.
- **Policy Integration:** Aligning satellite data applications with national and state-level disaster management plans.

Future Directions

- **Technological Advancements:** Harnessing AI, ML and IoT to enhance satellite data analysis.
- **Collaborative Platforms:** Fostering partnerships between government agencies, private sectors and research institutions.
- **Community-Centric Approaches:** Developing localized solutions tailored to the needs of rural populations.
- **Policy Support:** Strengthening funding and regulatory frameworks for satellite-based disaster management.

Conclusion

Droughts and floods significantly impact rural agriculture, threatening livelihoods, food security and overall rural development. Exploiting satellite technology offers transformative solutions by providing precise data for monitoring, early warning and risk mitigation. Indian and global satellite programmes, combined with collaborative efforts, enhance disaster preparedness and sustainable agricultural practices. Despite challenges like data accessibility and infrastructure gaps, the integration of advanced technologies such as AI, ML and IoT promises to revolutionize agricultural resilience. By facilitating community-centric approaches and aligning policies with satellite-based insights, India can effectively mitigate the effects of natural disasters and ensure sustainable growth for its rural populations. ❑



Krishi-Decision Support System (Krishi-DSS)

Krishi DSS spearheads a transformative journey in Indian agriculture. Often referred to as the "Gati Shakti" for Indian agriculture, Krishi DSS presents a master plan to expedite the development and adoption of geospatial and non-geo spatial technologies. Together, it will help build a resilient, sustainable, and prosperous agriculture for India.

The geo-spatial platform, Krishi- Decision Support System (Krishi DSS), is a powerful tool to empower stakeholders with real-time data-driven insights on weather patterns, soil conditions, crop health, crop acreage and advisories.

An initiative of the Department of Agriculture and Farmers Welfare, launched on 16th August this year, Krishi-DSS is a first-of-its-kind geospatial platform specifically designed for Indian agriculture. The platform provides seamless access to comprehensive data including satellite images, weather information, reservoir storage, groundwater levels and soil health information, which can be easily accessed from anywhere at any time.

Unlocking the Power of Data for Sustainable Agriculture Development

Krishi DSS spearheads a transformative journey in Indian agriculture through cutting-edge geospatial technologies. Often referred to as the "Gati Shakti" for Indian agriculture, Krishi DSS presents a master plan to expedite the development and adoption of geospatial and non-geo spatial technologies. Hosting hundreds of agriculture data layers in one place, Krishi DSS embodies the potency of data in driving evidence-based and cost-effective solutions. Krishi DSS will empower Indian agriculture with a seamless integration of geospatial insights.

Indigenous Geo-Spatial Platform for Informed Decision-Making in Agriculture

Krishi DSS, an integrated agriculture platform designed for informed decision-making, marks a leap for Indian agriculture to a realm of geospatial excellence. Representing a single reliable system for agricultural applications, Krishi DSS dynamically integrates data from state, central, and global levels, fostering a data-driven approach for sustainable agriculture. Agriculturists can unleash the power of geospatial maps, digital infrastructure, and comprehensive databases that collectively contribute to the platform's versatility. As the Krishi DSS database expands over the next few years, it will revolutionize the way we approach agriculture.

Connecting Stakeholders with Data-Driven Solution

Krishi DSS, the platform that serves as the bridge between farmers, stakeholders, and policymakers,

will equip Indian farm scientists, fertilizer companies, administration at various levels, and ultimately the farmers to arrive at informed decision-making. The application has been developed by the Department of Agriculture & Farmers Welfare and Department of Space as part of an MoU signed in December 2022 for using geospatial technologies and related databases for enhancing evidence based decision making capability of all the stakeholders in the agriculture sector.

Using RISAT-1A Earth observation satellite and VEDAS (Visualization of Earth observation Data and Archival System) portal of Department of Space, Krishi-DSS enhances the evidence-based decision-making capability of all the stakeholders in the agriculture sector by way of integration with MOSDAC and BHUVAN

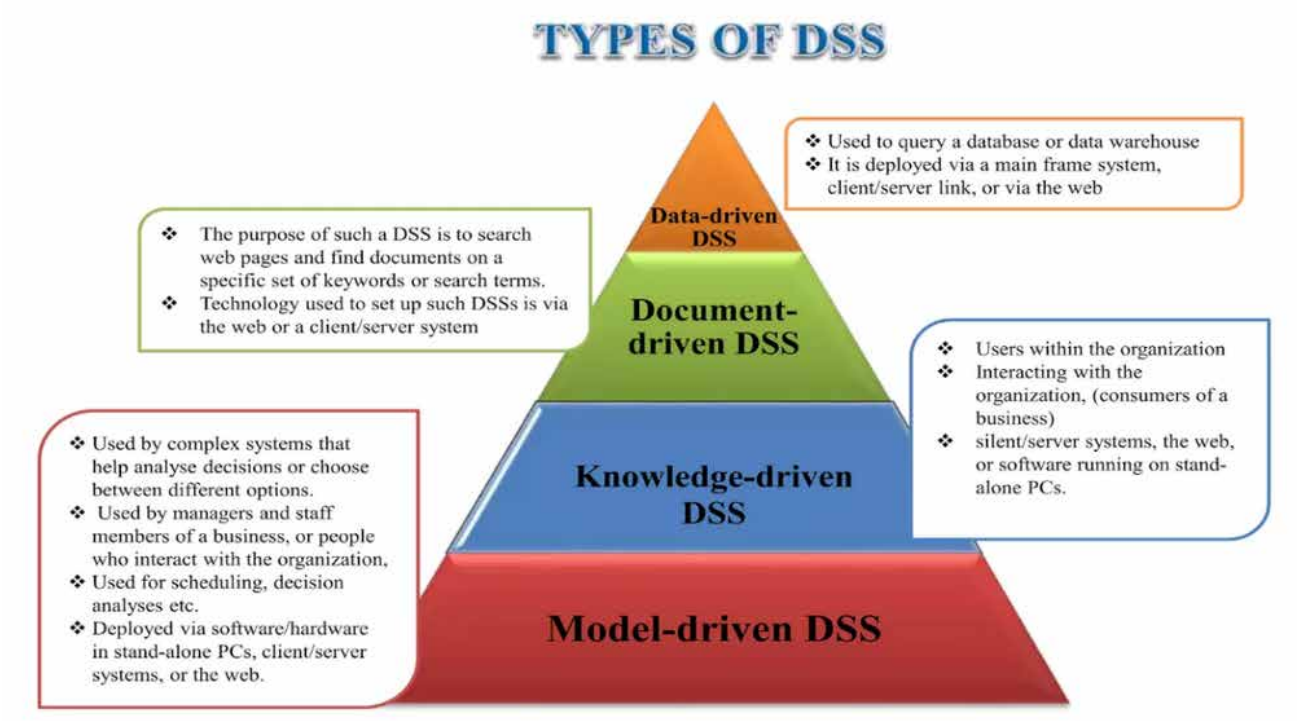
(Geo-platform) of ISRO and systems of ICAR. RISAT-1A is an all-weather satellite and can penetrate deep into vegetation. It can take high resolution geospatial images regardless of lighting conditions.

Krishi DSS empowers agriculture with data-driven insights, bridging the gap between those working in the fields and those shaping policies. Offering exclusive services such as closed group interactions, blogs, news, and surveys, the platform ensures that the wealth of information in its data library is accessible to all visitors. Users can register on Krishi DSS website **https://krishi-dss.gov.in/krishi-dss/** to unlock exclusive services and be part of the agriculture transformation.

Applications of Krishi DSS towards Sustainable Agriculture Development

Krishi-DSS includes several advanced modules designed to support comprehensive agricultural management. From the vast expanse of fields to the smallest soil particle, Krishi-DSS has it covered.

- With crop mapping and monitoring, it enables to understand cropping patterns by analysing parcel-level crop maps over the different years. This information helps in understanding crop rotation practices and promotes sustainable agriculture by encouraging the cultivation of diverse crops.
- Drought monitoring helps to stay ahead of the drought, which gives near real-time information on various indicators i.e soil moisture, water storages, crop condition, dry spells etc, while crop weather watch keeps stakeholders informed about how weather is impacting the crops, crop harvest status, crop residue burning etc.
- With Field parcel segmentation, experts will be able to accurately analyse field parcel units which will help in understanding each parcels unique needs and cropping patterns for targeted interventions. One Nation-One Soil information system gives a comprehensive soil data at your fingertips i.e soil type, soil pH, soil health etc. Soil data will help in assessing crop suitability and land capability for implementing soil water conservation measures.
- Ground truth data library of Krishi-DSS fosters innovation by providing essential resources like ground truth data and spectral libraries for different crops to the researchers and industry. From flood



impact assessment to Crop insurance solutions and many more, Krishi-DSS is a holistic solution. It's about empowering our farmers, informing our policies, and nourishing our nation. By integrating various data sources available on the Krishi DSS, various farmer-centric solutions can be developed such as right individual advisories to farmers, early disaster warning like Pest attack, Heavy rain, Hail storm etc.

Digital Agriculture Mission: Tech for Transforming Farmers' Lives

Krishi-DSS is more than just a tool, it's a catalyst for innovation and sustainability in agriculture. Developed as part of the Digital Agriculture Mission, its second major component is the Agri Stack.

After the completion of AgriStack, there will be a revolutionary change in the field of agriculture. Additionally, the mission includes 'Soil Profile Mapping' and aims to enable farmer-centric digital services to provide timely and reliable information for the agriculture sector. Together, it will help build a resilient, sustainable, and prosperous agriculture for India.

The Digital Agriculture Mission was approved by the Union Cabinet Committee, chaired by Prime Minister Narendra Modi on September 2, 2024 with a substantial financial outlay of Rs. 2,817 Crore, including a central government share of Rs. 1,940 Crore.

The Digital Agriculture Mission is designed as an umbrella scheme to support various digital agriculture initiatives. These include creating Digital Public Infrastructure (DPI), implementing the Digital General Crop Estimation Survey (DGCES), and supporting IT initiatives by the Central Government, State Governments, and Academic and Research Institutions. ❑

(Source : PIB and Krishi DSS website, Government of India)

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