Fostering the agricultural production through the Government of India initiative of "Antariksh mein Atmanirbharata"

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The integration of space technology and communication systems is revolutionizing rural development in India, addressing critical challenges in agriculture, disaster management, rural education, and healthcare. While India's space missions like Chandrayaan and Mangalyaan have gained global recognition, the contributions of space-based applications in agriculture and rural infrastructure remain underexplored. Remote sensing and satellite imaging play a transformative role in monitoring crop health, water resources, and land use, enabling precision farming to optimize water, fertilizers, and pesticides. Geographic Information Systems (GIS) are instrumental in planning rural infrastructure, including roads, irrigation networks, and electrification projects. India's remote sensing satellites (IRS-1A, RISAT, ResourceSat, CartoSat, and Oceansat) provide vast datasets to assess crop acreage, productivity, and yield estimates, supporting initiatives like FASAL, CHAMAN, and NADAMS for agricultural forecasting, horticulture management, and drought monitoring. Furthermore, space technology enhances rural governance through Bhuvan Panchayat and Digital India Land Records Modernization Programme (DILRMP), ensuring transparent land ownership records and improving decision-making. The Digital Agriculture Mission, powered by Krishi Decision Support System (Krishi-DSS) and Agri-Stack, leverages satellite-based geospatial data for soil health assessment, crop monitoring, and disaster response, bridging the gap between farmers, policymakers, and researchers. These advancements contribute to higher agricultural productivity, sustainable resource management, and improved rural livelihoods. By harnessing space-based technologies, India is transforming its villages into economically viable and technologically empowered growth centers, ensuring a resilient and sustainable future for its agrarian economy.

The intersection of communication 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. Especially, the contribution of space technology has been overlooked in the rural development. Nation's space missions, such as Chandrayan and Mangalyaan, are well known for their success in planetary exploration. Agriculture, the backbone of rural India is very much vulnerable to changing weather patterns, pests attacks and inadequate infrastructure. Space-based applications such as satellite imaging, have transformed the ability to monitor crop health, water resources and land use. Moreover, satellite imagery is used in precision farming techniques, helping farmers to optimize the use of resources such as water, fertilizers and pesticides. Space technology also supports the development of critical rural infrastructure. Geographic Information Systems (GIS) are extensively used for planning rural infrastructure projects such as roads, irrigation systems and electrification. The synergy between space technology and rural development in India is a promising and revolutionizing force. Critical gaps have been bridged in the field of agriculture, infrastructure development by enabling real-time data collection, communication and monitoring and space technology.

Agriculture in India holds a crucial place in the country's economy and society. India depends heavily on this sector for food security, employment and economic development. Agriculture contributes to 18-20% of India's GDP. India is the world's second largest producer of wheat and rice and a leading producer of pulses. Agriculture accounts for 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 analyzing the productivity for different seasons and geographical regions. The satellite imagery provides crucial information about the crops affected by pest and its propagation to contain the extent of damage. The land records mapping and asset tagging is very important for the farmers for regularizing the loans and insurance claims in case of any calamity. 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 productive crop, that yields a balanced revenue for the farmers. Majority of the farmers in India availing the government supports through various schemes such as Pradhan Mantri Fasal Bima Yojana

(PMFBY), soil health card scheme receive vital information through satellite imagery. 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.

Founder of Indian space programme had a dream and vision to harness space sciences for social benefits, national development and welfare of human being. So far, India has developed a plethora of advanced space technologies and tools that are contributing in various operations domains of national development. Among various spheres, agriculture and rural development are key beneficiaries due to their vast canvas and large number of potential tasks 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 key areas where space technologies have contributed immensely. The first practical application of a space technique in India was in the field of agriculture, where early detection of coconut wilt disease in Kerala was possible using air-borne infrared cameras. In addition to installations of remote sensing and communication satellites, India now has 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 demands of many applications of relevance to natural resource management.

Application of remote sensing 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. National Resources Management System in the country carry out various remote sensing application projects based on the experience of the CAPE. The Ministry of Agriculture and Farmers Welfare in collaboration with Indian Space Research Organization (ISRO) established a dedicated Mahalanobis National Crop Forecast Centre in New Delhi for the application of remote sensing technologies in various tasks in agriculture. 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 such as jute, kharif rice, rabi rice, rabi pulses, cotton, rapeseed and mustard, rabi sorghum, wheat and sugarcane are covered under the project. The 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.

NADAMS (National Agricultural Drought Assessment and Monitoring System) is a very critical project for Indian agriculture as it helps prevents losses due to abnormal weather conditions. It provides near-real time information regarding the prevalence, persistence and severity levels of the agricultural drought at state, district and sub-district levels. The project uses rainfall datasets, district-wise soil moisture models and remote sensing derived vegetation indices for issue of drought warnings and covers 17 drought-prone states of the country. Pradhan Mantri Fasal Bima Yojana (PMFBY) envisages to provide the insurance cover to meet the financial needs of the farmers when the crop get destroyed by various calamities and incidence of pests and diseases. Large number of farmers in the country get quick and hassle-free claims due to application of remote sensing. Remote sensing has been extensively used for planning purpose 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 estimation in certain regions. Hyperspectral remote sensing, Internet of Things, state of the art sensors, high speed data processing and intelligent systems are bringing a completely new dimension in the capabilities of remote sensing applications.

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 space tool used for land use; land cover are mainly optical sensors from satellites. The space-based service used for mapping of land use and land cover

encompasses all states and union territories. The datasets thus generated are used for planning of land and resources up to village and taluka level. 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 moisture content, where active roots of most crop plants are present.

Recently, an important geoportal developed by ISRO – Bhuvan Panchayat has been launched in the country. The aim of the initiative is to improve the governance and decision-making by using space-based information in the field of geospatial database monitoring and rural development. 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. The platform utilizes web technologies, which enables it to work seamlessly across devices, and provide continuous interface experience for users. With the availability of real-time data and analytics, the platform promotes transparency and accountability of rural projects. The Digital India Land Records Modernization Programme (DILRMP) 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. The objective of DILRMP is to develop a modern, holistic and transparent land records management system to create an integrated land information management system. 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. Satellite technology and remote sensing data play a vital role in digitization of land records, enduring accurate survey of land, geo-referencing and transparency and helping resolve land disputes. 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 management accurate.

Satellite imagery is increasingly being used in aquaculture to enhance productivity, sustainability and environmental management. The remote sensing capabilities of satellite allow aquaculture practitioners to monitor and manage fish farms and aquatic ecosystems efficiently. Satellite images can help 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. 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 satellites 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. Another domain that contributes to the revenue is horticulture which includes vegetables, fruits, flowers, herbs and ornamental plants. Hyperspectral satellite data is used to the extent of analyzing stress and quality of leaves and monitoring the health of 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.

Digital Agriculture Mission is designed as an umbrella scheme to support various digital agriculture initiatives. These include creating Digital Public Infrastructure, implementing the Digital General Crop Estimation Survey and supporting Information Technology initiatives by the Central Government, State Governments and Academic and Research Institutions. The scheme is built on two foundational pillars one is

Agri Stack and second is Krishi Decision Support System. The mission also 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 integrates remote sensing data on crops, soil, weather and water resources into a comprehensive geospatial system. 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 insight.

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. It 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. It is the platform that serves as the bridge between farmers, stakeholders and policymakers, Indian farm scientists, fertilizers 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 and 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 approach in the agriculture sector by way of integration with MOSDAC and BHUVAN which are 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 includes several advanced modules designed to support comprehensive agricultural management. From the vast expense of fields to the smallest of the soil particles. It enables understanding cropping patterns by analysing parcel-level crop maps over different years. This information helps in understanding crop rotation practices. Krishi DSS includes drought monitoring module which helps to stay ahead of the drought by giving near real-time information on various indicators like soil moisture, water storages, crop production. With field parcel segmentation, experts can accurately analyze field parcel units which 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. 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 more than just a tool, it is a catalyst for innovation and sustainability in agriculture. Developed as part of the Digital Agriculture Mission, its second major component is Agri-Stack. Completion of Agri-Stack 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 agricultural sector. Together, it will help build a resilient sustainable and prosperous agriculture for 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. Once enriched with the technical knowledge, many issues related to land use or reclamation of wastelands, agriculture, horticulture, water harvesting specific to local environment can be addressed at local level. Through satellite-based services and remote sensing, space advancements have become essential tools for rural development and societal well-being, showcasing broad and transformative impact of space innovations in everyday life.

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