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Space Technology for Sustainable Ecosystem & Geospatial Economy

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Honourable INCA Members, distinguished delegates, ladies and gentlemen.

It is truly a privilege for me to be amongst you all, delivering the prestigious S.P. Chatterjee Memorial Lecture at the 43rd International Congress of INCA. It is indeed an honour for me, as in the past, this lecture was delivered by several illustrious personalities. I am pleased to note that INCA has been organizing this annual event, since 2005 to commemorate the scientific contribution of Prof. Shiba Prasada Chatterjee, known as the Father of Indian Geography. Certainly, organizational systems like INCA have great bearing on fostering research, promoting technological advancements and disseminating knowledge for the benefit of cartographic community and academia at large.

Shri Shantanu Bhatawdekar while delivering the S.P. Chatterjee Memorial Lecture, 43rd INCA International Conference, Jodhpur (Dt. 06 Nov. 2023).

As we all know, space provides the vantage point to view the mother Earth in its totality; it facilitates connectivity cutting across the physical boundaries and drives the key for - scientific understanding of earth system processes, shaping country's economy by accelerating socio-economic development and improving the quality of life and livelihood. For a country like India, with vast geographic spread and diversity in its set up; striving for balanced & equitable growth, promoting sustainability and aspiring for climate adaptation & mitigation, the role of Space Technology for Sustainable Ecosystem cannot be questioned.

In today's talk, I will dwell upon how space technology has evolved over the years in terms of observational capabilities and in providing necessary technological interventions towards national imperatives, enabling sustainable growth and social well-being. I will also speak on changing landscape of geospatial economy with emergence of reforms, policies and disruptive innovations.

The humble past and evolution of remote sensing activities in India:

Let me recall briefly, the humble beginning and evolution of remote sensing activities in India. The potential of space technology for natural resource inventory and management was foreseen by the visionaries in 1970s and beginning was made with a pioneering experiment aimed at detection of coconut root-wilt disease using helicopter mounted multi-spectral camera system. India was early user of the first earth observing satellite "Landsat-1" from 1972. The then leadership was of the view that, India would not wait for its own satellites to begin application development and foreign satellites data were used in the initial stages so that applications could be proven, ground systems could be put in place and user community could be familiarized with the new technology and ultimately, aiming to build indigenous systems. Outcome of this strategy was the establishment of Indian Landsat Earth Station (ILES) established in 1979 in Shadnagar having capability of single mission at 15 mbps rate. Today, it has grown as a state-of-the-art integrated data acquisition and processing facility having capabilities to cater multiple missions simultaneously.

India (ISRO) initiated remote sensing activities by launching its first experimental RS Satellite, Bhaskara-1 in 1979 followed by Bhaskara-2 in 1981, carrying optical and microwave sensors. This provided valuable experience in the development and operation of spacecraft technology as well as interpretation of satellite based remote sensing data.

In early 80s, years before the launch of first operational Indian Remote Sensing (IRS) satellite, the need of actively involving user agencies in identifying requirements, defining the payloads and development of applications was envisioned. Prof. Satish Dhawan used to say that users must be so energized in advance, that by the time the satellite is up in space, the users are ready and eager to utilize the satellites. Accordingly, several joint experiments in application areas such as Agriculture, Geology, Forestry, Soil, Landuse and Oceanography were conducted with users during 1980-1985. National Remote Sensing Agency (NRSA) which was with DST, was brought under DOS in 1980 to integrate Remote Sensing activities. Similarly, Indian Photo-interpretation Institute (IPI) which was under Survey of India, was transferred to NRSA and renamed as Indian Institute of Remote Sensing (IIRS) and given proper function dealing with Satellite Remote Sensing (rather than only with Aerial photos).

The 1st meeting of the Preparatory Committee for the National Natural Resource Management was held on March 3, 1982 under the chairmanship of Dr. M.S. Swaminathan, the then Member (Science), Planning Commission. As per the decision of the committee, 50 end-to-end experiments were conducted essentially to consolidate the experiences of different studies across 18 themes and the results were presented in the national seminar held at Hyderabad during May, 1983. One of the resolutions emerged in the national seminar was that the application-specific National Task Forces should address "technical suitability, cost effectiveness, accuracy and integration of remotely sensed data with traditional techniques".

As a follow up to National Seminar, Government approved the establishment of NNRMS in February 1985, as a well-knit network involving Central & State Governments, Private sectors, Academia and Non-Governmental Organizations for enabling integration of Remote Sensing, contemporary technologies with the conventional practices for management of natural resources. The NNRMS framework included a Planning Committee of NNRMS (PC-NNRMS) chaired by Member (Science), Planning Commission and Secretaries of various Ministries/Departments as Members. It was supported by nine theme oriented Standing Committees, namely - i) Agriculture & Soils, ii) Bio-resources, iii) Cartography & Mapping, iv) Geology & Mineral resources, v) Oceanography & Meteorology, vi) Rural Development, vii) Urban Development, viii) Water Resources, ix) Training & Technology, responsible for utilization of space technology applications in respective areas.

The effectiveness of a virtual body like NNRMS stands testimony to the fact that, it continues to be replicated in several countries and multilateral bodies like Global Earth Observation System of Systems' (GEOSS) Nine "Societal Benefit Areas (SBAs)" of disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity, where the endorsement of EO data for societal use comes at global level.

Epochs of Imaging capabilities in India & IRS Missions:

ISRO's leadership saw the opportunity to exploit the space technology as a community resource capable of monitoring land, water and ocean resources, atmospheric studies, managing disasters & natural calamities and enable planning, monitoring and evaluation of developmental activities. This paved way for the definition of Indian Remote Sensing (IRS) Programme under which first operational satellite, IRS-1A was launched in 1988 and later lead to realization of thematic series, namely, (i) Land/water resources applications (RESOURCESAT & RISAT series); (ii) Ocean/atmospheric studies (OCEANSAT & INSAT series, Megha-Tropiques, SARAL); and (iii) Large scale mapping applications (CARTOSAT series). The imaging sensors have been developed providing spatial resolution ranging from 1 km to sub-meter; repeat observation from 22 days to every 15 minutes and radiometric ranging from 7 bit to 12 bit. The journey has witnessed many epochs of technological excellence in imaging capabilities.

Push-broom imaging: In its very first Remote Sensing satellite, IRS-1A in 1988, ISRO used innovation technology of push-broom imaging giving advantage of longer dwell time, better radiometric fidelity and no pixel distortion. Earlier, Landsat-1 to 6 used the whiskbroom imaging mode for opto-mechanical scanner. Later, Landsat-7 onwards it also adopted push-broom imaging to get better accuracy.

World's first Highest Resolution satellite: In mid 90s, IRS-1C/1D satellites with their unique combination of payloads have taken a lead position in the global remote sensing scenario. Panchromatic camera (PAN), with 5.8 m spatial resolution with off-nadir view capability, was the highest spatial resolution offered for civilian remote sensing satellite at that time.

Oceanography satellite: India's first dedicated mission for oceanography, Oceansat-1 in 1999, carrying Ocean Colour Monitor (OCM) and Multi-frequency Scanning Microwave Radiometer (MSMR) lead to Potential Fishing Zone services.

Step & Stare technology: With TES in 2001, ISRO introduced the technology for achieving very high spatial resolution images, using panchromatic camera having step and stare imaging mode.

Three-Tier Imaging: The glorious era for remote sensing user community was the launch of Resourcesat-1, in 2003. It was one of the world's most sophisticated satellites having a unique 3-tier imaging capability - AWiFS (56m), LISS-3 (23 m) and LISS-4 (5.8m) sensors. It demonstrated technological leadership of India in Earth Observation.

Along Track Stereo imaging: Cartosat-1 launched in 2005, was then first of its kind satellite in the world, providing stereoscopic images of the Earth at 2.5 m using two cameras mounted on the satellite for near simultaneous imaging of the same area from two different angles +26° and -5°. Usage of Stereo Strip Triangulation (SST) along with the new image matching procedure led to generation of Digital Elevation Model (CartoDEM) at national level. The Coastal DTM generated for the Indian East and West Coast of India has been extensively used Indian Tsunami Early Warning Centre as base elevation dataset.

Due to the unique nature of imaging and best quality of the images provided by the Cartosat-1 mission, the data was in huge demand internationally for high resolution DEMs over their countries and 13 International Ground Stations (IGS) were set up.

Global Scatterometry: Oceansat-2, launched in 2009 carried a Ku- band Pencil Beam Scatterometer (OSCAT) in addition to Ocean Colour Monitor and Radio Occultation Sounder. OSCAT ensured reliable global wind vector data measurement and continuity to QuickScat mission. Today, the Ku-band Scatterometer derived wind vector data are utilized for operational global weather prediction, improvement of potential fishing zone advisories as well for cyclogenesis.

All Weather Imaging: Towards day-night and all-weather imaging capability, India built & launched its first indigenous microwave satellite Radar Imaging Satellite-1 (RISAT-1) in April 2012, carrying a Synthetic Aperture Radar (SAR) Payload operating in C-band (5.35 GHz) with cross-polarization as well as circular polarization.

Joint satellites: Having built expertise in spacecraft technology and recognizing the need of providing EO data for wider applications, India also embarked on cooperation with other space-faring nations. One of the early examples were "Megha-Tropiques" for investigating the contribution of the water cycle in the tropical atmosphere to climate dynamics and "SARAL" for Ocean Altimetry satellites with CNES, France. Megha-Tropiques was also part of the constellation of 10 satellites participating in the Global Precipitation Measurement (GPM) mission

Early Geospatial efforts in India - Database, Standards & Application Missions:

Right from inception, NNRMS recognized the importance of - Standard classification systems for mapping and Standard methodology for harmonization results of thematic mapping. In early 1990s, ISRO undertook Integrated Mission for Sustainable Development (IMSD), for 84 mha area of the country, where remote sensing based thematic maps, integrated with socio-economic data, became the basis for generating optimal Land and Water Resources Development Plans on watershed basis. It was first of its kind approach of providing such planning and implementation plans at district level and inclusive of the participatory approach.

In 1998, NNRMS took a major leap in defining GIS standards in the country and adopted Natural Resources Information System Standards (NRIS standards-2001), which for the first time introduced GIS design, content and process standardization for 1:50,000 scale. Over many years, NRIS standards served the requirements of GIS databases as the de-facto national standards for GIS databases.

With a view to develop a comprehensive set of standards for images, thematic mapping, GIS and outputs/ services, especially in the context of geospatial activities across different organizations, the NNRMS Standards were evolved in 2004 as open standards to ensure a high-level interoperability across platforms, databases, development languages, and applications.

Several efforts were initiated across many organizations to build geospatial database across themes of their relevance. Such efforts resulted in generations of databases in silos and comprehensive view was not available for decision making. Under the aegis of PC-NNRMS, several Joint Application missions were initiated with concerned ministries/ departments as knowledge partners. Later, several user departments adopted those applications in their operational value chain. A few such applications include: - Crop Production Estimation & Agricultural Drought (M/o Agriculture & Farmers' Welfare); Forest cover mapping & Desertification (M/o Environment, Forest & Climate Change); Wasteland mapping, Watershed development (M/o Rural Development); Ground water & Irrigation Assessment (M/o Jal Shakti); Cyclone & PFZ (M/o Earth Sciences);

In 2005, ISRO launched the Natural Resources Census programme; the Large-Scale Mapping Programme & Cadastral map integration with a mandate to generate spatial database of natural resources management periodically on defined themes, such as annual & five yearly Cropped Area/ Land Cover/ Land Use, biennial forest cover, decadal land degradation, etc- (Mention themes & periodicity)

These efforts resulted in building comprehensive Pan-India geospatial database in the country in support of developmental planning and decision making.

Space Technology for Sustainable Ecosystem:

India is endowed with rich natural resources such as fertile soil, forests & biodiversity, water, glaciers and minerals. India, being seventh largest country with only 2.4% land area, hosts 18% of world population. Agriculture is the prime livelihood for more than half of Indians with 142-million-hectare net sown area and total forest area of about 71.38 Mha (21.7% TGA). A vast coastline of 7500 km provides income to more than 14 million people. India has large network of 12 major river basins, 46 medium river basins besides other water bodies like tanks and ponds with irrigation potential of 70 M ha.

However, the natural resources are under severe stress due to increasing rate of degradation and depletion mainly due to unscientific anthropogenic exploitations. Deforestation, soil erosion, salinization, over use of groundwater, sedimentation, overgrazing of pastoral lands and loss of biodiversity, ocean & air pollutions are the typical examples of degradation affecting the status of natural resources. Also, Indian sub-continent is one of the most disaster-prone witnessing recurrent events of Floods, Cyclones, Landslides, Drought, GLOFs, Forest Fire, etc.

As per estimation, India's population will be of the order of 1.67 billion by 2047, in which about half of the population will stay in urban areas demanding sustainable urban planning. Due to increasing population, there would be increased challenges for Food, water, energy & environmental security, Social Inclusivity etc., There would be also several global climate and environmental issues, such as predicted temperature rise of ~1.5 °C by 2035, expected double rate of sea level rise by 2050, reduction in per capita water availability, triple rate of depletion of ground water by 2041, 15-times increase in disaster mortality rates, increase in greenhouse gases & air pollution, degradation of resources, shift in climatic patterns, reduction in snow cover and ice-caps, acidification of ocean water, loss of bio-diversity, etc. Also, India is committed to reduce the GHGs emission to 43% by 2030 and net zero by 2070, support the sustainable development goals monitoring, rejuvenate degrading planet by decarbonization and resilient ecosystems.

Addressing these challenges calls for sustainable utilization of natural resources, long term sustainability & conservation to balance the demands of exploitation with a respect for regenerative capacities; developmental planning with a focus on reducing environmental impacts, building disaster resilient society and promoting well-being of our planet and quality of life.

In this regard, space technology plays a critical role by providing data at different spatio-temporal scales for scientific understanding and up-to-date mapping and management of ecosystems for long-term sustainability. The multi-criteria analytical models and applications employing multi-dimensional/ multi-resolution time-series data help to draw meaningful results encourage data-driven decision-making and delivery of advisory services to the grassroots. India's space programme distinctly exemplifies how space could be the harbinger for promoting sustainable development. India has well defined space application programmes utilizing the space technology related to 13 SDGs (out of 17 SDGs) having direct reference to Food, water & energy security, natural resources conservation & sustainable development, natural resources, shelter, environment, health, education, climate change induced impacts and disaster resilience. Let me dwell on a few of these:

Food security and doubling agricultural productivity by 2030:

Five decades after the start of the "Green Revolution", India's food grain production has increased five-fold and today India is one of the world's largest producers of staples like rice and wheat. However, agricultural productivity levels are still low as compared to world average.

To feed ever-growing population, substantial increase in crop production by - (i) Bringing more land under cultivation (Wasteland mapping), (ii) Increasing crop productivity (BGREI), (iii) Crop protection against Pests & Diseases and (iv) reliable and timely estimates on Crop production for major field crops (FASAL) and (v) Inventory & site suitability of horticultural crops (CHAMAN) are important for formulation of marketing strategies such as export/import, price fixation, public distribution.

The space technology is being used for Crop insurance to determine smart sampling locations for conducting crop cutting experiments (CCEs) for crop insurance under Pradhan Mantri Fasal Bima Yojana (PMFBY) scheme. The methodology has been demonstrated for Kharif Rice, Rabi Rice, Wheat, Rabi Sorghum & mustard crop.

In India, more than 7 million people living along the 7500 km coastline are dependent on fishing for their livelihood. Sea Surface Temperature & Chlorophyll information retrieved from satellites are used for providing Potential Fishing Zone advisories to the fishing community on a daily basis. Such advisories help them in increased fish catch (2-5 times) and reducing searching time (about 30-70%), which leads to savings towards cost of fuel.

Water security and providing Clean Water: Water resources of India are highly variable in their occurrence, distribution and utilization. The annual precipitation aggregated as 4000 BCM with total utilizable resource of 1123 BCM (which is 28% of total water availability). Currently, in India about 71 mha (50%) of the agricultural land is covered by irrigation, whereas the rest is dependent on rainfall.

Satellite remote sensing is helpful for - (i) time stamping the Irrigation Infrastructure progress and monitoring irrigation status through the season, (ii) inventory of irrigated area and crop productivity in irrigation systems, (iii) severity of waterlogging and salinization, (iv) National Drinking Water Mission to map prospective zones and sources of safe potable drinking water to problematic villages. (v) Sustainable development of ground water resources at village level, optimizing recharge and exploitation

To increase the share of renewable energy: 48 hourly forecasts on Solar Power Potential are derived using insolation data from INSAT-3D/ 3DR meteorological satellites. Similarly, off-shore Wind Energy & wave energy Potential is assessed utilising scatterometer & altimeter data.

Environment Security: Bio-resources & Biodiversity:

Forest Mapping: India accounts for two per cent of the world’s total forest area and ranked tenth in the world. Since 1987, FSI is regularly carrying out biennial forest cover mapping using satellite data on 1:50,000 scale. As per State of India Forest Report, 2021 - Total Forest area is 71.38 mha (21.71 % TGA). India’s forest cover has increased by more than three per cent during 2011 to 2021, mainly attributed to increase in very dense forest, which grew by 20 per cent during the period

Further, using satellite data, India has developed automated detection of national annual forest loss locations for generating actionable alerts.

Forest Above Ground Biomass (AGB), is one of the parameters recognized as key parameter for the status of the forest. The quantification of the tropical forests’ parameters has gap areas with regards to the available databases. Microwave remote sensing enables generation of a robust database for the tropics due to the sensitivity to the roughness and physical geometry of forests.

Bio-diversity: India is one of the 17 mega-biodiversity countries of the world having diverse pool of flora (7%) and fauna (6%) in the world. Satellite data has been effectively used for mapping and monitoring the biodiversity at landscape level. The efforts are extended for community level biodiversity mapping

Wetland Ecosystem: Wetlands are important ecosystem interconnecting the processes between land, hydrology, flora and fauna. National Wetland Inventory has been carried out with the objective to update wetland inventory and perform decadal change analysis using satellite data to support developmental planning and decision-making processes.

Coral reefs provide critical coastal and marine habitats and have enormous ecological and economic resource value. Worldwide decline in coral species abundance, mass coral bleaching events and overall loss and degradation of coral reef habitats are serious environmental issues today.

Towards building Sustainable Cities & Villages:

India, being the second most populous country accounts for about 32% of people living in cities, which is expected to increase to 50% by 2051. Urban Local Bodies (ULBs) prepare master plan, a statutory document for guided & planned development indicating detailed land use allocation for future development, say over next 20 years or so based on existing demography, land use, infrastructure and socio-economic conditions. Ministry of Urban affairs is employing High resolution satellite images for formulating master plans for 500 AMRUT cities and 100 Smart Cities.

ISRO carried out 'Large scale (1:4,000 scale) Urban GIS database creation of 238 AMRUT cities from 20 states / Union Territories, which were used by ULBs for formulation of GIS based Master Plans.

Space based Information Support for Decentralized Planning aims to empower Panchayati Raj Institutions (PRIs) and grassroots for participatory decentralized planning. Gram Panchayat Spatial Development Planning is part of the first-ever pilot studies at national level covering 34 GPs across in Maharashtra, Madhya Pradesh and Chhattisgarh for preparation of detailed Land Resources Development Plan & Water Resources Development Plan.

Climate Change induced impacts:

Climate change & its impact on the earth system are of concern to global scientific community and needs understanding of physical, chemical and biological processes regulating the Earth System and how the system is influenced by the natural forces and human activities. It requires systematic and long-term observation of geophysical variables parameters, proper calibration/ validation and analysis to build a climate qualified database.

ISRO has setup a multi-institutional endeavour, National Information system for Climate & Environment Studies (NICES), which operationally disseminates 67 Geophysical Products including 13 ECVs related to Terrestrial, Ocean and Atmosphere.

ISRO proposes to build a G20 satellite carrying payloads for environment and climate observations onboard for the benefits for G20 nations.

Building Disaster Resilience:

Sustainable development also envisages effective disaster risk reduction related to flood, cyclone, landslides drought, forest fire and earthquake. Aided by forecast mechanism on impending disasters helps in disaster mitigation to a significant extent. ISRO has in place a well-coordinated Disaster management programme aimed to render support in all phases viz. Early warning, Preparedness, Monitoring, Response, Recovery and Mitigation. Satellite Communications & navigation provide the critical path for relief in emergency situations. Disaster Management Authorities are equipped with Hazard Zonation Maps (Flood, Landslide), Early Warning for Cyclone, Flood, Forest fire alerts and near-real-time value-added products during the events of disaster.

National Database for Emergency Management (NDEM) is a comprehensive & seamless national repository of multi-scale geospatial database, POI data coupled with decision support system tools for addressing emergency/disaster management in the country.

The Geospatial Economy:

The Global Space Market reached $424 Billion in 2022 (about +8% with respect to 2021). Out of this, only 11% is spent on upstream activity (spacecraft manufacturing, launch services, ground segment) and rest 89% constitute the downstream activities (satellite operations and services). This shows the importance of geospatial and EO segment. EO still represents only a small fraction (4%) of this overall figure [Ref. Euroconsult, Space Economy Report, 9th edition, 2023]. The Indian Space economy is measured at about $8 Billion, which is only about 2% of the global space economy. The aim of the recent measures taken by the Government is to take it to 8% in the next 10 years.

India's Geospatial Economy which was valued at around INR 41600 crore in 2022, is poised to grow to INR 63,000 crores by 2025, and to provide employment to more than 10 lakh people mainly through Geospatial Start-Ups as reported by the Geospatial Strategy for National Development report. As an industry, geospatial services generate US$400 billion in revenue per year. However, their total economic contribution is several times higher.

The Changing Landscape of Reforms & Policies:

To open India's potential in space sector, Government of India has announced space sector reforms in June 2020, to enable and promote greater participation of NGEs in end-to-end space activities as co-traveller. A conducive ecosystem along with favourable regulatory and policy environment is incubated for authorizing, handholding, sharing expertise and technology through Indian National Space Promotion and Authorization Centre (IN-SPACe) to enable NGEs to climb the value chain.

This is intended to bring a commerce-oriented approach to space activities by positioning Light-touch domestic regulation, with focus on ease of doing business to bring industry into the space sector in line with Atmanirbhar Bharat and make them cost competitive within the global market.

National Geospatial Policy-2022 holds the promise to liberalize the geospatial sector and democratize the datasets generated using the public funds. As per this, there will be no requirement for prior approval, security clearance, license or any other restrictions on the mapping within the territory of India. Self-certification will be used to convey adherence to the implementation Guidelines. Also, it advocated that geospatial data produced using public funds shall be made easily accessible for scientific, economic and developmental purposes to all Indian entities. Drone Rules 2022 abolished remote pilot certificate for flying small to medium size drones for non-commercial purposes.

With regard to EO and Geospatial domain, Indian Space Policy 2023 has brought path-breaking changes in the EO domain by positioning an open, inclusive & forward-looking policy. We are opening the EO sector for private players, who can engage in the entire gamut of activities, right from owning & operating space infrastructure, to dissemination of data, value added products, and services. The access to EO data & products is made Easy and Open for bringing in new avenues for Research, innovative solutions and employment generation. ISRO is making public funded satellite data of 5m and coarser, rich heritage of archived data and satellite derived data freely available, so that industry can come up with innovative solutions using such data.

The demand-driven approach for space application sector has been also introduced, which means the satellite missions are required to be funded by the concerned User Ministries and hence creation of new assets to be made contingent on confirmation of demand from user agencies/ entities. This is basically to bring a sense of accountability and optimal utilization of EO data. In this regard, a Space Applications Management System (SAMS) framework has been constituted with objective to dwell on need aspect of satellite missions and associated ground segment, development of applications aligned with national imperatives, and their optimal utilization to harness the benefits of space-based services.

Geospatial Ecosystem and Governance: With an emphasis on technology and all-around development to drive the nation to the future, the new Geospatial ecosystem supported with favourable policies and armed with disruptive innovations has immense potential to assist sustainable development and provide employment opportunities for youth, and make Indian industry more efficient and competitive.

Now a days there is no dearth of platforms for obtaining Geospatial data - EO Satellite, aerial vehicles, UAVs, terrestrial mapping System, mobile sensors. Data is available is multi-dimensional/ multi-resolution/ time-series. Thus, the data is not only huge, but it is also complex because of its dimensionality and demands high computing, processing and advanced analytical capabilities to draw meaningful results.

We are also witnessing rapid advances in computational capabilities - huge storage systems, high power & high-speed computing systems, Cloud & Edge Computing handling the complex data.

Next Generation algorithms & advanced analytics like Artificial Intelligence, Machine Learning or Deep Learning can make data-driven decisions, predict what can happen based on patterns and also explain how it happened. Amazing advances can be seen in delivery mechanisms on the ground, essentially enabled through Location technology and broadband networking.

Geospatial expertise needs to be integrated from the inception, enabling planners to optimize resource allocation, anticipate challenges and make informed decisions based on accurate data and predictive insights. PM Gati Shakti program with seven initiatives -

roads, railways, airports, ports, mass transport, waterways and logistics infrastructure – makes use of geospatial technology for efficient planning and implementation.

Space-based observations and geospatial technologies help to create an extensive database for better governance and development and provide critical inputs in planning, execution and monitoring of major national initiatives and flagship programmes. Capabilities of Geospatial services & API from Bhuvan, Bhoonidhi, MOSDAC and VEDAS are used to support flagship programmes like GEO-MGNREGA, PMAY, IWMP, AMRUT PMGSY, NHP, TWRIS, International Solar Alliance, etc.

Geospatial community is looking at constantly improving high throughput and very low latency in the delivery of images and products, integration of multiple sensor data and advanced space data analytics to bring a phenomenal change in space-based services/ advisories and provide quick insights for decision making.

Primary focus would be towards –

(i) Continuity of the operational applications, with improved accuracy, scale and frequency;

(ii) (ii) Augmentation of the space systems through development of newer instruments, constellations of autonomous missions with multiple payloads

(iii) On-board data processing

(iv) Multi-resolution Data Cubes with embedded Analytical Models

(v) Transition from Reactive to Proactive Disaster Risk Reduction; (vi) GNSS based applications

The key steps in this process will be building in-house capability in front-ranking research areas, developing advanced systems using innovative technologies, setting up appropriate institutional arrangements to adapt and absorb the innovative applications into national development needs. There would be enhanced opportunities for entrepreneurship, business development, job creation, and social welfare.

As India steers towards its vision of becoming a developed nation by 2047, the role of geospatial technology is paramount. The geospatial community must rise to the forefront, asserting its pivotal role in shaping a sustainable and resilient future for India and for making India the global hub for hi-tech research, development, production and services.

I thank the organizers for giving me the opportunity to be with you and deliver this prestigious S.P. Chatterjee Memorial Lecture.

Thank you all.

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