Space Technology for Agricultural Development

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Abstract

The twin challenge of faster and more-inclusive agricultural growth of our country calls for concerted efforts towards natural resources management and disaster management. Rapid developments occurring in the cutting edge technologies such as agricultural biotechnology and information and communication technology together with contemporary modeling techniques enable developing an appropriate framework for implementation at the grass-root level. In India, the space programme has been conceived to meet the national imperatives and the societal needs. Space technology, with its three major components *viz*., the satellite communications, the close weather watch and the Earth observations, plays a significant role towards national development. Agriculture has a strong reliance on the natural resources. In this regard, Earth Observation satellite data have been extensively used in India towards building up the national natural resource database with an objective to improve the resource use efficiency for the overall development of the country. Remote sensing has enabled mapping, assessing, monitoring and management of various natural resources like soil or land, forestry, geology, water, ocean and atmosphere, etc. It has further enabled monitoring of environment and thereby helping in planning for their sustained and enhanced use. In the last four decades it has become a major tool for collecting information on several aspects of natural resources available on the Earth. With the availability of remotely sensed satellite data of varying specifications, the applications of this technology have multiplied both for civilian and strategic purposes.

Keywords: GIS, GPS, remote sensing, space technology

1. Introduction

The twin challenge of faster and more-inclusive agricultural growth of our country calls for concerted efforts towards natural resources management and disaster management. Rapid developments occurring in the cutting edge technologies such as agricultural biotechnology and information and communication technology together with contemporary modeling techniques enable developing an appropriate framework for implementation at the grass-root level. This approach could further enhance the rural prosperity and improved access to essential services in health and education. In a country with diverse and dynamic agro-climate and resource-base, spatio-temporal databases, generated using satellite data, enable generation of valuable information for the knowledge based decision support at various spatial hierarchies to meet the global, regional and local requirements.

2. Space Technology

In India, the space programme has been conceived to meet the national imperatives and the societal needs. Space technology, with its three major components viz., the satellite communications, the close weather watch and the Earth observations, plays a significant role towards national development. The data from EO satellites can contribute to sustainable development by providing information, measurements and quantification of different features on the Earth's surface. The synoptic view provided by satellite imagery offers technologically the most appropriate method for quick and reliable mapping and monitoring of various natural resources, both in space and time domains at different levels of spatial hierarchy (Figure 1). Change detection through repetitive satellite remote sensing over various temporal and spatial scales, offers the most economical means of assessing environmental impact of the developmental processes, monitoring of bio-species diversity of an ecosystem and evolution of appropriate action plans for initiating sustainable development. Availability of data at different spatial resolutions (as coarse as 1 km, or as fine as 5 m or better in multispectral mode) with revisit period ranging from twice a day to 24 days provides a means for observing the earth simultaneously at macro and micro levels, thus, catering to cater to various thematic applications. The advent of

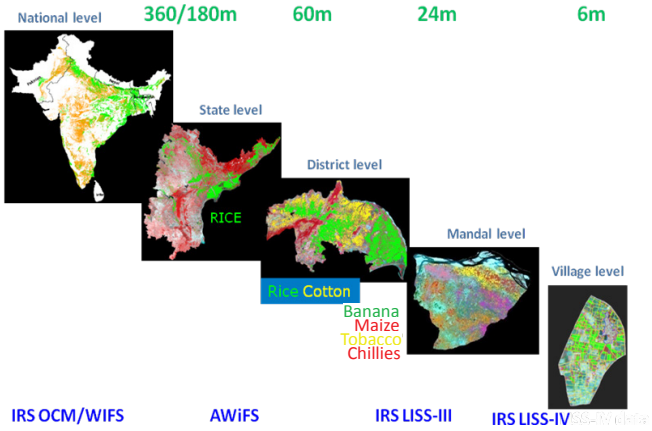

Figure 1: Variants of Typical IRS –Satellite Data providing Information at Different Spatial Levels

microwave remote sensing has provided another quantum jump in remote sensing capability due to its unimpaired penetration through cloud cover to provide all weather capability to remote sensing.

One of the main advantages of the space technology is its compatibility with various other emerging technologies such as GIS, GPS, mobile phones, computing systems and instrumentation for collection of observations from different platforms (Figure 2). Together, these technologies provide valuable data for transformation into knowledge and wisdom. Taking this advantage, several major programmes related to sustainable development, in which Earth observation has played a key role have been launched. These can be grouped as: (a) those that aim towards sustainable natural resources inventorying and monitoring, (b) those that provide support to the disaster management system and (c) those that provide access to education and health.

3. Inventorying and Monitoring of Natural Resources

Agriculture has a strong reliance on the natural resources.

Figure 2: Convergence of Geo-spatial Solutions

In this regard, Earth Observation satellite data have been extensively used in India towards building up the national natural resource database with an objective to improve the resource use efficiency for the overall development of the country. Remote sensing has enabled mapping, assessing, monitoring and management of various natural resources like soil or land, forestry, geology, water, ocean and atmosphere, etc. It has further enabled monitoring of environment and thereby helping in planning for their sustained and enhanced use. In the last four decades it has become a major tool for collecting information on several aspects of natural resources available on the Earth. With the availability of remotely sensed satellite data of varying specifications, the applications of this technology have multiplied both for civilian and strategic purposes. In India remote sensing is being put to use for meeting various societal needs and has been contributing significantly towards national development. A brief summary of the operational applications of remote sensing for agriculture in India have been narrated hereunder. The details could be found in the websites: www.nrsc.gov.in, www.sac.isro.gov.in, www.isro.gov.in, www. nnrms.gov.in

4. Land Resources Assessment

Information on the spatial spread and monitoring the dynamics of the land use or land cover is the basic prerequisite for planning and implementing various developmental activities. Apart from this, nation- wide land use information is important for addressing the changing patterns in land use or land cover and also fan overall reporting on the nation's land use or land cover scenario. Satellite data is operationally used for generation of land use land cover (LULC) on annual basis to estimate the net sown area of the nation from 2004-05 onwards, while once in 5 years LULC information is being generated on 1:50000 scale. Similarly, the spatial distribution of wastelands and of land degradation on 1:50000 scale is generated.

5. Water Resources Assessment

Glaciers are monitored using satellite data and the estimates of snow-melt run off is being carried out on a regular basis. This information is useful in planning irrigation in the Indo-Gangetic plains. Performance of different irrigation commands is evaluated by using satellite data to provide information for improving the performance of existing irrigation systems leading to more effective utilization of available resources. . High resolution satellite data is used for assessing the irrigation potential created, through mapping of irrigation infrastructure consisting of canal network, cross drainage and other related irrigation structures under Accelerated Irrigation Benefit Programme.

6. Ground Water

The occurrence and movement of groundwater is mainly controlled by many factors such as rock types, landforms,

geological structures, soil, land use, rainfall etc. Remote sensing based groundwater prospect zone map serves as a base for further exploration using hydro geological and geophysical methods to locate well sites. Studies have shown that if remote sensing data are used at first level to delineate prospective zones and further followed up by hydro geological and geophysical surveys, higher success could be achieved besides savings in terms of cost, time and work. Further remote sensing data helps in identifying suitable areas for recharging ground water.

7. Crop Inventorying

Generation of conventional crop inventories is tedious, time consuming and at times subjective. Space derived in-season pre-harvest crop acreage and production estimates enable administrators to make strategic decisions on import or export, public distribution, pricing and market intervention operations in a timely manner. Crop discriminability from space platforms coupled with the availability of satellite data in optimal bio-windows of the crop growth form the basis for estimation of crop acreage.The methodology includes analyses of Remote sensing data acquired during crop season using limited field observations for crop identification and use of stratified random sampling (5×5 km land area) with 15–20% sample size of population for acreage estimation. Agromet model, time trend and crop simulation models are used for crop yield prediction. District and state level acreage and production estimates of select crops are being generated are being benerated by the Ministry of Agriculture, Govt. of India.

8. Crop Condition Assessment

Anomalies of the spectral vegetation indices derived from satellite data discern the information on the crop growth stage and the condition of the crop. Though the diagnostics are not deduced, anomalies in the growth pattern of the crops can be inferred. Prevalence, severity and spatial extent of crop water stress during the kharif season are being monitored operationally by integrating the spectral information with ground information on rainfall, soil moisture and crop growth stage. However, studies are in progress to forewarn the occurrence of stresses.

9. Watershed Monitoring and Development

Satellite data, by virtue of its capability to provide realistic spatial information on the natural attributes of the watershed, is used extensively in characterizing and prioritizing the watersheds. The different terrain attributes studied in watershed development are its geological, hydro-geological, soil, land cover or land use related parameters. These in turn helps in estimation of soil-loss, runoff, etc., and planning of scientific conservation and development activities. Specific usage of the technology has been in the areas of watershed prioritization, resources inventory, land and water resources action plan, monitoring of implementation, multi-temporal impact assessments, post project evaluations and run-off studies. Such kind of usage of the technology with judicious MIS of conventional technology has shown a phenomenal success in project implementation and ensuring that the poor farming community gets the best advantage of watershed development in their respective areas.

10. Potential Fishing Zones

Potential fishing zones were initially forecasted using sea surface temperature data. Addition of chlorophyll information derived from OCEANSAT-1 onwards has introduced the important link of sea food chains and improved the accuracy of forecast. A third parameter, the Sea Surface Wind (SSW), which indicates the effect of currents on feeding grounds, has now been incorporated resulting in further improvement in forecasts. Thus, an integrated approach for Potential Fishing Zone based on Chlorophyll & Sea Surface Temperature have been developed, validated for operational use. It is understood that about 40,000 users are benefited through PFZ forecast. The average increase in net profit is about 2-4 %.

11. Space Information Support for Decentralized Planning (SISDP)

Realizing the potential and capability of remote sensing and GIS for providing cost and time-effective resource database, the Planning Commission, Ministry of Panchayati Raj and Ministry of Rural Development have proposed to prepare District Resource Atlases using remote sensing and GIS techniques to strengthen various aspects of decentralized district level planning through a co-ordinated approach. All the thematic layers are being generated on 1:10,000 scale using ortho-rectified high resolution satellite images (Cartosat + LISS 4 Mx fused). The goal of the project is to develop ICT enabled geospatial platform using space based EO systems and engaging local bodies for planning and carrying out area developmental activities in a decentralized, speedy and transparent manner.

The outcome of the SISDP mission is to establish and enable the information system comprising of spatial natural resources and non-spatial data towards supporting the districts for the decentralized planning. This GIS database will be customized to meet the requirements of stake holder departments or concerned in providing the digital resource atlases and any other requirements of the States based on their problems or priority or developmental programme at Village or Block or Taluka or District level.

12. Disaster Management Support

The Disaster Management Support (DMS) Programme of ISRO, provides timely support and services from aero-space systems, both imaging and communications, towards efficient management of disasters in the country. The DMS programme addresses six natural disasters such as flood, cyclone, drought,

forest fire, landslide and earthquake. These include creation of digital data base for facilitating hazard zonation, damage assessment, etc., monitoring of major natural disasters using satellite and aerial data; development of appropriate techniques and tools for decision support, establishing satellite based reliable communication network, deployment of emergency communication equipments and R&D towards early warning of disasters.

13. Information Systems and Decision Support

The best advantages of the data, generated on various natural resources, in terms of the quantity, state and their dynamics and interactions can be assessed for realization by way of developing information systems, which in turn become the pre-requisite for developing decision support systems (DSS). DSS provides solutions by answering querries with the data and information background. E.g., A detailed Water Resources Information System has been developed as a single window solution for comprehensive, authoritative and consistent data and information of India's water resources in a standardized national GIS framework for planning and development of water resources.

14. Satellite Communication (Satcom) Technology

Satellite Communication (Satcom) technology offers the unique capability of simultaneously reaching out to very large numbers spread over large distances even in the most remote corners of the country. The hallmark of Indian Space Programme has been the application oriented efforts and the benefits that have accrued to the country. In the past two and a half decades Indian National Satellite (INSAT) system have revolutionized the country's telecommunications, TV broadcasting, DTH services, business communications, rural area connectivity, Tele-education, Tele-medicine, Village Resource Centres, Search and Rescue operations and Emergency Communications.

15. Bhuvan

Bhuvan is the geoportal of Indian Space Research Organisation showcasing Indian imaging capabilities in a multi-sensor, multi-platform and multi-temporal domain. The portal serves as a gateway to explore and discover, virtual earth in 3D space, with specific emphasis on the Indian region. This visualisation is of vital use for planners, decision makers, social groups, village community and even to a common man. It offers visualization and free downloads of archived satellite data and several thematic, disaster and oceanic services. Several collaborative applications in the agriculture, forestry and water resources etc. are also featured in Bhuvan. Several applications have been developed using smart mobile phones for collection of field information, which is simultaneously time stamped and geo-coded. E.g., This information is of importance during the time of floods and catastrophies for assessment of damage and claim for relief. This field information could be transferred to any server with GPRS connectivity from remote. Bhuvan geo-portal is being extensively used this purpose.

16. Conclusion

Improved performance in sustainable agriculture is essential for inclusive growth. Hence, reviving dynamism in agriculture, building the necessary infrastructure, expanding access to health and education undertaking programmes for improving living conditions and improving access to economic opportunity have been considered as the stratagem by our country. Geospatial technologies that encompass the overall gamut of contemporary developments in remote sensing, GIS, GPS, photogrammetry, mobiles, data collections from aerial platforms and geo-portals, etc. could synergize developments in the field of crop management.

17. Ackowledgement

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