Utility of Remote Sensing Techniques in Balanced Agricultural Development

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Abstract: Earth observation (EO) consisting of satellite, aerial and in-situ systems is being increasingly recognized as a vital tool for studying and monitoring natural resources and unraveling the complex behaviour of the Earth's complex dynamic processes. Remote sensing research has evolved as a multi-disciplinary subject devoted to developing applications of remote sensing techniques of land ocean and atmosphere addressing geologic, vegetative and hydrological issues at national, regional and site-specific scales. Agriculture plays a major role in the economy of almost every country. Whether agriculture represents an important business industry for an economically strong country or is merely a means of sustenance for a hungry, overpopulated nation, it plays a vital role in almost every country. Food production is important for everyone and producing food in a cost-effective manner is the goal of every farmer, large-scale farm manager and regional agricultural agency. A farmer must be informed to be efficient, and this includes knowledge and information products to formulate viable strategies for farming operations. These tools will help him understand the health of his crop, the extent of infection or stress damage, or the potential yield and soil conditions.
Key Word: Modern agricultural methods and remote sensing technology.

The remarkable development during the last two decades in space technology has firmly established its immense potential for optimal use of this technology to undertake numerous application projects in various sectors of national development. The Indian remote sensing satellites, IRS-IA, launched in March 1988 and DIRS IB, launched in August 1991 are providing good quality data with a combined recurrence of 11 days. The initiation of a full-fledged operational remote sensing programme, which only a few countries across the world could achieve, is now set to reach even greater heights through the development of second generation Indian remote sensing satellite series, IRS-IC and IRS-ID, with improved capabilities. These satellites are planned to be launched during the time period 1995-98. Efforts are underway to realise an indigenously developed ocean satellite. Under the National Natural Resource Management System (NNRMS), remote sensing has been operationalised in many new application areas with active participation of user agencies. IRS data are being used on operational basis for many applications such as agricultural crop area and yield estimation, drought monitoring and assessment, flood mapping, land use and land cover mapping, wasteland management, urban planning, mineral prospecting, forest resource survey and management, soil mapping, water resource management, fisheries potential forecasting, coastal zone management, environmental impact assessment, etc. Towards human resource development, regular training programmes are being conducted in addition to incorporating remote sensing in the curriculum of many universities and institutes.

The pressure of increasing population, rising demand for food, fodder and fuel and rapidly growing industrialization and urbanization have put tremendous pressure on natural resources and environment. These activities have resulted in distress in the agro-ecosystem, such as land degradation, accelerated erosion, shifting cultivation, deforestation, increased frequency of floods, pollution, urban sprawl etc. Therefore, the biggest challenge in the country is how to balance the process of degradation and undesirable changes in the environment.

With the development of National Natural Resource Management System (NNRMS) towards full exploitation of the capabilities of space remote sensing and establishment of necessary ground based data, development of Indian Remote Sensing Satellite series, establishment of Remote Sensing Application Centres in a number of States under various Government organizations, today remote sensing has become an integral part of national development efforts in the critical areas of agriculture, hydrology, geology, forestry, oceanography, mineral resources and disaster management such as drought, flood, cyclone, earthquake, landslide, crop pests, forest fire etc. Today, India has acquired a strong self-reliance base to exploit the full potential of this technology and as a result, the national objective of achieving sustainable development at micro level by integrating remote sensing data with other relevant collateral information to arrive at locally specific, environmentally friendly, economically viable and culturally acceptable treatment packages is being accomplished.

Evolution of Remote Sensing Technology:

The beginning of remote sensing is associated with the development of photography technology. Initially, photography was the only way to record and store terrestrial information. The era of remote sensing actually began with the development of aircraft and the expansion of flight. Continuously progressing, it has now become established as a satellite or spacecraft based technology. Remote sensing systems continued to develop from systems developed for war in the 1950. Significant progress was made in the field of radar in this decade. In the 1960, remote sensors began to be placed in space for observing the earth. TIROS (Television Infrared Observation Satellite) was the first meteorological satellite. After this, a long series of meteorological satellites were developed. In the early 1970, the first satellite was developed and launched specifically to collect information (data) about the earth's surface and its resources. The sensors installed on these satellites proved capable of collecting high quality images with reasonable details. These images gave worldwide recognition to remote sensing as an important technique.

Important dates in the gradual development of remote sensing

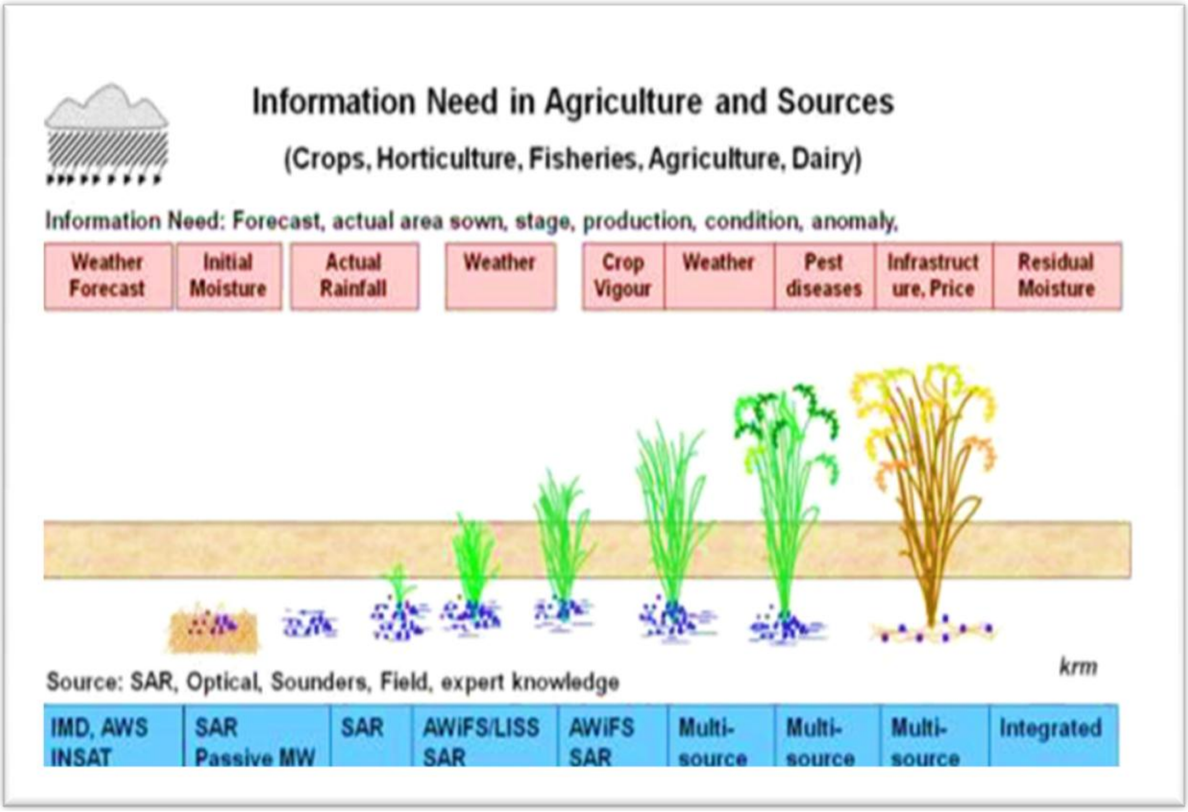
1800	Infrared was discovered by Sir W. Herschel.
1838	The practice of photography began.
1847	J.B.L. Foucault discovered the properties of the infrared spectrum.
1885	Aerial photography began with the help of balloons.
1873	The theory of electromagnetic spectrum was propounded by James Clerk Maxwell.
1909	Aerial photography began with the help of aeroplanes.
1916	During the First World War, aeroplanes were used for aerial photography.
1935	Radar was developed in Germany.
1940	During the Second World War, the application of the invisible part of the spectrum began.
1950	The use of remote sensing for military research and development work started rapidly.
1959	Explorer-6 took the first photograph of the earth from space.
1960	The first meteorological satellite TIROS was launched.
1970	Remote sensing observation started from Skylab in space.
1972	Landsat-1 (ERTS-1) with MSS Sensor was launched.
1972	Rapid progress was made in the field of digital image processing.
1982	Landsat-4 equipped with new generation sensor TM was launched.
1986	French Earth Observation Satellite SPOT was launched.
1986	Hyperspectral sensor was developed.
1990	High Resolution Space borne Systems were developed. 1991 First radar satellite ERS-1 was launched.
1992	Japan launched JERS-1 radar satellite.
1995	Canada launched Radarsat.
1995	Radar satellite ERS-2 was launched.
1998	Development of target based satellite systems started.
1999	NASA's Earth Observation Mission was launched.
1999	IKONOS based on very high resolution sensor system was launched.
2001	QuickBird equipped with very high spatial resolution sensor system was launched.
2008	Satellite with optical sensors and radar equipment was launched.
2009	DigitalGlobe was launched.
2013	Landsat-8 was launched.

In recent years, advances in sensor technology and the increasing availability of satellite data have significantly expanded the field of remote sensing. New sensors such as radar and lidar have been developed to provide new types of information, and the development of machine learning and other data analysis techniques has made it possible to extract more information from satellite data than ever before. Remote sensing technology is becoming an important tool for monitoring the Earth and its resources and will be increasingly used in the future. The field of remote sensing is constantly evolving with new technologies, new sensors, and new analysis methods. It allows for a more accurate and detailed understanding of the Earth and its resources and is an essential tool in agriculture, forestry, urban planning, disaster management, and many other fields.

The Role of Remote Sensing in Agriculture:

Agriculture provides humanity with raw materials, fuel, fiber, and food (of course!). This role must be fulfilled within climate change and environmental sustainability, as well as maintaining the viability of agricultural activities to sustain livelihoods with a growing population. Application of remote sensing in agriculture can help in the development of agricultural practices to meet a variety of challenges by providing information related to crop status at various scales throughout the season. Agricultural resources are important renewable dynamic natural resources. In India, the agriculture sector alone sustains the livelihood of the majority of the population and also contributes significantly to the net national product. Increasing agricultural productivity has been a major concern as the scope for increasing the area under agriculture is limited. This requires judicious and optimal management of both land and water resources.

Currently, agriculture is facing problems such as anthropogenic depletion of soil fertility, soil diseases, environmental pollution, wide yield gaps, GHG emissions, frequent unpredictable weather due to climate change, increasing intensity of pests and diseases, inefficiency of water use, etc. Using remote sensing and spatial data analysis, it is possible to recommend strategies to reduce the yield gap, climate smart agricultural practices, crop calendars and grow more grain per drop. During the last two decades, remote sensing techniques have been applied to find out comprehensive and reliable information on agricultural applications such as crop growth monitoring (plant population, nutrient deficiencies, diseases, water deficit or excess, weed infestation, pest and herbicide damage), land use/cover, forest cover, soil, geological information, extent of wasteland, agricultural crops, water resources (both surface and underground) and hazardous/natural calamities like drought and flood, wind and hail damage etc.



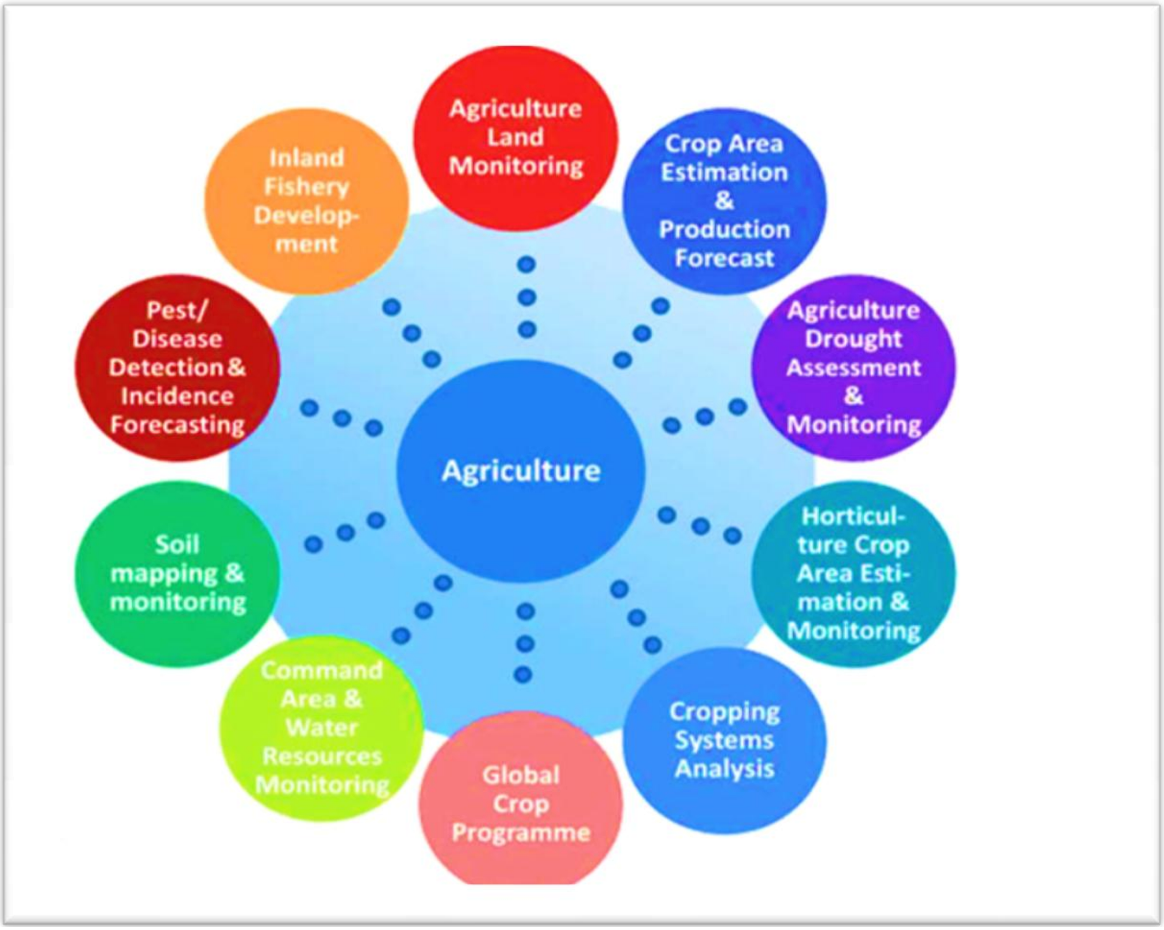
https://www.crcpress.com/GIS-Applications-in-Agriculture/Pierce- Clay/p/book/9780849375262

Significant impact of remote sensing techniques on agriculture:

Remote sensing plays a vital role in crop classification, crop monitoring and yield evaluation.Monitoring of agricultural production system follows strong seasonal variation pattern with respect to biological life cycle of crops. All these factors are highly variable in space and time dimensions. Moreover, due to unfavourable growing conditions, agricultural productivity may change within a short time period. Season-wise information on crops, their area, potential and production enables the country to adopt suitable measures to meet the shortfall, if any, and to implement appropriate support and procurement policies. Information obtained from remote sensing can be used as base maps in variable rate applications of fertilizers and pesticides. Information obtained from remote sensing images allows farmers to treat only the affected areas of the field.

Problems in a field can be identified remotely before they can be identified visually.Use of remote sensing to identify key grazing areas, overgrazing areas or areas with weed infestation for appropriate action. Lending institutions use remote sensing data to evaluate the relative values of land by comparing the collected images with photographs of surrounding fields.

Major Applications of Remote Sensing:



https://nrsc.gov.in/Agriculture

Natural Resource Management: Analysis of land use, water resource management, assessment of forest cover, and detection of soil erosion.
Weather Monitoring: Weather forecasting, study of climate change, and forecasting of disasters such as floods and droughts.
Disaster Management: Detection of disasters such as earthquakes, tsunamis, and cyclones and assessment of their impact.
Agriculture: Assessment of crop condition, irrigation management, and analysis of agricultural land.
Forestry: Mapping of forest cover, detection of fires in forest areas, and monitoring of forest products.
Urbanization: Mapping of urban areas, analysis of change in urban land use, and assessment of urban development.
Environmental Monitoring: These satellites are used for environmental studies, including monitoring of land degradation, wetland conservation, and assessment of biodiversity. They contribute to environmental impact assessment for various projects.
Water Resource Management:IRS satellites help in monitoring and management of water resources, including river basin planning, reservoir management, and flood forecasting. They also aid in assessing water quality and availability.
Disaster Management: IRS satellites are invaluable for disaster management. They provide real-time data for disaster preparedness, response, and recovery, covering natural disasters such as floods, cyclones, earthquakes, and landslides.

Rural Development: IRS data is used for rural development initiatives, such as watershed management, soil health assessment, and rural infrastructure planning.

Mapping and Mapping: High-resolution imagery obtained from satellites such as Cartosat is essential for mapping, map making, and topographical surveys.

Weather Forecasting: IRS satellites, especially those with atmospheric sensors, provide inputs for weather forecasting and climate studies. They contribute to climate modeling and climate change monitoring.

Security and Defense: Some IRS satellites are also used in the defense sector, aiding in activities such as border surveillance, target identification, and situational awareness.

Health care: Remote sensing data can be used to monitor the spread of vector-borne diseases, such as malaria, and to plan health care interventions.

Telecommunications: INSAT satellites, which are part of the IRS programme, support telecommunications and broadcasting services.

Education and research: IRS data are valuable to academic institutions and research organisations for a wide range of scientific studies and research projects.

List of Indian Remote Sensing (IRS) satellite

Satellite	Launch Date	Launch Vehicle	Application
EOS-04	Feb 14, 2022	PSLV-C52/EOS-04 Mission	Earth Observation
EOS-01	Nov 07, 2020	PSLV-C49/EOS-01	Disaster Management System, Earth Observation
RISAT-2BR1	Dec 11, 2019	PSLV-C48/RISAT-2BR1	Disaster Management System, Earth Observation
Cartosat-3	Nov 27, 2019	PSLV-C47 /Cartosat-3 Mission	Earth Observation
RISAT-2B	May 22, 2019	PSLV-C46 Mission	Disaster Management System, Earth Observation
HysIS	Nov 29, 2018	PSLV-C43 /HysIS Mission	Earth Observation
Cartosat-2 Series	Jan 12, 2018	PSLV-C40/Cartosat-2 Series Satellite Mission	Earth Observation
Cartosat-2 Series	Jun 23, 2017	PSLV-C38 /Cartosat-2Series Satellite	Earth Observation
Cartosat -2 Series	Feb 15, 2017	PSLV-C37 /Cartosat -2 Series Satellite	Earth Observation
RESOURCESAT-2A	Dec 07, 2016	PSLV-C36 /RESOURCESAT-2A	Earth Observation
SCATSAT-1	Sep 26, 2016	PSLV-C35 /SCATSAT-1	Climate & Environment
INSAT-3DR	Sep 08, 2016	GSLV-F05 /INSAT-3DR	Climate & Environment, Disaster Management System
CARTOSAT-2 Series	Jun 22, 2016	PSLV-C34 /CARTOSAT-2Series Satellite	Earth Observation
RISAT-1	Apr 26, 2012	PSLV-C19/RISAT-1	Earth Observation
Megha-Tropiques	Oct 12, 2011	PSLV-C18/Megha-Tropiques	Climate & Environment, Earth Observation
RESOURCESAT-2	Apr 20, 2011	PSLV-C16/RESOURCESAT-2	Earth Observation
CARTOSAT-2B	Jul 12, 2010	PSLV-C15/CARTOSAT-2B	Earth Observation
Oceansat-2	Sep 23, 2009	PSLV-C14 /OCEANSAT-2	Climate & Environment, Earth Observation
RISAT-2	Apr 20, 2009	PSLV-C12 /RISAT-2	Earth Observation
CARTOSAT – 2A	Apr 28, 2008	PSLV-C9 /CARTOSAT – 2A	Earth Observation
IMS-1	Apr 28, 2008	PSLV-C9 /CARTOSAT – 2A	Earth Observation
CARTOSAT-1	May 05, 2005	PSLV-C6/CARTOSAT-1/HAMSAT	Earth Observation
IRS-P6 /RESOURCESAT-1	Oct 17, 2003	PSLV-C5 /RESOURCESAT-1	Earth Observation
Technology Experiment Satellite (TES)	Oct 22, 2001	PSLV-C3 / TES	Earth Observation

Oceansat (IRS-P4)	May 26, 1999	PSLV-C2/IRS-P4	Earth Observation
IRS-1D	Sep 29, 1997	PSLV-C1/IRS-ID	Earth Observation
IRS-P3	Mar 21, 1996	PSLV-D3 / IRS-P3	Earth Observation
IRS-1C	Dec 28, 1995	Molniya	Earth Observation
IRS-P2	Oct 15, 1994	PSLV-D2	Earth Observation
IRS-1B	Aug 29, 1991	Vostok	Earth Observation
IRS-1A	Mar 17, 1988	Vostok	Earth Observation
Rohini Satellite RS-D2	Apr 17, 1983	SLV-3	Earth Observation
Bhaskara-II	Nov 20, 1981	C-1 Intercosmos	Earth Observation, Experimental
Rohini Satellite RS-D1	May 31, 1981	SLV-3D1	Earth Observation

Remote sensing application scenario in India:

- Pre-harvest area and production estimation (CAPE) for wheat, rapeseed and mustard, sorghum, rice, cotton and sunflower for large parts of the country.
- Monitoring of seasonal drought conditions across the country based on satellite derived vegetation index.
- Near real-time assessment of flood damage in all major flood prone river basins using optical and microwave data.
- Current land use/land cover mapping for the entire country for agro-climatic regional planning.
- Forest cover monitoring on biennial basis to assess and detect changes.
- Mapping of saline/alkaline soils for the entire country.
- Coastal land use mapping for all maritime states of the country.
- Sea surface temperature (SST) retrieval and its applications including fisheries.
- Development of methodology for retrieval of winds, waves, bathymetry, seamounts, internal waves, ocean circulation etc. from ERS-1 microwave data.
- Applications of microwave SAR data for soil moisture estimation and crop identification.
- Studies on carbon cycle in geosphere biosphere oceans, macro vegetation dynamics, forest biodiversity, forest ecosystem dynamics etc.

Conclusion:

With the establishment of expertise and self-reliance in operating the Indian remote sensing satellite series, establishing a well-designed infrastructure for acquisition, processing, dissemination, analysis and interpretation of remote sensing data, handling remote sensing data, undertaking remote sensing applications in a wide range of resource themes and developmental areas and development of a resource information system using geographic information techniques, India had achieved a viable, self-reliant remote sensing programme. With the launch of a unique planning system of Integrated Mission for Sustainable Development using space remote sensing inputs with GIS to provide a holistic view and meet the growing demand of the increasing population, remote sensing is set to play a vital role in the overall development of the nation. The assessment of crop damage caused by natural disasters like rain and hailstorms can now be done more accurately with the help of remote sensing technology. Indian researchers have found in a study that remote sensing technology can prove to be more effective in assessing the losses caused by natural disasters.

In India, crops often suffer a lot due to hailstorms and heavy rains and due to lack of timely and accurate assessment, farmers are not able to get proper compensation. Usually, the assessment of crop damage is done on the basis of estimates, which are often far from reality. For actual assessment, large-scale and ground level surveys have to be done, which takes a lot of time, money and labor. Despite this, the data obtained cannot be said to be completely accurate.

The use of remote sensing technology is increasing rapidly in various fields. In this, many types of maps can be easily prepared in a short time by the images obtained from the satellite. Scientists believe that this technology can prove to be helpful in assessing crop damage at the field level under the recently introduced crop insurance program of the Government of India (Pradhan MantriFasalBimaYojana). This will require very clear remote sensing images. Also, there is a need to develop remote sensing index-based models for determining the amount of crop damage.

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