NABARD

National Sectoral Paper
Geo-Informatics

Farm Sector Development Department
National Bank for Agriculture and Rural Development
Mumbai

NABARD's Vision

Development Bank of the Nation for fostering rural prosperity

NABARD's Mission

Promote sustainable and equitable agriculture and rural development through participative financial and non-financial interventions, innovations, technology and institutional development for securing prosperity

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National Sectoral Paper

Geo-Informatics

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Department
National Bank for Agriculture
and Rural Development
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Foreword

Agriculture is the cornerstone of India's rural economy, sustaining a significant share of the population and contributing to food security, employment, and socio-economic stability. However, the sector faces a complex set of challenges—ranging from declining land and water productivity to increasing climatic uncertainties and market pressures. Addressing these multifaceted issues requires a transition from conventional, input-intensive practices to knowledge-based, technology-enabled approaches.

In this evolving landscape, Geospatial Technology has emerged as a transformative enabler. Technologies such as Geographic Information Systems (GIS), Remote Sensing (RS), Global Positioning Systems (GPS), and drones are equipping stakeholders with powerful tools for precise, timely, and location-specific decision-making. These tools support a range of applications—from soil and crop health monitoring to irrigation planning, land use optimization etc. By unlocking the power of spatial data, Geo-Informatics is paving the way for smarter and more resilient agricultural systems.

As we look into the future, it is imperative that we build institutional capacities, promote open data ecosystems, and encourage innovation to harness the full potential of spatial technologies. NABARD remains committed to mainstreaming such approaches in rural development efforts, ensuring that the benefits of Geo-Informatics reach even the most remote corners of the country.

As India stands at the crossroads of agricultural evolution, leveraging Geospatial Technology is not just an option but a strategic imperative. The future of our rural economy depends on visionary leadership, collaborative efforts, and robust institutional frameworks that translate technological advances into tangible benefits for farmers. NABARD is committed to drive inclusive growth and resilience across India's agricultural landscape, ensuring prosperity for generations to come.

Shaji K V
Chairman
National bank for Agriculture and Rural Development
Mumbai
June 2025

Message

India is a leading global force in agriculture, serving as the principal source of livelihood for approximately 55% of its population. Today, technology plays a vital role in transforming this sector by improving efficiency, increasing productivity, and fostering sustainable practices. In particular, the integration of geospatial technology into agriculture and rural development has unlocked new opportunities for precision, data-driven decision-making, and scalable solutions that enhance both productivity and sustainability across diverse landscapes.

Government of India is increasingly integrating geospatial technology to modernize the agricultural sector. Drones are being actively promoted for applications like precision farming, crop monitoring, and resource management, alongside efforts in Digital Crop Survey and nationwide soil resource mapping, all aimed at enhancing agricultural productivity and sustainability. NABARD has also integrated geospatial technologies to strengthen our programme delivery— from digital monitoring of watershed assets via the NABARD Bhuvan Portal to developing DPRs and conducting impact assessments using geospatial tools.

This National Sectoral Paper on Geo-Informatics captures the current status, policy landscape, institutional interventions, and emerging opportunities in this dynamic field. I compliment the Team C-TAG of Geo-Informatics Discipline for bringing a well-documented sectoral paper.

We would be glad to receive valuable feedback and suggestions for the furtherance of this endeavour

Dr A K Sood
Deputy Managing Director
National Bank for Agriculture and Rural Development
Mumbai
June 2025

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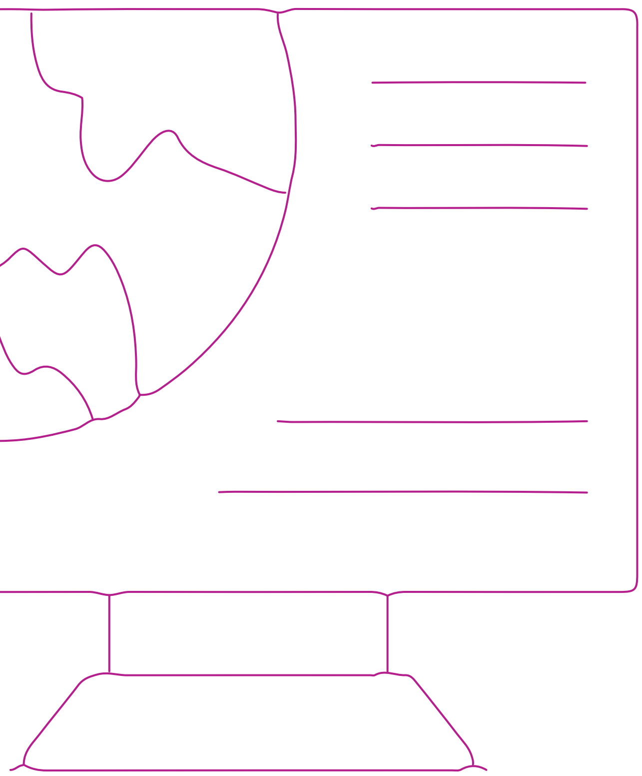


01
Introduction

Geoinformatics is an interdisciplinary field that combines techniques from geography and information technology to collect, process, analyze, and visualise spatial data. It plays a crucial role in addressing real-world problems across various domains including agriculture, rural development, environment, urban planning, disaster management, natural resource management, and more.

Geoinformatics encompasses the integration and application of various geospatial technologies. It involves collecting, analyzing, and interpreting geographic data to solve complex problems and make informed decisions The key technologies and techniques include:

- **Geographic Information Systems (GIS)**: Deals with the acquisition, storage, analysis, and visualization of spatial data. Used in agriculture, urban planning, transportation management, environmental monitoring.
- **Remote Sensing (RS)**: Involves collecting data about Earth's surface from satellites, drones, or aerial sensors. Applications include crop monitoring, land use mapping, climate monitoring, and disaster management.
- **Global Positioning System (GPS) and Global Navigation Satellite Systems (GNSS)**: Focuses on the use of satellite-based navigation systems for determining precise locations. Widely used in navigation, transportation, and location-based services.
- **Spatial Data Science and Analytics**: Involves applying statistical and computational methods to analyse spatial patterns and relationships. Helps in predictive modelling, resource optimization, and spatial decision-making.
- **Cartography**: The art and science of map-making. Includes designing and creating visual representations of spatial data.
- **Geostatistics**: Combines statistical techniques with spatial data analysis. Often used for resource estimation, environmental modelling, and spatial interpolation.
- **Photogrammetry**: Involves extracting spatial information from photographs, particularly aerial images. Often used in 3D mapping and terrain modelling.
- **Geo-visualization**: The science of visualizing spatial data in ways that make patterns and relationships easily interpretable. Includes interactive maps, dashboards, and 3D modelling.

Geoinformatics has numerous applications across different fields. Here are some of the key applications:

1. **Agriculture**: Enhances precision farming by providing data on soil health, crop conditions, and weather patterns. It helps optimize the use of resources and increase crop yields.
2. **Urban Planning and Development**: Helps in zoning, land use planning, infrastructure development, and smart city initiatives.
3. **Forestry & Ecology :** Assists in deforestation tracking, biodiversity conservation, and habitat mapping.

4. **Water Resource Management:** Aids in watershed analysis, groundwater exploration, and flood prediction.
5. **Disaster Management**: Assists in predicting, preparing for, and responding to natural disasters such as floods, cyclones and hurricanes. It helps in damage assessment and recovery planning.
6. **Transportation and Logistics**: Improves route planning, traffic management, and navigation. It supports the management of transportation networks and logistics operations.

Geospatial technology's versatility makes it an indispensable tool in many industries, driving efficiency, sustainability, and informed decision-making.

02

Current Status of the Geo-Informatics Sector

The Geo-Informatics sector is rapidly evolving, driven by advancements in GIS, Remote Sensing, GNSS, AI, and big data analytics. Governments and industries are leveraging geospatial technology for urban planning, disaster management, climate resilience, and precision agriculture. Increased satellite launches, cloud-based GIS platforms, and real-time spatial data integration are enhancing decision-making.

Policies promoting open geospatial data and private sector collaboration are fueling growth. Emerging trends include AI-driven geospatial analytics and UAV-based mapping, making the sector more efficient and accessible. Geo-Informatics is set to play a crucial role in future smart technologies and sustainable development.

I. Key technological advancements in Geoinformatics:

a. Remote Sensing (RS)

Remote Sensing technology, a cornerstone of Geoinformatics, has witnessed significant progress with the advent of high-resolution satellites AND unmanned aerial vehicles (UAVs). The ability to capture real-time, multi-spectral, and high-definition imagery has revolutionized the ways in which environmental and spatial data are collected. Advances in sensor technology, including LiDAR, hyperspectral, and thermal sensors, have expanded the range of applications from precision agriculture and urban monitoring to climate change assessment and disaster response.

b. Geographic Information Systems (GIS)

GIS technology has also evolved considerably, from desktop-based applications to cloud-based solutions. GIS platforms have become more user-friendly, with the integration of artificial intelligence (AI) and machine learning (ML) algorithms allowing for more intelligent spatial analysis and automated decision-making. Modern GIS systems can process vast amounts of geospatial data and provide actionable insights in real time, enhancing the efficiency and effectiveness of resource management.

c. Satellite Navigation Systems:

Satellite Navigation Systems including, Global Navigation Satellite Systems (GNSS) operated by India, Global Positioning System (GPS) operated by USA, GLONASS Operated by Russia, Galileo Operated by the European Union, and BeiDou Operated by China, have become indispensable in geospatial applications, offering precise positioning and navigation capabilities. With growing demand for high-accuracy positioning in fields like navigation, surveying, and disaster management. The technology has seen major advancements in both accuracy and availability.

India has also made notable advancements in Satellite Navigation Systems, mainly through NavIC (Navigation with Indian Constellation), developed by ISRO. Recent progress includes broadening NavIC's use for civilian and commercial applications, incorporating it into smartphones, vehicle tracking, and maritime systems.

II. Industry Growth and Market Dynamics

The Geoinformatics sector is experiencing robust growth driven by technological advancements, increasing demand across industries. The global market for geospatial services and geoinformatics solutions is expanding, with projections indicating a compound annual growth rate (CAGR) of around 10% over the next decade. Key drivers of this growth include:

- **Government investments** in infrastructure development, agriculture, urban planning, and disaster management.
- **Private sector applications,** particularly in industries like telecommunications, energy, and agriculture.
- **Advances in artificial intelligence and machine learning**, enhancing the analytical capabilities of geospatial systems.
- **Increased accessibility of geospatial data**, with open-source platforms and satellite imagery becoming more widely available.

Regional dynamics also play a significant role in shaping the Geoinformatics sector. The government is increasingly relying on geospatial data for policy-making and infrastructure development, creating a favorable environment for the growth of geospatial technologies.

03
Applications of Geo-Informatics in Agriculture and Rural Development

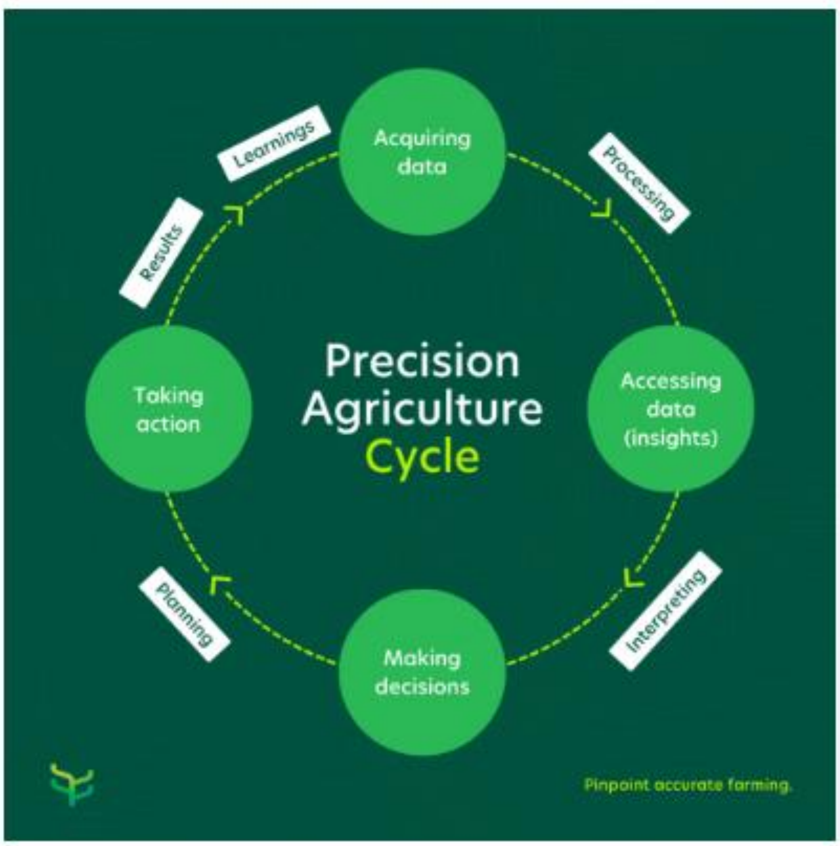
Geo-Informatics offers wide range of applications in agriculture and rural development. These technologies enable better decision-making, efficient resource management, and enhanced sustainability in farming and rural communities. Below are key applications of geo-informatics in these areas:

I. Precision Agriculture

Remote Sensing and GIS play a crucial role in precision agriculture, offering advanced tools for efficient farm management. By integrating satellite imagery, sensor data, and spatial analytics, these technologies enable farmers to monitor crop health, optimize irrigation, assess soil conditions, and predict yields with greater accuracy. This integration enhances decision-making, reduces costs, and promotes sustainable agricultural practices, ultimately improving productivity and resource management.

a) Field Monitoring and Crop Health Assessment

- **Remote Sensing for Crop Health**: Satellite and drone-based sensors capture real-time data about crop conditions, allowing farmers to monitor plant health, detect pests, diseases, or water stress early. These tools help identify problem areas in fields, enabling timely intervention and minimizing crop damage.
- **Soil Moisture Monitoring**: Satellite systems monitor soil moisture levels, offering crucial



data for optimizing irrigation schedules. In regions with limited water resources, these technologies ensure that water is applied efficiently, preventing waste and supporting crop growth in dry conditions.

- **Nutrient Content Assessment**: Multi-spectral sensors, often deployed on drones, detect nutrient deficiencies in crops by analyzing the reflectance of light from plant leaves. This allows farmers to apply fertilizers precisely where they are needed, reducing costs and environmental harm while improving crop health and productivity.

b) Soil Mapping and Fertilizer Management

- Remote sensing can capture surface indicators like vegetation health, which often correlates with soil pH levels, while GIS integrates this data with field measurements. Mapping soil pH helps optimize fertilizer application, crop selection, and irrigation practices, improving soil health and crop productivity.

c) Yield Prediction and Crop Modeling

- **Yield Prediction**: Combining data from remote sensing, weather patterns, and soil conditions, farmers can predict crop yields more accurately. These predictions help farmers make decisions regarding resource allocation, harvest timing, and market strategy, ultimately maximizing profitability and reducing waste.
- **Crop Modeling**: Crop modeling tools simulate plant growth under different environmental and management conditions. By providing data on temperature, rainfall, soil quality, and agronomic practices, farmers can estimate how different factors will affect crop yields and adjust their practices to optimize production.

II. Water Resource Management in Agriculture

Water is essential for agriculture, and its efficient management is crucial for sustainable farming. Geo-Informatics technologies play a pivotal role in improving water resource management. These tools help optimize irrigation systems, plan water distribution, and monitor water quality. Below are the key applications of geo-informatics in water resource management.

a) Irrigation Management

Irrigation is one of the most critical uses of water in agriculture. Geo-Informatics tools enable more efficient irrigation practices, reducing water wastage and enhancing crop yields.

- **Soil Moisture and Crop Water Requirements**: Soil moisture levels can be assessed and crop water needs can be monitored, enabling efficient irrigation planning.
- **Monitoring Crop Water Stress**: Remote sensing based satellite data can detect crop water stress by analyzing vegetation indices like the Normalized Difference Vegetation Index (NDVI). This allows farmers to detect areas of their fields that are stressed due

Fig: Weather Station

to insufficient water, enabling timely irrigation adjustments.

- **Weather Patterns and Forecasting**: Satellite-based weather forecasting systems can provide real-time weather updates and rainfall predictions, helping farmers plan irrigation schedules effectively, especially in areas with unpredictable weather patterns.

b. Watershed Management

Watershed management ensures long-term water availability, flood prevention, and sustainable agricultural practices. Geo-Informatics technologies aid in mapping watersheds, monitoring water quality, and planning better water distribution systems.

- **Watershed Mapping and Planning**: GIS tools help map watershed boundaries, identify key water sources, and plan efficient water distribution.
- **Flood Risk Assessment and Management**: Remote sensing and GIS can assess flood risks by analyzing rainfall patterns, topography, and river flow data. It enables the design of flood mitigation measures, such as levees or diversion channels, to protect agricultural land and infrastructure.

III. Land Use Planning and Rural Infrastructure Development

Effective land use planning and infrastructure development are critical for sustainable agriculture and rural growth. Geoinformatics technologies—such as Geographic Information Systems (GIS), Remote Sensing (RS), and Global Positioning Systems (GPS)—are key tools for improving decision-making in land management and rural development. These technologies provide essential data for optimizing land use, supporting agriculture, and ensuring rural infrastructure.

a) Land Suitability and Zoning for Agricultural Development

- **Assessing Land Suitability for Agriculture**: GIS helps identify areas best suited for specific crops by mapping soil characteristics, topography, and climate. Satellite data and soil tests allow for determining the most productive land, ensuring higher yields and minimizing risks. For example, GIS can pinpoint fertile regions suitable for rice or livestock farming.
- **Zoning for Crop Diversification**: GIS maps can identify areas where both staple crops and high-value crops can thrive. This promotes resilience against market and climate volatility, enhancing food security and economic stability.

b) Infrastructure Planning for Rural Development and Agriculture

- **Road Network and Transport Infrastructure**: GIS aids in designing rural road networks by analyzing terrain and population distribution, ensuring efficient transport routes for agricultural products. In areas with poor infrastructure, GIS can prioritize road construction, improving farmers' access to markets and reducing post-harvest losses.
- **Optimizing Water Supply and Irrigation Systems**: GIS helps plan irrigation systems by mapping water sources and evaluating crop water needs. It ensures water is distributed sustainably and helps design efficient irrigation systems, especially in water-scarce regions.
- **Market Location and Rural Economy**: GIS supports the strategic placement of agricultural markets by analyzing population densities and transportation routes. It ensures markets are accessible to farmers, supporting the rural economy by improving supply chain connections and reducing transportation costs.

IV. Agricultural Supply Chain Optimization

Efficient management of the agricultural supply chain is essential for improving rural livelihoods, enhancing food security, and reducing post-harvest losses. Geoinformatics technologies, particularly GIS and remote sensing, play a key role in optimizing various aspects of the agricultural supply chain:

a) Market Access and Distribution

- **Route Optimization**: GIS tools help farmers identify the shortest, safest, and most cost-effective routes for transporting their products from farms to local or regional markets. By analyzing road networks, traffic conditions, and proximity to transportation hubs, GIS ensures that agricultural products reach consumers more efficiently, reducing transportation costs and time delays.

- **Infrastructure Mapping**: GIS also helps in identifying areas with inadequate infrastructure (e.g., poorly connected roads or underdeveloped market hubs). This allows policymakers and developers to prioritize the construction of roads, storage facilities, and market areas, improving access to wider markets for farmers.

b. Supply Chain Monitoring

- **Supply Chain Transparency**: GIS provides transparency in tracking the movement of goods, reducing inefficiencies, ensuring fair pricing, and helping farmers and consumers know where and how products are sourced. It also aids in identifying bottlenecks and delays within the supply chain, allowing for timely interventions to address these issues.

- **Logistical Efficiency**: By monitoring the entire supply chain, GIS and remote sensing tools allow for the analysis of key factors such as delivery times, costs, and storage conditions. This data helps identify areas for improvement, streamline operations, and enhance logistical efficiency.

V. Poverty Alleviation

Geoinformatics, encompassing GIS, Remote Sensing (RS), and GPS, plays a vital role in rural development and poverty alleviation by enhancing the planning, implementation, and monitoring of development projects. Below is a concise overview of its contributions:

a. Resource Mapping and Targeting

- **Resource Gap Analysis**: GIS identifies gaps in access to essential resources like water, healthcare, and education by mapping their distribution and comparing it to socio-economic needs. This analysis helps prioritize regions that require urgent attention and infrastructure development.

- **Targeted Development Programs**: Once poverty hotspots and resource gaps are identified, geospatial data informs the design of specific development interventions (e.g., building wells, schools, healthcare centers) in the most underserved areas, improving the efficiency and impact of development efforts.

b. Monitoring Development Programs

- **Land Redistribution**: GIS plays a critical role in tracking the implementation of land reform policies, ensuring equitable land distribution to marginalized communities.

- **Infrastructure Monitoring**: GIS and remote sensing technologies are invaluable tools for tracking the progress of rural infrastructure projects, such as roads, housing, and healthcare facilities. In India, GIS was used to monitor the Pradhan Mantri Gram Sadak Yojana (PMGSY), a program aimed at improving rural road connectivity, ensuring timely completion of projects.
- **Social Welfare Programs**: Geoinformatics helps monitor social welfare initiatives such as food distribution, health campaigns, and job creation programs.

VI. Agricultural Extension Services: Enhancing Support with Geoinformatics

Remote Sensing and GIS have been increasingly integrated into agricultural extension services in India. These tools provide spatial data and decision support, enhancing the effectiveness of advisory systems and farmer training initiatives. By leveraging geospatial information, agricultural extension services in India are empowering farmers with precise, actionable insights that improve productivity, sustainability, and rural development.

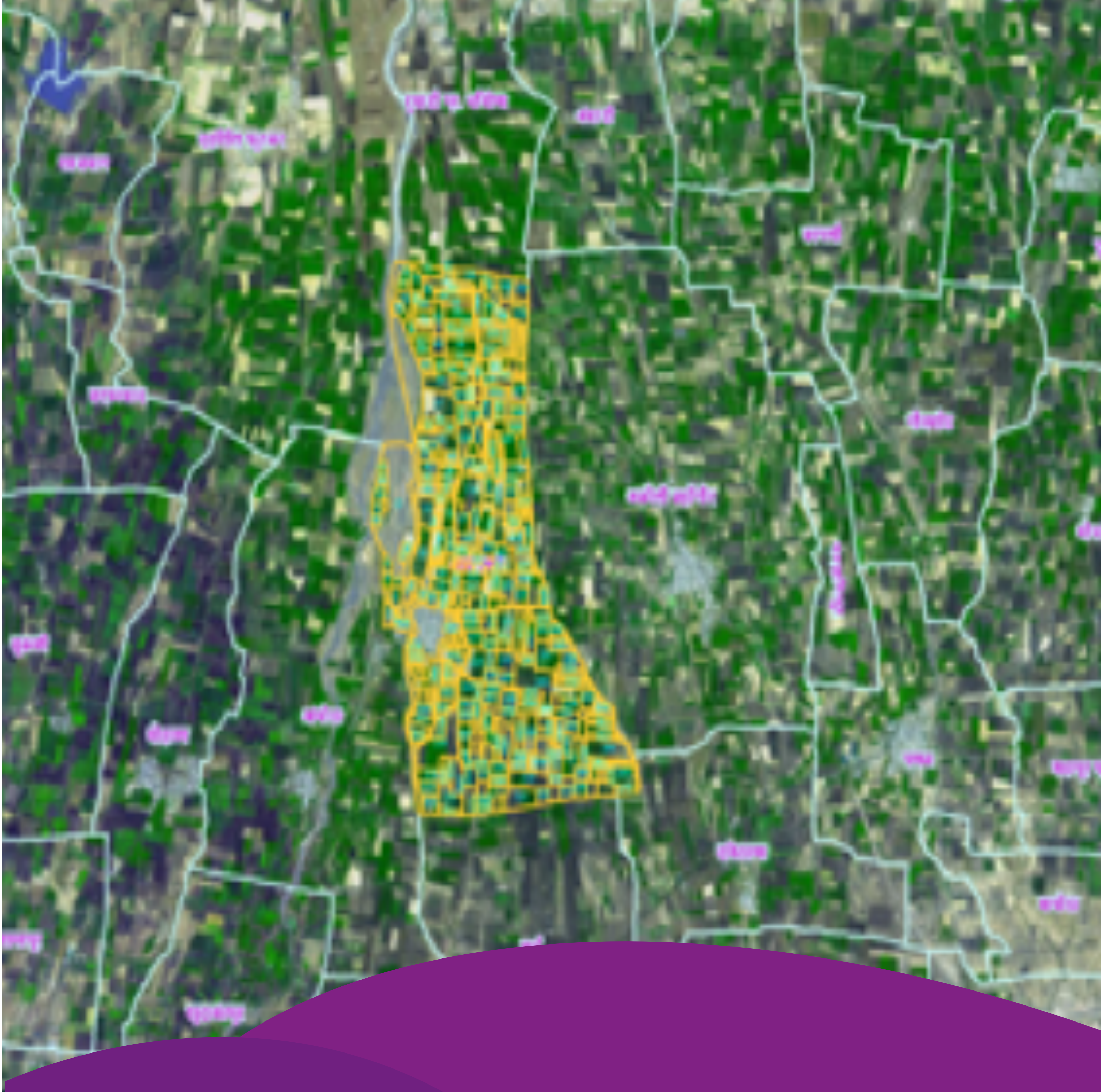
a. Agro - Advisory Services:

- **Pest and Disease Forecasting**: Remote sensing tools integrated with GIS can detect early signs of pest and disease outbreaks by analyzing environmental variables. The Indian Council of Agricultural Research (ICAR) has developed systems to monitor pest outbreaks such as locusts, and these systems help farmers in states like Rajasthan and Madhya Pradesh prepare early and take preventive measures.
- **Weather Forecasting and Planning**: GIS-based systems help farmers access localized weather forecasts, enabling them to make timely decisions regarding sowing, irrigation, and harvesting. Indian Meteorological Department (IMD) provides weather forecasting services through GIS-based applications, helping farmers plan their agricultural activities around weather patterns and reduce crop losses caused by unforeseen climate events like floods or droughts.
- **Market Price Information**: GIS tools can be used to track market prices in different regions, helping farmers decide the best time and place to sell their produce. The National Agricultural Market (eNAM) platform uses GIS to provide real-time information on market prices, helping farmers make better decisions on when to sell crops and vegetables based on price trends. This reduces the risk of farmers selling at a loss due to market volatility.

b. Farmer Training and Awareness

- **Creation of Visual Training Materials**: Geoinformatics tools help create visual aids, maps, and charts that simplify complex agricultural and environmental issues.

- **Interactive Platforms for Learning**: GIS-based mobile apps and online platforms are increasingly used to enhance farmers' learning experiences. The Maharashtra State Agriculture Department has developed a GIS-based mobile application called "MahaVISTAAR" that provides farmers with information on crop management, pest control, and agricultural practices. These platforms allow farmers to interact with the data and improve their farm management strategies by making them more aware of the environmental and economic factors affecting their crops.



04
Government of India Initiatives/Schemes

Several Indian government schemes are utilsing geoinformatics for their successful implementation. Here are a few initiatives undertaken by the government:

A. National Geospatial Policy 2022:

The Government of India introduced the National Geospatial Policy 2022, aiming to liberalize the geospatial sector and foster its growth.

Key Objectives of the National Geospatial Policy 2022:

- To establish India as a global leader in the geospatial sector.
- To promote the use of geospatial technologies for economic growth and development.
- To improve public service delivery by leveraging geospatial data.
- To enhance national security through the effective use of geospatial intelligence.

Key aspects of this policy include:

- Liberalization: The policy significantly liberalizes the sector by removing the requirement for prior government approval for most geospatial data acquisition and mapping activities.
- Data Access: It aims to enhance the availability of geospatial data by promoting data sharing among government agencies and encouraging the private sector to contribute to data generation.
- Innovation: The policy seeks to foster innovation in the geospatial sector by encouraging the development of new technologies and applications.
- Skill Development: It emphasizes the importance of developing a skilled workforce in the geospatial domain through education and training programs.

Implementation:

The government has taken several steps to implement the National Geospatial Policy 2022, including:

- Simplifying licensing procedures: The government has streamlined the licensing process for geospatial data acquisition and mapping activities.
- Promoting data sharing: The government is actively promoting data sharing among government agencies and encouraging the private sector to contribute to data generation.
- Fostering innovation: The government is supporting research and development in geospatial technologies and encouraging the development of innovative geospatial applications.
- Developing human resources: The government is investing in education and training programs to develop a skilled workforce in the geospatial domain.

Overall, the National Geospatial Policy represents a significant step forward in the development of the geospatial sector in India. It is expected to have a positive impact on various sectors of the economy, including agriculture, and rural development.

B. Digital India:

This flagship program aims to transform India into a digitally empowered knowledge economy. Geoinformatics plays a crucial role in various aspects of Digital India, such as:

- Broadband Connectivity: Mapping and planning of telecommunication infrastructure, including fiber optic networks and mobile towers, rely heavily on geospatial data and analysis.
- Smart Cities Mission: Geoinformatics is essential for urban planning, infrastructure development, traffic management, and resource allocation within smart cities.
- E-Governance: Geospatial technologies are used to improve service delivery, enhance citizen engagement, and streamline administrative processes.

C. National Health Mission (NRHM):

This program aims to improve the accessibility and quality of healthcare services in rural areas. Geoinformatics is used to:

- Map healthcare facilities: Identify gaps in healthcare infrastructure and prioritize resource allocation.
- Track disease outbreaks: Monitor the spread of infectious diseases and plan effective public health interventions.
- Improve access to healthcare: Optimize the location of healthcare facilities and ensure equitable access to healthcare services.

D. National Agricultural Mission:

This mission aims to enhance agricultural productivity and improve farmer incomes through

- Precision Agriculture: Implement precision farming techniques, such as site-specific nutrient management and variable rate irrigation, based on soil and crop data.10
- Crop Yield Prediction: Predict crop yields based on weather patterns, soil conditions, and historical data.
- Disaster Management: Assess the impact of natural disasters on agriculture and plan effective relief and rehabilitation measures.

E. National Disaster Management Authority (NDMA):

NDMA utilizes geoinformatics for:

- Disaster Risk Assessment: Map and assess areas vulnerable to natural disasters such as floods, earthquakes, and cyclones.
- Early Warning Systems: Develop and implement early warning systems for natural disasters.12
- Emergency Response: Coordinate relief and rescue operations during disasters.

F. Smart Cities Mission:

This mission aimed to transform 100 Indian cities into smart cities. Geoinformatics played a crucial role in various aspects of smart city development, including:

- Urban Planning: Develop sustainable urban plans, including transportation networks, infrastructure development, and land use planning.
- Traffic Management: Implement intelligent traffic management systems to optimize traffic flow and reduce congestion.
- Waste Management: Optimize waste

collection routes and improve waste management efficiency.

G. SVAMITVA Scheme

The SVAMITVA Scheme (Survey of Villages and Mapping with Improvised Technology in Village Areas) utilizes geospatial technology to transform rural land ownership in India.

- Central to the initiative are drone surveys and Continuously Operating Reference Stations (CORS) Networks. These advanced tools enable precise mapping of rural inhabited areas, with accuracy up to 5 centimeters. By creating highly accurate land records, the scheme helps issue 'record of rights' to property owners, reducing disputes and legal conflicts. Additionally, it allows rural homeowners to use their property as financial assets, facilitating loans and other economic benefits.
- This geospatial approach not only ensures clarity in property boundaries but also enhances rural planning by providing detailed and reliable data for comprehensive Gram Panchayat Development Plans (GPDP). The integration of geospatial technology into rural governance and planning is a crucial aspect of the SVAMITVA Scheme, promoting financial stability and sustainable development in rural India.

H. Pradhan Mantri Fasal Bima Yojana (PMFBY)

The Pradhan Mantri Fasal Bima Yojana (PMFBY) is a comprehensive crop insurance scheme designed to protect farmers against crop losses due to natural calamities, pests, and diseases. Central to the scheme's effectiveness is the use of geospatial technology.

- Real-time weather data collection to assess crop health and predict potential risks, as well as satellite imagery and remote sensing to monitor crop conditions and assess damage. (GIS) is also employed to accurately identify and manage crop areas, ensuring precise claim settlements.
- By integrating these geospatial technologies, PMFBY provides timely and accurate data for crop insurance claims, enabling farmers to receive necessary support swiftly and efficiently. This technological approach not only mitigates the financial impact on farmers but also enhances the overall resilience of the agricultural sector in India.

I. Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

- The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) scheme leverages geospatial technology to enhance urban planning and development.
- The National Remote Sensing Centre (NRSC), ISRO, plays a crucial role in this initiative by creating GIS-based master plans for 238 AMRUT cities.
- These plans utilize Very High-Resolution satellite data to prepare accurate base maps and land use maps, which are then used by Urban Local Bodies (ULBs) for ground verification and attribute data collection1.

- By integrating geospatial technology, AMRUT ensures precise urban planning, aiding in the development of infrastructure and amenities for urban areas. This approach not only improves the efficiency of urban management but also supports sustainable development and better decision-making for future projects.

J. Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)

- The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) effectively uses geospatial technology to enhance its planning, monitoring, and evaluation processes.
- By employing Geographic Information System (GIS), Global Positioning System (GPS), and Remote Sensing (RS) technologies, MGNREGS ensures accurate mapping and tracking of rural assets and projects.
- Geospatial technology has become an integral part of the scheme, improving transparency, monitoring, and planning of assets. Through the use of GIS and Remote Sensing, the Ministry of Rural Development has developed the "GeoMGNREGA" platform, which geo-tags and maps works such as water harvesting structures, plantations, and rural infrastructure. This enables real-time tracking of assets, better planning of natural resource management activities, and effective evaluation of outcomes, ensuring accountability and optimal utilization of funds.

K. Namami Gange Programme

- The Namami Gange Programme is a significant initiative by the Government of India aimed at cleaning and rejuvenating the Ganga river.
- Central to this mission is the use of geospatial technology, particularly GIS technology, for effective planning and decision-making. Digital Elevation Model (DEM) technology ensures accurate data collection essential for river basin management. Additionally, real-time water quality monitoring is achieved through satellite data and GIS mapping, allowing for continuous assessment of pollution levels. Community participation is fostered through the Bhuvan Ganga app and other geo-portals, enabling citizens to report issues and provide feedback directly. Moreover, mapping the outlets of sewerage and other discharges helps in effective discharge management and regulation of protected zones along the riverbanks. This integration of geospatial technologies ensures a transparent, interactive, and data-driven approach to the Namami Gange Programme. By involving both the government and the public, the programme fosters collaboration in the mission to clean and rejuvenate the Ganga, promoting environmental sustainability and public health.

L. Bharat Maps

- **Bharat Maps** is a multi-layer GIS platform developed by the National Informatics Centre (NIC) under the Government of India. It provides geo-spatial data and services for planning and governance across the country.
- The platform integrates core foundation data, base map services, and various thematic layers from sources like the Survey of India, ISRO, and Forest Survey of India. These layers include administrative boundaries, transport networks, forest areas, settlement locations, and terrain maps. Bharat Maps supports a wide range of applications, from urban planning and infrastructure development to environmental monitoring and disaster management.

05

NABARD interventions in Geospatial technology

NABARD's diverse Natural Resource Management (NRM) portfolio focuses on enhancing rural livelihoods, promoting sustainability, and ensuring environmental conservation. To strengthen its NRM and rural development initiatives, NABARD has actively embraced geospatial technology. The key interventions of NABARD in geospatial Technology are indicated below:

I. Web-based monitoring of Watershed Development Projects through NABARD Bhuvan Portal

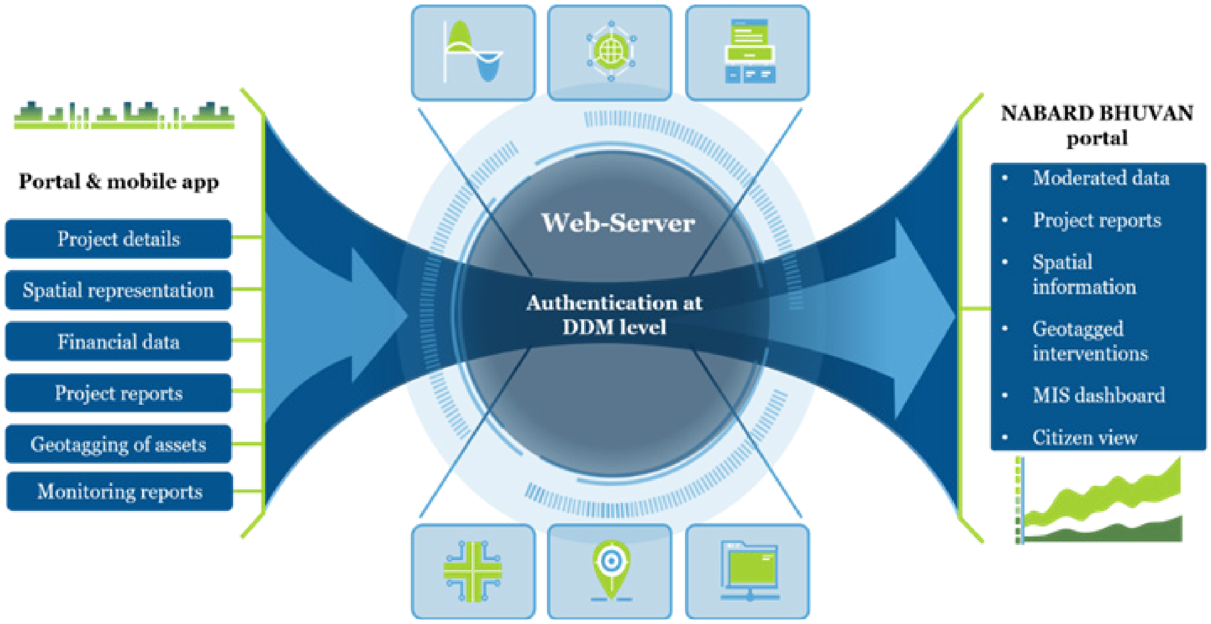
One of NABARD's flagship NRM programmes is the Watershed Development Programme, which is being implemented since last three decades to address challenges in rainfed farming. With the increasing number of projects each year and the growing need for digitization, web-based monitoring was introduced to supplement physical monitoring.

The NABARD Bhuvan Portal (https://bhuvan.nabard.org), developed in collaboration with NRSC, ISRO, is a web-based geospatial platform for monitoring of various interventions under the Watershed Development Programme. The portal facilitates digitisation of the various activities under the programme, monitoring the progress and evaluation. Digitization of watersheds facilitates the creation of permanent digital records, while geotagging of assets created during the project implementation ensures transparency, accountability, and efficient monitoring.

This portal has achieved a significant milestone of geotagging over 2 lakh assets across 1,174 watershed projects.

In addition to hosting an extensive database of geotagged assets, the NABARD Bhuvan Portal provides a range of comprehensive utilities, including:

- Permanent digital record and easy access
- Holistic and synoptic view of watershed
- Online status of implementation for tracking of progress at HO/RO/district level
- Monitoring end use of grant released through geotagged assets
- Facilitate effective end use monitoring providing valuable insights into the outcomes and impact of the grants.
- Facilitates evidence based monitoring and impact evaluation that will help to make informed and data-driven decisions in near future, leading to more effective and efficient use of resources
- It may also be utilized for carbon sequestration potential assessment and claiming carbon credits in near future



Overview of web monitoring of projects through NABARD BHUVAN system.

II. Preparation of geospatial technology based DPR of watershed projects

Geospatial technology has been integrated into the watershed planning process to overcome existing challenges effectively. This technology has the potential to streamline the planning efforts, making them more efficient, effective and transparent, ultimately leading to improved results.

The planning process leverages open-source tools like QGIS and Google Earth for cadastral-level micro-watershed planning, ensuring a holistic and science-based approach. It integrates multi-layer spatial data from sources such as the Bhuvan Portal, WRIS, and Geological Survey of India to generate thematic layers like geomorphology, slope, and drainage, which are crucial for identifying recharge and discharge zones. A weighted overlay analysis ranks these layers to pinpoint potential recharge sites, while Land Capability Classification (LCC) maps aid in accurately selecting locations for soil and water conservation structures.

The comprehensive plan is validated in the field with input from village watershed committees, ensuring effective and well-informed decision-making.

The salient advantages include:

- Comprehensive understanding can be efficiently achieved within a limited time frame.
- Multiple surveys conducted by implementing agencies can be reduced to save the time and financial resources.
- Proposed interventions are based on analytical reasoning i.e. recharge potential mapping and land capability classification, backed by the spatial data in comparison to

traditional method of planning

- Covers the entire area while taking into account the location of existing structures as well.
- It promotes digitization thus easy to access, share and modify.

III. Geospatial technology for Impact Assessment of Watershed Projects

As the watershed development approach is an integrated one, there is a need for a suitable indicator to assess the progress of project implementation. It is necessary to holistically assess and evaluate the long-term effects and the impact of the activities through reliable methods.

The repetitive coverage of the satellite provides an excellent opportunity to monitor the land resources and evaluate the land cover changes through a comparison of satellite images acquired for the same area at different time periods.

Pre and post-implementation satellite images are used to detect changes, involving the application of multi-temporal datasets (multiple images of the same area taken at different times) to quantitatively analyze the temporal effects of the phenomenon.

Advantages of remotely sensed data for change detection in watersheds:

Repetitive data acquisition allows for continuous monitoring. Provides a synoptic view, covering large areas at once. Digital format enables efficient computer processing. Supports timely detection of changes in watershed conditions. Enhances local governments' capacity for sound environmental management.

A Impact evaluation study of Shekhar Nawadih Watershed, Deoghar District, Jharkhand using Geospatial Technology is presented below:

Shekhar Nawadih watershed is located in the Deoghar district of Jharkhand state and covers an area of 1,186.26 ha. The watershed area extends from 24.20' N to 24.25' N latitude and 86.93' E to 86.98' E longitude. Shekhar Nawadih features slightly undulating terrain with elevations ranging between 295 and 305 meters above mean sea level. A large number of people in the area are involved in agricultural activities.

To assess the impact of the measures taken in the watershed area, the pre- and post-project periods of the same

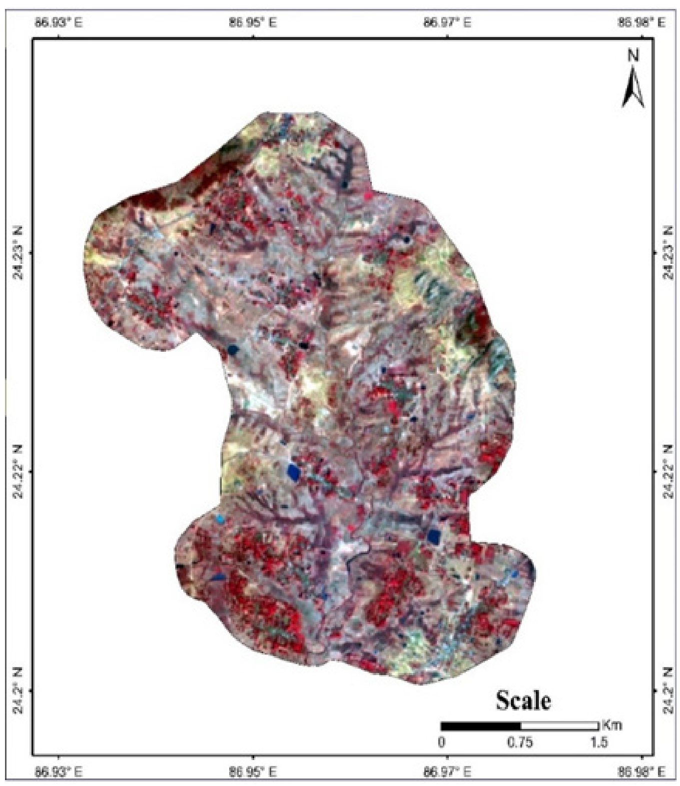


Fig. Shekhar Nawadih Watershed

cropping season (Rabi) were considered. Specifically, the periods of January 2019 (pre-project) and January 2023 (post-project) were analyzed for changes in land use and land cover.

Impact on land use /land cover

The figure 2 and 3 below show the land use/land cover changes in the Shekhar Nawadih watershed for the years 2019 and 2023, respectively.

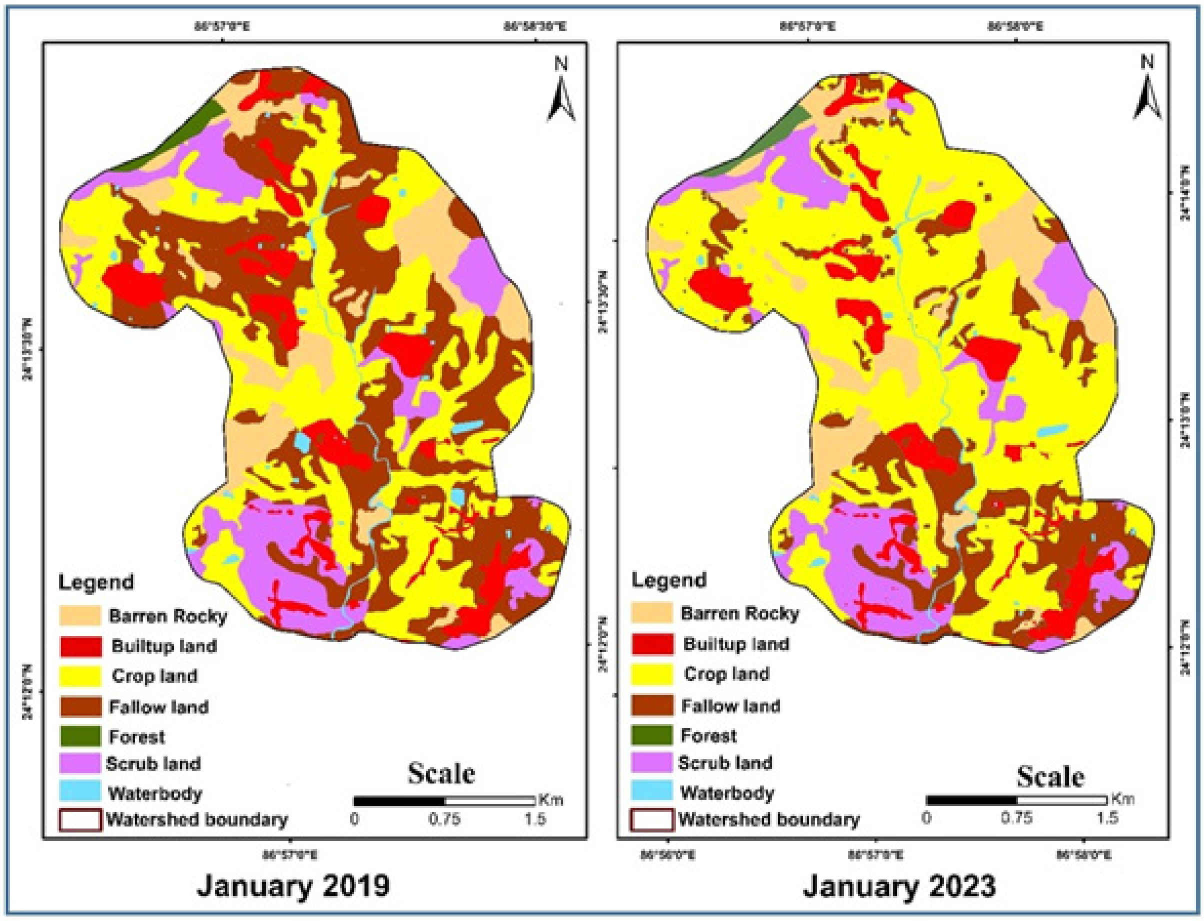
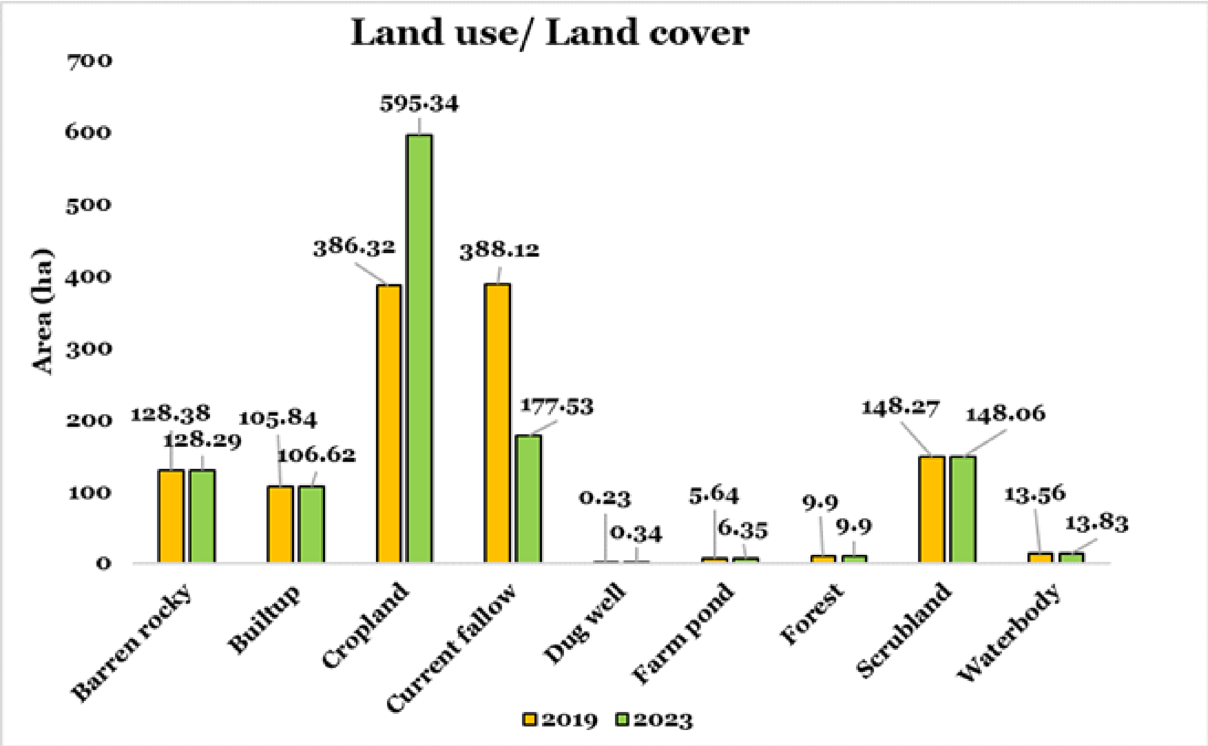


Fig. Land use/land cover change map of Shekhar Nawadih watershed



In the study area, the total area under cultivation was 386.32 ha (32.57% of the total area) in 2019, which increased to 595.34 ha (50.19% of the total area) in 2023. Consequently, the area of fallow land decreased by 210.59 ha.

06
Drone Technology and its role in Agriculture

India relies heavily on agriculture but lags in adopting modern technologies. Several countries have integrated UAVs (Unmanned Aerial Vehicles) in precision agriculture for tasks like crop monitoring and pesticide spraying.

I. Applications of Drones in Agriculture

A. Crop Health Monitoring:

- Drones equipped with visible, NIR (Near Infrared), and thermal infrared sensors can monitor crop conditions throughout the season. By computing multispectral indices like NDVI (Normalized Difference Vegetation Index), drones can assess. High NDVI values indicate healthy vegetation.

B. Water Stress Monitoring:

- Drones use multispectral, hyperspectral and thermal imagery to detect water stress. Variables like canopy temperature and indices such as CWSI (Crop Water Stress Index) are used. CWSI is based on the difference between canopy temperature and air temperature, normalized by the vapor pressure deficit.

- For example, Different genotypes of a crop may show varying canopy temperatures under the same conditions due to differences in stomatal conductance and transpiration rates. Thermal infrared imagery can highlight these variations, helping farmers manage irrigation more effectively.

C. Nutrient Status and Deficiency Monitoring:

- UAVs can identify nutrient deficiencies using NIR/multispectral imagery long before they become visible. This allows for targeted interventions to correct nutrient imbalances.

- For example, nitrogen deficiency can be detected using the SPAD (Soil-Plant Analyses Development) chlorophyll meter, which measures leaf chlorophyll content. Multispectral images can be used to calculate vegetation indices that correlate with nutrient levels.

D. Disease Monitoring:

- **Infrared Cameras**: Drones equipped with infrared cameras can detect infections early by seeing inside plants. This allows for the removal of infected plants before the disease spreads.

- **Image-Based Tools**: RGB and multispectral images are commonly used to detect and recognize plant diseases. For example, UAVs can monitor sugar beet leaf spot disease using image processing techniques.

E. Weed Control:

- **Precision Spraying**: Drones can create precise weed cover maps for targeted herbicide application, reducing chemical use and environmental impact. Hyperspectral images can discriminate between weed species based on their spectral signatures.

- In India, yield losses due to weeds can be significant, with rice losses ranging from 10-100%. Drones can help manage weeds more effectively by applying herbicides only where needed.

F. Evapotranspiration Estimation:

- Evapotranspiration (ET) is the process by which water is transferred from the land to the atmosphere. Accurate ET estimation is crucial for water management in agriculture.
- Drones use thermal and multispectral sensors to estimate ET. For example, a fixed-wing UAV equipped with a TIR (Thermal Infrared) camera and a multispectral camera can collect high-resolution imagery to estimate ET in a peach orchard.

G. Spraying:

- Drones can spray fertilizers, pesticides, and other chemicals more precisely and safely, reducing human exposure and environmental pollution. For instance, a quadcopter can be used for autonomous pesticide spraying using an android device for real-time operation.
- The WHO estimates over 1 million pesticide poisoning cases annually, with significant fatalities. Using drones for spraying can mitigate these risks by reducing human contact with harmful chemicals.

II. Problems and Bottlenecks in Using Drones in Agriculture

A. Flight Time and Range:

- **Limited Duration**: Drones used in agriculture typically have a short flight duration, ranging from 20 to 60 minutes. This is due to the relatively high payloads they carry, such as cameras, sensors, and spraying equipment.
- **Coverage Limitations**: The limited flight time restricts the area that can be covered in a single flight, necessitating multiple flights to cover larger fields. This increases operational time and costs.
- **Cost Implications**: Extending flight time requires more advanced and expensive battery technology, which significantly increases the cost of drones.

B. Initial Cost:

- **High Purchase Price**: Agricultural drones, especially those equipped with advanced sensors and imaging technology, can be very expensive.
- **Additional Equipment**: The cost of drones often includes imaging sensors, software, hardware, and tools necessary for their operation. This makes the initial investment substantial.
- **Affordability Issues**: Small and medium-scale farmers may find it difficult to afford such high initial costs, limiting the adoption of drone technology.

C. Regulations:

- **Strict Guidelines**: The operation of drones is governed by strict regulations to ensure safety and privacy. In India, the Directorate General of Civil Aviation (DGCA) has issued comprehensive guidelines that include obtaining permits and adhering to no-fly zones.
- **Operational Restrictions**: Regulations often prohibit beyond visual line-of-sight (BVLOS) operations and the carriage of certain payloads, such as pesticides, without specific clearances. This limits the full potential of drones in agricultural applications.

- **Compliance Challenges**: Farmers and drone operators must navigate complex regulatory requirements, which can be time-consuming and costly.

D. Connectivity:

- **Lack of Internet Access**: Many rural and agricultural areas lack reliable internet connectivity, which is essential for operating drones and processing the data they collect.
- **Data Storage and Transfer**: Without internet access, farmers need drones with local data storage capabilities and the means to transfer and process this data later, adding to the complexity and cost.
- **Adverse Conditions**: Drones are highly sensitive to weather conditions. Windy, rainy, or stormy weather can make flying drones difficult or impossible.
- **Operational Delays**: Weather dependency can lead to delays in agricultural operations, affecting the timely application of fertilizers, pesticides, and other critical tasks.

E. Knowledge and Skill:

- **Technical Expertise**: Operating drones and analyzing the data they collect require specialized skills and knowledge. Farmers need to be trained in drone operation and data interpretation.
- **Training Requirements**: Acquiring these skills involves training programs, which can be costly and time-consuming. Farmers may also need to hire skilled personnel, adding to operational costs.

F. Misuse:

- **Privacy Concerns**: Drones can potentially be misused to infringe on the privacy of individuals, leading to legal and ethical issues.
- **Security Risks**: There is a risk of drones being used for illegal activities, such as unauthorized surveillance or data theft. Ensuring secure and responsible use of drones is a significant challenge.

III. Case Studies of Drone Use in Indian Agriculture

A. Grape Growers in Nashik, Maharashtra:

- **Overview**: The Grape Growers Association in Nashik engaged drones for disease surveillance in vineyards. This initiative aimed to monitor and manage grapevine health more effectively.
- **Implementation**: Drones equipped with high-resolution cameras and sensors are used to capture detailed images of the vineyards. These images are analyzed to detect early signs of diseases such as powdery mildew and downy mildew.
- **Benefits**: The use of drones has enabled timely interventions, reducing the spread of diseases and minimizing crop losses. Farmers have reported improved grape quality and higher yields. Additionally, the precision of drone surveillance has reduced the need for excessive pesticide use, promoting more sustainable farming practices.

B. Farmers in Dahanu-Palghar, Maharashtra:

- **Overview**: Tribal farmers in the Dahanu-Palghar region have adopted drone technology for various agricultural activities, including organic farming, fish farming, crop rotation, and bio-control.
- **Implementation**: Drones are used to monitor crop health, manage fish ponds, and apply bio-control agents. The technology helps in mapping fields, assessing soil health, and planning crop rotations.
- **Benefits**: The adoption of drones has empowered these farmers with precise data, enabling better decision-making and resource management. The technology has also facilitated organic farming practices by reducing the reliance on chemical inputs. Overall, the use of drones has led to increased productivity and sustainability in the region.

C. Rice Farmers in Tamil Nadu:

- **Overview**: In Tamil Nadu, rice farmers have started using drones for crop monitoring and pesticide spraying. This initiative is part of a broader effort to modernize rice farming practices in the state.
- **Implementation**: Drones equipped with multispectral cameras are used to monitor crop health and identify areas affected by pests and diseases. Additionally, drones are used to spray pesticides and fertilizers with high precision.
- **Benefits**: The use of drones has significantly reduced the labor required for crop monitoring and pesticide application. Farmers have reported better pest control and higher rice yields. The precision of drone spraying has also minimized the environmental impact of pesticide use.

D. Sugarcane Farmers in Uttar Pradesh:

- **Overview**: Sugarcane farmers in Uttar Pradesh have integrated drone technology into their farming practices to improve crop management and yield estimation.
- **Implementation**: Drones are used to capture high-resolution images of sugarcane fields, which are then analyzed to estimate crop biomass and predict yields. The technology also helps in identifying areas with nutrient deficiencies and pest infestations.
- **Benefits**: The use of drones has provided farmers with accurate and timely information, enabling better crop management and yield predictions. This has led to increased productivity and profitability for sugarcane farmers in the region.

The drone technology is being used across the word for various applications. Some of the key highlights are indicated below:

a. Corn Fungicide Spraying in the US:

- **Overview**: In the United States, DJI Agriculture drones have been used to spray fungicides on corn fields. This method has significantly improved the efficiency and precision of fungicide application.
- **Benefits**: The drones can cover large areas quickly and apply fungicides

precisely where needed, reducing the overall amount of chemicals used and minimizing environmental impact. This has led to healthier crops and higher yields

b. Sugarcane Farming in Thailand:

- **Overview**: In northeastern Thailand, DJI Agras T30 drones have been integrated into sugarcane farming. These drones are used for tasks such as spraying fertilizers and pesticides.
- **Benefits**: The use of drones has revolutionized sugarcane farming by increasing the precision of chemical applications, reducing labor costs, and improving crop health. Farmers have reported higher yields and better quality sugarcane

c. Wheat Farming in Romania:

- **Overview**: Romanian farmers have adopted DJI Agriculture drones to enhance wheat production. The drones are used for monitoring crop health, spraying pesticides, and applying fertilizers.
- **Benefits**: The drones provide real-time data on crop conditions, allowing farmers to make informed decisions. This has resulted in increased wheat yields and reduced input costs

IV. Way Forward for Drone Use in Indian Agriculture Research and Development:

a. Research and Development:

- **Optimization**: Conduct research to optimize drone operations for various agricultural applications. This includes studying the impact of drone rotor speed on pesticide distribution and developing protocols for different crops.
- **Validation**: Validate the effectiveness of drone technology through field trials and experiments. This will help in establishing best practices and standard operating procedures for drone use in agriculture.

b. Policy Reforms:

- **Regulatory Framework**: Simplify and streamline the regulatory framework for drone operations in agriculture. This includes updating the DGCA guidelines to facilitate beyond visual line-of-sight (BVLOS) operations and night-time flights.
- **Training and Certification**: Develop accessible and affordable training programs for drone operators. This includes integrating drone technology into agricultural education curricula and providing certification for trained operators.

c. Infrastructure Development:

- **Connectivity**: Improve internet connectivity in rural areas to support drone operations and data processing. This will enable real-time monitoring and decision-making.
- **Custom Hiring Centers**: Establish custom hiring centers for drones, similar to those for other agricultural equipment. This will make drone technology more accessible to small and medium-scale farmers.

d. Public-Private Partnerships (PPP):

- **Collaboration**: Encourage collaborations between government agencies, private companies, and research institutions to promote the adoption of drone technology. This includes developing infrastructure for spatial data, digital soil maps, and weather information.

- **Support for Start-ups**: Provide support for start-ups and entrepreneurs in the drone industry. This includes financial incentives, incubation programs, and access to markets.

e. Awareness and Extension:

- **Field Demonstrations**: Conduct field demonstrations and awareness campaigns to showcase the benefits of drone technology to farmers. This will help in building trust and encouraging adoption.
- **Extension Services**: Train extension workers to assist farmers in using drone technology. This includes providing technical support and guidance on drone operations and data interpretation.

Drones have the potential to transform agriculture by making it more efficient and sustainable. They provide real-time, high-quality aerial imagery, enabling farmers to manage their fields better. As technology advances, drones are expected to become more economical, attracting younger generations to farming.

07

Key Issues and Challenges in the Geoinformatics Sector

The Geoinformatics sector has seen remarkable advancements in technology and application over the past few decades. However, despite its transformative potential, the sector faces several critical issues and challenges that can hinder its widespread adoption, effective use, and long-term sustainability. Addressing these challenges is essential to fully harness the power of geospatial data and ensure its integration into national and global decision-making processes. This chapter discusses the key issues and challenges that the Geoinformatics sector currently faces, ranging from technological limitations and data management concerns to regulatory and societal obstacles.

I. Data Quality and Availability

a. Data Accuracy and Precision

One of the most significant challenges in Geoinformatics is ensuring the accuracy and precision of geospatial data. Geospatial data, especially from remote sensing platforms, can suffer from errors due to factors such as sensor limitations, atmospheric conditions, and computational inaccuracies. High-resolution data, particularly from satellite imagery or LiDAR sensors, can be expensive, and low-cost data sources may not always provide the required accuracy for specific applications.

Data from different sources, such as satellite images, UAVs, and ground surveys, may have varying degrees of accuracy and resolution, leading to inconsistencies in spatial analysis.

b. Data Gaps and Incompleteness

The availability of up-to-date geospatial data is critical for many applications, yet gaps in data coverage remain a problem. While satellite imagery is abundant, temporal gaps in data collection can impede the ability to monitor dynamic changes.

Incomplete or outdated data can lead to inaccurate analysis and decision-making.

II. Data Interoperability

a. Standardization of Data Formats

Geospatial data often comes from various sources, including satellites, drones, government agencies, and private sector organizations. Each of these sources may use different data formats, standards, and coordinate systems, which can complicate data sharing and integration. The lack of standardized data formats can result in increased processing time, additional costs, and potential errors in data analysis when merging datasets.

Integrating geospatial data from various sources (e.g., remote sensing, GPS, IoT sensors) without common standards can hinder effective data exchange and utilization.

b. Complex Data Integration

Geospatial data is increasingly being integrated with data from other domains such as transportation, healthcare, agriculture, and climate science. The integration of these diverse datasets requires the alignment of various data types (spatial and non-spatial), and ensuring compatibility across platforms and applications can be a complex task. The integration process also demands advanced tools and methodologies, such as data fusion and multi-sensor fusion techniques, to handle the inherent heterogeneity of the data.

Combining geospatial data with

non-spatial information (e.g., social, economic, or environmental data) from various sources requires sophisticated techniques to ensure the data is meaningful and accurate.

III. Privacy, Security, and Ethical Concerns

a. Privacy Issues

Geospatial technologies, particularly GPS, tracking systems, and remote sensing, can collect highly detailed information about individuals, properties, and activities. While this data is invaluable for planning, management, and research, it raises significant privacy concerns. The growing availability of geospatial data from open sources and social media platforms can potentially lead to privacy violations, misuse of data, and unauthorized surveillance.

b. Data Security and Cyber Threats

Geospatial data is highly valuable, making it a prime target for cyber-attacks, theft, and unauthorized manipulation. Given that geospatial data underpins critical infrastructures (e.g., transportation, utilities, disaster management), the security of such data becomes paramount. Breaches in geospatial data security can have severe consequences, including compromised national security, disrupted services, and even loss of life in the case of emergency response systems.

Safeguarding large volumes of geospatial data from cyber threats requires robust cybersecurity protocols, regular monitoring, and security updates.

IV. High Costs of Advanced Technologies

Acquiring high-quality geospatial data, such as high-resolution satellite imagery, LiDAR data, or UAV-based surveys, is often costly. Moreover, processing and analyzing large datasets can require significant computational resources and specialized software, which may be financially prohibitive for many organizations, especially in developing nations.

High upfront costs for advanced data acquisition technologies, coupled with the need for expensive infrastructure and skilled personnel, can limit access to geospatial technologies for smaller businesses, NGOs, and other stakeholders.

V. Skill Gaps and Capacity Building

a. Shortage of Skilled Professionals

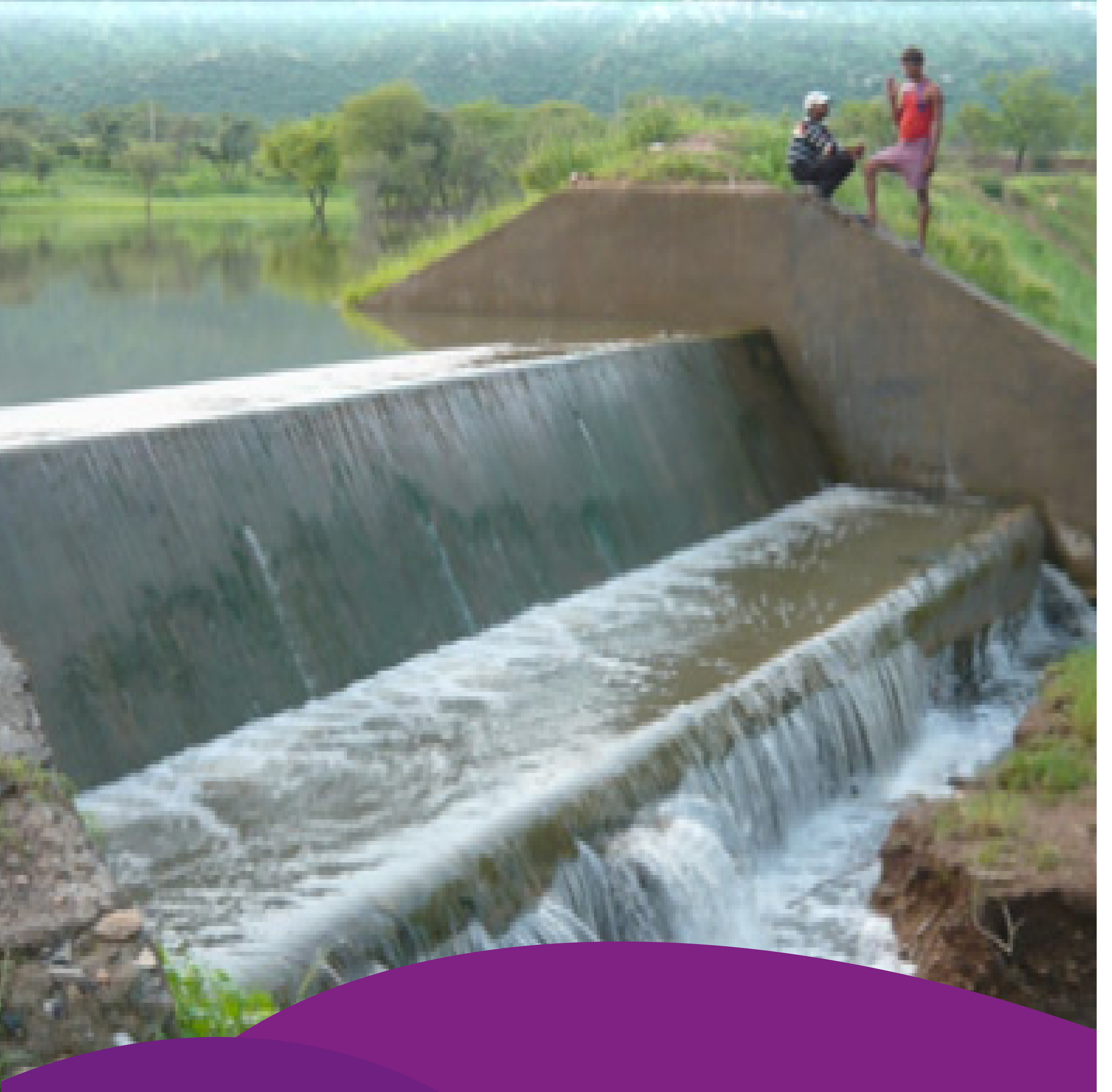
The growing demand for geospatial data analysis has outpaced the supply of skilled professionals in the Geoinformatics sector. Although there is an increasing number of educational programs, there is still a significant gap in the number of experts trained in GIS, remote sensing, spatial data analysis, and geospatial software development. Additionally, rapid technological advancements require continuous skill upgrading, and professionals must adapt to evolving tools and techniques.

The shortage of qualified personnel in geospatial fields makes it difficult to meet the growing demand for geospatial services and hampers innovation.

b. Public Awareness and Acceptance

While the potential applications of Geoinformatics are vast, there remains a lack of awareness among the public and non-expert stakeholders about the power and potential of geospatial data. Misunderstanding or lack of knowledge can lead to resistance or reluctance to adopt geospatial technologies in various sectors.

Without widespread public understanding, the benefits of Geoinformatics may not be fully realized, and potential users may not embrace these technologies.



08
Potential Action Research Projects

NABARD

I. Use of Technology - Drones Technology/Digital Agriculture:

Drones have been primarily used by companies working in industrial sectors such as mining and construction, army, and hobbyists.

But now, drone technology is increasingly available for use in various sectors of agriculture as well. Though the technology is still nascent in India, many companies are trying so that it is easily available to Indian farmers and ready to be used to increase efficiency in agricultural production.

A lot of drone-based agricultural initiatives have been undertaken as:

- The Government of India notified a drone certification scheme making it easier to obtain type certificate by drone manufacturers.
- During 2022, to promote the use of drones for agricultural purposes and reduce the labour burden on the farmers, the government of India has recently offered, a 100% subsidy or 10 lakhs, whichever is less, to the Farm Machinery Training and Testing Institutes, ICAR Institutes, Krishi Vigyan Kendras & State Agriculture Universities.
- Additionally, a contingency fund of Rs.6000/hectare was also included in the scheme to up for hiring Drones from Custom Hiring Centres (CHC). The subsidy and the contingency funds will help the farmer's access and adopt this extensive technology at an inexpensive price.

Drone Didi scheme

- On March 11, 2024, Prime Minister Narendra Modi launched the Namo Drone Didi scheme under the Sashakt Nari-Viksit Bharat programme. The scheme aims to empower rural women by providing them with agricultural drones and training them to become drone pilots for agricultural purposes.
- Under the Namo Drone Didi scheme, 15,000 women-led Self-Help Groups (SHGs) will receive agricultural drones to assist in crucial tasks such as crop monitoring, fertilizer spraying, and seed sowing. The initiative not only provides women with employment opportunities but also enhances agricultural productivity through the integration of modern technology.
- The PLP writers may refer to PMs Drone DIDI scheme for further details on use of Drones in agriculture. The availability of trained pilots, Service providers and other factors may be kept in mind while assessing the potential. Drones can be used for direct seeding and to apply plant protection chemicals. The PLP writer are advised to assess the need for Drones in the District and make assessment in the PLP. The cost of drones may please be obtained from Department of Agriculture in the State.

A model special refinance scheme for Kisan Drones is enclosed herewith as Annexure I.

II. Precision Agriculture with GIS

Precision agriculture is an innovative farming approach that leverages modern technologies to enhance productivity, minimize waste, and optimize resource usage. It integrates advanced tools like GPS, GIS, remote sensing, and sensor-based systems to collect and analyse data related to various aspects of farming, such as soil conditions, crop health, and weather patterns. With this information, farmers can make more precise decisions about crop management, leading to improved efficiency and sustainability.

- **Site-specific management**: Precision agriculture involves the use of site-specific management techniques, where the field is divided into smaller management zones based on soil type, nutrient availability, topography, and other factors. This allows farmers to apply inputs, such as fertilizers and pesticides, only where they are needed, reducing waste and improving efficiency.
- **Remote sensing**: Remote sensing involves the use of satellite and aerial imagery to capture detailed information about crop health, soil conditions, and environmental factors. This technology allows farmers to monitor their crops remotely, providing real-time insights into variables like nutrient levels, moisture content, and the overall vigor of the plants. By analysing these images, farmers can detect issues such as nutrient deficiencies, pest infestations, or water stress early, before they become widespread problems. This early detection allows for targeted interventions, minimizing the use of fertilizers and pesticides and reducing costs. Remote sensing data is also invaluable in assessing crop yield potential, which helps farmers plan for harvest and manage resources effectively throughout the growing season.

GIS complements remote sensing by providing tools for managing and analysing the spatial data gathered through these imaging technologies. GIS allows farmers to map out their fields in precise detail, considering factors like soil type, topography, and water availability. With GIS, farmers can create management zones within their fields, identifying areas that require specific attention. For example, a field might be divided into zones based on soil fertility or moisture content, allowing farmers to apply inputs like fertilizers, water, or pesticides only where they are needed most. This approach reduces waste, lowers costs, and ensures that resources are used efficiently. Together, remote sensing and GIS represent the forefront of precision agriculture, enabling farmers to make data-driven decisions that optimize their use of resources. These technologies help farmers monitor and manage their fields more effectively, improving crop yields while minimizing environmental impact. As the agricultural industry continues to embrace these tools, the potential for more sustainable and profitable farming practices becomes even greater. Ultimately, remote sensing and GIS empower farmers to manage their operations with precision, improving productivity while ensuring the long-term health and sustainability of their land.

III. ACABC extension units with GIS support

The Agri Clinic and Agribusiness Centres Scheme (ACABC), implemented by the Ministry of Agriculture and Farmers' Welfare in collaboration with NABARD, aims to strengthen agricultural extension services, support agricultural development, and generate employment opportunities for agricultural graduates and diploma holders. Geographic Information Systems (GIS) can play a significant role in achieving the objectives of this scheme by enhancing the precision, efficiency, and effectiveness of the services provided.

1. **Improved Extension Services**: One of the core objectives of the ACABC scheme is to supplement public extension services by offering tailored agricultural advice to farmers. GIS can help agri-preneurs and agri-business centres identify the specific needs of farmers in different geographical locations. By analysing spatial data, GIS can provide insights into soil types, water availability, climate conditions, and crop performance, enabling more accurate and region-specific recommendations for crop management, pest control, and resource utilization. This localized knowledge improves the effectiveness of extension services, whether provided on a paid or free basis.

2. **Support for Agricultural Development**: GIS aids in the strategic planning and implementation of agricultural development projects by providing detailed mapping and data analysis. It can help identify areas of the country where agricultural productivity can be improved or where specific crops are most suitable. GIS technology can also assist in monitoring agricultural trends, tracking crop yields, and evaluating the impact of different agricultural practices. Through such insights, agri-preneurs can offer services that directly contribute to enhancing agricultural productivity and sustainability, thus supporting the overarching goal of agricultural development under the ACABC scheme.

3. **Identification of Self-Employment Opportunities:** One of the goals of the ACABC scheme is to create gainful self-employment opportunities for unemployed agricultural graduates and diploma holders. GIS can assist in identifying regions with potential for setting up Agri Clinics and Agribusiness Centres based on various factors such as market demand, agricultural needs, and existing infrastructure. By analysing the distribution of agricultural activity, potential target groups, and local market dynamics, GIS helps in locating areas with the greatest need for agri-services and, therefore, the highest potential for success. This data-driven approach ensures that entrepreneurs establish their businesses in regions with significant opportunities for growth.

4. **Monitoring and Evaluation:** GIS enables ongoing monitoring and evaluation of the impact of Agri Clinics and Agribusiness Centres. By collecting spatial data on the outcomes of interventions, such as changes in crop yield, pest management, or resource usage, GIS can help assess whether the services provided are having the desired effect. This information is crucial for refining business models, improving service delivery, and ensuring that the objectives of the ACABC scheme are being met.

In conclusion, GIS serves as a vital

tool in the success of the Agri Clinic and Agribusiness Centres Scheme. It enhances the precision of agricultural extension services, supports agricultural development through data-driven decision-making, helps identify areas for self-employment opportunities, and enables effective monitoring and evaluation of the scheme's impact. By leveraging GIS, the ACABC scheme can create more efficient, localized, and sustainable agricultural services that benefit both farmers and agri-preneurs.

Annexure I
Model Scheme for Kisan Drones

Our country reigns the world as the most prominent producer of pulses, milk, rice, wheat, sugarcane, spices, etc. The Indian agricultural sector contributes a tremendous 17% to India's GDP (Gross Domestic Product). It is considered the prime source of livelihood for approximately 60% of the country's population, mainly for rural areas. Indian agriculture sector, along with forestry and fishing, results in a Gross Added Value of around Rs 20 lakh crore as of 2021. The agricultural sector expands with parallel industries at a growth rate of 3.4% (2020-21).

Regardless of Indian agriculture's contribution to the GDP, our country is yet to enhance productivity and efficiency in the sector to reach the highest potential. The hindrances have granted multiple opportunities for growth and development in the world of technology. The influence of technology in the agricultural sector has been invariably positive since its commencement.

Kisan Drones

Drone technology has gotten most of the recognition in the industry because of its diversity and considered the future for the agrarian community. Unmanned Aerial Vehicles (UAVs) enhance overall performance and encourage farmers to solve other assorted barriers and receive plenty of benefits through precision agriculture. With the market for agricultural drones reaching a whopping $1.3 billion, UAVs fill the gap of human error and inefficiency by traditional farming methods. External factors like weather, soil conditions, and temperature play a critical role in farming. Agriculture drones empowers the farmer to adapt to specific environments and make mindful choices accordingly. The gained data helps regulate crop health, crop treatment, crop scouting, irrigation, and carry out field soil analysis and crop damage assessments. The drone survey helps boost crop yields and minimize time and expenses.

According to experts, the predicted world population will be 9 billion by 2050. Agricultural consumption is also said to increase simultaneously by nearly 70%. Drone technology, equipped with artificial intelligence (AI), machine learning (ML), and remote sensing features, are rising in demand because of its advantages. The central government has acknowledged the importance of UAVs, ML, and AI with their 'Digital Sky Platform' online. In the Union Budget 2022-23, the Union Minister for Finance & Corporate Affairs, Smt. Nirmala Sitharaman announced that the Centre is promoting 'Kisan Drones' to help farmers assess crops, digitise land records as well as spray insecticides and nutrients. Startups will be promoted to facilitate 'Drone Shakti' and for Drone-As-A-Service (DrAAS). Drone startups in India have used this opportunity to accomplish better technological capacities.

Kisan Drone Technology

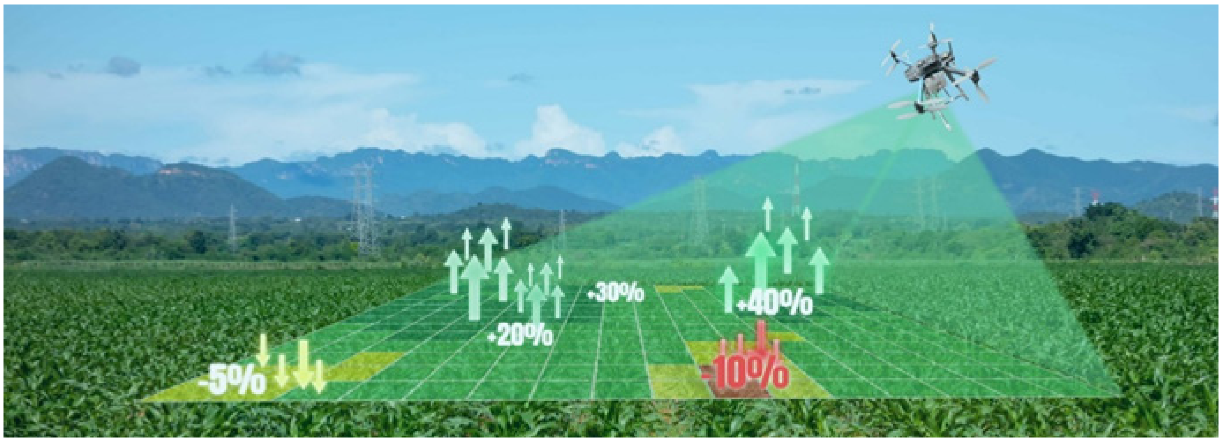
Only after complete recognition of drones characteristics can one gain in-depth knowledge about agriculture drones. Typically, drones include a navigation system, GPS, multiple sensors, high-quality cameras, programmable controllers, and tools for autonomous drones. Most farmers currently use satellite imagery as an introductory guide for farm management. Furnished with modern technology, UAVs can get more precise data than satellites for precision agriculture. They then process the data captured into agri-tech software to produce beneficial knowledge. Capturing data from agriculture drone takes place as in the following stages:

- **Analyzing the area**: This identifies the territory being tested. Therefore, the first step includes establishing a boundary, analyses of the area, and then finally, uploading the technical GPS information into the drone's navigation system.
- **Using Autonomous Drones**: Since UAVs are independent, they enter flight patterns into their already established system to collect required data.
- **Uploading the data**: After capturing all the required data through sensors such as the multispectral sensor/RGB sensor, it is processed through numerous software for further analysis and interpretation.
- **Output**: After collecting the data, they format it so that farmers can understand the data with no hassle, bringing them a step closer to precision farming. 3D mapping or Photogrammetry are popular methods to display extensive data collected.

- **There are two main types of drone platforms**:
  - Rotor based including, single-rotor and multi-rotor, such as tricopters, quadcopters, hexacopters and octocoptors.
  - Fixed-wing, which include the hybrid vertical take-off and landing (VTOL) drones that don't require runways.

Usage of Kisan Drones

1. **Irrigation Monitoring**: Drones, including hyperspectral, thermal, or multispectral sensors, recognize areas that are too dry or need improvement by the farmer. Drone survey helps improve water efficiency and disclose potential pooling/leaks in irrigation by providing Irrigation monitoring yields calculations of the vegetation index to help realize the health of crops and emitted heat/ energy.
2. **Crop Health Monitoring and Surveillance**: It is crucial to track the health of the vegetation and spot bacterial/fungal plagues in the early stages. Agriculture drones can see which plants reflect different amounts of green light and Near-infrared spectroscopy (NIRS) light.



This data helps produce multispectral images to track crop health. Quick monitoring and discoveries of any defects can help save crops. In circumstances of crop failure, the farmer can also document the damages for accurate insurance claims.

3. **Crop Damage Assessment**: Agricultural drones fitted along with multispectral sensors and RGB sensors also detect field areas inflicted by weeds, infections, and pests. According to this data, the exact amounts of chemicals needed to fight these infestations are known, and this helps diminish the costs inflicted by the farmer.

4. **Field Soil Analysis**: The drone survey allows farmers to obtain information about their land's soil conditions. Multispectral sensors allow seizing data useful for seed planting patterns, thorough field soil analysis, irrigation, and nitrogen-level management. Precise Photogrammetry/ 3D mapping permits farmers to analyze their soil conditions thoroughly.

5. **Planting**: Drone startups in India have invented drone-planting systems that allow drones to shoot pods, their seeds, and crucial nutrients into the soil. This technology doesn't only reduce costs by almost 85% but also increases consistency and efficiency.

6. **Agricultural spraying**: Through drone crop spraying, human contact with such harmful chemicals is limited. Agri-drones can carry out this task much quicker than vehicles/airplanes. Drones with RGB sensors and multispectral sensors can precisely identify and treat problematic areas. Professionals say that aerial spraying is five times faster with drones when compared to other methods. As per reports a 10 litre capacity kisan drone can spray 20 acres/charging.

7. **Livestock tracking**: The drone survey allows the farmers to monitor the movements of their cattle also. Thermal sensor technology helps find lost animals and detect an injury or sickness.

8. **3D mapping of water bodies**: The drone technology makes mapping of water bodies easy and reachable to the farmers, which in turns helps in watershed development planning.

Benefits of Kisan Drones

As innovators introduce new technologies, their commercial uses increase day by day. In agriculture, they have a plethora of advantages. Some are as follows:

a. Enhanced Production - The farmer can improve production capabilities through comprehensive irrigation planning, adequate monitoring of crop health, increased knowledge about soil health, and adaptation to environmental changes.

b. Effective and Adaptive Techniques - Drone usage results in regular updates to farmers about their crops and helps develop strengthened farming techniques. They can adapt to weather conditions and allocate resources without any wastage.

c. Greater safety of farmers - It is safer and more convenient for farmers to use drones to spray pesticides in terrains challenging to reach, infected areas, taller crops, and power lines. It also helps farmers prevent spraying the crops, which leads to less pollution and chemicals in the soil.

d. 10x faster data for quick decision-making - Drone surveys back farmers with accurate data processing that encourages them to make quick and mindful decisions without second-guessing, allowing farmers to save the time invested in crop scouting. Various sensors of the drone enable capturing and analyzing data from the entire field. The data can focus on problematic areas such as infected crops/unhealthy crops, different colored crops, moisture levels, etc. The drone can be fixed with several sensors for other crops, allowing a more accurate and diverse crop management system.

e. Less wastage of resources & Cost Effective - Agri-drones enables optimum usage of all resources such as fertilizer, water, seeds, and pesticides. As per data collected from different RO's to spray one acre of land manually it takes approximately 4 hours and labour charges @ Rs.600 per person. Traditionally the farmer or another one person has to assist the person who is spraying the pesticides. In the case of drone 1 acre land is covered in 10 to 15 minutes @Rs.600 and saves on the labour charge.

f. 99% Accuracy rate - The drone survey helps farmers calculate the precise land size, segment the various crops, and indulge in soil mapping.

g. Useful for Insurance claims - Farmers use the data captured through drones to claim crop insurance in case of any damages. They even calculate risks/losses associated with the land while being insured.

h. Evidence for insurance companies - Agricultural insurance sectors use Agri-drones for efficient and trustworthy data. They capture the damages that have occurred for the right estimation of monetary payback to the farmers.

- **Combat locust storms**: Most nations battling locust swarms rely significantly on organophosphate chemicals. Drones can diffuse pesticides on approximately 2.5-acres in merely 15 minutes. Using drones to combat the locust swarms is an immediate, secure, and practical approach.

Factors that impact the successful utilization of drones in Agriculture

Sl No	Factors	Remarks
1	Weight Limit	25 Kg drones are ideal for agriculture usage. Note: For lifting a drone weighing 25kg into the air, downward force of 50kg is exerted below
2	Optimal Height	Ensure no damage to standing crops. SOPs have been developed by GOI/States.
3	Maneuvering	Based on Agro-Climatic zone and Terrain.
4	Capacity	10-12 Litre capacity for good efficiency.
5	Multi-Utility Drone	Attachments to use the same device for Seed, Pesticide, insecticide, and survey
6	Ergonomics	Man – Machine interaction. Drones produce sound in the range of 150-180 decibel. Exposure to more than 90 Decibel for a prolonged time will affect the hearing of operator/farmer.
7	Training	License to operate the Drone / Availability of institutes to train.
8	Maintenance	Do regular maintenance and service to prolong the life of drone.
9	Cost of Drone	Affordability for farmer & viability for an entrepreneur

3.0 Support from Government of India

In a major boost to promote precision farming in India, the Union Ministry of Agriculture and Farmers Welfare has issued guidelines to make drone technology affordable to the stakeholders of this sector. The guidelines of "Sub-Mission on Agricultural Mechanization" (SMAM) have been amended which envisages granting up to -

a. 100% of the cost of agriculture drone or Rs.10 lakh, whichever is less, as grant for purchase of drones by the Farm Machinery Training & Testing Institutes, ICAR institutes, Krishi Vigyan Kendras and State Agriculture Universities for taking up large scale demonstrations of this technology on the farmers' fields.

b. 75% of the cost of agriculture drone as grant to Farmers Producers Organizations (FPOs) for its demonstrations on the farmers' fields.

c. 40% of the basic cost of drone and its attachments or Rs.4 lakh, whichever less would be available as financial assistance for drone purchase by existing Custom Hiring Centers which are set up by Cooperative Society of Farmers, FPOs and Rural entrepreneurs.

d. 50% of the basic cost of drone and its attachments or up to Rs.5 lakh in grant support for drone purchases by Agriculture graduates establishing Custom Hiring Centers.

Government of India (GoI) through "Agri Infrastructure Fund" Scheme is establishing decentralized Post Harvest Management infrastructure as well as community farming assets. GoI is providing interest subvention @3% for loans up to Rs.2 crore to the beneficiaries viz. FPOs, CHCs, Cooperative Societies SHGs, JLGs, National and State Level Federation of Co-operatives, FPOs federations, Federations of SHGs, National and State Level Agencies purchasing drones for agriculture purpose and also covering the loans under Credit Guarantee Trust for Micro Small Enterprises (CGTMSE).

7.0 Unit Cost and Model Bankable Scheme of Kisan Drone

In order to arrive at reasonable unit cost, NABARD had several rounds of interactions with the End-to End solution providers in the field of UAS/ UAV Technology from Concept Design to Manufacturing & after-market operational support services. For hybrid model of drones, the drone runs on petrol with back up battery for safe landing in the case of any emergency. While fuel is available locally in all places, back up battery is available at all major cities. The pilot is generally trained to carry out all normal and regular maintenance work and also trouble shooting to some extent. The warranty for the engine is for one year. With extended warranty for 2-3 more years, the engine maintenance can be ensured. Carbon fibre props have to be handled properly. Adequate provision has been made in the model for the annual requirement of spares. The unit cost for model scheme has been worked out at Rs.1030000/- (including one month w/c capitalised) for procurement of kisan drone. The details of unit cost and loan component are given in Appendix I.

The assumptions and technoeconomic parameters for working out the economics of the project are given in Appendix II. The items of income include custom hiring charges received for the services rendered by the service provider, while the items of expenditure include the onetime training cost, salary of pilot and assistant, operating expenses, extended warranty, miscellaneous expenses, replacement of battery/ spares etc. The economics are presented in Appendix III. The cash flow analysis covering the Benefit Cost Ratio (BCR), Net Present Worth (NPW) and Internal Rate of Return has been worked out for the project and presented in Appendix IV. Since the life of the drone is expected to be around 5 years, repayment period has been considered at 5 years (Appendix V). The key financial indicators are as under:

S.No.	Particulars	Details
1	BCR at 15% DF	1.16:1
	NPW	Rs.642404
2	IRR	More than 15%
3	Average DSCR	2.14

With the various income and expenditure parameters assumed in the model, the break-even level of kisan drone would be around coverage of 3300 acres of spraying in a year. Considering an average membership of 500 in an FPO/PACS and assuming at least one acre of land with each of them, this works out to about 5 sprays in a year per farmer which is a very conservative estimate. Banks may ensure that the rural entrepreneurs should have passed class tenth examination or its equivalent from a recognized Board and should have remote pilot license from Institute specified by the Director General of Civil Aviation (DGCA) or from any authorized remote pilot training organization. The investment in kisan drone is financially viable and the amount of surplus available is good enough to attract the FPOs/PACs/CHCs to come forward to take up the project. Regular monitoring by the bank officials is required along with line department of State Government to ensure proper end use and also adequate income generation from hiring of drone.

8.0 Special Refinance Scheme (SRS) for Kisan Drones

It is proposed that NABARD will facilitate Rural/Agri entrepreneurs, startups, PACS / Cooperative Societies and FPOs to acquire UAVs through their CHCs to leverage the support of DA&FW, GoI under AIF and Sub-Mission on Agricultural Mechanization" (SMAM) for Kisan Drones. NABARD through Special Refinance Scheme will promote Kisan Drones in a phased manner spanning three years with an objective of meeting the national goal of doubling of farmers' income.

In order to encourage banks to come forward for extending institutional credit and extend loans at cheaper rate to the eligible beneficiaries for acquiring Kisan Drones, NABARD has prepared Model Bankable Scheme for Kisan Drones. NABARD will extend concessional refinance to all eligible banks / FIs by earmarking an amount of Rs.1000 crore Special Refinance dispensation for the period upto 2025-26.

8.1 Objectives

i. To promote precision farming in India

ii. To give a boost to the agricultural drone technology, equipped with artificial intelligence (AI), machine learning (ML), and remote sensing features in rural sector

iii. To encourage Banks to extend financial support at concessional rate to FPOs / CHCs / PACS for acquiring Kisan Drones.

iv. Credit intensification and enhancing GLC flow in priority sector

v. To encourage Startups to facilitate 'Drone Shakti' and for Drone-As-A-Service (DrAAS)

8.2 Eligible financial institutions

All Rural Financial Institutions Viz. **Commercial Banks, SFBs, RRBs, Cooperative Banks and subsidiaries of NABARD are eligible for concessional refinance under the scheme for loans provided to** FPO's/PACS, Cooperatives, SHGs, JLGs and their federations, Start-ups (Definition of GOI is to be considered for start-ups eligibility) & Agri-Entrepreneurs etc.

8.3 Interest rate on Refinance

The proposal will be placed before ALCO for finalization of interest rate on refinance to all eligible banks and FIs as indicated at . The prevailing interest rate on LT refinance to StCBs, RRBs, Subsidiaries under SRS on AIF is 6% for eligible borrowers. As per recently finalised guidelines on PACS as MSCs StCBs can seek support under PACS as MSC program at 3% for acquiring Kisan Drones and the scheme will continue till 2025-26. Banks financing Kisan Drones will get Interest Subvention at 3% under Agri Infrastructure Fund(AIF) from GoI. However, interest rates are subject to revision by NABARD from time to time. Banks need to pass on the benefit to ultimate beneficiaries.

9.0 Conclusion

As announced in the Union *Budget* 2022-23, keeping up with the changing times, adoption of technology across sectors such as agriculture, education, finance and infrastructure will fast-track India's transition into a digitally-enabled economy. Technology can be a catalyst for both backward and forward linkages and the public/ private sector has a role of play. Special Refinance Scheme for Kisan Drones will promote precision farming at farmers fields and meet the national goal of doubling of farmers' income.

Appendix I

Capital Cost (Sources & Appplication)

S no.	Particular	Amount (In Rs.)
	Application of Fund	
1	Cost of 10 litre Capacity Drone(includes 8 batteries, propellers, 3 sets of additional nozzles, trolley, drone station, Insurance etc)	910000
2	Operating Exps of 1 months (Capitalized)	120000
	Total Capital Expenditure /Unit cost	**1030000**
	Sources of Fund	
4	Margin @ 15%	154500
5	Bank Loan @85%	875500
	Susbsidy @40% of drone cost	364000
	Bank Loan Net of Subsidy (40%)	511500
	Cost of Drone	
	Cost of 10 litre capacity drone	600000
	Cost of 8 Batteries	180000
	Cost of 3 pair propeller	8000
	3 sets of additional nozzles	12000
	Drone station, Trolley, Generator	30000
	Misc items	20000
	Insurance	60000
	Total Cost	**910000**

Appendix II - Project Operation Details

S no.	Techno Economic Parameters	Values
1	No. of days of service in a year	165
2	No. of acres covered per day	20
3	Life of Drone (Years)	5
4	Training Cost	60000
5	Operating Expenses per acre(Rs)	200
6	Duration of salary	12
7	Salary of Pilot and Assistant	25000
8	Cost of battery replacement every 18 months	30000
9	Extended warranty charge for 2nd year onwards	80000
10	Exps on spares per annum	40000
11	Annual Misc. Expenses	10000
12	capacity utilization	
	Year 1	60
	Year 2	70
	Year 3 onwards	80
13	Rate of Interest p.a.	10
14	Custom hiring Charges (Rs. Per acre)	550
15	Depreciation Rate	33%
16	Capitalization cost of 30 days	120000

Appendix III - Income & Expenditure of Project

S.No	Particular	I	II	III	IV	V
A	**Income**					
	Capacity Utilization (%)	70	80	80	80	80
1	Custom hiring charges	1270500	1452000	1452000	1452000	1452000
	Total Income	1270500	1452000	1452000	1452000	1452000
B	**Expenditure**					
1	Training for pilot	60000	0	0	0	0
2	Operational expenses	462000	528000	528000	528000	528000
3	Salary of pilot & assistant	300000	300000	300000	300000	300000
4	Replacement of back up battery	0	30000	0	30000	
5	Spares	40000	40000	40000	40000	40000
6	Extended Annual Warranty	0	80000	80000	80000	80000
7	Annual Miscellaneous expenses	10000	10000	10000	10000	10000
	Total Expenditure	872000	988000	958000	988000	958000
	Gross Surplus	**398500**	**464000**	**494000**	**464000**	**494000**

Appendix IV - Key Financial Indicators of Project

S.no	Items	I Year	II Year	III Year	IV Year	V Year
1	**Capital Cost**	1030000	0	0		
2	Recurring Cost	872000	988000	958000	988000	958000
3	Total Cost	1902000	988000	958000	988000	958000
4	**Benefits**	1270500	1452000	1452000	1452000	1452000
5	Residual Value of Equipment					10000
6	**Total Benefit**	1270500	1452000	1452000	1452000	1462000
7	Net Benefit	-631500	464000	494000	464000	504000
	Discounting Rate	15				
	PCV	1653913	747070	629901	564892	476295
	Aggregate PCV (5 Years)					4072071
	PCB	1104783	1097921	954714	830186	726872
	Aggregate PCB (5 Years)					4714475
	NPW					642404
	BCR					1.16
	IRR					65%

Sensitivity Analysis

	Sensitivity analysis :		1.05				
			0.95				
1	Increase in cost by 5%	1997100	1037400	1005900	1037400	1005900	
2	Decrease in benefit by 5%	1206975	1379400	1379400	1379400	1388900	
3	Net Income	-790125	342000	373500	342000	383000	650375
4	DF at 15 %	0.870	0.756	0.658	0.572	0.500	
5	NPW @ 15% DF	-687065	258601	245582	195540	191500	**204158**
6	PWC	1736608	784424	661395	593137	502950	4278514
7	PWB	1049543	1043025	906978	788676	694450	4482672
8	BCR	**1.05**					
9	IRR	**16.11%**					

Appendix V -

Repayment Schedule & DCSR (With Subsidy)

Year	Bank loan outstanding at the beg. of the year	Bank loan outstanding at the end of the year	Gross Surplus	Payment of Interest	Repayment of Principal	Total Repayment	Net Available	DSCR
1	875500	695500	398500	87550	180000	267550	130950	1.49
2	695500	515500	464000	69550	180000	249550	214450	1.86
3	515500	335500	494000	51550	180000	231550	262450	2.13
4	335500	155500	494000	33550	180000	213550	280450	2.31
5	155500	0	494000	15550	155500	171050	322950	2.89
							Average DSCR	**2.14**
	Total Repayment				**875500**			

National Sectoral Paper

Geo-Informatics

Farm Sector Development Department
National Bank for Agriculture and Rural Development
Mumbai