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Application of Remote Sensing and Drones in Insect Pest Monitoring

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Insect pests pose a severe threat to global food security, with estimated losses of 20-40% of crop yield each year. Day by day traditional monitoring being difficult to monitor insect pest often too late in reacting and cause damage. In the integration of remote sensing and drone-based technologies which helps in the insect pest monitoring by enabling rapid, precise, and large-scale surveillance of agricultural landscapes. Remote sensing, through satellite and multispectral imaging, facilitates early detection of pest induced stress capturing subtle changes in crop reflectance patterns, vegetation indices, and canopy temperature. Remote sensing includes passive sensors, and active sensors. These are divided in many parts such as aerial photography, orthophoto maps, colour infrared, microwave, etc. Drones, equipped with high resolution cameras and analytics, provide flexible, on demand monitoring at field level, allowing for targeted scouting and real time data acquisition. A drone mediated precision application of insecticides could reduce the total number of sprays and contribution in the reduction of pesticide use. It also helps in releasing of natural enemies and also mediated for the sterile insect technique (SIT) and mating disruption. For the drone application some statutory provisions involved as per the Insecticides Rules, 1971 under the Insecticide Act, 1968. Also follow the detailing, precautions and pre-requisites for drone-based pesticide application which ensure the safety, calibration, dose making, pesticides spray safely, and ensure proper operator training and certification. Overall, we conclude the adoption of modern technologies in agriculture, such as the use of drones have great potential to revolutionize the Indian agriculture and ensure country's food security.

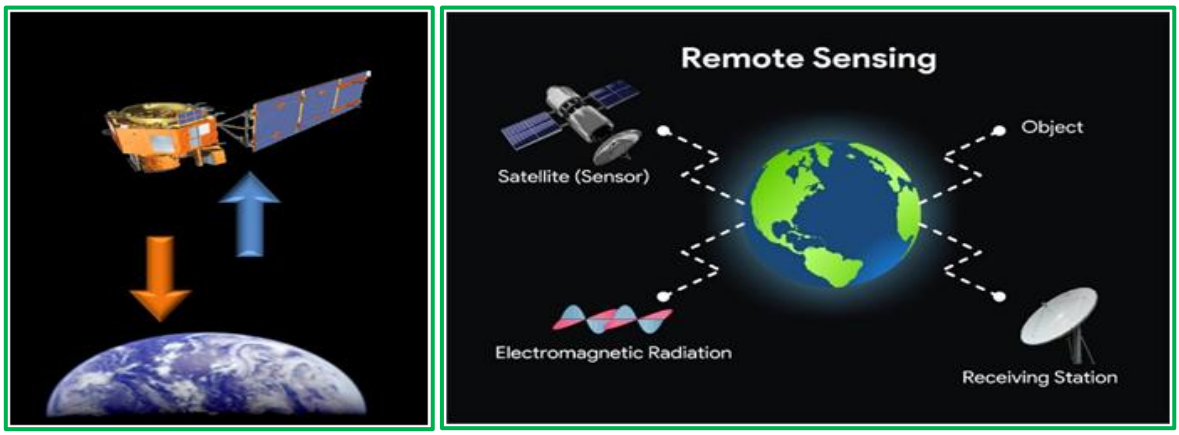
Keywords: Insect pest management, remote sensing, drone, monitoring.

Introduction to Remote Sensing

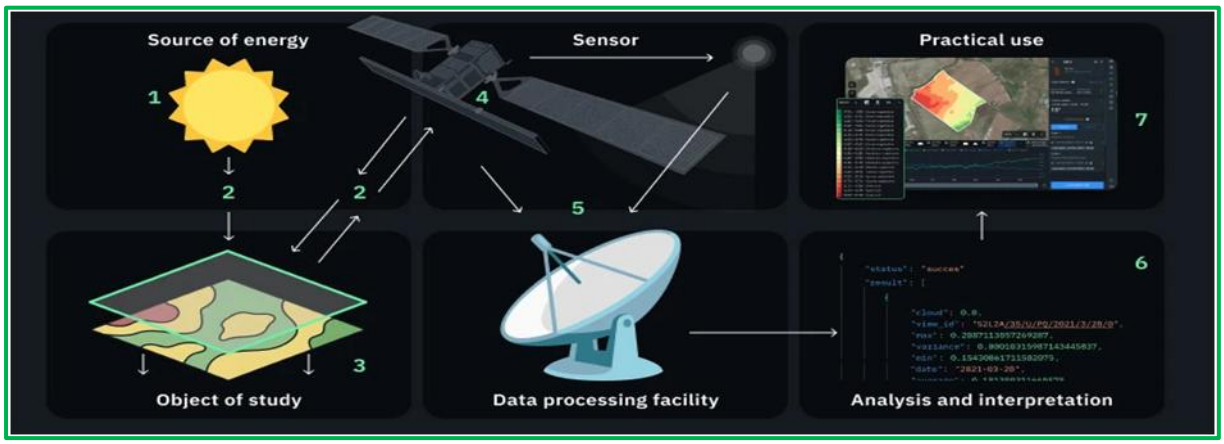
Remote sensing is the science and technology of collecting information about the Earth's surface without direct contact. It uses sensors mounted on satellites, drones, or aircraft to record reflected or emitted energy from objects such as soil, crops, water, and vegetation. These data help in understanding, monitoring, and managing natural resources. In agriculture and environmental studies, remote sensing plays an important role in crop monitoring, soil moisture assessment, land-use mapping, weather analysis, and disaster management. It provides timely, large-area, and cost-effective information, supporting better decision-making for sustainable development.

What is Remote Sensing

Remote sensing is a method of gathering information about an area or object from a distance, typically using sensors on aircraft or satellites. It helps detect crop stress, monitor growth, and manage land efficiently. Example- Google Maps, Sonar



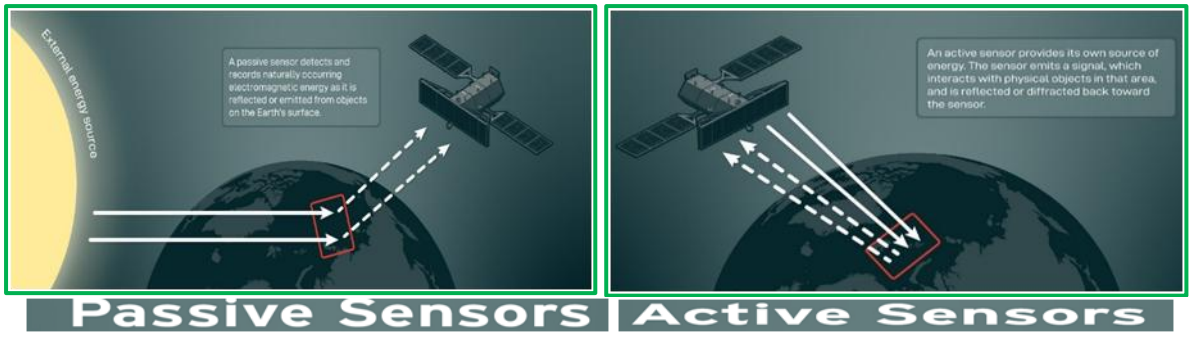
Processes of Remote Sensing



Type of Remote Sensing

Remote sensing is broadly categorized based on the source of energy, platform, and wavelength used. It is mainly of two types;

1. Passive Sensors- Cameras, Infrared sensors, and radiometers.
2. Active Sensors- LiDAR, RADAR, and GPS



Apart from active and passive remote sensing, it is divided into various parts which are as follows;

Aerial Photography

Aerial photography is the technique of taking photographs of the Earth's surface from aircraft or drones. It is used for mapping, land-use studies, agriculture, and environmental monitoring.

Orthophoto Maps

Orthophoto maps are aerial photographs that have been geometrically corrected to remove distortions. They provide accurate, map-like images with true scale and position.

Colour Infrared (CIR)

colour infrared images use infrared, red, and green bands to show vegetation health. Healthy plants appear red, making it easy to identify crop stress and vegetation cover.

Thermal Infrared

Thermal infrared sensing measures heat energy emitted from objects. It is used to study surface temperature, soil moisture, water stress in crops, and heat patterns.

Microwave

Microwave remote sensing uses long-wavelength radiation and can penetrate clouds, rain, and sometimes vegetation. It is useful for soil moisture estimation, rainfall measurement, and surface roughness studies.

Multi-spectral

Multispectral sensing collects data in multiple wavelength bands of the electromagnetic spectrum. It helps in identifying land cover types, crop conditions, and environmental changes.

Drones

A drone is a small flying machine that works without a person sitting inside it. It is controlled by a remote and used for taking photos, spraying crops, and monitoring fields.

Statutory Provisions: - As per the provisions of the Insecticides Rules1971, Under the Insecticides Act, 1968

- Marking of the area shall be the responsibility of the operators;
- The operators shall use only approved insecticides and their formulations at approved concentration and height;
- Animals and persons not connected with the operations shall be prevented from entering such areas for a specific period; and
- The pilots shall undergo specialization training including clinical effects of the insecticides

Registration requirements of pesticides for drone application

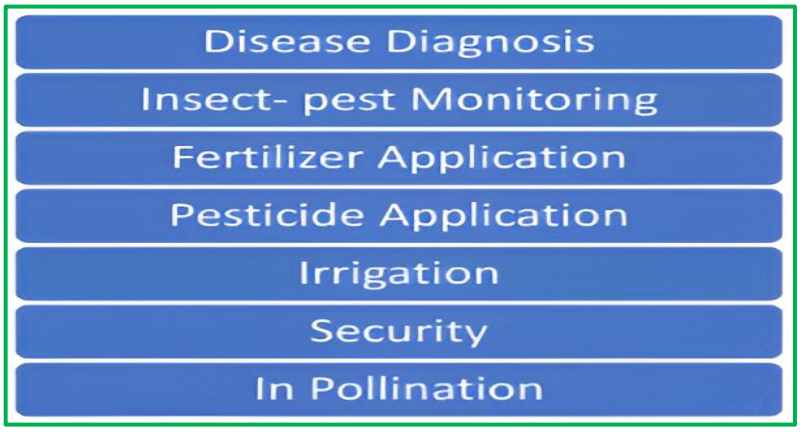
Drone users shall use only (CIB&RC) Central Insecticides Board and Registration Committee approved pesticides. For registration of insecticides/pesticides and for use with drone, the applicant shall apply before Secretariat of CIB&RC, in the manner, as prescribed by CIB& RC under the Insecticides Act, 1968.

Working principle of Sprayer drone

The basic components of any drone are Brushless Direct Current Motors (BLDC), Electronic Speed Control (ESC), flight controller, Camera, Transmitter and Receiver. The main parts of any spraying system are the pump and its controlling system. In GPS are used for controlling the drone.

Role of Drones in Crop Protection

Drones are going to be important for increasing efficiency of application of crop protection chemicals by reducing manpower requirement, reducing time of application, reducing volume of water, quantity of chemicals and saving drift to environment along with reducing exposure to human being to hazardous chemicals.



How are Drones being used in Agriculture

Fertilizer and Pesticide Application: - Drones are used for precise spraying of fertilizers and pesticides. They ensure uniform application, reduce chemical wastage, save labour, and minimize environmental pollution.

Irrigation Management: -Drones equipped with thermal and multispectral sensors help identify water-stressed areas in fields. This supports efficient irrigation planning and optimal use of water.

Farm Security: - Drones are used for field surveillance to protect crops from theft, animal intrusion, and unauthorized activities, especially in large and remote farms.

Pollination: - In areas with declining natural pollinators, drones assist in artificial pollination by spreading pollen over crops, supporting improved fruit set and yield.

Insect-pest Monitoring: - Checking field, landscape, forest, or other site to identify which pests are present, how many there are, or what damage they've caused. Correctly identifying the pest is key to knowing whether a pest is likely to become a problem and determining the best management strategy.

Planting and Seedling: - Planting with drones means very hard to reach areas can be replanted Without

Case Study: 1

This study was conducted in Juksan Township close to the city of Kimje where the most serious outbreak of *Spodoptera exigua* was reported during the 2018 outbreak in South Korea. An initial field visit by the entomologists at the National Institute of Agricultural Sciences of South Korea confirmed that the larvae feeding on soybean foliage were exclusively armyworm, Spodoptera *exigua*.

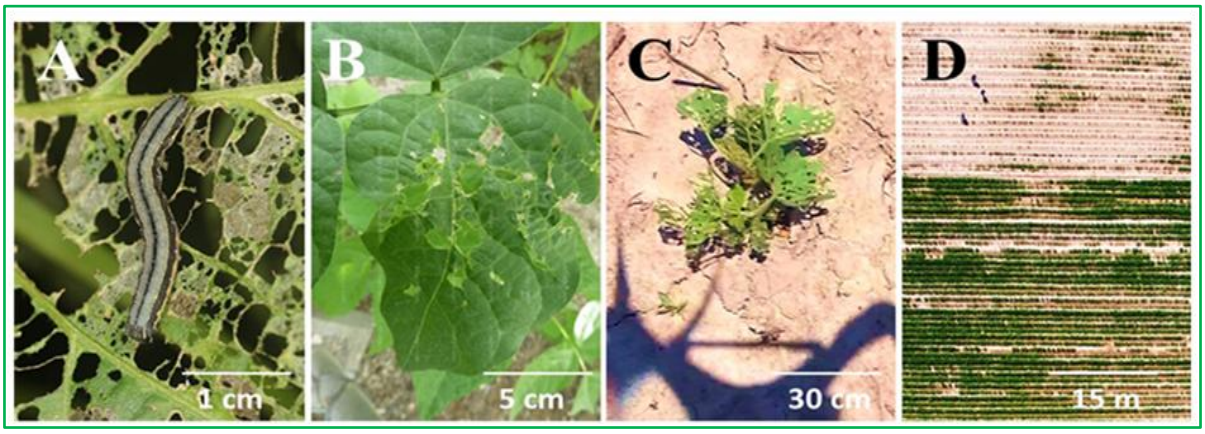


Figure. Damage of soybean caused by *S. exigua* from the ground (A, B) and aerial (C, D) views. (A), a larva feeding on soybean; (B), a typical sign of soybean damage caused by *S. exigua*; (C, D), aerial views of soybean damage at 5 and 15 m above the ground, respectively.

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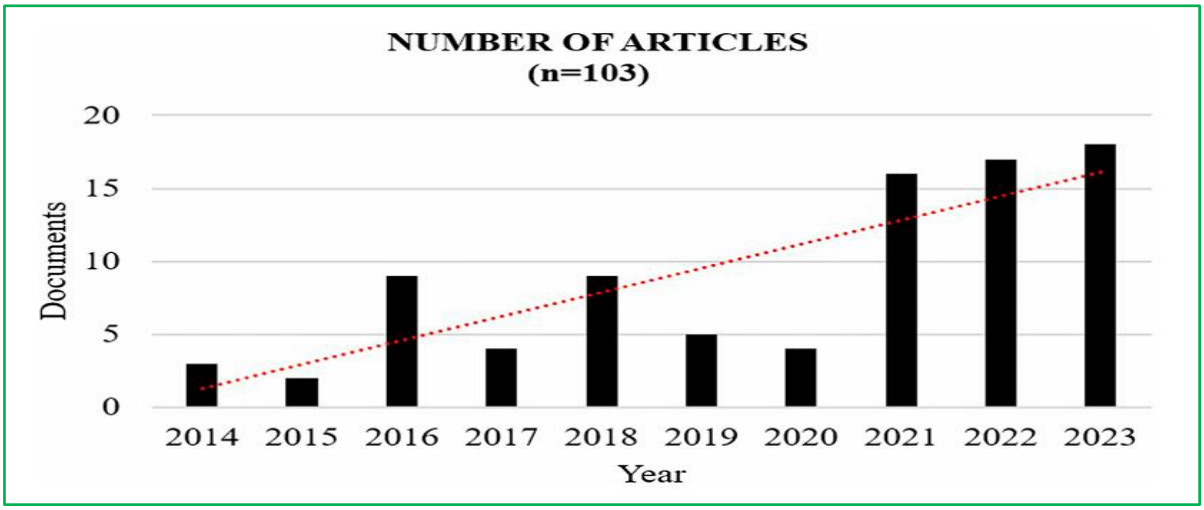
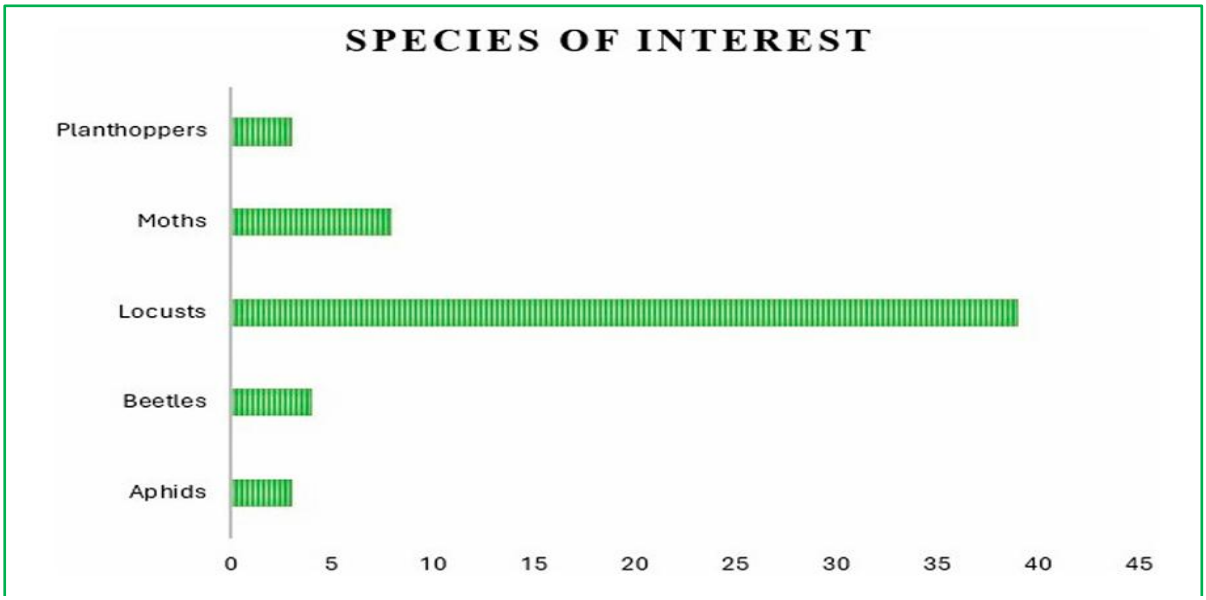
Case Study: 2



Annual scientific production of remote sensing insect monitoring studies (2014-2023)



Total number of species categorized by species of interest

The distribution of application areas in remote sensing and Drons documents

Cost of drone and Government Support

Financial assistance @ 100% of the cost of agriculture drone up to a maximum of Rs. 10 lakhs per drone is provided for purchase of drones by institutes under Indian Council of Agricultural Research, Krishi Vigyan Kendra (KVKs), State Agriculture Universities (SAUs), State and other Central Government Agricultural Institutions/Departments and Public Sector Undertakings (PSUs) of Government of India engaged in agricultural activities. The Farmers Producers Organizations (FPOs) are provided grants up to 75% of the cost of agriculture drone for its demonstrations on the farmers' fields. For individual purchase of drones, the Small and Marginal, Scheduled Caste/Scheduled Tribe, Women and North Eastern State farmers are provided financial assistance @ 50% of the cost up to a maximum of Rs. 5.00 lakhs and other farmers @ 40% up to a maximum of Rs. 4.00 lakhs.

NAMO Drone Didi Scheme: - Offers 80% subsidy on the cost of drones + accessories (up to ₹ 8 lakh) for women Self-Help Groups. Provides training: 5-day pilot training + 10-day agricultural application training. The SHGs can take a loan for the remaining cost via National Agriculture Infrastructure Financing Facility (AIF) at ~3% interest. Outlay: ₹ 1,261 crore for 2024-25 to 2025-26 period. Intended for SHGs to rent out drone services (e.g. spraying) to farmers, generating income.

Kisan Drone Subsidy Scheme: - Subsidies for farmers (individual, SC/ST, FPOs, Cooperatives, Custom Hiring Centers) to buy Agri-drones. Rates differ by category: e.g. individual farmers 50% (up to ₹ 5 lakh), SC/ST or small farmers 60% (up to ₹ 6 lakh), FPOs/cooperatives 75% (up to ₹ 8 lakh), Custom Hiring Centers 40% (up to ₹ 4 lakh). Covers various drone functions: crop imaging, spraying, soil moisture detection, GPS-based surveying.

Advantages of drones in agriculture pest management

High payload capacity, Higher flight time, Higher speed, Strong and durable, Access to remote areas, Less time consuming And Low labor requirement.\

Disadvantages of Agriculture Drones

High costs, requires skilled labors for operation, Complexity in collection of data, its analysis and interpretation, can't be used during adverse climatic conditions, Applicable only for large scale spray and Drone Crashes.

Futures Prospects

Remote sensing and drones have a bright future in insect pest monitoring. With advancements in AI, machine learning, and high-resolution sensors, pest detection will become more accurate and faster. Real-time data collection will help farmers take timely actions. These technologies will lead to sustainable, smart, and eco-friendly pest management in agriculture.

Conclusion

Drones and remote sensing offer quick, precise, and wide-area pest monitoring, assisting farmers in identifying issues early, these technologies improve crop protection decision-making, save time, and reduce labor. Pest forecasting is more accurate with real-time data and high-resolution photos. All things considered, combining drones with remote sensing promotes precision farming and results in crops that are healthier and require less chemicals.

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