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Role of Artificial Intelligence and ICT in Insect Pest Surveillance

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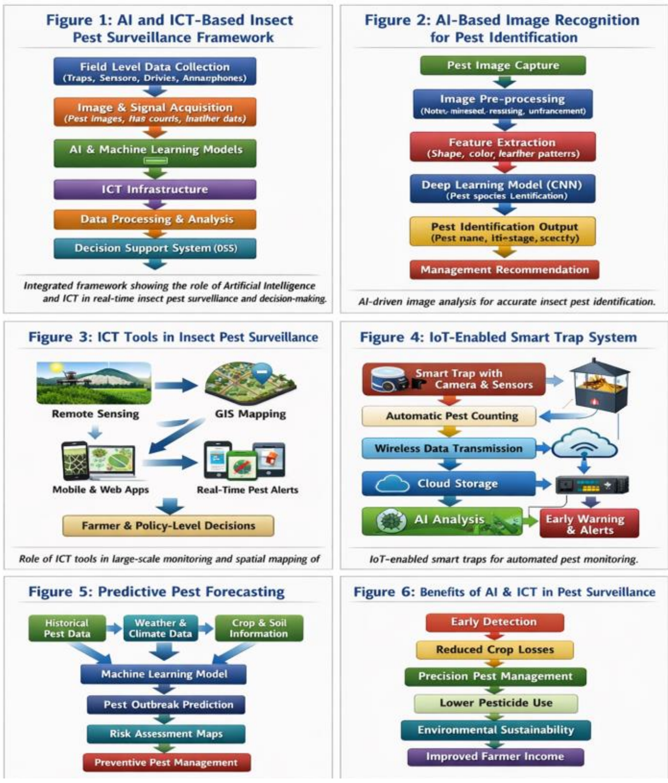
INTRODUCTION

Insect pests cause significant yield losses in field and horticultural crops, often exceeding 20% to 30% annually. Effective pest surveillance is critical for Integrated Pest Management (IPM) because it enables early detection and prompt intervention. Traditional methods, such as field scouting and manual trapping, suffer from human error, slow responses, and inadequate coverage.

The rise of Artificial Intelligence (AI) and ICT-based technologies has shifted pest surveillance from a reactive to a proactive approach. These digital innovations allow for continuous monitoring, accurate pest identification, and predictive analysis, thereby improving the efficiency and reliability of pest management strategies.



2. Artificial Intelligence in Insect Pest Surveillance

Artificial Intelligence refers to computer systems that can perform tasks needing human intelligence, like learning, recognizing patterns, and making decisions.

2.1 Image-Based Pest Identification

AI-powered computer vision systems use deep learning and convolutional neural networks (CNNs) to identify insect pests from images taken with smartphones, drones, or automated cameras. These systems:

- ✓ Accurately classify pest species
- ✓ Differentiate pests from beneficial insects
- ✓ Detect pest life stages (egg, larva, adult)

Examples include AI-based mobile apps and smart traps that can recognize pests automatically.

2.2 Smart Traps and Automated Monitoring

AI-integrated pheromone and light traps come with cameras and sensors that:

- ✓ Count insect populations automatically
- ✓ Transmit real-time data to cloud platforms
- ✓ Reduce manual labor and monitoring costs

These systems provide continuous surveillance over large agricultural areas.

2.3 Predictive Pest Forecasting

Machine learning algorithms analyze historical pest data, weather conditions, cropping patterns, and soil features to:

- ✓ Predict pest outbreaks
- ✓ Identify high-risk areas
- ✓ Support early warning advisories

Predictive models are especially useful for managing migrating pests and insect populations sensitive to climate changes.

3. Role of ICT in Pest Surveillance

Information and Communication Technologies help collect, store, analyze, and share pest-related information.

3.1 Remote Sensing and GIS

Satellite imagery, drones, and Geographic Information Systems (GIS) assist in:

- ✓ Detecting crop stress caused by insect infestation
- ✓ Mapping pest hotspots
- ✓ Monitoring pest spread at regional and national levels

Vegetation indices like NDVI and EVI are often used to spot early crop damage caused by pests.

3.2 Mobile-Based Pest Advisory Systems

ICT-enabled mobile apps offer:

- ✓ Pest identification guides
- ✓ Real-time pest alerts
- ✓ Location-specific management recommendations

These tools give farmers timely and accurate information, helping connect research with practical use in the field.

3.3 Internet of Things (IoT) Integration

IoT devices, such as field sensors and automated traps, gather ongoing data on:

- ✓ Temperature
- ✓ Humidity
- ✓ Pest population dynamics

This information is sent to centralized platforms for real-time analysis and decision support.

4. Decision Support Systems (DSS)

AI and ICT come together in Decision Support Systems, which merge pest surveillance data with agronomic knowledge to:

- ✓ Recommend optimal control measures
- ✓ Suggest need-based pesticide application
- ✓ Reduce chemical use and environmental risks

DSS platforms are increasingly used by extension agencies and policymakers to plan regional pest management.

5. Benefits of AI and ICT-Based Pest Surveillance

- ✓ Early detection and timely intervention
- ✓ Reduced crop losses and input costs
- ✓ Minimized pesticide misuse
- ✓ Improved accuracy in pest identification
- ✓ Support for sustainable and precision agriculture
- ✓ Broader reach of extension services

6. Challenges and Limitations

Despite their potential, several issues limit large-scale adoption:

- ✓ High initial investment costs
- ✓ Limited digital skills among farmers
- ✓ Poor internet connectivity in rural areas
- ✓ Need for localized AI models and validated datasets
- ✓ Data privacy and system maintenance concerns

7. Future Prospects

The future of insect pest surveillance depends on:

- ✓ Integrating AI, IoT, big data, and climate models
- ✓ Creating affordable, farmer-friendly technologies
- ✓ Strengthening public and private partnerships
- ✓ Building capacity and providing digital extension services
- ✓ Supporting policies for digital agriculture initiatives

With ongoing innovation, AI and ICT are expected to significantly impact climate-resilient and sustainable pest management.

CONCLUSION

Artificial Intelligence and ICT have become powerful tools in insect pest surveillance. They allow for real-time monitoring, accurate identification, and predictive forecasting. Their integration strengthens Integrated Pest Management and promotes sustainable agricultural production. To fully benefit from these technologies, strategic investment, farmer training, and institutional support are crucial for the future of agriculture.