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How Climate Change is Altering Insect Pest Behavior in Indian Farms

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Abstract

Climate change is transforming pest dynamics in India. Higher temperatures, altered rainfall, elevated CO_2, and extreme weather are shifting insect physiology, life cycles, ranges, and interactions with crops and natural enemies. These shifts heighten outbreak risks, support invasive pests like fall armyworm, and complicate management for farmers. This article outlines the mechanisms driving these changes, presents India-focused cases (fall armyworm, desert locusts, stem borers, whiteflies), summarizes current and projected impacts on cropping systems, and highlights adaptation options including better surveillance, forecasting, climate-smart IPM, biological control, resilient cultivars, and supportive policies, with key references for further reading.

Introduction

Climate change is emerging as a major challenge for agriculture, especially in India, where most people depend on farming. Farmers are increasingly noticing unusual pest outbreaks, shifted infestation timings, and new invasive species. These changes closely relate to rising temperatures, erratic rainfall, and frequent extreme weather events (Skendžić *et al*., 2021). Insects are cold-blooded, so temperature directly affects their growth and activity. Even slight warming accelerates development (Skendžić *et al*., 2021), increases feeding, and shortens life cycles, causing pests that once appeared once or twice a season to occur more frequently or during vulnerable crop stages. Pests like whiteflies, thrips, stem borers, and armyworms already show such shifts. Rainfall changes also influence pest behaviour. Long dry spells followed by sudden rains favour migratory pests such as desert locusts (Liu *et al*., 2024), while drought-stressed crops become more vulnerable to sap feeders. These disruptions also disturb the balance between pests and their natural enemies, allowing pest populations to rise rapidly. Invasive pests are another concern. Fall armyworm, which entered India in 2018, spread quickly due to favourable climate and host availability (FAO, 2018). With warming temperatures, more invasive insects may survive in previously unsuitable regions. Climate change also complicates pest management. Traditional knowledge about normal pest timings is becoming unreliable, leading to early or prolonged pest activity. This often results in excessive pesticide use, higher production costs, resistance development, and harm to the environment and beneficial insects. Biological control agents such as ladybirds, lacewings, parasitoids, and entomopathogenic fungi are also affected. Their activity may no longer align with pest outbreaks, reducing their natural control and allowing pests to multiply unchecked.

Mechanisms: how climate drivers change pest behaviour

1. Temperature — acceleration of life cycles and range shifts

Insects are ectotherms, so their metabolism and development depend on temperature. Warmer conditions speed development from egg to adult, increasing the number of generations and raising outbreak risks, though extreme heat can reduce survival. Higher minimum temperatures also help pests overwinter in areas that were once too cold, leading to poleward and upward range expansion.

2. Precipitation and soil moisture — creating boom conditions

Changing rainfall patterns, with heavier rains and longer dry spells, alter pest habitats and food sources. Sudden rains that green up vegetation can trigger large outbreaks of migratory pests like desert locusts (Liu *et al*., 2024). In contrast, drought-stressed crops become more vulnerable to certain insects or may favor pests adapted to dry conditions.

3. CO_2 enrichment — subtle effects via crop physiology

Elevated atmospheric CO_2 often increases plant growth but changes tissue quality (e.g., lower nitrogen concentration). Many chewing pests respond by eating more or altering feeding patterns; some phloem feeders (aphids, whiteflies) respond differently because sap composition changes. These indirect effects can alter pest performance and crop damage in non-intuitive ways.

4. Extreme weather events and wind patterns aiding dispersal

Stronger storms and shifts in wind regimes can carry adult insects long distances. Migratory pests such as desert locusts and certain moths can thus invade new areas. Extreme events (storms, unseasonal rains, heatwaves) can also synchronise pest outbreaks across regions, complicating localized control.

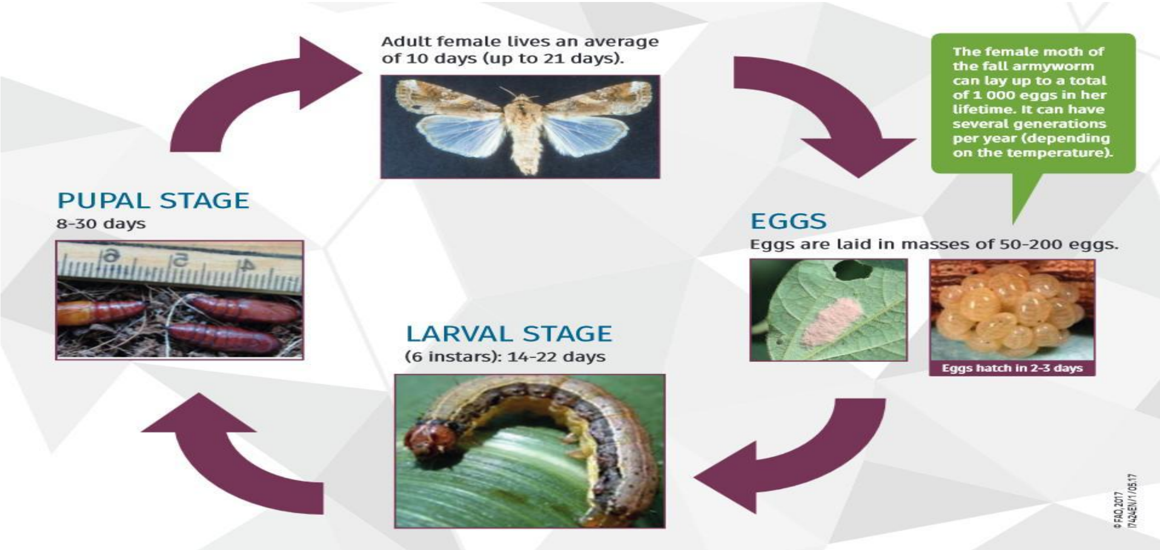

Figure 1: Lifecycle diagram: how temperature shortens development time

Indian case studies — pests to watch

A. Fall armyworm (*Spodoptera frugiperda*): a recent invader with high adaptability

Detected in India in 2018, fall armyworm (FAW) quickly spread through maize regions and later to sorghum, millets, and some vegetables (FAO, 2018). Its high reproduction, broad host range, and strong dispersal make it highly responsive to climate and cropping patterns. Warmer conditions increase its generations and extend its activity, while continuous cropping provides year-round hosts. Management has required integrated measures such as monitoring, pheromone traps, biocontrols like *Trichogramma*, and careful insecticide use.

B. Desert locusts (*Schistocerca gregaria*): extreme outbreaks and climate links

Recent desert locust swarms in South Asia, including India's northwest, illustrate climate-driven migratory pest crises. Research links increasing erratic heavy rains and shifting wind patterns to unusual locust breeding and large swarm movements. Extreme weather and altered winds raise the risk of synchronized, cross-border outbreaks. For India, such swarms can inflict rapid, severe damage on rabi and kharif crops across vast areas.

C. Rice stem borers, sugarcane borers, and stemborers of millets

Stem borers (e.g., *Chilo* spp., *Scirpophaga incertulas*) have temperature-dependent development. Warmer nights and higher mean temperatures can shorten larval periods, leading to more frequent generations and intensified damage in paddy, maize and sorghum. Modelling efforts show potential shifts in outbreak timing and possible range expansions at higher elevations.

How climate change complicates pest management

1. **More uncertainty and sudden outbreaks.** Traditional calendars for scouting and spraying become less reliable as phenology shifts.
2. **Greater reliance on reactive chemical control.** Farmers often respond to sudden infestations with emergency sprays, raising costs and resistance risks.
3. **Biocontrol challenges.** Natural enemies may not track pest phenology, reducing the effectiveness of classical biological control (Skendžić *et al*., 2021).
4. **Invasives become a bigger threat.** Changing climate makes it easier for species from other continents to find suitable niches in India (FAW is an example).

Adaptation strategies — what can be done

1. Strengthen surveillance and early-warning systems

- Expand meteorological-station-linked pest surveillance (automated weather stations + pheromone/ light traps) so risk windows are detected early.
- Use regional forecasting models, combining climate projections with species biology (degree-day models, species distribution models).

2. Climate-smart Integrated Pest Management (IPM)

- Promote cropping practices that reduce pest build-up: crop rotation, intercropping (push–pull), habitat management for natural enemies.
- Emphasize biopesticides and targeted use of selective insecticides only when thresholds are breached.

3. Deploy biological control and habitat management

- Strengthen use of parasitoids and predators (mass-releases, conservation biocontrol).
- Protect refuges for natural enemies and avoid broad-spectrum insecticides.

4. Resistant varieties and agronomic measures

- Breed for pest-resistant and climate-resilient crop varieties (drought-tolerant, heat-tolerant) to reduce vulnerability.
- Adjust planting dates, when possible, to avoid peak pest windows (phenology matching).

5. Policy, insurance and farmer support

- ❖ Invest in public early-warning systems, subsidised advisory services (KVKs, mobile apps), and insurance schemes that account for pest-related crop failures.
- ❖ Promote regional cooperation for migratory pests (locust control requires transboundary coordination).

Conclusion

Climate change is not a distant threat; its fingerprints are already visible on pest behaviour in India. While some outcomes are complex and species-specific, the general trend points to increased unpredictability and higher outbreak risk for many pests. The response must be equally multifaceted: better surveillance and forecasting, stronger IPM and biological-control programs, farmer education, climate-informed breeding, and policy support for rapid, regionally coordinated action. Investing now in climate-smart pest management will pay dividends in saved yield, reduced pesticide dependence, and resilient livelihoods.

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