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Research Paper

Effect of Climate Change on Insect Pollinators: Challenges and Adaptation Strategies

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Abstract*:* Climate change is one of the most crucial environmental, social, and economic issues the world facing today. Changes in land use, pesticide applications, agricultural monocultures and the spread of non-native species and pathogens all threat, which is likely to be exacerbated by climate change. Climate change harm pollinators and their habitats. Pollinator populations are declining worldwide and 85% of flowering plant species and 87 of the leading global crops rely on pollinators for seed production. Key biological events such as insect emergence, their foraging behavior and date of onset of flowering need to occur in synchrony for successful pollination interactions. On a large scale, changes in temperature, disturbances on rainfall pattern and other many environmental changes over the entire season may alter the abundance, diversity and foraging behavior of pollinators. Therefore, climate change may cause very serious impact on insect pollinators and flowering plants and hence it may cause global food insecurity. By implementing adaptive strategies such as habitat conservation, sustainable farming practices, and research initiatives, we can mitigate the impacts and support the resilience of these vital species. Proactive measures are essential to secure their role in maintaining global biodiversity and food security.

Keywords: Climate change, Insect pollinators, Extreme Weather events, Pollinator decline, Foraging behavior, Adaptation and resilience.

Introduction:

Climate change refers to long-term alterations in temperature, precipitation patterns, wind patterns, and other elements of the Earth's climate system. These changes may be driven by both natural factors and human activities such as the burning of fossil fuels, deforestation, and industrial processes, which increase the concentration of greenhouse gases like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) in the atmosphere. Climate Change has been happening since the Earth was formed but the main issue is

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that it happen much more quickly than in the past. Climate change is impacting both natural and human-managed systems around the world. As a result, many species on Earth are unable to adapt quickly enough to these rapid changes. The observed and anticipated effects of climate change on ecosystems are expected to intensify, which will have significant consequences for global biodiversity and the essential ecosystem services that support human well-being (Intergovernmental Panel on Climate Change, IPCC 2022). Researchers have identified that climate change as the most pressing threat to pollinators worldwide, overshadowing other human-induced factors such as habitat loss, pesticide use, pollution, and non-native species (Figure 1).

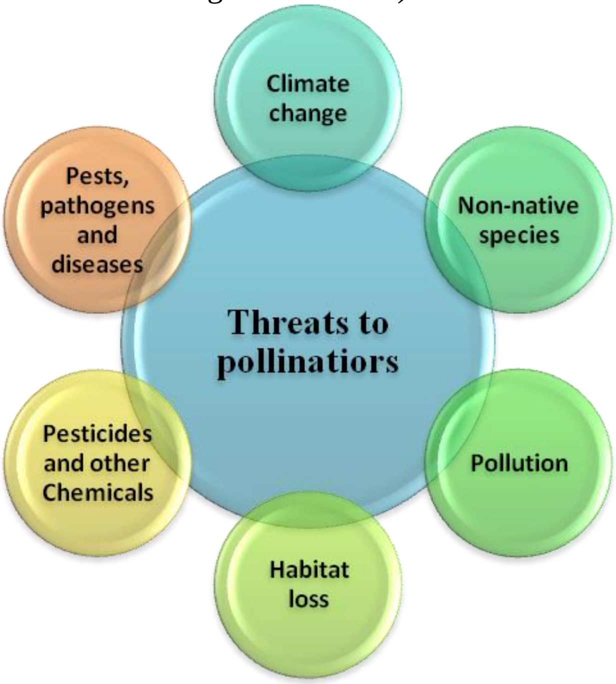

Figure 1. Main threats to pollinators

Pollination is the process by which pollen grains are transferred from the anther of a flower to the stigma of either the same flower, another flower on the same plant, or a flower on a different plant of the same species and insect pollinators play crucial role in this process (Dhakal, 2003). Losey and Vaughan (2006) highlighted the crucial role insect pollinator's play in supporting global crop production through their pollination services. Despite their significance, various factors negatively affect these essential pollinators. Climate change significantly affects pollinators by altering their habitats, behaviors, and interactions with plants, posing risks to their survival and the ecosystems they support. Hence regarding such context this paper reviews about the impact of climate change on insect pollinators.

Climate change and insect pollinators

Direct effects of climate change on pollinators

Climate change has a significant impact on insect pollinators, affecting their populations, behavior, distribution, and interactions with plants. Climatic factors directly influence the physiology, morphology, reproduction, development, survival, and movement of insect pollinators. For instance, temperature can impact their physiology, foraging behavior, body size, and lifespan,

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potentially changing their ability to transfer pollen and reducing the effectiveness of pollination in plants (Scaven and Rafferty, 2013). Solitary species (e.g., sweat bees) and cavity-nesting species (e.g., bumble bees) are more vulnerable to climate change than other taxa, due to their relatively low critical thermal maxima (Hamblin *et al*., 2017). Experimental studies have revealed harmful effects of warming on the body mass, fat content, emergence, and survival of wild bees, such as *Osmia* spp. (Hymenoptera: Megachilidae) (Caradonna *et al*., 2018; McCabe *et al*., 2022). Extreme climatic events can also affect pollinators. For example, heat waves reduce male fertility and attractiveness to females in bumble bees (Martinet *et al*., 2021).

Indirect effects of climate change on pollinators

The indirect effects of climate change on pollinators are potentially as significant as the direct biological impacts (Gilman *et al*., 2010; Ockendon *et al*., 2014). Climate change predictions and models indicate that suitable habitats will decrease for many pollinators, such as bees in South America, while as bees and flies in Europe, may experience less impact (Dormann *et. al*., 2008; Giannini *et. al*., 2020; Gonzalez *et al*., 2021). Warming has led to shifts in the range of some pollinators, moving them poleward or to higher altitudes (Hickling *et al*., 2006; Inouye, 2020). Changes in the timing of floral and pollinator activity can create mismatches (Gerard *et al*., 2020; Ogilvie *et al*., 2017), while alterations in plant chemistry can impact floral rewards and attractiveness for pollinators (Hoover *et al*., 2012; Tylianakis *et al*., 2008), potentially affecting populations (Iler *et al*., 2021). Extreme weather events can also harm floral resources (Hoye *et al*., 2013), negatively influencing honey bee colony development (Flores *et al*., 2019). Honey bee declines worldwide are linked to multiple factors, including *Varroa* mites (*Varroa destructor*) (Acari: Mesostigmata), *Nosema* spp. (Microsporidia: Nosematidae), and viruses. Climate change may intensify the risks posed by these factors. For instance, warmer autumns and winters enable honey bees to make more late-season flights, which leads to an older age composition in overwintering hive populations. These older bees are more susceptible to threats, and the extended activity increases the chances of hives acquiring pathogens and parasites (Rajagopalan *et al*., 2022). Pollinators, such as honey bees, are impacted by both lethal and sublethal effects of pesticides (Tosi *et al*., 2022). The pollination of native bees relies not only on their abundance but also on pollinator diversity (Vasiliev and Greenwood, 2020). Warming can decrease both inter- and intra-species diversity, weakening their ability to cope with disturbances (Vasiliev and Greenwood, 2021).

So, climate change, along with other human-driven factors, is impacting the biology, abundance, and diversity of insect pollinators essential for agriculture, while also influencing pests and their natural predators. The added stress of climate change can worsen the effects of other factors on honey bees, managed bees, and native bees. Effective pollinator management in agriculture needs to address and mitigate these factors as part of a comprehensive strategy that also includes managing pests and beneficial insects.

Adaptation strategies to address the influence of climate change on insect pollinators include:

1. Habitat Protection and Restoration: Preserving and restoring natural habitats,

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such as wildflower meadows and forests, can provide pollinators with stable environments and food sources, helping them adapt to changing conditions.

2. Creating Pollinator-Friendly Environments: Agricultural practices can be adjusted to include pollinator-friendly landscapes, such as planting diverse flowering crops or creating hedgerows that offer shelter and resources for pollinators.

3. Improving Crop Diversity: By planting a variety of crops that bloom at different times, farmers can provide a continuous food supply for pollinators, helping them adapt to changing seasonal patterns.

4. Climate-Smart Agricultural Practices: Integrating climate-resilient farming techniques, such as adjusting planting times or using drought-resistant crop varieties, can help mitigate the impacts of climate change on pollinator-dependent crops.

5. Monitoring and Research: Ongoing research into the behavior and population dynamics of pollinators can help better understand how they are responding to climate change, allowing for more targeted conservation and adaptation strategies.

6. Pollinator Conservation Programs: Implementing conservation programs that focus on protecting specific pollinator species or populations can help maintain healthy insect communities, reducing the risk of pollinator decline due to climate impacts.

7. Mitigating Climate Change: Taking steps to reduce greenhouse gas emissions and slow climate change is essential for long-term protection of pollinators, as it directly influences the environmental factors they depend on.

These strategies collectively aim to support insect pollinators, enhancing their resilience to climate change while safeguarding ecosystems and agricultural systems.

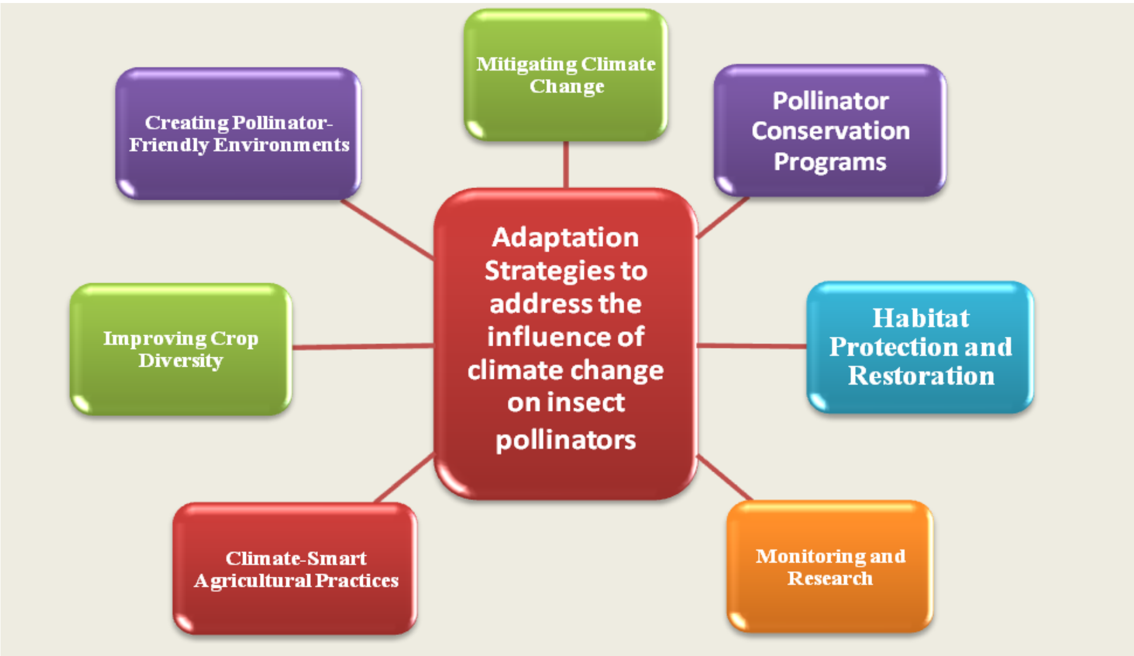

Figure 2. Adaptation Strategies to address the influence of climate change on insect pollinators

Conclusion:

It is concluded that climate change significantly affects insect pollinators by altering their habitats, behavior, and interactions with plants. Rising temperatures, changes in precipitation patterns, and other environmental shifts disrupt the timing and efficiency of pollination. These changes threaten biodiversity, weaken trophic relationships, and ultimately reduce crop yields, contributing to food insecurity. Addressing these impacts requires urgent action to mitigate climate change and protect pollinator populations.

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