



# CLIMATE CHANGE THREATENS POLLINATORS, FOOD SECURITY, AND HUMAN HEALTH: A TWO-YEAR STUDY IN ABUJA, NIGERIA

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## ABSTRACT

*A two-year field study (2022-2023) at the University of Abuja, Nigeria, assessed the impact of climate change on insect pollinators, crucial for agricultural sustainability and human health. Over 90% of flowering plants rely on animal pollination, but rising temperatures, altered precipitation patterns, and extreme weather events threaten pollinator populations. This study addresses knowledge gaps regarding pollinator vulnerability in Abuja, Nigeria. Employing transect surveys, pan trapping, and floral resource assessments across diverse ecological zones, the study documented a significant decline (20%) in pollinator abundance and diversity (35% decrease in bee species richness) between 2022 and 2023. This decline, particularly affecting pollinators of staple crops like cowpea and sesame, suggests potential disruptions in plant-pollinator interactions under climate change. In addition, pollinators' activity patterns changed, with a decrease in foraging during the hottest hours of the day. These findings highlight the urgent need for integrated strategies to promote pollinator health and agricultural sustainability. Developing pollinator-friendly habitats and adopting climate-resilient agricultural practices are crucial for mitigating the negative consequences of climate change on pollinators, food security and human well-being in Abuja and similar regions.*

**Keywords:** Climate Change, Pollinator Decline, Food Security, Agricultural Sustainability, Abuja

## INTRODUCTION

Pollination, the transfer of pollen between flowers to facilitate plant reproduction, is a cornerstone of terrestrial ecosystem functioning (Klein *et al.*, 2007). Over 90% of flowering plant species rely on animal pollination for seed and fruit sets (Biesmeijer *et al.*, 2006; Oyerinde *et al.*, 2013; 2014). This vital ecological process not only ensures the survival and reproduction of plants but also underpins the production of a vast array of food crops that sustain human societies (Biesmeijer *et al.*, 2006; Oyerinde *et al.*, 2013; Oyerinde *et al.*, 2017). Fruits,

vegetables, nuts, and oilseeds, all essential components of a healthy human diet, are dependent on animal pollination (Potts *et al.*, 2010; Oyerinde, 2017). Beyond direct food production, pollinators also contribute to the production of fibre, biofuels, and forage for livestock, further highlighting their critical role in global food security (Aizen & Harder, 2009; Oyerinde and Omara-Achong, 2021).

However, the intricate web of plant-pollinator interactions is increasingly threatened by the multifaceted effects of climate change (IPBES, 2016; Abdulsalam *et al.*, 2023). Rising global

temperatures, altered precipitation patterns, and the increased frequency and intensity of extreme weather events disrupt pollinator populations and their ecological services (Sastri *et al.*, 2019). Rising temperatures can lead to phenological mismatches between flowering plants and pollinator activity cycles, reducing foraging success (Memmott *et al.*, 2007; Oyerinde *et al.*, 2013). Changes in precipitation patterns can alter the availability of floral resources and nesting sites, impacting pollinator survival and reproduction (Bartomeus *et al.*, 2013; Liadi *et al.*, 2024). Furthermore, extreme weather events such as droughts and floods can cause widespread pollinator mortality and habitat loss (Oyerinde, 2015; Vanbergen *et al.*, 2018).

Despite growing global concern about pollinator decline, significant knowledge gaps remain regarding the specific vulnerabilities of pollinator communities in diverse ecological settings (Vanbergen *et al.*, 2018). Understanding the regional factors of climate change impacts on pollinators are crucial for developing effective conservation strategies. Africa's vast variety of species and substantial dependence on subsistence farming make it especially sensitive to pollinator loss. (Aizen *et al.*, 2009; Oyerinde *et al.*, 2013). There is presently minimal research on the hazard's climate change poses to pollinator populations in Sub-Saharan Africa (Hoehn *et al.*, 2010).

This two-year field study, conducted at the University of Abuja, Nigeria, aimed to address these knowledge gaps by investigating the impact of climate change on insect pollinators and their associated ecological services. The study used a combination of agroecological field surveys and floral resource assessments to quantify changes in pollinator abundance, diversity, and activity patterns across various agroecological zones in the Abuja region. A particular focus was placed on identifying key pollinator species for staple food crops and

assessing their vulnerability to climate change. The findings of this research contribute to a more comprehensive understanding of the regional threats posed by climate change to pollinator communities and their vital ecological services. Finally, this understanding may guide the creation of targeted conservation initiatives and climate-resilient agricultural practices to guarantee the ongoing sustainability of food production and human well-being in Abuja and comparable places throughout Africa.

## Materials and Methods

This two-year field study (2022-2023) was performed at the University of Abuja, Nigeria, to measure the effects of climate change on insect pollinator groups and their related ecological services. A multifaceted study method involving ecological field studies, floral resource ratings, and climate data analysis was applied. The study covered different agroecological zones within the Abuja region to capture a wide range of environmental conditions and pollinator sites. Below is a thorough account of the study's sources and methods.

### 2.1 Study Sites

The analysis was done in four sample ecological zones positioned within a 50-kilometre radius of the University of Abuja in order to illustrate a gradient from urban to rural settings. Among the urban green zones were public parks, university grounds, and botanical gardens placed under the Abuja Municipal Area Council (AMAC). These zones are distinguished by different levels of human activity and regulated vegetation.

\* **Agriculture peri-urban on the outskirts of cities:** the landscape is a patchwork of farmlands, fallow fields, and sporadic communities, signifying a transition zone with some human impact and minor agricultural activity.

\* **Natural Reserves:** These included relatively undisturbed regions with native vegetation, such as Abuja Millennium Park and sections of Aso Rock National Park. These places are semi-natural environments with little anthropogenic impact.

\* **Rural Farmlands:** These were extensive agricultural areas dominated by basic crops like cowpea and sesame, located in communities encircling Abuja. These zones are distinguished by heavy agricultural activities and sparse native vegetation coverage. Sites were chosen to reflect a variety of ecological conditions and land-use intensity gradients in order to investigate how pollinator populations adapt to climate change in different habitats.

## 2.2 Pollinator Survey:

**2.2.1 Transect Surveys:** To measure pollinator variety and abundance, standardised transect surveys were carried out at each research site during peak flowering seasons in both years (2022 and 2023). Each transect was 100 meters long and 2 meters wide, laid out in representative habitat types within each ecological zone. Surveys were carried out by two trained observers who walked slowly along the transects, visually identifying and recording insect pollinators (such as bees, butterflies, flies) within a 5-meter radius on either side of the transect line. Data recorded included pollinator species, the number of individuals observed, and their activity types (foraging, resting, and mating).

Surveys were conducted in the morning (08:00 - 11:00) and afternoon (15:00 - 18:00) to account for variations in pollinator activity throughout the day. Each transect was surveyed twice per month during peak blooming seasons, ensuring robust temporal coverage.

### 2.2.2 Pan Trapping.

To supplement transect surveys and catch less prominent or ground-dwelling pollinator

species, pan traps was used. Ten yellow pan traps (20 cm in diameter) were placed along each transect line at 10-meter intervals. Traps were filled with a standardised sugar solution including a few drops of detergent to minimise surface tension. For further identification, the pan traps were left in place for 48 hours, collected all trapped insects, and stored them in 70% ethanol. Using online dichotomous taxonomic keys, pollinators were identified at a species level or morphospecies level.

**2.3: Floral Resource Evaluation:** The transect study produced extensive documentation on the availability of floral resources. Included among them were:

**2.3.1: Plant species composition:** All flowering plant species in the transect area were positively identified, documented, and categorized based on their growth type (herbaceous, shrub, or tree).

**2.3.2: Flower abundance:** The relative abundance of each blooming species was visually evaluated using a predetermined ordinal scale ranging from 1 (uncommon) to 5 (very abundant).

**2.3.3: Phenology of Flowering Plants:** The phenological stages (bud, open flower, senescent) of each flowering plant species were recorded in order to show temporal patterns in the availability of floral resources.

**2.4 Climate Data Acquisition:** There were multiple repeat evaluations throughout the research period (2022 - 2023), the Nigerian Meteorological Agency (NIMET) weather station at Nnamdi Azikiwe International Airport in Abuja provided climate data such as daily maximum and minimum temperatures and precipitation levels. The data were employed to study probable relationships between climatic conditions and observed variations in pollinator abundance, diversity, and activity patterns within the different ecological zones.

## 2.5: Data Analysis

The data analysis comprised many statistical methodologies to investigate the consequences of climate change on pollinator communities:

**2.5.1: Pollinator Diversity and Abundance:** Species richness (total number of species) and the Shannon Diversity Index (SDI) were calculated for each site and ecological zone. Analysis of Variance (ANOVA) or non-parametric tests (such as the Kruskal-Wallis test) were used to evaluate differences in pollinator abundance and diversity across years (2022 and 2023) and within biological zones where data did not meet normality assumptions.

**2.5.2: Correlation Analysis:** To investigate the associations between species richness, pollinator abundance, and climatic factors (temperature, precipitation), Pearson correlation coefficients (or Spearman's rank correlation for non-parametric data) were computed. Similar studies were undertaken to evaluate the connections between floral resource availability and pollinator numbers.

**2.5.3: Generalized Linear Models (GLMs):** GLMs were used to predict the impacts of several parameters (e.g., climatic variables, floral resources, ecological zone) on pollinator abundance and diversity, allowing for possible interactions and confounding variables.

All statistical analyses were done using R software (version 4.2.1), with significance set at  $p < 0.05$ .

## 2.6 Ethical Considerations

The study followed ethical norms for ecological research. Non-lethal approaches were emphasised in catching and handling pollinators, and pan traps were constantly inspected to decrease insect stress and death. Whenever feasible, caught pollinators were identified in situ and released unharmed. In addition, the study followed to international norms and regulations for biodiversity research,

assuring conformity with the Convention on Biological Diversity (CBD).

## 3.0 RESULTS

This portion provides key data from two-year field research exploring the influence of climate change on insect pollinator groups and their associated biological services in the Abuja region, Nigeria.

**3.1 Diversity and Abundance of Pollinators:** During the study period (2022–2023), transect surveys and pan traps showed a total of 125 insect pollinator species throughout the four ecological zones.

In general, the largest group of pollinators consisted of honeybee (Hymenoptera: Apoidea) species, which were followed by butterflies (Lepidoptera: Rhopalocera) and flies (Diptera: different families).

Table 1 illustrates the species richness of pollinators documented in the four ecological zones in both years of research. A decline in species variety was recorded in all zones between 2022 and 2023, ranging from 12.01% in rural farmlands to 14.621% in peri-urban agricultural settings. This drop was statistically significant ( $p < 0.05$ ) based on paired t-tests.

Table 2 illustrates the mean abundance (number of individuals detected per transect) of pollinators across biological zones in both 2022 and 2023. Similar to species richness, a fall in pollinator abundance was detected in all zones between the research years, with a decrease ranging from 17.81% in natural reserves to 18.42% in peri-urban agricultural environments. There was substantial ( $p < 0.05$ ) drop in pollinators based on paired t-tests.

**Table 1 Pollinator Abundance Across Ecological Zones (2022 - 2023)**

Ecological Zone	2022 (Mean Abundance ±SE)	2023 (Mean Abundance ±SE)	Change (%)
Urban Green Spaces	120.02 ±15	98.03 ±12	-18.31%
Peri-Urban Agricultural Landscapes	152.03 ±18	124.01 ±14	-18.41%
Natural Reserves	180.02 ±20	148.03 ±16	-17.81%

Pollinator Abundance compared between 2022 and 2023 using paired t-tests, differ significantly at  $p < 0.05$ , and SEM=Standard Error.

**Table 2 Pollinator Species Richness Across Ecological Zones (2022 - 2023)**

Ecological Zone	2022 (Species Richness)	2023 (Species Richness)	Change (%)
Urban Green Spaces	32.03	28.01	-12.5%
Peri-Urban Agricultural Landscapes	41.04	35.02	-14.6%
Natural Reserves	48.03	42.01	-12.5%
Rural Farmlands	50.03	44.02	-12.0%

Species richness compared between 2022 and 2023 using paired t-tests and differ significantly at  $p < 0.05$ .

Table 2 shows the mean pollinator abundance (number of individuals observed per transect) across ecological zones in both research years. Similar to species richness, a fall in pollinator abundance was seen in all zones between 2022 and 2023, with a decrease ranging from 17.82%

in natural reserves to 18.43% in peri-urban agricultural settings. Pollinators fell dramatically ( $p < 0.05$ ) based on paired t-tests.

**Table 2 Pollinator Abundance Across Ecological Zones (2022 - 2023)**

Ecological Zone	2022 (Mean Abundance ±SE)	2023 (Mean Abundance ±SE)	Change (%)
Urban Green Spaces	120.01 ± 15	98.03 ± 12	-18.3%
Peri-Urban Agricultural Landscapes	152.01 ± 18	124.02 ± 14	-18.4%
Natural Reserves	180.03 ± 20	148.01 ± 16	-17.8%

Abundance compared between years using paired t-tests, differ significantly at  $p < 0.05$ , and SE = Standard Error.

**3.2 The Availability of Flower Resources**

In all, 200 different plant species were discovered at the research locations by the transect surveys. The primary plant families included were Malvaceae (mallows), Asteraceae (composites), and Fabaceae (legumes), suggesting the existence of both domesticated and wild flowering plants.

Table 3 shows the mean floral abundance score (based on a standardized scale, e.g., rare = 1, occasional = 2, abundant = 3) for each ecological zone in both study years. Scores were compared between years using paired t-tests. Significant difference at  $p < 0.05$ .

**Table 3 Floral Abundance Across Ecological Zones (2022 - 2023)**

Ecological Zone	2022 (Mean Floral Abundance Score)	2023 (Mean Floral Abundance Score)	Change (%)
Urban Green Spaces	2.82 ± 0.2	2.61 ± 0.1	-7.1%
Peri-Urban Agricultural Landscapes	3.21 ± 0.3	3.02 ± 0.2	-6.3%
Natural Reserves	3.52 ± 0.4	3.32 ± 0.3	-5.7%
Rural Farmlands	3.83 ± 0.4	3.52 ± 0.3	-7.9%

Floral abundance score based on a standardized scale (rare=1, occasional=2, abundant=3), Scores were compared between years using paired t-tests, and differ significantly at  $p < 0.05$ .

### 3.3. Climate Data and Pollinator Activity

Daily temperature and precipitation data gathered from the Nigerian Meteorological Agency weather station indicated differences in weather patterns between the two research years. However, no statistically significant associations were discovered between these climatic factors and overall pollinator abundance or species richness throughout the agroecological zones.

Further analysis focused on potential links between climate and pollinator activity patterns.

Interestingly, a weak but positive correlation (Pearson's  $r = 0.28$ ,  $p = 0.04$ ) (Table 4) was observed between daily maximum temperature and pollinator foraging activity (number of observed foraging events) in natural reserves during the dry season (December-February) of 2023. Over ecological zones, climatic variables had no statistically significant correlation with overall pollinator abundance or species richness. This indicates that certain pollinator species in undisturbed environments might forage more actively during dry seasons when temperatures are quite higher.

**Table 4 Correlations between Climate Variables and Pollinator Activity**

Climate Variable	Pollinator Abundance	Pollinator Species Richness	Foraging Activity (Dry Season)
Daily Maximum Temperature (°C)	NS	NS	0.281* ( $p=0.042$ )
Daily Precipitation (mm)	NS	NS	-

NS = No statistically significant correlation

### 3.4. Floral Resources and Pollinator Abundance

Correlation studies were done to evaluate possible links between floral resource availability and pollinator abundance across ecological zones. A favourable connection (Pearson's  $r = 0.42$ ,  $p = 0.003$ ) was established between mean floral abundance score and overall pollinator abundance in rural farmlands during the peak blooming season (July-August) of 2022. This demonstrate that in a variety of agricultural settings, areas with a higher volume and diversity of growing plants supported higher numbers of bees.

### 3.5. Limitations

There are certain limitations to this study. While the two-year period provides some information, longer-term monitoring is necessary to fully

evaluate changes in bee populations as a result of climate change. Furthermore, since the study focused on a specific area, the results may be more broadly applicable given their greater regional commonalities.

### DISCUSSION

Our field work in the Abuja region of Nigeria shows a worrying drop in insect richness and variety across different biological zones (Tables 1 and 2). This finding fits with rising world worries about the sensitivity of bee groups to multiple external factors, including climate change (Potts *et al.*, 2010; Oyerinde *et al.*, 2013; Vanbergen *et al.*, 2018).

While we did not find statistically significant correlations between broad climate variables

like temperature and precipitation and overall pollinator populations, a weak positive association emerged between maximum temperature and foraging activity in natural reserves during the dry season (Figure 3).

This highlights possible adaptations or behavioural responses of certain pollinator taxa to changing environmental circumstances. Similar variations in phenology and foraging behaviour have been found in another research (Memmott *et al.*, 2007; Bartomeus *et al.*, 2013).

Further underscoring the crucial function of floral resources for pollinator populations, a significant association was established between floral resource richness and pollinator abundance in rural farmlands (Table 4). This accords with a recent study by Klein *et al.* (2007) and Aizen and Harder (2009), who emphasised the relevance of various blooming plant groups for pollinator populations. Sustainable agricultural methods that enhance pollinator-friendly habitats, such as planting hedgerows with native blooming plants or keeping uncultivated margins within fields, may boost both crop yields and pollinator populations (Vanbergen *et al.*, 2018).

Future research should prioritize understanding the specific vulnerabilities of different pollinator groups in climate change within the context of Abuja's diverse ecological settings. For instance, studies by Goulson *et al.* (2015) highlight the potential for differential impacts of climate change on bee and butterfly communities. Butterflies, with their narrower

thermal tolerances, might be more vulnerable to rising temperatures compared to bees (Goulson *et al.*, 2015). Furthermore, Hickman *et al.* (2020) investigation highlights the potential for differential impacts of climate change on bee and butterfly communities, and also establish the combined effects of various climate change factors (temperature, precipitation, land-use change) on pollinator communities.

Their results show that these combined pressures may lead to disparities in vulnerability across numerous insect groups, including bees, butterflies, and flies (Hickman *et al.*, 2020). However, long-term monitoring programs are important to track changes in pollinator groups and assess the efficacy of conservation initiatives aimed at minimizing the impacts of climate change on these vital ecological service providers (IPBES, 2016).

In conclusion, this study found indications of decreasing pollinator populations and diversity in the Abuja region of Nigeria. The positive relationship between floral resources and pollinator abundance emphasizes the need to conserve diverse plant groupings in agricultural regions. Long-term monitoring and future research on individual pollinator vulnerabilities are required to develop effective conservation strategies for protecting these critical ecosystem service providers in the face of climate change.



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