



## Original Research Paper

# Agricultural Expansion and Human Encroachment Shaping Bat Roosting Behaviour Activity Patterns and Population Connectivity

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### Key Words    Abstract

Bat roosting behaviour, Agricultural expansion, Human encroachment, Acoustic monitoring, Population connectivity, Habitat fragmentation, Conservation ecology.

The role of bats in maintaining balance in insects, as well as other activities like pollination and seed dissemination, is vital. However, the roosting and foraging behavior of bats has been increasingly influenced by agricultural intensification and land development by humans. The current study explores the impact of modifications in habitats on roosting behavior, feeding behavior, and emergence time of bats in a few selected agricultural/semi-rural areas in the district of Coimbatore, Tamil Nadu, India. Agricultural crop fields, plantations, irrigation pools, scattered trees, villages, and vegetated areas served as the habitat for the species being studied. Acoustic detectors were installed at selected sites for the recording of bat passes, feeding calls, emergence timings, etc. From the findings, it was noted that bat activity was highest near irrigation ponds, crop fields bordered by tree lines, and canal borders with high vegetation cover, while agricultural lands and pure crops had low bat activity. Reference areas had more bats roosting, greater stability of bat colonies, and early emergence from the roost. Human disturbance factors such as artificial light, noise from machines, the presence of roads, pesticides, and human movements had an adverse effect on bats. It is concluded that conservation of hollow trees, old buildings, hedgerows, water sources, and dark corridors will aid in maintaining bats in modified agricultural ecosystems.

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## Introduction

Bats are ecologically significant mammals that help with insect regulation, pollination, seed dissemination, and maintenance of the ecosystem (Russo-Petrick & Root, 2023). Roosting is necessary for bats as roosts offer protection from predators, provide a suitable microclimate, serve as places for mating and breeding, and serve as refuges during rest between feeding. Bats choose their roosts according to temperature, humidity, prey presence, proximity to water sources, and disturbance (Hemasundari et al., 2025). Nevertheless, agriculture has transformed natural habitats into farms, plantation lands, irrigation lands, roads, storage facilities, and human settlements (Brinda, 2025). This has led to the decline and fragmentation of forests, wetlands, old trees, and scrub habitats, which are increasingly reduced or fragmented, directly affecting roost availability and habitat quality (Patil, 2018).

The main issue is that human encroachment and agricultural practices have influenced bat roosting, their time of activity, and connectivity, and this is not always properly accounted for during conservation management (Saidova et al., 2024). Artificial lighting, pesticide application, machine sounds, removal of trees, construction activities, and increased human presence around roosts could make bats leave secure natural roosts and move to less suitable locations (Hale et al., 2012). This type of disturbance could influence the reproductive ability, roosting behavior, foraging behavior, and ultimately the ability of the populations to survive. The behavioral traits

of bats, such as acoustic activity, timing of emergence, foraging times, and flight patterns, are indicative of how bats cope with the disturbances (Browning et al., 2021; Sippola et al., 2026). This project, therefore, will explore how agricultural development and human disturbance impact bat roosting and behavioral activity patterns and population connectivity.

## Key Contribution

1. The study identifies how agricultural expansion, habitat loss, artificial lighting, and human movement reduce bat activity and disturb natural roosting behaviour.
2. It shows that vegetation corridors, irrigation ponds, old trees, and abandoned structures support higher bat activity and better colony stability.
3. The study highlights the need for wildlife-friendly farming, reduced pesticide use, protected roosts, and dark movement corridors to improve bat conservation.

Section I presents an overview of bat ecology, roosting behavior, expansion of agriculture, and the problem statement. Section II describes prior research and the research gap. Section III describes the study location, bat detection, and data analysis methodology. Section IV describes the outcomes from bat activities and roosting behavior. Section V presents the conclusion of the conservation relevance of the study.

## Literature Review

Ecological research shows that bats choose roosts depending on security, constant temperature, proper humidity, and proximity to food sources. Roosts offer a place for protection,

breeding, and safety from predators, thus are important for the survival of colonies (Rulli et al., 2021). Man-made activities interfere with the process of choosing a proper roost since they involve cutting down older trees, altering old structures, adding artificial lighting, and altering the vegetation around the roosting sites. This might lead to delayed emergence of bats, frequent changes of roosting spots, small colony sizes, and decreased reproductive success. Bats roosting in trees and cave-roosting species are generally more susceptible to disturbance compared to adaptive species that use structures, plantations, and agricultural edges.

Habitat modification due to agricultural activity mainly occurs in ways such as habitat simplification, pesticides, decline in the food source for bats, and loss of native vegetation. Agricultural practices such as monoculture will simplify habitats, reducing feeding and roosting sites for bats. Pesticide use can reduce the insect population available for feeding by the bats. Furthermore, it poses risks to insect-eating bats by exposing them to chemicals (Meyer et al., 2015). But all agricultural landscapes do not have similar impacts on bats (Walsh et al., 2017). Agricultural practices that involve mixed cropping, hedgerows, native trees, ponds, and fields provide insects and other benefits necessary for bat activity. Thus, agricultural lands can be either suitable habitats or barriers based on agricultural practices.

The disturbances caused by human encroachment include roads, settlements, open

grounds, lights, sounds, and human movement near the roosting grounds (Walsh et al., 2017). Disturbances can disrupt commuting routes for the bats, and thus decrease safe movement between their roosting grounds and foraging locations. Habitat fragmentation can lead to isolation of the bat colony, decreased gene flow among populations, and eventually make the populations susceptible to extinction (Stafford et al., 2026). While the biology of bats has been studied in forests, caves, and urban settings, studies that correlate the effects of agricultural disturbances, habitat disturbance, bat roost choice, acoustics, and habitat connectivity are not numerous. This study aims to fill this gap by examining bat responses across disturbed and less disturbed agricultural areas.

## **Materials and Methods**

### **Study Area and Site Selection**

This research was carried out in selected agricultural and semi-rural environments of Coimbatore district, Tamil Nadu, India, which included areas surrounding Pollachi, Kinathukadavu, Thondamuthur, and other villages. These areas include crop cultivation zones, coconut and banana groves, irrigation ponds, some trees, villages, and semi-natural vegetation patches. Selected areas included disturbed agricultural zones and undisturbed natural reference zones. The disturbed zones included areas close to roads, villages, artificial lighting, and agricultural activity. Reference zones had good tree cover, availability of water sources, roosting trees, and less disturbance.

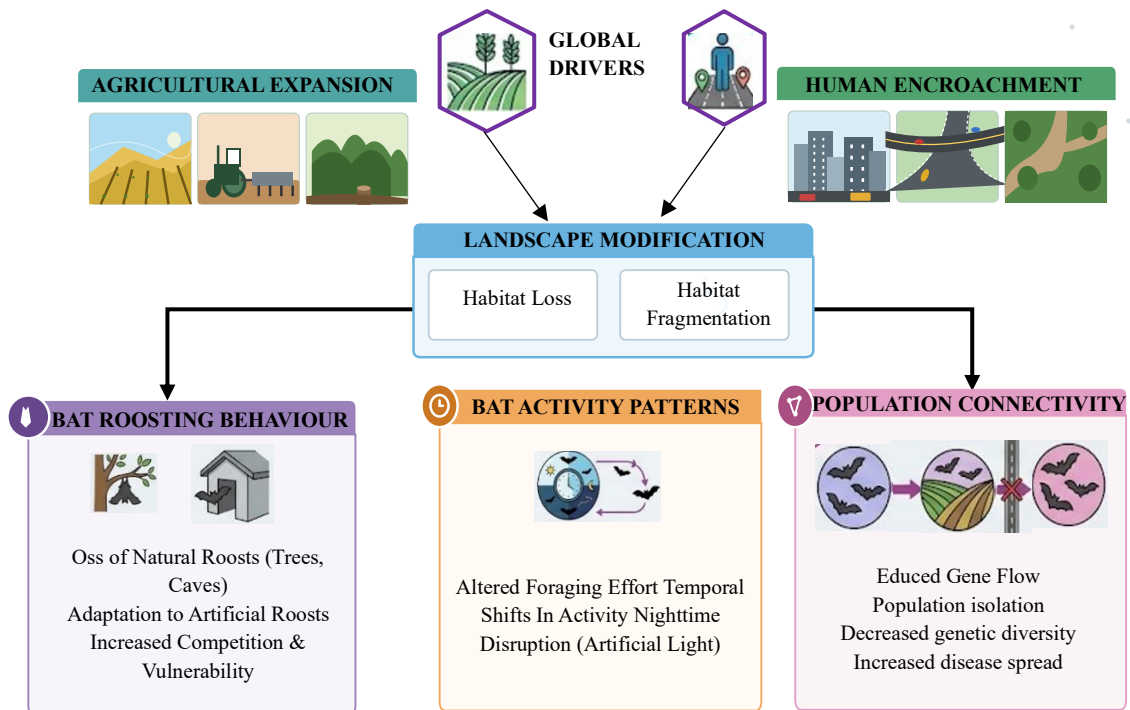


Figure 1. Conceptual Diagram of Drivers of Bat Ecology Change

Figure 1 depicts the effect of agricultural expansion and human encroachment on bats through habitat loss and fragmentation. The resulting changes in the landscape impact the roosting behavior, activity, and connectivity of bats through roost reduction, change in movement, inhibition of nocturnal activity, and increased population isolation.

### Monitoring Bat Activity Using Acoustic Detectors

Bat activity was monitored using ultrasonic acoustic detectors placed near roosting sites. The presence of bats was detected through the use of ultrasonic detectors around the roost sites, edges of the crops, irrigation ponds, along tree lines, abandoned buildings, and along possible commuting routes. These detectors collected the calls of bats at dusk and during the nighttime, particularly during evenings. This detection process was carried out on several nights to

observe the difference in bat activities in varying disturbance scenarios. The presence of bats, feeding buzzes, and peak time periods of activity were determined through acoustic observations. Other environmental variables such as temperature, humidity, wind speed, rainfall, and moonlight were also observed, as these factors can influence bat movement and foraging behaviour.

### Data Analysis to Determine Correlations Between Human Activities and Bat Behaviour

Acoustic recordings were analyzed to assess the difference in bat activity between areas experiencing human disturbances and undisturbed agricultural areas. Indicators of human disturbance were the distance from human settlements, the presence of roads, the amount of lighting at night, the use of pesticides, the level of agricultural production, and human

movements through the site. The indicators of bat behavior were the frequency of bat passes, feeding activities, roosting activities, time of emergence, and movements along vegetative corridors. The relationship between the two sets of variables was assessed using correlation analysis. Comparison was made between the disturbed sites and low-disturbance sites to assess changes in roosting, feeding, and connectivity behavior.

## Results

### Patterns of Bat Activity in Relation to Agricultural Expansion

Variation in bat activity was seen in different agricultural environments. Mixed agriculture fields with trees, ponds, and vegetation connectivity had higher bat activity as compared to intensive monoculture fields. The highest numbers of bat passes occurred in the proximity of coconut agriculture, canal periphery, and field boundaries with natural vegetation. On the contrary, open agricultural fields with less tree cover and high pesticide use exhibited lower acoustic activity. Table 1 suggests that agricultural encroachment decreases bat activity by decreasing natural vegetation and simplifying habitat structure.

Table 1: Bat Activity Across Agricultural Habitat Types

Habitat Type	Vegetation Cover	Average Bat Passes/Night	Feeding Buzzes/Night	Activity Level
Mixed crop fields with tree lines	High	148	42	High
Coconut and banana plantations	Moderate–High	132	36	High
Irrigation pond edges	High	156	45	Very High
Monoculture crop fields	Low	78	18	Moderate
Open agricultural land	Very Low	52	11	Low

### Differences in Roosting Behaviour Between Disturbed and Undisturbed Areas

Table 2 reveals the significant difference in roosting characteristics between disturbed and less disturbed sites.

Table 2: Roosting Behaviour in Disturbed and Undisturbed Sites

Site Category	Roost Occupancy (%)	Roost Switching Frequency	Average Emergence Delay	Colony Stability
Undisturbed reference sites	82	Low	8 minutes	High
Moderately disturbed sites	64	Moderate	18 minutes	Medium
Highly disturbed agricultural sites	41	High	31 minutes	Low

The reference sites were characterized by high roost occupation, presence of constant colonies, and early evening emergence. Old trees, abandoned buildings, and vegetated roosts were preferred in reference sites. However, in disturbed sites close to roads, night lighting, settlements, and farming, bats were seen roosting in multiple roosts and delaying their emergence. High canopy coverage and disturbance by humans seemed to render the roosts unsuitable for constant colonies.

### Effects of Human Presence on Bat Activity Patterns

Human presence caused decreased activity among bats, particularly within zones characterized by human movement, the presence of artificial lights, loud noise from machines, and pressure for human settlement. Bat activity was low around lit roads, farms with sheds, and the outskirts of villages compared to dark corridors. Areas where pesticide spraying and night-time farming were practiced had fewer bats feeding. Highly disturbed open areas had very few bats moving through them, while bats mostly used areas around canals, trees, and shaded agricultural fields. Figure 2 shows how human disturbance can change bat movement.

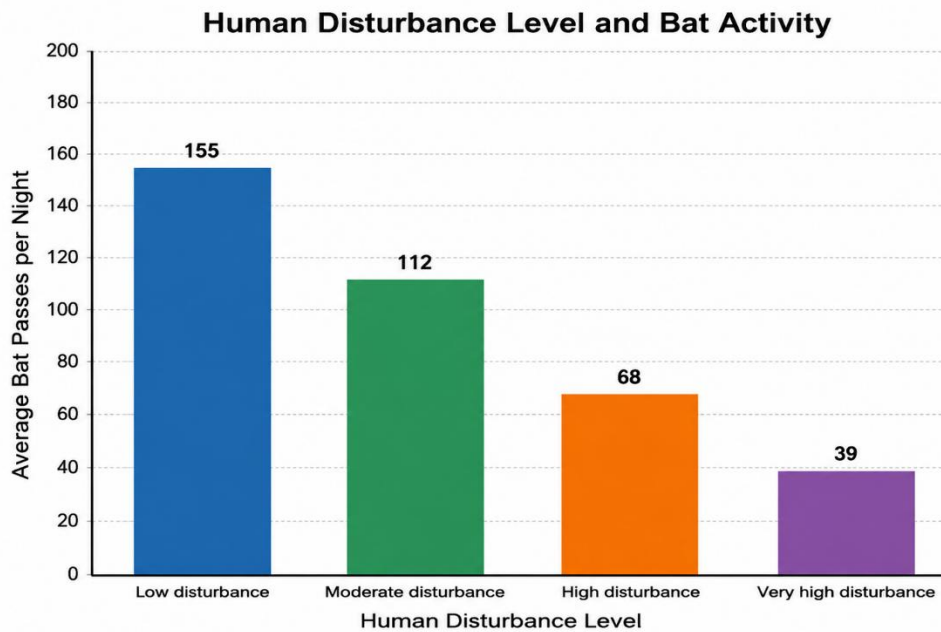


Figure 2: Human Disturbance Level and Bat Activity

### Discussion

Habitat conversion through agricultural development and human intervention can significantly affect bat conservation by rendering habitats unsuitable, changing the activity times,

and disrupting connectivity. Cutting down old trees, increasing artificial lighting, pesticides, noise from machinery, road development, and human disturbance can compel bats to leave their roosts and settle in unsuitable roosts, causing

delayed emergence and inefficient feeding activities. Thus, bat conservation within an agricultural area must also consider the protection of smaller habitats such as hollow trees, abandoned buildings, water sources, hedgerows, canal borders, and movement pathways that remain dark during flight. Wildlife farming can contribute to conservation efforts by creating conditions that favor insects, which will benefit bats. Landscape planning in the future should take into consideration areas known to have roosts, as well as ensuring that movement pathways between these areas remain connected. Long-term studies on sound monitoring, genetics, pesticides, and individual species need to be considered in the conservation of bats in human-altered agricultural landscapes.

## Conclusion

The findings prove that agricultural development and human presence have an effect on the roost selection behavior, timing of nocturnal activities, and connectivity of bats in semi-rural agricultural landscapes. The results observed at the selected sites in the Coimbatore District indicate high bat activity levels in areas with mixed crops, irrigation pools, indigenous vegetation, hedgerows, and canals. On the other hand, bat activity levels were observed to be low in areas characterized by open agricultural fields and areas that experienced intense human activity. The availability of relatively undisturbed sites where bats had access to old trees, abandoned buildings, water sources, and little artificial lighting contributed to a higher rate of roost occupancy. Disturbed sites close to roads, settlements, night lights, and farming areas were

found to have regular roost switches, delayed emergence times, less stable colonies, and lower feeding activity among bats.

This paper emphasizes the importance of incorporating bat conservation in agriculture and rural landscapes. Conservation does not necessarily have to occur only in vast forests, as bats also require smaller habitats such as hollow trees, hedgerows, abandoned structures, irrigated ponds, riparian strips, and dark flight paths. Bat conservation can be achieved through wildlife-friendly agricultural practices, reduction in pesticide use, maintenance of indigenous flora, and limited lighting around roosting sites. Future research must consider prolonged acoustic surveys, species identification, studies of genetic connectivity, and effects of pesticides on bats in an altered agricultural environment. It is crucial that bats are conserved in man-modified landscapes for maintaining biodiversity, insect control, and ecological balance.

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