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Safeguarding Heritage Buildings: Balancing Bat Conservation with Effective Tourism Management

Biyas Ghosh [1] **,** ***Manager Rajdeo Singh*** [2*]

[1] *National Research Laboratory for Conservation of Cultural Properties, Mysore Karnataka 570001, India*

[2] *Department of Tourism Administration, Dr Babasaheb Ambedkar Marathwada University, Aurangabad Maharashtra 431005, India*

ABSTRACT

This study investigates the complex relationship between insectivorous bats and built heritage, focusing on their presence in historic structures such as the 17th-century Chander Nagar Gate in Lucknow, India. While bats play a beneficial ecological role in regulating insect populations and supporting agricultural ecosystems, their habitation within heritage sites raises concerns related to structural deterioration, hygiene, and visitor experience. Employing a multidisciplinary framework that bridges conservation biology, architectural heritage management, and sustainable tourism, this paper evaluates both the ecological importance of bats and their impact on cultural monuments. Field observations, photographic documentation, and pilot deterrent trials using naphthalene were conducted to assess roosting behavior and mitigation outcomes. Results revealed minor guano-related staining but no immediate structural erosion, with species such as Pipistrellus pipistrellus showing adaptability to artificial lighting. The study further explores non-invasive management strategies, including acoustic deterrent devices, light modulation, and installation of bat boxes, emphasizing the importance of tailoring interventions to specific site conditions and species behavior. In parallel, the paper addresses visitor attitudes and potential conflicts through proposed survey instruments, advocating for inclusive tourism strategies that balance biodiversity conservation with public comfort and safety. It concludes that bats need not be expelled but rather managed through evidence-based, site-sensitive approaches that uphold both ecological and heritage values. This integrated model supports the dual goals of

*CORRESPONDING AUTHOR:
Manager Rajdeo Singh, Department of Tourism Administration, Dr Babasaheb Ambedkar Marathwada University, Aurangabad Maharashtra 431005, India; Email: m_singh_asi@yahoo.com

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conserving biological diversity and sustaining the cultural integrity of heritage tourism destinations.

Keywords: Heritage Site Conservation; Bat-Human Interaction; Ecological Pest Control; Sustainable Tourism Management; Non-Invasive Deterrents; Built Heritage and Biodiversity

1. Introduction

In recent years, the need to address environmental challenges has fostered interdisciplinary collaborations across archaeology, biology, ecology, and tourism studies [1]. One underexplored yet critical intersection lies in the management of bat populations inhabiting historic monuments. In India, thousands of ancient temples, mosques, caves, and heritage structures are currently under conservation, yet many of these sites are inhabited by bats whose ecological and economic significance is often overlooked. This paper explores the complex role bats play within such spaces—both as natural pest regulators and as biological agents contributing to material degradation—while examining how integrated tourism and conservation strategies can address this duality.

Bats are ecologically important mammals that consume vast quantities of agricultural pests, supporting food security and reducing reliance on chemical pesticides [2]. However, their long-term occupation of heritage structures can pose challenges. Their excreta (guano and urine) contain corrosive compounds such as uric acid, ammonia, and phosphoric acid, which can chemically interact with walls, plaster, murals, and carved surfaces [3, 4]. Guano deposits are also known to foster microbial growth, including fungi and algae, which further accelerate biodeterioration processes [5]. These impacts are particularly relevant in rock-cut caves and ancient temples where microclimatic stability and surface preservation are vital to long-term conservation efforts.

Although the ecological role of bats is well-documented, their management within built heritage contexts has received limited academic attention in India. Previous studies have emphasized the transformation of guano into authigenic materials over decades, contributing to stratigraphic records in prehistoric caves [6]. Yet, in active heritage sites, these same materials can obscure surface iconography or damage historic finishes. The challenge is compounded by the fact that eradication or exclusion of bats without designated alternative roosts could harm already vulnerable populations, many of which are protected under Indian and international wildlife laws [7, 8].

Moreover, the presence of bats in heritage buildings influences the visitor experience. While some tourists express fascination with bats, others report discomfort due to odor, perceived disease risk, or visual impact on the interiors of sacred or historic spaces. A study reports a 16% increase in conservation willingness among urban tourists following bat-watching exposure, demonstrating a clear link between wildlife tourism and public attitudes [9]. A recent research examines bat populations and tourist dynamics in Gupteswar Cave, Odisha, India, and recommends gated entries, monitoring of breeding seasons, and educational signage to balance conservation with tourism [10]. The implications for sustainable tourism are significant: poorly managed bat-human interactions can detract from site appeal, while ecologically sensitive approaches may enhance public engagement with biodiversity and heritage conservation alike [11].

Despite their ecological and agricultural value, bats are often seen as pests in conservation discourse. However, emerging research recognizes the need to balance wildlife protection with the integrity of built heritage. Studies from Europe and Southeast Asia suggest that adaptive strategies such as installing acoustic deterrents, altering lighting regimes, and creating controlled roosting zones can help mitigate damage while preserving bat populations [12, 13]. These approaches remain underutilized in India's heritage management framework.

This study, therefore, investigates the intersection between bat conservation and the preservation of archaeological monuments in India, with a focus on ecological services, structural impact, and visitor perception. Drawing from conservation biology, architectural heritage studies, and sustainable tourism literature, it aims to propose integrated strategies that align biodiversity protection with heritage conservation goals. By understanding both the ecological significance and the conservation challenges posed by bats in these culturally valuable spaces, this research advocates for multidisciplinary policies that ensure the long-term sustainability of both wildlife and monuments.

2. Materials and Methods

Work Undertaken to Mitigate Bat-Related Impacts on Heritage Structures:

2.1. Site Survey and Observations

Bats frequently roost in archaeological buildings and heritage monuments, where their biological activity—particularly the accumulation of droppings and urine—can result in the degradation of wall surfaces, plasters, and ornate textures. Over time, the corrosive chemical content in guano and urine contributes to material deterioration, salt efflorescence, and micro-environmental changes that compromise the aesthetic and structural integrity of historical sites [4]. Therefore, safeguarding these structures while respecting wildlife protection laws requires an integrated approach that combines architectural conservation with ecological sensitivity [14, 15].

To better understand and manage such impacts, a field survey was conducted at two prominent Indo-Islamic heritage sites in Lucknow, Uttar Pradesh: Chander Nagar Gate (Alambagh) and Kothi Roshan-ud-Daula (Kaiserbagh). These sites are emblematic of Nawabi and Indo-French architectural fusion, making them key tourist attractions for both domestic and international visitors due to their historic and cultural significance (**Figure 1**).

Figure 1. General View of the 17th Century Chander Nagar Gate, Lucknow – A Historic Structure Affected by Bat Colonization.

The survey was conducted during both summer and winter seasons to assess seasonal variations in bat activity and roosting patterns. Bats were visually documented and photographed in situ, primarily during daylight hours when they are less active (**Figure 2**). It was noted that smaller colonies of bats occupied areas with partial light exposure, while dense, darker cavities and roof gaps harbored larger colonies. These behavioral patterns align with the bats' preference for low-disturbance roosting environments, often coinciding with architectural voids and gaps created by aging structural elements.

Figure 2. Bat Colonies Roosting Within Structural Gaps of the 17th Century Chander Nagar Gate, Lucknow.

At Chander Nagar Gate, a substantial colony of microchiropteran bats was observed. Based on size and behavioral characteristics, the species was identified as Pipistrellus pipistrellus (Pipistrelle bats), typically weighing around 3.43 g with a wingspan of 17.4 cm (**Figure 3**). Their nesting within the fissures and beams of this 17th-century structure raises concern over cumulative guano deposition and the associated formation of bio-corrosive deposits [5]. These findings are critical for heritage site managers, as they indicate areas where conservation strategies—such as periodic cleaning, monitoring of surface degradation, and installation of passive bat deterrents—could be effectively implemented [16].

Figure 3. Roosting Behavior of Pipistrellus Bats Observed at Chander Nagar Gate, Lucknow.

Given the legal protection of bats in India under the Wildlife Protection Act and their recognized ecological benefits, such as insect population regulation (Chakraborty and Bhattacharya, 2019), eradication is neither desirable nor permissible. Instead, adaptive strategies, such as designating alternative roosting zones away from culturally sensitive areas or deploying non-intrusive deterrents like low-frequency acoustic devices or controlled lighting systems, offer viable management pathways. These approaches have shown promise in minimizing bat presence in vulnerable parts of historic structures without disrupting ecological functions [17].

Furthermore, understanding visitor perception of bat presence at such sites is essential. While some tourists may express discomfort due to odor or droppings, others are drawn to the ecological narrative of cohabitation between wildlife and heritage [1]. Balancing these divergent expectations can enhance sustainable tourism planning by incorporating interpretive signage or guided narratives that contextualize the role of bats in both heritage decay and biodiversity.

2.2. Experiment on Setting up Bat Deterrence Measures

Given the negative impacts of bat guano and urine on historical structures—such as salt crystallization, plaster staining, microbial colonization, and bio-corrosion of stone and lime surfaces—non-lethal mitigation measures were tested to assess their effectiveness in discouraging bat habitation without compromising the ecological balance or violating wildlife protection laws [4]. One such deterrence measure involved the use of naphthalene, a chemical compound registered as a general vertebrate repellent by the U.S. Environmental Protection Agency (EPA) in 1981. Naphthalene has historically been applied for pest control, including use against squirrels, rabbits, and bats, with a recommended dosage of 2.5 pounds per 1,000 cubic feet (or 1.2 kg per 30 cubic meters) [18]. Its volatile nature allows it to release detectable vapors that disrupt the olfactory comfort zone of bats, encouraging relocation.

2.3. Experimental Framework

A field-based deterrent experiment was conducted at Chander Nagar Gate, a 17th-century Nawabi monument in Lucknow. The goal was to evaluate the feasibility of naphthalene as a non-invasive chemical deterrent to redirect bat colonies away from conservation-sensitive zones. To ensure methodological rigor, the following design was employed:

Treatment Zone: Naphthalene flakes (1.2 kg) were placed in muslin pouches and suspended from ceiling joints, structural voids, and entry gaps used by bats.

Control Zone: Architecturally similar areas within the same monument, but without chemical placement, were selected as the control.

Duration: The trial was conducted over a period of 30 days (March–April), covering both day-roosting and night activity cycles.

Environmental Monitoring: Temperature and humidity were logged daily, and airflow within the monument was qualitatively recorded to assess vapour dispersal.

Bat Activity Monitoring: Bat presence was recorded daily through a combination of visual inspection, acoustic detection (echolocation monitoring), and guano accumulation measurement.

Replication: A similar setup was tested at Kothi Roshan-ud-Daula to validate results across site types.

3. Results

3.1. Preliminary Findings

Initial observations indicated a visible reduction in bat activity in the treated areas by the end of the second week, while no significant change was recorded in control zones. Accumulated guano below the treated areas was reduced by nearly 40%, indicating partial deterrence success. However, some bats appeared to shift roosting to adjacent untreated areas, highlighting the importance of site-wide application strategies rather than localized efforts. The general properties of naphthalene, including volatility and odor threshold (0.08 ppm), are listed in **Table 1** for reference. Its ease of deployment and affordability make it an attractive option, but concerns remain regarding potential human exposure, flammability, and long-term residue, especially in enclosed heritage interiors.

Conservation and Policy Implications:

While chemical deterrents such as naphthalene offer temporary relief from bat infestations in heritage zones, they should be deployed only as part of a broader integrated pest and site management strategy. These must include:

Regular monitoring of bat populations and guano-related damage; Use of structural interventions (e.g., mesh barriers, sealing of unused voids); Designation of alternative roosting niches or artificial bat boxes; Periodic reassessment of chemical efficacy and environmental safety.

Future work should also include visitor-centric studies to evaluate whether bat deterrent efforts improve visitor satisfaction, especially in sites where fear, odor, or noise are perceived as detracting from the cultural experience [1]. A structured survey (as outlined in the next section) is proposed to address this gap.

Table 1. General Properties of Naphthalene.

Molecular Formula	C10H8
Molar mass	128.17052 g/mol
Appearance	White solid crystals/flakes, Strong odor of coal tar
Density	1.14 g/cm³
Melting point	80.26 °C, 353 K, 176 °F
Boiling point	218 °C, 491 K, 424 °F

3.2. Chemical Response and Impact on Heritage Structures

To assess the effectiveness of naphthalene as a non-lethal deterrent for bats inhabiting heritage buildings, a site-specific study was undertaken at the left wing of Chander Nagar Gate, an area with limited tourist movement but known for its dense population of Pipistrellus bats (**Figure 3**). This location provided a controlled environment to monitor behavioral response and guano deposition over time. The experimental focus was on evaluating the spatial influence of chemical deterrence and its potential in minimizing architectural damage caused by prolonged bat habitation. Areas of frequent bat activity were mapped, and blotting papers were placed beneath roosting sites to collect guano (**Figure 4**). The quantity of guano deposited was then used as a proxy to estimate bat population density and assess site usage intensity. This methodology also allowed for indirect evaluation of the corrosive threat posed by bat excreta to historic lime plasters, stone joints, and woodwork—key elements in vulnerable heritage structures.

Figure 4. Accumulation of Bat Guano in Interior Spaces of Chander Nagar Gate, Lucknow.

Naphthalene Deployment:

The chemical deterrent—naphthalene—was introduced in muslin cloth bags (10 × 15 cm), placed strategically near roosting points within the monument. These bags were replaced periodically to maintain vapor efficacy. Within the treated zones, particularly at Chander Nagar Gate, a notable decrease in guano accumulation and reduction in bat activity were observed over a three-month monitoring period (**Figure 5**). In contrast, untreated areas continued to show consistent guano deposits and bat movement. These results suggest that naphthalene disrupted the spatial consistency of bat colonies, likely by altering the ambient chemical profile of their environment. While the physiological mechanism was not directly measured in this study, existing literature supports the view that strong volatile compounds can disrupt olfactory cues critical for roost site fidelity [18].

Implications for Site Management:

The successful reduction of bat occupancy in the chemically treated zones demonstrates the potential of naphthalene as a short-term deterrent for sensitive heritage sites, especially those under restoration or active tourist use. However, its use must be:

Time-bound and localized, due to flammability and human exposure concerns; Integrated with structural exclusion measures (e.g., sealing of entry gaps post-deterrence); Subject to environmental monitoring to ensure no residual chemical impact on architectural materials. Additionally, this experiment strengthens the argument that bat management strategies can be aligned with heritage conservation goals. Future studies should include material degradation analysis (e.g., plaster pH, microbial colonization) before and after deterrent use to further substantiate conservation benefits.

Figure 5. Use of Naphthalene Bags as A Chemical Deterrent in the Interior of Chander Nagar Gate, Lucknow.

4. Identification of Zoological Problems in Heritage Structures

During site surveys, multiple zoological intrusions were observed at heritage monuments, notably bats, pigeons, spiders, and insects. These animals often exploit architectural voids, ornamental crevices, or shaded alcoves for shelter—locations that coincide with the most fragile components of heritage structures, including lime plasters, wooden beams, and stone joints. The resulting accumulation of biological waste, particularly guano and uric acid, accelerates material decay through acidification, microbial colonization, and staining, especially in humid microenvironments. This overlap of animal habitation and architectural fragility introduces a significant conservation dilemma: how to protect the ecological integrity of these animals without compromising the historical, aesthetic, and material value of built heritage. The conflict is particularly complex in the Indian context, where many animals—including bats—are protected under the Wildlife (Protection) Act, 1972, necessitating non-invasive and ecologically sensitive interventions.

Impact of Bat Colonies and Proposed Mitigation Measures:

As highlighted by Srinivasulu and Srinivasulu (2001), it is critical to go beyond visual identification and include behavioral studies such as: Daily activity rhythms that help identify peak periods of bat movement within structures; Spatial mapping of roosting sites to correlate bat presence with zones of architectural degradation; Guano analysis for fungal and microbial content to assess the bio-deterioration risks to heritage materials [19].

Furthermore, systematic monitoring of environmental parameters, such as humidity and temperature, is essential. These factors not only influence bat congregation but also accelerate chemical and microbial weathering of historic building materials.

Multi-Pronged Zoological Mitigation Approaches:

To address the recurring problem of animal intrusion in heritage buildings, a range of context-appropriate strategies can be explored:

Natural plant-based oils (e.g., eucalyptus or citronella) offer low-impact repellents for pigeons and bats.

Chemical deterrents such as para-dichlorobenzene may be cautiously evaluated, with risk assessments for material compatibility and human exposure.

Electromagnetic field deterrents, strobing light devices, and ultrasonic sound systems represent non-contact physical interventions, though their long-term efficacy in open heritage sites remains under review.

Mechanical solutions, including netting and exclusion mesh, and creation of artificial roosts away from monuments, offer practical long-term options that balance species protection with site preservation.

Raising public awareness among tourists is also crucial. Information panels and digital kiosks explaining the importance of coexistence and non-intrusive observation can align visitor behavior with site management goals. Responsible tourism practices that minimize human-wildlife conflict not only support heritage conservation but enhance the authenticity and ecological value of the visitor experience.

5. Pathogens and the Role in the Transmission of Zoonotic Diseases

While bats are ecologically important, their role as potential vectors of zoonotic diseases—such as rabies, Henipavirus (Hendra and Nipah), and SARS-like coronaviruses—has raised health and safety concerns, particularly in the context of public access to built heritage sites [20, 21]. Their dense roosting behaviors, high mobility, and capacity to carry pathogens without exhibiting symptoms make them unique reservoirs of infection. In the context of heritage buildings, this presents two critical concerns:

Risk to Maintenance Personnel and Tourists: Guano accumulation in enclosed spaces, especially under domes, vaulted ceilings, and attics, can aerosolize pathogen-bearing particles, particularly if disturbed. Though direct human-bat contact is rare, the potential for airborne rabies exposure, as suggested by Shapiro et al. (2021), cannot be ignored, especially in spaces where guano build-up is significant and ventilation is poor [20].

Impact on Visitor Behavior and Tourism Management: Fear of disease or perception of uncleanliness due to visible bat colonies may deter visitors or reduce the aesthetic and experiential quality of the site. In high-footfall areas like Chander Nagar Gate and Roshan Ud Daula Kothi, these negative visitor perceptions could undermine tourism potential.

To address these dual risks—health hazards and deterioration of visitor appeal—site managers must include bio-safety protocols as part of conservation planning. This can involve:

Routine guano removal using protective equipment; Installation of physical barriers or deterrents in confined roosting zones; Health and safety signage educating visitors about low-risk coexistence and reporting protocols in case of exposure.

Although existing literature [21] emphasizes the biological complexity of zoonotic diseases, the focus here is narrowed to the risk mitigation measures necessary to prevent disease transmission in built heritage environments, especially where human interaction is frequent. Moreover, future conservation plans should incorporate a visitor-centric health survey, gauging public awareness and acceptance of bats at heritage sites, to inform sustainable strategies that protect both cultural assets and human well-being.

6. Discussion

Effective conservation of heritage sites inhabited by bats requires a dual approach: minimizing damage to the built fabric while also respecting the ecological role of bats. Managing this balance not only helps safeguard the physical integrity of historical buildings but can also contribute positively to tourism and visitor engagement. This integrated approach recognizes bats not merely as hazards but as components of the ecosystem that can be managed thoughtfully and innovatively within the framework of built heritage conservation.

Rather than viewing bats solely as pests, they may be reimagined as contributors to heritage site character and ecotourism. For example, the dramatic visual of bat emergence at dusk can enhance the cultural experience for tourists [22]. At sites like Chander Nagar Gate, where bats are already present in wall cavities and domes, their visibility could be leveraged to enrich visitor interpretation, if properly managed. Public interpretation strategies that educate visitors on the ecological importance of bats, including their role in pest regulation and pollination, could increase acceptance and promote eco-sensitive tourism. These messages can be conveyed through signage, digital media, and guided tours.

However, when their presence directly compromises building materials or visitor safety, targeted interventions become necessary. Some claims of structural damage by bats—such as guano-induced decay—are often overstated. Kunz and Racey (1988) note that deterioration is largely influenced by material composition and environmental conditions[23]. In many cases, especially in stone masonry structures, the corrosive effects of bat excreta are less severe than presumed. Nonetheless, accumulated guano and urine can cause staining, odor, and microbial growth, particularly in poorly ventilated or moisture-retentive architectural settings. These effects can degrade the aesthetic, hygienic, and olfactory qualities of interiors, particularly when the structures are used as tourism destinations.

Biswas J. et al. (2011) recommend expulsion only when scientific assessment confirms irreversible or substantial damage[24]. This principle of evidence-based action is essential to prevent unnecessary eviction or habitat loss. As such, preliminary assessments should involve microbial swab tests, pH analysis of deposits, and monitoring of changes to plaster or stone surfaces over time. Guano sampling and mapping can also indicate colony activity and space usage.

To avoid this, routine removal of guano with appropriate PPE, the installation of barriers at entry points, and restricting public access to active roost areas (Talerico, 2008) are practical measures that preserve both structural and visitor health integrity[25]. Such access control can be achieved through simple gated partitions or mesh covers, allowing bats to move freely while discouraging unprotected tourist entry. These solutions are particularly effective in controlling secondary damage from human interference or accidental contact.

Technological solutions such as Acoustic Deterrent Devices (ADDs) show promise for heritage structures where chemical or mechanical deterrents are inappropriate. Recent studies[26] suggest that filtered acoustic emissions can deter bats while remaining inaudible to humans, allowing daytime use without disrupting the visitor experience. The placement and calibration of ADDs should be optimized through behavioral mapping of flight paths and roost entrances. Gilmour et al. (2021) investigated ultrasonic deterrent devices in a foraging environment and found that overall bat activity decreased by 30%, with 27%–68% reductions across species such as Pipistrellus pygmaeus and Myotis spp. This highlights the need for species-specific behavioral data when deploying acoustic deterrents—a context similar to your heritage-building management scenario[26].

Similarly, artificial bat boxes can provide roosting alternatives. While newly introduced boxes may require acclimatization time, placing them near existing entry points increases their efficacy. Boxes designed with internal grooves, proper thermal regulation, and local wood material can enhance bat acceptance. These measures are most beneficial when paired with ongoing behavioral monitoring, ensuring that bats are not inadvertently displaced into more sensitive architectural zones. Longitudinal studies assessing occupancy rates and shifting roosting preferences can provide valuable insights.

Lighting control is another key strategy. Limiting light intensity and spillage can reduce bat flight and associated guano accumulation, particularly in conservation-sensitive interiors. Zhou D. et al. (2024) investigated nine bat species using LED lighting and spectral filters at cave entrances. Key findings include: Use of white, green, and yellow light significantly reduced emergence activity. Blue and red spectra had minimal effects, indicating species-specific sensitivity. The study highlights the importance of spectral light management to minimize disturbance[27]. Therefore, lighting design in heritage spaces should favor red-spectrum LEDs and install shielding to reduce spill into roost zones.

However, as Stone et al. (2015) caution, excessive lighting can disrupt bat behavior and ecology. Lighting designs should therefore consider motion sensors, spectral properties, and shielding, balancing deterrence with species well-being[28]. In open-air structures like archways or stepwells, indirect lighting schemes could serve the dual function of enhancing safety while limiting disturbance.

In situ observations revealed that Pipistrellus species (including P. pygmaeus and P. pipistrellus) showed reduced activity in well-lit zones but were not fully deterred. Past research reported that even security-lit churches hosted substantial bat populations, indicating adaptive behavior and highlighting the need for more targeted species-specific studies[29]. Thus, management should not rely solely on lighting but integrate it into a broader toolkit.

Ultimately, conservation planning should prioritize data-driven decision-making. This includes detailed documentation of roosting behavior, guano distribution patterns, and visitor attitudes, which would provide an empirical foundation for long-term strategies. Instruments such as motion-triggered cameras, ultrasonic detectors, and periodic visitor surveys can yield actionable insights. Importantly, aligning bat management with the architectural fabric and tourism goals of heritage sites ensures that interventions are sustainable, ethical, and site-specific.

In conclusion, bats in heritage structures represent both an ecological asset and a conservation challenge. With integrated monitoring, adaptive management, and public engagement, it is possible to transition from reactive removal strategies to a more informed, proactive coexistence model. The lessons learned from such interventions in Indian heritage settings may also contribute to broader international discussions on wildlife-friendly architectural conservation in tourism-driven economies.

7. Tourism and Visitor Attitudes Toward Bats

Bats occupy a unique intersection between biodiversity conservation and heritage tourism management, especially within culturally and architecturally significant sites [30]. Their presence in ancient temples, forts, and caves contributes not only to the ecological integrity of these environments but also offers potential for enhancing visitor engagement. When managed appropriately, bat colonies can be repositioned as ecological assets that add depth and meaning to the heritage tourism experience.

Many visitors are intrigued by the opportunity to observe bat colonies in historical settings, transforming these sites into experiential ecotourism destinations [31]. This niche appeal resonates particularly with wildlife enthusiasts and adventure tourists seeking immersive, educational experiences that go beyond traditional sightseeing. As a result, bats can become catalysts for diversifying tourism offerings at heritage sites.

When strategically framed, the integration of bat habitats into site narratives supports both ecological awareness and tourism enrichment. Guided bat-watching walks, interpretive displays, and educational workshops on bat ecology not only enhance the visitor experience but also contribute to local livelihoods by generating opportunities for community-led tourism initiatives [32]. Such programs align with sustainable tourism goals by positioning heritage sites as custodians of both cultural identity and environmental stewardship.

Moreover, bats deliver vital ecosystem services such as insect control and pollination, which are critical to local agriculture and broader landscape health [33]. These indirect benefits have cascading effects on rural economies, including agritourism. Integrating such messages into heritage interpretation can shift public perception, helping transform bats from feared or misunderstood creatures into symbols of ecological interdependence.

However, their presence in fragile built environments requires a cautious and site-sensitive approach. Guano accumulation, odor, and potential microbial activity can adversely affect building materials and visitor comfort, particularly in confined or poorly ventilated interiors. Still, as Kunz and Racey (1988) emphasize, interventions should avoid indiscriminate deterrence, especially when species-specific behavior and architectural context are not fully understood [23].

Many conventional deterrents are not tailored for heritage structures and may pose risks to both bat welfare and material conservation. For example, sealing entry points without offering alternative roosts can inadvertently shift colonies to more vulnerable architectural zones or trigger population stress.

An integrated “carrot-and-stick” model is thus recommended—combining the installation of artificial roosts (e.g., bat boxes near existing entry paths) with strategically deployed acoustic deterrents in high-risk zones. These approaches must be informed by behavioral monitoring to ensure they are species-specific, reversible, and compatible with both conservation ethics and site aesthetics. Ongoing research into bat behavior, roosting dynamics, and visitor tolerance thresholds is crucial before implementing such dual strategies.

Ultimately, co-managed habitats within heritage structures offer a compelling model for synergy between conservation and tourism. When supported by cross-disciplinary collaboration among wildlife ecologists, conservation architects, tourism planners, and local stakeholders, these efforts can safeguard biodiversity while also creating unique and ethically grounded visitor experiences. In doing so, heritage sites become active platforms for ecological education and sustainable tourism, reinforcing their roles as protectors of both natural and cultural legacies [34].

8. Policy Implications and Future Research

The findings of this study underscore the pressing need for integrated policy frameworks that recognize bats as both ecologically beneficial agents and potential stressors to heritage infrastructure. Heritage management policies must adopt a dual approach—ensuring non-invasive conservation of insectivorous bats while preventing structural deterioration and negative visitor experiences. Authorities should formalize guidelines for species-specific monitoring, environmentally safe deterrents, and the creation of alternative roosting zones within or near heritage sites. Institutional collaboration among wildlife departments, archaeological authorities, and tourism boards is essential to implement evidence-based strategies.

Future research should prioritize long-term monitoring of bat activity and its impact on material degradation (e.g., guano-induced erosion or bio-corrosion), combined with visitor perception studies to assess public attitudes toward bat presence. Comparative studies across multiple heritage sites in varied climatic zones would further elucidate context-specific conservation solutions. Emphasis on technological tools such as acoustic mapping and infrared tracking can enhance non-invasive documentation and inform adaptive site management.

9. Conclusions

This study underscores the need to adopt a holistic, interdisciplinary framework to manage the presence of bats in heritage buildings—one that integrates conservation biology, architectural preservation, and sustainable tourism management. Bats, often misunderstood and marginalized in the context of built heritage, are essential ecological agents that provide invaluable services such as insect population control and pollination. When properly understood and managed, their presence in historic structures can be reframed not as a nuisance but as an asset to cultural tourism and biodiversity conservation. Findings from the Chander Nagar Gate case study demonstrate the adaptability of certain bat species to human-made environments and highlight both the conservation opportunities and management challenges they pose. While bat guano and urine can contribute to staining or minor material degradation, severe structural damage is not typically observed unless colonies are very large and remain unmanaged. Consequently, the eviction or exclusion of bats from heritage structures should be a last resort, supported by scientific assessment. The study advocates for context-sensitive interventions, such as the use of non-invasive acoustic deterrents, controlled lighting, and the strategic installation of bat boxes, to encourage relocation without harm.

Tourism perspectives are integral to this discourse. Field observations suggest that bat-related concerns among visitors—such as smell, fear, or perceived health risk—must be mitigated through targeted visitor education, guided access management, and periodic cleaning of bat-inhabited zones. At the same time, interpretive programming around bats can enhance wildlife tourism appeal, especially among ecotourists and biodiversity-conscious travelers. As such, bats can be positioned not only as subjects of conservation but also as unique experiential elements within cultural heritage tourism.

To move from reactive management to proactive policy development, more empirical research is needed, especially regarding visitor attitudes, bat species-specific behavior in architectural contexts, and the long-term effectiveness of deterrents. Moreover, broader stakeholder collaboration involving conservationists, architects, local communities, and tourism planners will be essential for designing adaptive management frameworks. Ultimately, this study positions bats as a focal point for rethinking the convergence of natural and cultural heritage in tourism landscapes. By reframing bats not as threats, but as contributors to the ecological and cultural fabric of heritage sites, this paper argues for management approaches that respect biodiversity while preserving the authenticity and structural integrity of our historic monuments.

Author Contributions

Conceptualization, B.G. and M.R.S.; methodology, B.G.; software, B.G.; validation, B.G., and M.R.S.; formal analysis, B.G.; investigation, B.G.; resources, B.G.; data curation, M.R.S.; writing—original draft preparation, B.G.; writing—review and editing, M.R.S.; visualization, M.R.S.; supervision, M.R.S.; project administration, M.R.S.; funding acquisition, M.R.S.; conceptualization, B.G. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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