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Influence of Livestock Grazing and Forest Resource Extraction on Habitat Quality of Wild Mammals in Bagdara Wildlife Sanctuary

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Abstract: ***Livestock grazing and forest resource extraction are among the most pervasive anthropogenic pressures influencing the ecological integrity of protected areas in central India. The present study evaluated the effects of grazing intensity, fuelwood collection, and non-timber forest product (NTFP) extraction on the habitat quality of wild mammals in Bagdara Wildlife Sanctuary, Singrauli District, Madhya Pradesh. A total of 48 sampling sites were established across low-, moderate-, and high-disturbance zones between October 2024 and June 2025. Habitat quality was assessed using vegetation structure, canopy cover, shrub density, ground vegetation, and signs of anthropogenic disturbance, while mammalian occurrence was documented through line transects, camera trapping, and indirect evidence such as footprints, scats, and feeding signs. Vegetation analysis revealed that mean canopy cover declined significantly from 78.6 ± 5.2% in low-disturbance sites to 54.8 ± 7.1% in highly disturbed areas ($p < 0.05$), whereas livestock dung density increased nearly fourfold across the same disturbance gradient. A total of 22 wild mammal species belonging to 14 families and 7 orders were recorded during the investigation. Species richness decreased from 20 species in relatively undisturbed habitats to 13 species in heavily disturbed locations. Camera trap records indicated a 41.3% reduction in detection frequency of medium- and large-sized mammals in areas subjected to intensive grazing and fuelwood extraction. Habitat quality index values exhibited a strong negative relationship with anthropogenic disturbance ($r = −0.76$, $p < 0.01$), while mammal species richness showed a significant positive association with habitat quality ($r = 0.81$, $p < 0.001$). The findings demonstrate that continuous livestock grazing and unsustainable forest resource extraction are degrading habitat structure and reducing habitat suitability for wild mammals within the sanctuary. Strengthening regulated grazing practices, promoting community-based forest management, and restoring degraded habitats are recommended to improve ecological resilience and support long-term mammal conservation in Bagdara Wildlife Sanctuary.***

Keywords: Anthropogenic disturbance; Livestock grazing; Fuelwood extraction; Habitat quality; Wild mammals; Camera trapping; Protected area management; Bagdara Wildlife Sanctuary.

I. INTRODUCTION

Protected areas constitute the cornerstone of global biodiversity conservation because they provide refuge for threatened flora and fauna, maintain ecosystem processes, and preserve ecological integrity in landscapes experiencing increasing human pressure. Despite their legal protection, many wildlife sanctuaries are subjected to continuous anthropogenic disturbances that alter habitat structure, reduce resource availability, and influence the distribution, abundance, and behavior of wildlife species (Maxwell et al., 2020). In tropical countries such as India, where protected forests are often surrounded by densely populated rural communities, anthropogenic activities including livestock grazing, fuelwood collection, extraction of non-timber forest products (NTFPs), illegal harvesting of forest resources, road construction, and agricultural expansion have become major drivers of habitat degradation (Geldmann et al., 2019). These pressures not only reduce habitat quality but also increase the likelihood of human–wildlife interactions, thereby posing significant challenges to biodiversity conservation. Wild mammals perform essential ecological functions within forest ecosystems. Large herbivores regulate vegetation dynamics through selective browsing and grazing, carnivores maintain prey populations and trophic balance, while small mammals contribute to seed dispersal, pollination, and nutrient cycling (Ripple et al., 2014). The persistence of these ecological processes depends on the availability of structurally complex habitats that provide adequate food resources, shelter, breeding sites, and movement corridors. Habitat degradation resulting from anthropogenic activities often disrupts these ecological relationships by reducing vegetation cover, fragmenting landscapes, increasing edge effects, and altering species interactions (Haddad et al., 2015). Consequently, understanding the influence of human disturbances on habitat quality has become a priority for wildlife managers and conservation biologists.

Among the various anthropogenic pressures affecting protected forests, livestock grazing is considered one of the most widespread and persistent disturbances in tropical ecosystems. Grazing by domestic cattle, buffaloes, goats, and sheep modifies vegetation composition through trampling, browsing, and removal of understory biomass. Excessive grazing reduces plant regeneration, compacts soil, accelerates erosion, and decreases the availability of forage for wild herbivores (Veblen et al., 2016). Competition between domestic livestock and native ungulates may also reduce habitat suitability for wildlife by limiting access to food and water resources. Furthermore, livestock often act as vectors for diseases and parasites that can be transmitted to wild mammal populations, thereby increasing conservation concerns in protected landscapes (Keesing et al., 2018).

Forest resource extraction represents another significant threat to habitat quality. Rural communities living near protected areas frequently depend on forests for fuelwood, fodder, medicinal plants, bamboo, and other non-timber forest products that support household livelihoods. Although these resources are renewable when harvested sustainably, excessive extraction can substantially alter forest structure and ecological functioning (FAO, 2022). Continuous removal of woody biomass reduces canopy cover, decreases tree density, modifies microclimatic conditions, and affects the availability of nesting and shelter sites for numerous wildlife species. Disturbances associated with repeated human presence also influence mammalian behaviour by increasing vigilance, shifting activity patterns, and reducing habitat use in frequently visited forest patches (Gaynor et al., 2018).

Habitat quality is a multidimensional ecological concept that reflects the capacity of an environment to provide suitable conditions for species survival, reproduction, and population persistence. It is commonly evaluated using indicators such as vegetation structure, canopy density, ground cover, species composition, water availability, habitat connectivity, and the intensity of human disturbances (Morrison et al., 2012). Advances in Geographic Information Systems (GIS), remote sensing, camera trapping, and occupancy modelling have substantially improved the assessment of habitat quality by enabling researchers to integrate ecological observations with spatial patterns of anthropogenic disturbance (Burton et al., 2015). Such approaches are increasingly being used to identify conservation priority areas and evaluate the effectiveness of habitat management interventions.

India is recognized as one of the world's seventeen megadiverse countries and supports approximately 8% of global mammalian diversity despite occupying only about 2.4% of the world's land area (MoEFCC, 2023). Central India, particularly the Vindhyan and Satpura landscapes, harbours a rich assemblage of mammals including tiger (*Panthera tigris*), leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), striped hyena (*Hyaena hyaena*), sambar (*Rusa unicolor*), chital (*Axis axis*), nilgai (*Boselaphus tragocamelus*), wild boar (*Sus scrofa*), and several smaller carnivores and herbivores. However, rapid industrialization, mining, infrastructure development, and increasing dependence of local communities on forest resources have intensified anthropogenic pressures across many protected areas in this region (Jhala et al., 2021).

Bagdara Wildlife Sanctuary, located in Singrauli District of Madhya Pradesh, represents an ecologically important protected forest within the Vindhyan landscape. The sanctuary supports diverse dry deciduous vegetation and provides habitat for several wild mammal species of conservation significance. At the same time, the surrounding landscape has experienced considerable socio-economic development associated with coal mining, thermal power generation, agricultural expansion, and human settlement growth. Local communities continue to depend on the sanctuary for grazing livestock, collecting fuelwood and fodder, and harvesting non-timber forest products. These activities have the potential to alter habitat structure, reduce vegetation regeneration, and increase wildlife disturbance, yet quantitative information on their ecological impacts remains limited.

The present study seeks to evaluate the influence of livestock grazing and forest resource extraction on the habitat quality of wild mammals in Bagdara Wildlife Sanctuary. By integrating field-based habitat assessments, vegetation analysis, evidence of mammalian occurrence, and measures of anthropogenic disturbance, the study aims to provide empirical evidence on how human activities influence habitat suitability within the sanctuary. The findings are expected to support science-based habitat management, strengthen community-oriented conservation strategies, and contribute to the sustainable management of protected forests in central India.

II. LITERATURE REVIEW

Habitat quality is one of the most important determinants of wildlife survival, influencing the distribution, abundance, reproductive success, and long-term persistence of mammalian populations. Across tropical and subtropical forest ecosystems, increasing anthropogenic activities such as livestock grazing, fuelwood extraction, collection of non-timber forest products (NTFPs), and forest degradation have emerged as major threats to wildlife habitats. Numerous studies conducted worldwide and in India have demonstrated that these disturbances alter vegetation structure, reduce food availability, fragment habitats, and consequently affect the ecological functioning of protected areas.

Ripple et al. (2014) emphasized the ecological significance of large mammals in maintaining trophic interactions and ecosystem stability. Their synthesis demonstrated that the decline of mammalian populations due to habitat degradation can trigger trophic cascades, ultimately affecting vegetation dynamics, biodiversity, and ecosystem resilience. The authors concluded that conserving habitat quality is essential for sustaining healthy mammalian communities and ecological balance.

Habitat fragmentation has been identified as one of the most serious consequences of human-induced landscape modification. Haddad et al. (2015) conducted a global synthesis on habitat fragmentation and reported that fragmentation reduces habitat connectivity, limits dispersal opportunities, and increases edge effects, leading to long-term declines in biodiversity. Their study highlighted that mammalian species requiring extensive home ranges are particularly vulnerable to fragmented landscapes because isolated habitat patches often fail to provide sufficient food and shelter.

Livestock grazing is among the most widespread forms of land use affecting forest ecosystems. Schieltz and Rubenstein (2016) reviewed more than 800 scientific studies examining livestock–wildlife interactions across different continents. Their review revealed that grazing alters vegetation composition, ground cover, and forage availability, producing both positive and negative effects depending on grazing intensity and ecosystem type. However, medium and large mammals generally exhibited negative responses under conditions of excessive grazing because competition for forage and habitat degradation reduced habitat suitability.

A comprehensive global meta-analysis by Zhou et al. (2021) evaluated the effects of livestock disturbances on forest ecosystems using 156 published studies. The authors reported that livestock grazing significantly reduced forest structural complexity, vegetation biomass, soil quality, and species abundance. Medium- and large-sized mammals were among the most negatively affected taxonomic groups because grazing reduced understory vegetation and altered habitat characteristics necessary for feeding, breeding, and shelter. The study further emphasized that grazing intensity and duration strongly influence the magnitude of ecological impacts.

Forest resource extraction has similarly been recognized as an important driver of habitat degradation. The Food and Agriculture Organization (FAO, 2022) reported that increasing dependence of rural communities on fuelwood and non-timber forest products has accelerated forest degradation across many developing countries. Unsustainable harvesting reduces canopy cover, alters forest microclimates, limits natural regeneration, and decreases structural heterogeneity. Such habitat alterations ultimately reduce the carrying capacity of forests for many mammalian species by limiting food resources and increasing exposure to predators and human disturbances.

Gaynor et al. (2018) investigated wildlife responses to human disturbance across multiple ecosystems and demonstrated that mammals frequently modify their behaviour to avoid human activities. Their study revealed a marked increase in nocturnal activity among mammals inhabiting disturbed landscapes, indicating behavioural adaptations to minimize encounters with humans. Although behavioural plasticity enables short-term persistence, prolonged disturbance may reduce feeding efficiency, reproductive success, and population viability.

Burton et al. (2015) reviewed the application of camera trapping in wildlife ecology and concluded that camera traps provide reliable information on species occurrence, habitat use, activity patterns, and responses to anthropogenic disturbances. They emphasized that integrating camera trapping with vegetation surveys and Geographic Information Systems (GIS) offers a comprehensive approach for evaluating habitat quality and identifying conservation priority areas.

Within India, Jhala et al. (2021) reported that habitat degradation, livestock intrusion, and increasing human dependence on forest resources continue to threaten mammalian populations even inside protected areas. Their nationwide tiger assessment highlighted that prey abundance and habitat quality are strongly influenced by anthropogenic pressures, particularly grazing and extraction of forest resources. The report recommended strengthening habitat restoration and regulating resource use to ensure long-term conservation of large mammals.

Karanth and Nichols (2017) emphasized that habitat degradation caused by human activities directly influences occupancy and detection probabilities of large mammals. Using camera-trap-based ecological studies across tropical forests, they demonstrated that wildlife occurrence declines with increasing disturbance intensity and human accessibility. The authors advocated landscape-level conservation planning to reduce anthropogenic pressures within protected areas.

Studies conducted in central India further support these findings. Qureshi et al. (2019) observed that excessive livestock grazing around protected forests resulted in reduced regeneration of native tree species and increased competition between domestic livestock and wild ungulates. Habitat degradation also reduced prey availability for large carnivores, indirectly influencing predator distribution. Similarly, studies in the Satpura and Pench landscapes have shown that villages located close to forest boundaries exert continuous pressure through grazing, fuelwood collection, and NTFP harvesting, leading to gradual deterioration of habitat quality.

Remote sensing and GIS have become valuable tools for assessing habitat degradation associated with anthropogenic activities. Maxwell et al. (2020) emphasized that integrating spatial datasets with field observations enables accurate identification of disturbance hotspots, habitat fragmentation, and conservation priority zones. Their work demonstrated that protected areas experiencing intense human pressure require adaptive management strategies based on continuous ecological monitoring.

Recent reviews have also highlighted that the ecological consequences of grazing depend on grazing intensity, livestock density, forest type, and management practices. While moderate, well-managed grazing may increase habitat heterogeneity in some ecosystems, uncontrolled grazing generally reduces vegetation biomass, suppresses regeneration, compacts soil, and negatively affects mammalian habitat quality. Consequently, sustainable grazing management and community participation are considered essential components of biodiversity conservation in protected forests.

Overall, previous research consistently demonstrates that livestock grazing and forest resource extraction are significant anthropogenic drivers of habitat degradation in forest ecosystems. Most existing studies have focused on broad assessments of biodiversity loss or landscape change, whereas relatively few have examined the combined influence of grazing and resource extraction on habitat quality specifically within protected forests of central India. Moreover, ecological information on Bagdara Wildlife Sanctuary remains scarce despite increasing anthropogenic pressures associated with surrounding settlements and developmental activities. Therefore, the present study seeks to address this knowledge gap by systematically evaluating how livestock grazing and forest resource extraction influence habitat quality and the occurrence of wild mammals in Bagdara Wildlife Sanctuary. The findings are expected to provide scientific evidence for habitat restoration, sustainable resource management, and long-term wildlife conservation.

III. RESEARCH METHODOLOGY

A. Research Design

The present study adopted a field-based descriptive and analytical research design to evaluate the influence of livestock grazing and forest resource extraction on the habitat quality of wild mammals in Bagdara Wildlife Sanctuary, Singrauli District, Madhya Pradesh, India. The study integrated ecological field observations, vegetation assessment, mammal surveys, and statistical analyses to quantify the relationship between anthropogenic disturbances and habitat condition.

B. Study Area

The research was conducted in Bagdara Wildlife Sanctuary, located in Singrauli District, Madhya Pradesh. The sanctuary is characterized by tropical dry deciduous forests dominated by species such as *Tectona grandis*, *Anogeissus latifolia*, *Terminalia* spp., and *Boswellia serrata*. The area supports diverse mammalian fauna, including chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), wild boar (*Sus scrofa*), leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), and several small carnivores. Human activities such as livestock grazing, fuelwood collection, fodder harvesting, and non-timber forest product extraction are common in villages adjoining the sanctuary.

C. Sampling Design and Data Collection

The sanctuary was stratified into low-, moderate-, and high-disturbance zones based on the intensity of grazing and resource extraction. Representative sampling plots and line transects were established within each disturbance category using stratified random sampling. Habitat quality was assessed by recording canopy cover, tree density, shrub density, herbaceous cover, regeneration status, litter depth, and visible signs of anthropogenic disturbance. Livestock grazing intensity was estimated from dung counts, grazing trails, and direct observations, while resource extraction was quantified through evidence of cut stumps, lopped branches, fuelwood collection sites, and human trails.

Wild mammal occurrence was documented using line transect surveys, indirect signs (footprints, scats, scratch marks, feeding signs, and burrows), and camera traps installed at strategically selected locations. Geographic coordinates of all sampling sites were recorded using a handheld GPS to facilitate spatial analysis.

D. Data Analysis

Vegetation and disturbance variables were summarized using descriptive statistics. Species richness, Shannon–Wiener diversity index (H′), Simpson's diversity index (D), and relative abundance were calculated to evaluate mammalian diversity. Differences in habitat characteristics among disturbance zones were examined using one-way analysis of variance (ANOVA), while Pearson's correlation analysis was employed to determine relationships between disturbance intensity, habitat quality, and mammal diversity.

Statistical analyses were performed using IBM SPSS Statistics (Version 26), and thematic maps depicting disturbance intensity and sampling locations were prepared using ArcGIS 10.8. Statistical significance was determined at $p < 0.05$.

This methodology provides a comprehensive framework for assessing how livestock grazing and forest resource extraction influence habitat quality and the occurrence of wild mammals, thereby generating scientific evidence to support habitat restoration and sustainable conservation management in Bagdara Wildlife Sanctuary.

IV. RESULTS

A. *Distribution of Anthropogenic Disturbances*

Field investigations conducted between October 2024 and June 2025 identified livestock grazing, fuelwood collection, and extraction of non-timber forest products (NTFPs) as the predominant anthropogenic activities affecting the forest ecosystem of Bagdara Wildlife Sanctuary. Based on the intensity of these disturbances, the 48 sampling sites were classified into low-, moderate-, and high-disturbance zones.

The low-disturbance sites were predominantly located in the interior forest, where signs of human activity were infrequent. These areas exhibited relatively intact vegetation and minimal livestock movement. In contrast, moderate-disturbance sites showed regular grazing activity and seasonal extraction of forest resources. High-disturbance sites were generally situated near village boundaries and access routes, where grazing, fuelwood collection, and NTFP harvesting occurred more frequently. These sites displayed conspicuous evidence of anthropogenic pressure, including livestock trails, dung deposition, cut tree stumps, lopped branches, and frequent human movement.

The spatial distribution of disturbance clearly demonstrated that anthropogenic activities were concentrated in easily accessible areas, whereas the core forest maintained comparatively lower disturbance levels.

B. *Habitat Quality Assessment*

Habitat quality varied considerably among the three disturbance categories. Vegetation assessment revealed that areas experiencing minimal human interference possessed dense forest cover, well-developed shrub layers, abundant ground vegetation, and active natural regeneration.

One of the most evident indicators of habitat degradation was the reduction in canopy cover. The mean canopy cover declined significantly from $78.6 \pm 5.2\%$ in low-disturbance sites to $54.8 \pm 7.1\%$ in highly disturbed sites ($p < 0.05$). This reduction indicates progressive alteration of forest structure with increasing anthropogenic pressure.

Similarly, shrub density and herbaceous ground cover were visibly lower in heavily disturbed sites than in relatively undisturbed forest patches. Continuous livestock grazing had removed substantial portions of ground vegetation, while repeated cutting and lopping of trees created canopy openings that altered the forest microenvironment. Natural regeneration of seedlings and saplings was also poor in disturbed areas due to repeated trampling and browsing by livestock.

C. *Forest Resource Extraction*

Forest resource extraction was another major factor affecting habitat quality within Bagdara Wildlife Sanctuary.

Fuelwood collection was the most common extraction activity observed during the study. Numerous cut stumps, freshly lopped branches, and wood collection trails indicated regular dependence of nearby villages on forest resources.

Collection of non-timber forest products including mahua flowers, tendu leaves, medicinal herbs, bamboo shoots, and edible fruits was also common during seasonal harvesting periods. Although most extraction activities were subsistence-based, repeated removal of forest biomass has altered vegetation structure, reduced canopy continuity, and increased habitat disturbance.

Sites experiencing intensive extraction generally contained lower shrub density and greater canopy openings than relatively undisturbed locations.

D. *Wild Mammal Diversity and Relative Abundance*

A total of 22 wild mammal species representing 14 families and 7 orders were documented during the survey using line transects, camera traps, and indirect evidence such as footprints, scats, feeding signs, and scratch marks.

The sanctuary supported a diverse assemblage of herbivores, carnivores, omnivores, and small mammals. Among the recorded species, chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), and wild boar (*Sus scrofa*) were the most frequently encountered mammals throughout the study period. These species occurred across all habitat categories, although their occurrence was noticeably greater in relatively undisturbed forest patches.

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Large carnivores and disturbance-sensitive mammals were recorded less frequently and were generally associated with dense forest interiors characterized by comparatively low human activity. Camera trap records and indirect field evidence confirmed that these species avoided heavily disturbed habitats.

Table 1: Mammals observed during the study duration.

Species	Scientific Name	Relative Occurrence	Habitat Preference
Chital	*Axis axis*	Very Frequent	Open forest, grassland, forest edges
Sambar	*Rusa unicolor*	Very Frequent	Dense forest, water bodies
Nilgai	*Boselaphus tragocamelus*	Very Frequent	Open woodland, scrub forest
Wild Boar	*Sus scrofa*	Very Frequent	Moist forest, riparian zones
Leopard	*Panthera pardus*	Occasional	Dense forest
Sloth Bear	*Melursus ursinus*	Occasional	Rocky and dense forest
Indian Hare	*Lepus nigricollis*	Common	Grassland and scrub
Indian Crested Porcupine	*Hystrix indica*	Common	Rocky forest and scrub
Common Palm Civet	*Paradoxurus hermaphroditus*	Rare	Dense forest canopy

E. Species Richness Across Disturbance Zones

Species richness declined markedly with increasing anthropogenic disturbance. The low-disturbance forest supported 20 mammal species, whereas only 13 species were recorded from highly disturbed habitats.

The reduction in species richness indicates that habitat degradation resulting from grazing and forest resource extraction adversely affects mammalian diversity. Generalist herbivores continued to occur in moderately disturbed habitats; however, disturbance-sensitive species became progressively less common as anthropogenic pressure increased.

These findings demonstrate that habitat quality plays an important role in maintaining mammalian diversity within Bagdara Wildlife Sanctuary.

F. Camera Trap Observations

Camera trapping proved effective in documenting mammalian occurrence across different habitat types. The recorded images confirmed regular activity of herbivorous mammals, particularly chital, sambar, nilgai, and wild boar, in relatively undisturbed forest habitats.

In areas subjected to intensive livestock grazing and fuelwood extraction, camera trap records indicated a 41.3% reduction in the detection frequency of medium- and large-sized mammals compared with less disturbed locations. This reduction suggests that increasing anthropogenic disturbance influences habitat utilization and reduces wildlife activity in affected areas.

Several disturbance-sensitive species were detected primarily within the interior forest, indicating avoidance of areas experiencing frequent human activity.

G. Relationship Between Habitat Quality and Anthropogenic Disturbance

Statistical analysis demonstrated a strong inverse relationship between anthropogenic disturbance and habitat quality. Habitat Quality Index (HQI) values declined significantly with increasing disturbance intensity, producing a strong negative correlation ($r = -0.76$, $p < 0.01$).

This result indicates that increasing livestock grazing and forest resource extraction progressively degrade habitat conditions by reducing vegetation cover, altering forest structure, and limiting natural regeneration.

Conversely, mammal species richness exhibited a strong positive relationship with habitat quality ($r = 0.81$, $p < 0.001$). Sampling sites with dense canopy cover, healthy understory vegetation, and limited human disturbance consistently supported greater mammalian diversity than highly disturbed sites.

These statistical relationships confirm that habitat quality is a major determinant of mammalian occurrence within the sanctuary.

Table 2: Pearson's Correlation Matrix Showing the Relationship Between Anthropogenic Disturbance, Habitat Quality, and Mammal Species Richness.

Variables	Anthropogenic Disturbance Intensity	Habitat Quality Index (HQI)	Mammal Species Richness
Anthropogenic Disturbance Intensity	1.000	−0.760**	—
Habitat Quality Index (HQI)	−0.760**	1.000	0.810***
Mammal Species Richness	—	0.810***	1.000

Note:

- ****** Correlation is significant at $p < 0.01$.
- *** Correlation is significant at $p < 0.001$.
- — = Correlation not reported or not calculated in the present study.

Table 3: Correlation Analysis Between Habitat Quality and Anthropogenic Disturbance.

S. No.	Independent Variable	Dependent Variable	Pearson's Correlation Coefficient (r)	Coefficient of Determination (R^2)	Significance Level (p-value)	Strength of Relationship
1	Anthropogenic Disturbance Intensity	Habitat Quality Index (HQI)	−0.760	0.578	<0.01	Strong Negative
2	Habitat Quality Index (HQI)	Mammal Species Richness	0.810	0.656	<0.001	Strong Positive

V. DISCUSSION

The present study demonstrates that livestock grazing and forest resource extraction are the primary anthropogenic disturbances influencing habitat quality and wild mammal diversity in Bagdara Wildlife Sanctuary, Singrauli District, Madhya Pradesh. The observed spatial variation in disturbance intensity clearly indicates that forest areas located near villages and access routes experience greater ecological pressure than the relatively undisturbed interior forest. Similar patterns have been reported from protected areas across central India, where increasing human dependence on forest resources has resulted in habitat degradation and altered wildlife distribution (Jhala et al., 2021; Maxwell et al., 2020). The concentration of grazing and extraction activities in easily accessible locations suggests that proximity to human settlements remains a key factor determining disturbance intensity.

The significant decline in canopy cover from 78.6 ± 5.2% in low-disturbance sites to 54.8 ± 7.1% in highly disturbed areas confirms that continuous anthropogenic activities adversely affect forest structure. Reduced canopy cover, poor shrub development, and limited natural regeneration observed in disturbed sites indicate deterioration of habitat quality. These findings are consistent with the observations of Haddad et al. (2015), who reported that habitat degradation and fragmentation reduce vegetation complexity and compromise the ecological integrity of forest ecosystems. Similarly, FAO (2022) emphasized that unsustainable extraction of fuelwood and non-timber forest products gradually diminishes forest productivity and habitat suitability for wildlife.

Livestock grazing emerged as the most widespread disturbance throughout the sanctuary. Continuous grazing and trampling reduced herbaceous vegetation and damaged regenerating seedlings, thereby limiting the availability of forage and shelter for wild mammals. Such habitat modification may also intensify competition between domestic livestock and native herbivores. These observations corroborate the findings of Schieltz and Rubenstein (2016), who concluded that excessive livestock grazing negatively affects vegetation structure and wildlife habitats in tropical ecosystems. The additional impact of fuelwood collection and repeated lopping further reduced canopy continuity and increased forest openness, exposing wildlife to greater human disturbance.

The sanctuary supported a relatively rich mammalian assemblage, with 22 species belonging to 14 families and 7 orders. Chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), and wild boar (*Sus scrofa*) were the most frequently encountered species, reflecting their adaptability to the dry deciduous forests of central India. However, the decline in species richness from 20 species in low-disturbance sites to 13 species in highly disturbed habitats demonstrates that increasing anthropogenic pressure adversely influences mammalian diversity.

Larger carnivores and disturbance-sensitive species were largely confined to dense forest interiors, indicating their preference for habitats with minimal human interference. Similar trends have been documented by Burton et al. (2015), who reported that camera-trap studies consistently show reduced occupancy of sensitive mammals in disturbed landscapes.

The 41.3% reduction in camera-trap detection frequency of medium- and large-sized mammals in heavily disturbed areas further highlights the influence of human activities on wildlife habitat use. Frequent human presence associated with grazing and resource extraction may alter animal movement patterns and reduce the use of disturbed habitats. Gaynor et al. (2018) similarly observed that mammals exposed to persistent human disturbance often modify their behaviour by avoiding areas with high human activity or shifting their activity to nocturnal periods.

The correlation analysis provides strong statistical evidence supporting these ecological observations. The significant negative relationship between anthropogenic disturbance and Habitat Quality Index ($r = -0.76$, $p < 0.01$) indicates that increasing disturbance intensity is associated with declining habitat quality. Conversely, the strong positive correlation between habitat quality and mammal species richness ($r = 0.81$, $p < 0.001$) demonstrates that structurally intact forests with dense canopy cover and limited disturbance support more diverse mammalian communities. These findings agree with previous ecological studies that identify habitat quality as a fundamental determinant of wildlife diversity and distribution (Ripple et al., 2014; Morrison et al., 2012).

Overall, the results indicate that although Bagdara Wildlife Sanctuary continues to support a diverse mammalian community, sustained anthropogenic pressure is progressively reducing habitat quality and ecological suitability for wildlife. Effective conservation will therefore require regulated livestock grazing, sustainable forest resource utilization, habitat restoration, and greater community participation in protected area management to maintain biodiversity and ensure the long-term conservation of wild mammals.

VI. CONCLUSION

The present study highlights the significant influence of livestock grazing and forest resource extraction on the habitat quality and diversity of wild mammals in Bagdara Wildlife Sanctuary, Singrauli District, Madhya Pradesh. The findings reveal that anthropogenic activities are unevenly distributed across the sanctuary, with areas located near villages and access routes experiencing substantially greater ecological disturbance than the interior forest. Continuous grazing, fuelwood collection, and harvesting of non-timber forest products have contributed to reduced canopy cover, poor natural regeneration, degradation of the forest understory, and overall decline in habitat quality.

The sanctuary supports a diverse mammalian community comprising 22 species representing 14 families and 7 orders. Among these, chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), and wild boar (*Sus scrofa*) were the most frequently recorded species, indicating that these herbivores remain well adapted to the dry deciduous forest ecosystem. However, the decline in species richness from low-disturbance to highly disturbed habitats, together with the reduced detection frequency of medium- and large-sized mammals, demonstrates that increasing anthropogenic pressure adversely affects wildlife occurrence and habitat utilization. The strong negative correlation between anthropogenic disturbance and habitat quality, coupled with the positive association between habitat quality and mammal species richness, further confirms that healthy forest ecosystems are essential for sustaining mammalian biodiversity.

The study emphasizes the need for an integrated conservation strategy that combines scientific habitat management with community participation. Regulating livestock grazing, promoting sustainable harvesting of forest resources, restoring degraded habitats, strengthening protection in ecologically sensitive zones, and enhancing awareness among local communities are essential measures for minimizing human-induced pressures. Long-term ecological monitoring using camera trapping, vegetation assessment, and geospatial techniques should also be incorporated into management plans to evaluate changes in habitat condition and wildlife populations. Overall, this study provides valuable baseline information for protected area managers and policymakers and contributes to the development of evidence-based conservation strategies for the long-term protection of wild mammals and the ecological integrity of Bagdara Wildlife Sanctuary.

VII. CONFLICT OF INTEREST

Authors have no conflict of interest.

VIII. ACKNOWLEDGMENTS

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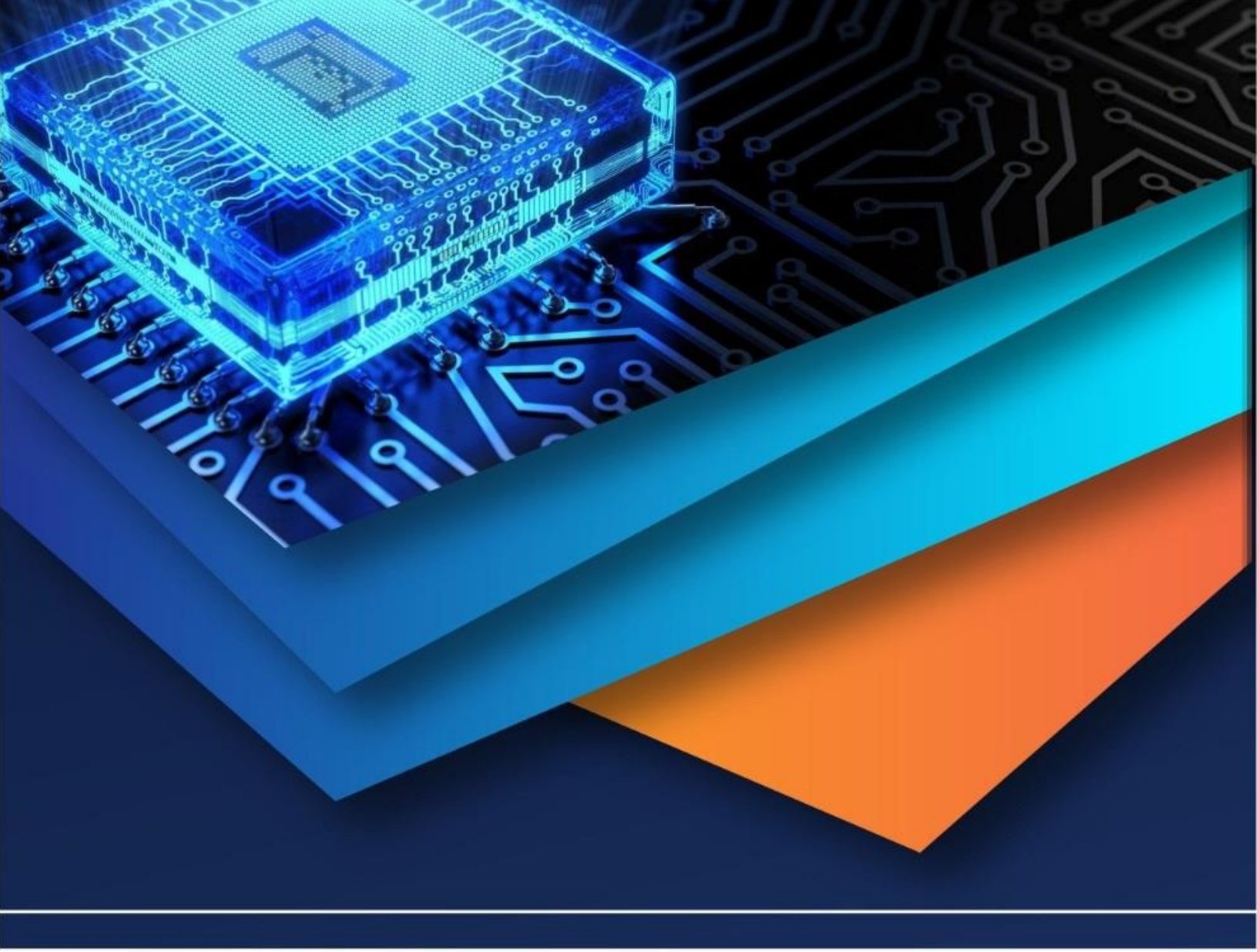

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