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Analysis of factors influencing human-wildlife conflict in the western Ghats of Tamil Nadu

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Abstract
Human-Wildlife Conflict (HWC) poses a significant threat to biodiversity conservation and rural livelihoods, particularly in ecologically sensitive landscapes like the Western Ghats of Tamil Nadu. This study employs a binary logistic regression model to investigate the key ecological and socio-economic factors influencing the occurrence of HWC at the household level. Data were collected from 400 households across conflict-prone regions through structured surveys, capturing both biophysical and anthropogenic variables. The results revealed that scarcity of essential resources (food and water), habitat loss and fragmentation, agricultural practices, urbanization, wildlife movement and increasing wildlife populations are statistically significant predictors of HWC. Among these, urbanization and resource scarcity emerged as the most influential, with odds ratios indicating a substantial increase in conflict probability. The final model demonstrated strong explanatory power (Nagelkerke $R^2 = 0.527$) and good fit based on deviance and Pearson chi-square tests. These findings underscore the need for integrated conflict mitigation strategies that address land use planning, community awareness and adaptive wildlife management.

Keywords: Human-wildlife conflict**,** logistic regression, Western Ghats, habitat fragmentation, agricultural encroachment, urbanization, wildlife conservation

Introduction

The interaction between expanding human settlements and natural ecosystems has increasingly led to frequent and often violent encounters between humans and wildlife. This phenomenon, known as Human-Wildlife Conflict (HWC), comprises various types of interactions, including crop raiding, livestock predation, infrastructure damage and in some cases, injuries or fatalities affecting both humans and animals (Treves *et al.*, 2006; Inskip and Zimmerman, 2009) [15, 6]. The implications of such conflicts are complex: they threaten rural livelihoods, foster negative perceptions of wildlife, trigger retaliatory killings and ultimately contribute to the decline of endangered species and the loss of biodiversity (Barua *et al.*, 2013; Woodroffe *et al.*, 2005) [2, 16].

Globally, HWC has become more common due to human-induced changes in land use, habitat encroachment and climate-related shifts in animal behavior (Nyhus, 2016) [11]. This issue is particularly acute in South Asia, where high human population density coexists with a rich diversity of animal species. In India, which is home to over 70% of the world's wild tiger population, as well as large populations of elephants, leopards, and other large mammals, the intensification of human-wildlife interactions is especially severe in biodiversity hotspots such as the Western Ghats (Karanth and Madhusudan, 2002) [7].

The Western Ghats, a UNESCO World Heritage Site, is recognized as one of the world's eight "hottest hotspots" of biodiversity (Myers *et al.*, 2000) [10]. It spans six Indian states and hosts numerous endemic and endangered species. In Tamil Nadu, the Ghats include protected areas like Mudumalai Tiger Reserve, Anamalai Tiger Reserve and Kalakad-Mundanthurai Tiger Reserve, which support populations of elephants (*Elephas maximus*), leopards (*Panthera pardus*), and sloth bears (*Melursus ursinus*). However, these species are increasingly venturing into adjacent human-dominated landscapes, leading to significant and ongoing conflict (MoEFCC, 2021) [9].

Various studies have explored the causes of HWC in India, highlighting ecological factors such as habitat loss (Ramesh *et al.*, 2022) [12], prey depletion (Athreya *et al.*, 2013) [1], and landscape fragmentation (Gubbi *et al.*, 2012) [5], along with socio-economic drivers such as population growth, land-use changes and reliance on forest resources (Barua *et al.*, 2013) [2]. Nonetheless, much of the existing literature tends to be either species-specific or location-specific and lacks a comprehensive analytical framework that integrates both ecological and human dimensions.

Although there is an abundance of qualitative studies and anecdotal evidence, there is a noticeable deficiency in rigorous quantitative analyses that assess the relative significance of various conflict-driving factors across broader landscape scales. Quantitative models such as logistic regression can effectively identify high-risk areas and key predictors of conflict occurrence by estimating probabilities based on empirical data (Treves *et al.*, 2006) [15]. Such models are particularly useful in human-dominated landscapes where multiple overlapping drivers interact dynamically and vary spatially and temporally.

This study aims to address this research gap by applying a binary logistic regression model to analyze household survey data collected from conflict-prone areas within the Western Ghats of Tamil Nadu. The model seeks to quantify the influence of ten independent variables, including resource scarcity, habitat loss, urban development, and wildlife movement, on the likelihood of HWC occurrence. By integrating both ecological and socio-economic parameters, the study aims to offer evidence-based insights that can inform conservation planning and conflict mitigation strategies. The findings are expected to be of value to government agencies, forest departments, and community-based organizations working to promote human-wildlife coexistence in the region.

Methodology

A purposive stratified multistage sampling design was employed to capture the diverse experiences of HWC across four ecologically sensitive districts in Tamil Nadu *viz*., Krishnagiri, Erode, Coimbatore and The Nilgiris. These districts were selected based on the severity of conflict, as reported by the Tamil Nadu Forest Department between 2021 and 2023. In each district, 100 respondents were selected from four villages with 25 participants from each village, using stratified sampling to ensure representation from key stakeholder groups, including farmers, livestock keepers, eco-tourism workers and residents indirectly affected by HWC. To identify individuals with direct experiences of HWC, snowball sampling was also employed. Data were collected through in-person interviews using a structured schedule developed from existing literature, expert input and preliminary testing. The interviews focused on capturing the perceptions, experiences, and coping strategies related to HWC of respondents. The final sample of 400 respondents ensured statistical adequacy for logistic regression analysis.

Logistic regression model

Binary logistic regression was used to identify the significant factors influencing the occurrence of HWC. The dependent variable was binary, whether a household has experienced HWC (Yes = 1, No = 0). The independent variables included various ecological, demographic and socio-economic factors perceived to contribute to HWC. The variables were selected based on extensive literature review, field-level consultations and pilot surveys.

Model specification

Let the dependent variable Y represent the binary response where

Y = 1, if HWC occurred (Yes)

Y = 0, if HWC did not occur (No)

Let $X_1, X_2, ..., X_{10}$ be the independent variables representing the following factors influencing HWC:

X_1: Scarcity of essential resources (food, water, etc.)

X_2: Habitat loss/fragmentation

X_3: Agriculture/land use practices

X_4: Increase in human population

X_5: Urbanization/Development

X_6: Wildlife movement and foraging behavior

X_7: Climate change affecting animal behavior

X_8: Lack of effective wildlife management

X_9: Lack of awareness/education

X_{10}: Increase in wildlife population

The logistic regression model is given by:

$$\text{Log}\,(P/(1-P)) = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10}$$

Where,

Log (P/(1-P)) is the logit (natural log of odds),

P is the probability that HWC occurs,

β_0 is the intercept,

β_1 to β_{10} are the regression coefficients.

Statistical analysis

Binary logistic regression was performed in R software (v4.2.1) using a backward elimination approach (α=0.05). Model fit and explanatory power were assessed using-2 Log Likelihood, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Pearson and deviance chi-square tests, and pseudo-R-squared (Nagelkerke R^2) and the results were presented in table1.

Results and Discussion

The logistic regression analysis identified resource scarcity, habitat fragmentation, urbanization, agricultural practices, and wildlife behavioural adaptations as significant predictors of conflict, supporting the multifactorial nature of HWC described in earlier studies (Barua *et al.*, 2013; Karanth *et al.*, 2012; Dutta *et al.*, 2016) [2, 8, 3].

Scarcity of essential resources

The regression model revealed that scarcity of essential resources such as food and water significantly increases the probability of HWC, nearly doubling the odds (OR = 1.97). The statistical significance (p<0.01) underscored the centrality of resource scarcity in driving wildlife, especially elephants and wild boars, out of their natural habitats and into villages and agricultural fields. Droughts, shrinking waterholes and the over-use of proximate forest areas for fuel and fodder have been documented to intensify these resource limitations, particularly during dry seasons (Karanth *et al.*, 2012; Ramesh *et al.*, 2022) [8, 12].

Habitat loss/fragmentation

With an odds ratio of 1.88, habitat fragmentation remained a core ecological driver of conflict, supported by a highly significant p-value. The breakdown of natural corridors, conversion of forest edges into croplands and unchecked infrastructure development had collectively forced wildlife into contact with human populations, consistent with earlier findings in the region (Sukumar, 1990; Gubbi *et al.*, 2012) [14, 5].

Agriculture/land use practices

The odds ratio (1.77) confirmed that present agricultural patterns amplified the likelihood of conflict as an issue, especially HWC-prone in districts like Erode and Coimbatore. Farms growing highly palatable crops such as maize, bananas, or sugarcane near forest peripheries are more likely to attract wildlife (Barua *et al.*, 2013) [2]. This predictor reflects the heightened risk associated with cultivating palatable crops near forest boundaries and the lack of mitigatory practices (like solar fencing).

Urbanization/development

Urbanization and infrastructure expansion nearly doubled the odds of HWC, the highest odds ratio of the model among all predictors. This variable's significance ($p<0.01$) reflected the growing interface between new settlements and wildlife habitats, with effects compounded by garbage dumps and open drains that act as attractants (Athreya *et al.*, 2013) [1]. Rapid development along migratory pathways heightens conflict, as seen in Coimbatore and Krishnagiri.

Wildlife movement and foraging behaviour

The model confirmed that adaptive changes in wildlife movement, often in response to human disturbance or environmental changes, significantly raised HWC risk (p = 0.03). Elephants and leopards are known to shift activity to night hours and utilize new travel routes (*e.g.*, culverts, human settlements) to access resources, which aligns with telemetry and field observations of Gubbi *et al.* (2012) [5].

Increase in wildlife population

Although more moderate in impact (OR = 1.80), the rise in wildlife population particularly Indian peafowl and wild boars were found to be significantly influence (p = 0.018)HWC occurrence. Indian peafowl (*Pavo cristatus*), increasingly found near protected areas and settlements, cause crop damage by raiding grains, fruits, and vegetables, leading to economic losses and more frequent conflicts (Dookia *et al.*, 2015) [4]. Wild boars (*Sus scrofa*), noted for adaptability and high reproductive rates, root in fields and forage near human habitations at night, increasing encounters and sustained conflicts (Senthilkumar *et al.*, 2020) [13]. Both species benefit from habitat fragmentation and access to anthropogenic food sources concentrating their populations near human use zones, which intensifies spatial crowding and habitat compression key drivers of conflict in the region.

Non-significant predictors

While increase in human population, ineffective wildlife management and lack of education were not statistically significant, qualitative data gathered during interviews suggest that they play supporting roles in shaping long-term conflict dynamics. Respondents frequently cited delays in compensation, inadequate fencing, and lack of awareness about reporting mechanisms as persistent frustrations. Though these may not have emerged as strong predictors in the regression model, they are essential for understanding the socio-political context of HWC and should be incorporated into broader mitigation frameworks (Treves *et al.*, 2006; Nyhus, 2016) [15, 11].

Table 1: Logistic regression analysis of factors influencing human-wildlife conflict (HWC)

Variable	β Estimate	Std. Error	z-value	P-value	Odds Ratio Exp (β)
Intercept	-1.32	0.31	-4.26	0.000	0.27
Scarcity of essential resources (food, water etc.,)	0.68**	0.26	2.62	0.009	1.97
Habitat loss/fragmentation	0.63**	0.24	2.63	0.008	1.88
Agriculture/land use practices	0.57*	0.27	2.11	0.035	1.77
Increase in human population	0.42	0.25	1.68	0.092	1.52
Urbanization/Development	0.72**	0.28	2.57	0.010	2.06
Wildlife movement and foraging behavior	0.65*	0.30	2.17	0.030	1.91
Climate change affecting animal behavior	0.18	0.32	0.56	0.573	1.20
Lack of effective wildlife management	0.40	0.27	1.48	0.139	1.49
Lack of awareness/education	0.13	0.34	0.38	0.705	1.14
Increase in wildlife population	0.59*	0.25	2.36	0.018	1.80

Model Fitting Criteria

Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	1012.314	1035.221	1000.314	--	--	--
Final Model	881.164	956.748	849.164	151.150**	10	0.000

Goodness of Fit Statistics

Test	Chi-Square	df	Sig.
Pearson	980.723	998	0.643
Deviance	849.164	998	1.000

Pseudo R-Square

Type	Value		
Cox and Snell R^2	0.491		
Nagelkerke R^2	0.527		
McFadden R^2	0.359		

Conclusion

The study underscores the complex interplay of ecological and socioeconomic factors that drive Human-Wildlife Conflict (HWC) in the Western Ghats of Tamil Nadu. HWC in Tamil Nadu's Western Ghats region was found to be primarily driven by resource scarcity, habitat fragmentation, agricultural practices, urbanization, wildlife behavioural adaptations and rising wildlife populations. Urbanization and resource scarcity have the strongest influence, nearly doubling the chances of conflict. Effective conflict mitigation requires integrated strategies focusing on sustainable land-use planning, resource management, wildlife-friendly agriculture and community involvement to balance conservation goals with rural livelihoods.

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