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REVIEW ARTICLE

Human – Monkey Conflict in Assam, Northeast India : A Review of Ecological Drivers, Socioeconomic Impacts, and Mitigation Strategies

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ABSTRACT

Human–monkey conflict involving the Rhesus macaque has emerged as a significant socio-ecological challenge across Assam and other parts of Northeast India. This review provides a comprehensive synthesis of human–monkey conflict (HMC) in Assam, integrating published literature to examine the ecological drivers, population trends, patterns of distribution, socioeconomic impacts, and existing mitigation strategies associated with increasing interactions between humans and macaques. A systematic assessment of available studies reveals that conflict is strongly associated with habitat loss, fragmentation, rapid urbanization, and increased dependence on anthropogenic food resources, compounded by the species' high behavioural plasticity. The analysis identifies distinct spatial and temporal conflict hotspots, especially in urban, peri-urban, and forest-edge landscapes. Documented impacts include economic losses, risks to human health and safety, altered public attitudes toward wildlife, and significant behavioural and demographic shifts in macaque populations. Importantly, the review highlights how human-mediated factors such as food provisioning and inadequate waste management intensify conflict dynamics. The review identifies critical research gaps, particularly in Northeast India, where studies remain sparse and fragmented despite escalating conflict incidents. The study underscores the need for integrated, long-term, and region-specific management approaches, combining habitat restoration, regulation of anthropogenic food sources, community engagement, and non-lethal mitigation strategies supported by effective policy frameworks. This work provides a consolidated foundation to guide future research and inform evidence-based conservation planning in human-dominated landscapes.

Keywords: Human–monkey conflict, Rhesus macaque, Anthropogenic food resources, Habitat fragmentation, Conflict mitigation

INTRODUCTION

Human–wildlife interactions are an increasingly prominent feature of the Anthropocene, as expanding human populations and land-use change bring people into closer contact with wild species. Among these, conflicts involving non-human primates have gained particular attention due to their ecological adaptability and behavioral flexibility (Pristonand McLennan 2013, Fuentes2008). The Rhesus macaque, one of the most widely distributed primates in Asia, exemplifies this adaptability, occupying habitats that range from dense forests to urban environments (Hasan et al. 2013,Roos and Zinner 2015). In India, Human–monkey Conflict (HMC) has become a significant socio-ecological concern, particularly in regions where rapid environmental transformation intersects with high biodiversity. The state of Assam, located within the Indo-Burma biodiversity hotspot, supports diverse primate communities but is increasingly experiencing habitat fragmentation and anthropogenic pressures (Srivastava2006, Mazumder 2014). Studies from Northeast India indicate that primate populations are responding to habitat loss and degradation by shifting their distribution and foraging behaviour, often moving closer to human settlements (Srivastava et al. 2001).
HMC manifests in a variety of forms, including crop raiding, food theft, property damage, and aggressive encounters. Empirical studies across South Asia and beyond highlight that these conflicts are not isolated events but follow recognizable patterns shaped by ecological and social variables (Marchal and Hill 2009, Dittus et al. 2019). Moreover, aggression and conflict intensity have been linked to factors such as provisioning, human population density, and group composition of macaques (Beisner et al. 2014). In Assam specifically, localized studies from regions such as Barak Valley, Karimganj, and Guwahati document recurring conflict scenarios involving crop loss, urban intrusion, and human safety concerns (Dutta et al. 2015, Deb et al. 2014, Dutta et al. 2024).

Importantly, HMC is not purely ecological, it is deeply embedded in human perceptions and cultural practices. In many parts of India, macaques are tolerated or even provisioned due to religious beliefs, which can inadvertently reinforce their dependence on anthropogenic food sources and increase the likelihood of conflict (Imam and Yahya2001, Anand and Radhakrishna2020). Public attitudes and long-term coexistence histories play a crucial role in shaping both the intensity of conflict and the success of mitigation strategies (Nahallageet al. 2008, Dittus et al. 2019).
Research on distribution and population dynamics provides insight into how macaque populations respond to environmental pressures and habitat change (Hasan et al. 2013, Srivastava 2006). Studies on activity patterns and behavioural ecology reveal how macaques adjust their daily routines and resource use in human-modified landscapes (Altmann 1974, Ganguly and Chauhan 2018). Furthermore, foundational work on social structure and behaviour highlights the role of dominance hierarchies, group dynamics, and reproductive strategies in shaping responses to both environmental and anthropogenic challenges (Chance 1956, Bercovitch 1997). In Northeast India, and particularly in Assam, there is a growing body of research that underscores the context-specific nature of human–monkey conflict. Case studies from urban and peri-urban environments, such as Guwahati, demonstrate how temple provisioning, waste availability, and habitat fragmentation contribute to increased human–macaque interactions (Bhuyan 2024, Das and Bharali2025). Similarly, studies from rural and forest-edge landscapes reveal how agricultural practices and forest dependency influence conflict patterns (Dutta et al. 2015, Das and Mandal 2015).Despite a growing body of literature on human–primate interactions across South and Southeast Asia, significant gaps remain in the context of Assam and the broader Northeast India. While regional studies have documented the occurrence and immediate impacts of human–macaque conflict such as crop damage and urban intrusion (Dutta et al. 2015, Deb et al. 2014, Dutta et al. 2024), there remains a clear lack of long-term, behaviourally informed research that explains the underlying drivers of persistence and escalation in these conflicts. Much of the existing work in Assam is descriptive and site-specific, with limited integration of activity budgeting, social structure, and population dynamics, which are crucial for understanding adaptive responses in rhesus macaque (Altmann 1974, Ganguly and Chauhan 2018). Furthermore, comparative and landscape-level studies remain scarce, restricting broader generalizations. This gap hinders the development of effective, evidence-based mitigation strategies tailored to the unique socio-ecological conditions of Northeast India.

Distribution and Population Dynamics of Rhesus macaque

The Rhesus macaque (*Macaca mulatta / M. mulatta*) is one of the most widely distributed non-human primates, occurring across a broad geographic range in South and Southeast Asia, including India, Nepal, Bangladesh, Bhutan, and parts of China (Roosand Zinner 2015). Distribution patterns of Rhesus macaques are not uniform but are shaped by a combination of ecological and anthropogenic factors (Table 1). Key determinants include food availability, vegetation structure, climatic conditions, and the degree of human disturbance. Empirical studies indicate that macaque populations are unevenly distributed across habitats, with higher densities often observed in areas where resources are abundant and easily accessible (Hasan et al. 2013) (Table 1). In India, *M. mulatta* is widely distributed across multiple ecological zones, ranging from the Himalayan foothills to the plains and urban centres. Its increasing presence in urban and peri-urban environments is particularly notable, highlighting its capacity to exploit anthropogenic niches (Shukla et al. 2019). In resource-rich environments, particularly urban and peri-urban areas, macaque populations often show higher growth rates due to increased reproductive success and reduced mortality (Ganguly and Chauhan 2017, Shukla et al. 2019). In contrast, populations in degraded forest habitats may decline due to resource scarcity and habitat fragmentation (Srivastava et al. 1998). The North eastern region of India, including Assam, represents an ecologically significant area for primate diversity. Although Rhesus macaques are widely present in this region, their distribution is increasingly influenced by habitat fragmentation, deforestation, and expanding human settlements (Mazumder 2014). In Northeast India, R Rhesus Rhesus macaques are found in a variety of habitats, including reserve forests, tea plantations, and human-modified landscapes (Mazumder2014). However, increasing anthropogenic pressures such as deforestation, agricultural expansion, and urbanization have significantly altered habitat availability. As natural habitats decline, macaques are increasingly forced to exploit human-dominated environments, where food sources such as household waste and religious offerings are readily available (Bhuyan 2023).

Behaviour and Social Structure

The behavioural ecology and social structure of the Rhesus macaque play a fundamental role in explaining its exceptional ability to adapt to human-dominated environments. As a highly social and behaviourally flexible primate, the species exhibits complex group dynamics, learning capacity, and ecological responsiveness, all of which contribute to its success across a wide range of habitats from forests to densely populated urban areas (Chance 1956,Bercovitch 1997). Rhesus macaques typically live in multi-male, multi-female groups characterized by stable dominance hierarchies and matrilineal social organization (Chance 1956). These hierarchies regulate access to resources, mating opportunities, and social interactions within the group. Grooming, alliance formation, and kinship bonds are central to maintaining group cohesion and reducing internal conflict (Drickamer 1976). At the same time, intergroup interactions can be competitive and, at times, aggressive, particularly in areas where resources are limited or unevenly distributed (Hausfater 1968). One of the most significant aspects of Rhesus macaque behaviour is its flexibility in response to changing ecological conditions. Early observational studies established that primate behaviour can be systematically studied through structured sampling methods, revealing patterns in time allocation and activity (Altmann 1974). Subsequent research has shown that Rhesus macaques adjust their activity budgets depending on habitat type and resource availability. In human-dominated landscapes, for instance, macaques often allocate more time to foraging on anthropogenic food sources and less time to natural foraging activities (Ganguly and Chauhan2018). Behavioural plasticity is further evident in the ways macaques modify their foraging strategies and movement patterns in urban and peri-urban environments. Studies have documented increased boldness, reduced fear of humans, and the development of innovative behaviours such as food snatching and use of man-made structures for movement and shelter (Imam and Yahya 2001, Beisner et al. 2014). These behaviours are often socially learned and transmitted within groups, indicating a strong role of cultural transmission in shaping adaptive responses.

Social structure also influences how macaque groups respond to conflict situations. Research suggests that group composition, sex ratio, and dominance relationships can affect levels of aggression and risk-taking behaviour (Beisner et al. 2012). For example, groups with higher competition for resources may exhibit increased aggression,

both within the group and toward humans. Additionally, reproductive strategies and mating behaviours, shaped by social hierarchy, contribute to population stability and resilience in changing environments (Bercovitch1997, Drickamer1974).Comparative studies with other macaque species further highlight the adaptability of Rhesus macaques. While species such as the Assamese macaque may exhibit more habitat-specific behaviors, Rhesus macaques demonstrate a broader ecological tolerance and greater behavioral flexibility (Khatri et al. 2020). In regions like Assam and Northeast India, these behavioural and social traits are particularly significant. Increasing urbanization, habitat fragmentation, and human provisioning create environments where macaques must continuously adjust their behavior to survive. Observations from urban populations indicate that macaques develop site-specific behavioral patterns, often centered around temples, markets, and residential areas where food availability is consistent (Bhuvan, 2024, Das and Bharali, 2025).

Human–Monkey Conflict (HMC)

HMC has emerged as a widespread and persistent challenge across many parts of Asia, particularly in regions where human-modified landscapes overlap with primate habitats. Among the species most frequently involved is the Rhesus macaque, whose ecological flexibility and opportunistic foraging behaviour enable it to thrive in close proximity to humans (Hasan et al. 2013, Priston and McLennan 2013). This adaptability, while beneficial for the species, often leads to increased competition for resources, resulting in a range of conflict situations that affect both human livelihoods and macaque populations. HMC typically manifests in forms such as crop raiding, food snatching, property damage, and, in some cases, physical aggression. Studies across different geographical regions have consistently shown that these interactions are not random but follow identifiable patterns influenced by habitat alteration and human practices (Marchal and Hill 2009, Dittus et al. 2019). In agricultural landscapes, macaques frequently raid crops due to the availability of high-energy food sources, which are often more predictable and nutritionally rewarding than wild foods (Marchal and Hill 2009). Similarly, in urban and peri-urban areas, the presence of open garbage, deliberate provisioning, and food waste creates conditions that encourage macaques to enter human settlements (Imam and Yahya 2001).

In India, the intensity and nature of human–monkey conflict vary across regions but are closely linked to anthropogenic pressures such as deforestation, urban expansion, and land-use change. Research suggests that many conflict situations arise not solely due to macaque behaviour but as a consequence of human-induced environmental changes that alter natural resource availability (Anand and Radhakrishna 2020). This perspective reframes human–monkey conflict as, in part, a “human–human conflict,” where differing land-use priorities and management strategies create ecological imbalances that affect wildlife (Anand and Radhakrishna 2020). Furthermore, studies on aggression in Rhesus macaques indicate that factors such as group size, provisioning, and human crowding significantly influence the likelihood of aggressive encounters (Beisner et al. 2014). The situation in Assam and Northeast India reflects both global patterns and region-specific dynamics. In forest-edge and rural areas such as the Barak Valley and Karimganj, conflicts are primarily associated with crop damage and resource competition, often leading to economic losses for local communities (Dutta et al. 2015, Deb et al. 2014). These conflicts are exacerbated by habitat fragmentation and the degradation of forest resources, which push macaques to rely more heavily on cultivated crops and human settlements. Another important dimension of HMC is the role of human perception and cultural attitudes. In many parts of India, macaques hold religious and cultural significance, which can lead to tolerance or even active provisioning (Imam and Yahya 2001). While such practices may reduce immediate hostility, they often contribute to long-term problems by encouraging dependency on human-derived food and increasing population densities in urban areas. Studies from Sri Lanka and other regions further demonstrate that public perception strongly influences the success of conflict mitigation strategies, highlighting the need for community-based approaches (Nahallage et al. 2008, Dittus et al. 2019). Importantly, human–monkey conflict is not uniform across landscapes but varies according to ecological conditions, human activities, and the behavioural adaptability of macaque groups. Comparative studies indicate that different macaque species and populations exhibit varying responses to human presence, shaped by local environmental and social contexts (Fuentes 2008, Roosand Zinner 2015).

Pattern of HMC

Human–monkey Conflict exhibits structured spatial, temporal, and behavioural patterns rather than occurring randomly, reflecting the interaction between ecological conditions and human activities (Pristonand McLennan 2013, Ahsan and Uddin 2014) (Table 2). Across South Asia, conflict frequency is consistently higher in areas where macaques have predictable access to anthropogenic food and where human presence is regular. Empirical evidence from Bangladesh demonstrates that macaque populations living in close proximity to human settlements rely heavily on human-derived food, resulting in frequent interactions that often escalate into competition and aggression (Ahsan and Uddin2014). Similarly, long-term observations in Sri Lanka indicate that conflict intensity has increased over time due to habitat encroachment and expanding human populations, reinforcing the role of habitat overlap and resource competition as primary drivers (Dittus and Gunathilake 2019). Spatially, HMC is most pronounced in urban and semi-urban environments, where Rhesus macaques (*Macaca mulatta*) have successfully adapted to anthropogenic landscapes. Studies from Delhi NCR reveal significantly higher conflict incidences in urban areas compared to rural settings, largely due to the availability of concentrated food resources and high human density (Ganguly et al. 2018) (Table 2). Within urban landscapes, conflict is not evenly distributed but is concentrated in localized "hotspots" characterized by consistent food availability, including unmanaged waste sites, markets, and areas associated with religious provisioning. In Assam, particularly in Guwahati, such hotspots are evident around temple complexes, residential zones, and institutional campuses, where macaques are attracted by food offerings and organic waste (Bhuyan 2023).

In contrast, rural and forest-fringe areas exhibit conflict patterns closely linked to ecological boundaries. Villages located near forest edges experience higher interaction rates due to direct spatial overlap between human settlements and macaque habitats. Research from southern India indicates that aggressive encounters are more frequent in settlements adjacent to forests, while crop raiding extends further into agricultural fields (Karayathil et al. 2023). Similar findings from the Najibabad forest division show that macaques cause significant damage to crops, orchards, and household property in areas near forest boundaries (Rathi and Bhatt2020). In Northeast India, including regions such as the Barak Valley, forest-fringe communities are particularly vulnerable due to overlapping resource use, where both humans and macaques depend on agricultural produce and surrounding vegetation (Dutta et al. 2015).
Temporal patterns further structure HMC, with clear seasonal and daily variations. Seasonal trends observed in Delhi NCR indicate that conflict peaks during summer, followed by post-monsoon and winter periods, with lower incidence during the monsoon (Ganguly et al. 2018). These variations are primarily driven by fluctuations in natural food availability and climatic conditions. During periods of resource scarcity, particularly in summer, macaques are more likely to exploit anthropogenic food sources, increasing the frequency of incursions into human settlements. Conversely, when natural food resources are abundant, reliance on human-derived food decreases, leading to reduced interaction rates. Daily activity patterns also influence the timing of conflict. As diurnal primates, Rhesus macaques are most active during daylight hours, with peak activity typically occurring in the morning and late afternoon. In human-dominated environments, macaques often synchronize their activity patterns with human routines. Consequently, conflict incidents are more frequent during periods of high human activity, such as morning market hours, midday religious feeding, and evening waste disposal (Adhikari and Chakraborty2024).

Behaviourally, HMC encompasses a spectrum of interactions ranging from low-intensity disturbances to severe aggression. Common manifestations include food snatching, crop raiding, property damage, house intrusion, and direct physical aggression such as biting and scratching (Ganguly et al. 2018). Studies from Tripura similarly report frequent behaviours such as stealing, garbage disturbance, and aggressive threats (Das and Mandal 2015). These behavioural patterns are closely linked to habituation and behavioural adaptation. Macaques that regularly access anthropogenic food often exhibit reduced fear of humans and increased boldness, leading to escalated interactions. Social dynamics within groups further influence conflict behaviour, dominant individuals, particularly adult males, are more likely to engage in aggressive encounters, especially in competitive feeding contexts (Beisner et al. 2014). Importantly, HMC is a reciprocal process shaped by the actions of both humans and macaques. Human behaviours such as intentional feeding, improper waste disposal, and direct provocation play a critical role in initiating and

sustaining conflict. Conversely, human responses often driven by economic loss or perceived threat can escalate interactions further (Beisner et al. 2014). In rapidly urbanizing regions such as Assam, these factors interact with habitat loss and land-use change to intensify conflict dynamics. Studies from districts like Nagaon indicate that macaques frequently enter agricultural fields and residential areas, imposing economic and social burdens on local communities (Dutta et al. 2024). Similarly, in Guwahati, the convergence of ecological conditions, urban expansion, and cultural practices creates persistent conflict hotspots, highlighting the complex and context-dependent nature of human–monkey interactions (Bhuyan 2023).

Causes of HMC

Rhesus macaques are highly opportunistic omnivores capable of exploiting crops, household waste, and food directly provided by humans. In urban and peri-urban environments, inadequate waste management and deliberate provisioning particularly at religious sites create reliable food sources that attract macaques. Repeated access to such resources leads to behavioural conditioning, whereby macaque associate humans with food. This reduces their natural avoidance behaviour, increases boldness, and elevates the frequency of direct interactions, including aggressive encounters when food is contested (Ganguly et al. 2018, Bhuyan 2023, Rathi and Bhatt 2020). Population growth and increased density further intensify conflict. In environments where food is abundant and predation pressure is low, macaque populations often exhibit high reproductive rates and reduced mortality. Studies from urban India and Northeast regions report a high proportion of juveniles and sustained population expansion under such conditions (Das and Mandal 2015, Ganguly and Chauhan 2017). As population density increases, intra-specific competition for resources intensifies, forcing macaques to expand their foraging range into human-dominated areas, thereby increasing the likelihood of conflict (Shukla et al. 2019).The inherent behavioural plasticity of Rhesus macaques is another critical factor. Their cognitive abilities and capacity for rapid learning allow them to adapt effectively to anthropogenic environments. Macaques can acquire complex foraging behaviours such as food snatching, container opening, and house intrusion. These behaviours are often reinforced through social learning, spreading within groups over time. Additionally, macaques may modify their activity patterns to align with human routines, increasing opportunities for interaction (Beisner et al. 2014, Jayapaliet al. 2023).

Human behaviour and perceptions significantly contribute to both the emergence and escalation of conflict. Actions such as feeding macaques, improper disposal of food waste, and aggressive responses toward animals directly influence macaque behaviour. Cultural and religious practices in many parts of India, where feeding monkeys is considered auspicious, further reinforce their dependence on anthropogenic food sources. At the same time, human responses often driven by economic losses or perceived threat scan escalate interactions into conflict situations. Divergent perceptions among stakeholders, including farmers, urban residents, and wildlife authorities, further complicate management efforts (Anand and Radhakrishna2020). Land-use change, particularly agricultural expansion and urbanization, is another major driver of HMC. The conversion of forests into agricultural land or urban settlements reduces natural habitats and increases habitat fragmentation. This forces macaques to move into human-dominated landscapes in search of food and shelter. Agricultural fields, in particular, offer concentrated and predictable food resources, making them frequent targets for crop raiding. Such interactions significantly impact rural livelihoods and contribute to negative attitudes toward macaques (Rathi and Bhatt 2020, Dutta et al. 2024).
Urban environments further exacerbate conflict by providing favourable conditions for macaque survival, including abundant food, shelter, and reduced predation risk. These conditions support higher population densities and sustained interaction with humans, as observed in cities such as Delhi and Guwahati (Ganguly et al. 2018, Bhuyan 2023). Environmental and seasonal factors also influence conflict dynamics. During periods of natural food scarcity, such as dry seasons, macaques are more likely to enter human settlements in search of alternative resources, increasing the frequency of encounters. Seasonal variation in human activity patterns further shapes the timing and intensity of interactions (Ganguly et al. 2018). Figure 1 shows different causes, mechanisms and outcomes of human-monkey conflict.

Impacts of HMC

HMC generates multidimensional impacts that extend beyond immediate human–animal interactions. These impacts are socio-ecological in nature, affecting human health, economic stability, social dynamics, and the behaviour and population ecology of macaques (Table 3). With increasing spatial overlap between human settlements and macaque habitats particularly in urban, peri-urban, and forest-edge landscapes, these effects have become more pronounced and interconnected (Ganguly et al. 2018, Rathi and Bhatt 2020). One of the most immediate impacts is on human health and safety. Direct encounters with macaques frequently result in physical injuries such as bites, scratches, and attacks, especially in situations involving competition over food or perceived threats. Studies from urban regions such as Delhi NCR and Mysuru report a substantial proportion of conflict incidents involving aggressive interactions that require medical attention (Ganguly et al. 2018, Karayathilet al. 2023). These injuries also pose risks of infection and zoonotic disease transmission, elevating their significance as a public health concern. Beyond physical harm, repeated encounters with aggressive or intrusive macaques contribute to psychological stress, fear, and anxiety among residents. In areas where macaques regularly enter homes and public spaces, such as parts of Guwahati and Nagaon, constant vigilance reduces perceived safety and affects overall well-being (Bhuyan 2023, Dutta et al. 2024).

The economic impacts of HMC are substantial and vary across landscapes. In rural and forest-fringe areas, crop raiding represents one of the most severe consequences. Rhesus macaques frequently damage crops and orchards, leading to direct losses in agricultural productivity and income. Such impacts are particularly significant for smallholder farmers who depend heavily on agriculture for subsistence (Rathi and Bhatt 2020, Dutta et al. 2024). In urban environments, economic losses are more commonly associated with property damage, including destruction of household infrastructure, water storage systems, and food supplies. Additionally, frequent food theft and garbage disturbance contribute to resource loss and increased household expenditure (Ganguly et al. 2018, Das and Mandal 2015).

HMC also has important social and cultural implications. Repeated negative interactions tend to alter human perceptions of macaques, shifting attitudes from tolerance to hostility. In many affected regions, macaques are increasingly viewed as pests or nuisances, which can undermine public support for wildlife conservation initiatives (Rathi and Bhatt 2020). At the same time, socio-cultural practices such as religious feeding create conflicting attitudes within communities, where reverence coexists with frustration. Furthermore, differences in perceptions among stakeholders, including farmers, urban residents, and wildlife managers, can lead to disagreements over appropriate management strategies, complicating policy implementation (Anand and Radhakrishna2020). From an ecological perspective, HMC significantly influences macaque behaviour. Regular exposure to anthropogenic food sources leads to habituation, whereby macaques become accustomed to human presence and exhibit reduced fear responses. This often results in increased boldness and the emergence of behaviours such as food snatching, house intrusion, and direct approach toward humans (Ganguly et al. 2018). Additionally, macaques may alter their activity patterns and time allocation in response to human pressure, showing increased vigilance and reduced engagement in natural social behaviours (Jayapali et al. 2023). Population dynamics are also affected by human–monkey interactions. In urban and peri-urban areas, abundant food availability and reduced predation pressures often result in higher reproductive success and lower mortality, leading to population growth (Ganguly and Chauhan 2017). Increased population density, in turn, intensifies intra-specific competition and expands the frequency of human–monkey interactions. Conversely, in natural habitats, populations may decline due to habitat degradation and fragmentation, as documented in parts of Assam (Srivastava et al. 1998).

Mitigation Strategies

HMC involving Rhesus macaques (*Macaca mulatta*) is a complex socio-ecological issue that requires integrated and context-specific mitigation strategies. Since the conflict arises from interactions among ecological disturbance, human behaviour, and macaque adaptability, no single intervention is sufficient. Instead, a combination of ecological, behavioural, community-based, and policy-level approaches is necessary to ensure both human well-being and wildlife conservation (Figure 2).

Habitat Management and Ecological Restoration: Habitat degradation, fragmentation, and loss of forest cover are major drivers of conflict, particularly in regions such as Northeast India. Reduction in canopy cover and natural food availability forces macaques to move into human-dominated landscapes (Srivastava et al. 2001, Mazumder 2014). Key measures include:

- Plantation of native fruiting and food-bearing species
- Restoration of degraded forest patches
- Development of ecological corridors to reconnect fragmented habitats

Regulation of Anthropogenic Food Sources: Access to anthropogenic food is a primary driver of conflict behaviour. In urban areas such as Delhi and Guwahati, open waste disposal and religious feeding practices attract macaques and reinforce their dependence on human environments (Ganguly et al. 2018, Bhuyan 2023). Effective mitigation requires limiting access to these resources through:

- Improved waste management (covered bins, regular disposal systems)
- Regulation or restriction of feeding practices, especially at religious sites
- Public awareness campaigns promoting "Do Not Feed Wildlife" behaviour

Reducing predictable food rewards discourages macaques from frequenting human-dominated areas.

Community-Based Conflict Management: Community participation is essential for long-term success, as local populations are directly affected by HMC. In many regions, such as Nagaon district, farmers rely on labour-intensive methods like crop guarding, which are not sustainable over time (Dutta et al. 2024). Effective community-based strategies include:

- Involving local communities in planning and decision-making
- Conducting awareness programs on safe human–macaque interactions
- Integrating traditional knowledge and local practices into management

Addressing differences in perception among stakeholders (e.g., farmers vs. wildlife authorities) is also crucial for coordinated action (Anand and Radhakrishna 2020).

Behavioural and Non-Lethal Deterrents: Non-lethal deterrents are widely used to reduce macaque incursions into human areas. These methods aim to discourage animals without causing harm. Common approaches include:

- Visual deterrents (e.g., predator models such as tiger or leopard figures)
- Auditory deterrents (noise-making devices)
- Active guarding of agricultural fields

While these methods can be effective in the short term, macaques may habituate to them over time due to their high cognitive ability. Therefore, deterrents are most effective when used alongside other strategies.

Population Management: Population growth in urban and peri-urban areas contributes to increased conflict due to higher reproductive rates and abundant food availability (Shukla et al. 2019, Rathi and Bhatt 2020). Sterilization programs have been proposed as a humane method to regulate population size. Their effectiveness depends on:

- Accurate identification and monitoring of individuals
- Long-term implementation and evaluation
- Adequate financial and logistical support

However, population control alone cannot resolve conflict without addressing underlying ecological and behavioural drivers.

Translocation and Its Limitations: Translocation has been widely attempted but shows limited long-term success. Studies indicate several challenges, including:

- High stress and mortality in relocated individuals
- Difficulty adapting to new environments
- Risk of creating new conflict zones or return migration

Due to these limitations, translocation is generally not recommended as a primary solution (Imam and Yahya 2000, Rathi and Bhatt 2020).

Policy, Governance, and Ethical Considerations: Effective mitigation requires strong institutional support and coordination among stakeholders, including wildlife departments, local communities, and urban planners. Legal protection of Rhesus macaques under national wildlife laws emphasizes the need for non-lethal and ethical approaches. Importantly, macaques are not inherently problematic, their behaviour reflects adaptation to human-induced environmental changes. Ethical management therefore requires shifting from a "pest control" perspective to one focused on coexistence and ecological balance.

Integrated Approach: Overall, no single strategy can effectively address HMC. The most successful approaches integrate multiple components, including:

- Habitat restoration and ecological management
- Regulation of anthropogenic food sources
- Community participation and awareness
- Non-lethal deterrents
- Scientific monitoring and population management
- Strong policy and governance frameworks

Such integrated strategies address both ecological and human dimensions, providing a sustainable pathway for coexistence between humans and Rhesus macaques in shared landscapes.

CONCLUSION

Human–monkey conflict involving the Rhesus macaque (*Macaca mulatta*) is an emerging conservation and management concern, particularly in rapidly changing landscapes such as Northeast India. This review indicates that conflict is driven by the combined effects of habitat loss and fragmentation, urbanization, availability of anthropogenic food resources, and the species' high behavioural adaptability. These factors increase spatial overlap between humans and macaques, leading to predictable interactions, especially in urban, peri-urban, and forest-fringe areas. The impacts are multidimensional, affecting human health, livelihoods, and perceptions toward wildlife, while also influencing macaque behaviour and population dynamics. Human practices, including food provisioning and poor waste management, play a significant role in sustaining and intensifying these interactions. Despite growing research, important gaps remain, particularly in Assam and other parts of Northeast India, where long-term, integrated studies are limited. Addressing these gaps is essential for developing effective, context-specific management strategies. Promoting coexistence ultimately requires proactive, landscape-level management that balances conservation priorities with human well-being.

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Table 1: Geographic distribution, habitat types, and influencing factors of *Macaca mulatta*

Regions	Habitat Types	Main Influencing Factors	Observations	References
Asia (South and Southeast Asia)	Forests, agricultural areas, urban habitats	Ecological generalism, climatic tolerance	Wide distribution due to adaptability	Roos and Zinner (2015)
Bangladesh	Forests, fragmented habitats	Resource availability, habitat quality	Variation in group size and composition across habitats	Hasan et al. (2013)

India	Himalayan foothills, plains, urban and peri-urban areas	Food availability, human presence	High density in urban areas due to predictable food	Shukla et al. (2019)
Northeast India (Assam)	Reserve forests, tea plantations, human-modified landscapes	Deforestation, fragmentation, human settlement	Increasing overlap with humans	Mazumder (2014)

Table 2: Spatial, behavioural, and temporal patterns of HMC involving *Macaca mulatta*

Type of Pattern	Category	Key Activity Trend	Areas in Context	References
Spatial	Urban	Highest conflict frequency	Markets, temples, residential areas	Ganguly et al. (2018), Bhuyan (2023)
	Semi-urban	Moderate conflict frequency	Expanding town areas	Ganguly et al. (2018)
	Rural	Lesser conflict frequency	Agricultural landscapes	Karayathil et al. (2023)
	Forest-fringe	High Interaction zones	Villages near forests	Rathi and Bhatt (2020), Dutta et al. (2015)
Temporal	Summer	Peak Conflict	Resource scarcity, more human dependence	Ganguly et al. (2018)
	Monsoon	Lowest Conflict	Natural food availability high	Ganguly et al. (2018)
	Post-Monsoon	Moderate Conflict	Transition period	Ganguly et al. (2018)
	Winter	Moderate Conflict	Reduced natural food in some areas	Ganguly et al. (2018)
Behavioural	Food snatching	Common (major rural issue)	Urban human interaction	Ganguly et al. (2018)
	Crop raiding	Frequent	Agricultural fields	Karayathil et al. (2023)
	Property damage	Common	Houses, storage areas	Rathi and Bhatt (2020)
	House intrusion, Garbage disturbance	Very frequent	Urban/peri-urban homes, Waste disposal sites	Das and Mandal (2015)
	Aggression (biting, scratching)	Less frequent	High human density zones	Ganguly et al. (2018)

Table 3: Major impacts of human–monkey conflict involving *Macaca mulatta*

Categories of Impact	Main Effects	Area of Context	References
Health and Safety of Human	Injuries, disease risk, and stress	Urban areas	Ganguly et al. (2018), Karayathil et al. (2023), Bhuyan (2023)
Economic	Crop loss and property damage	Rural and urban areas	Rathi and Bhatt (2020), Dutta et al. (2024), Das and Mandal (2015)
Social	Negative perception, cultural conflict	Rural and urban areas	Anand and Radhakrishna (2020)
Behavioural	Increased aggression	Rural and urban areas	Ganguly et al. (2018), Jayapali et al. (2023)
Population	Growth in urban areas, decline in natural habitats	Urban and forest areas	Ganguly and Chauhan (2017), Srivastava et al. (1998)

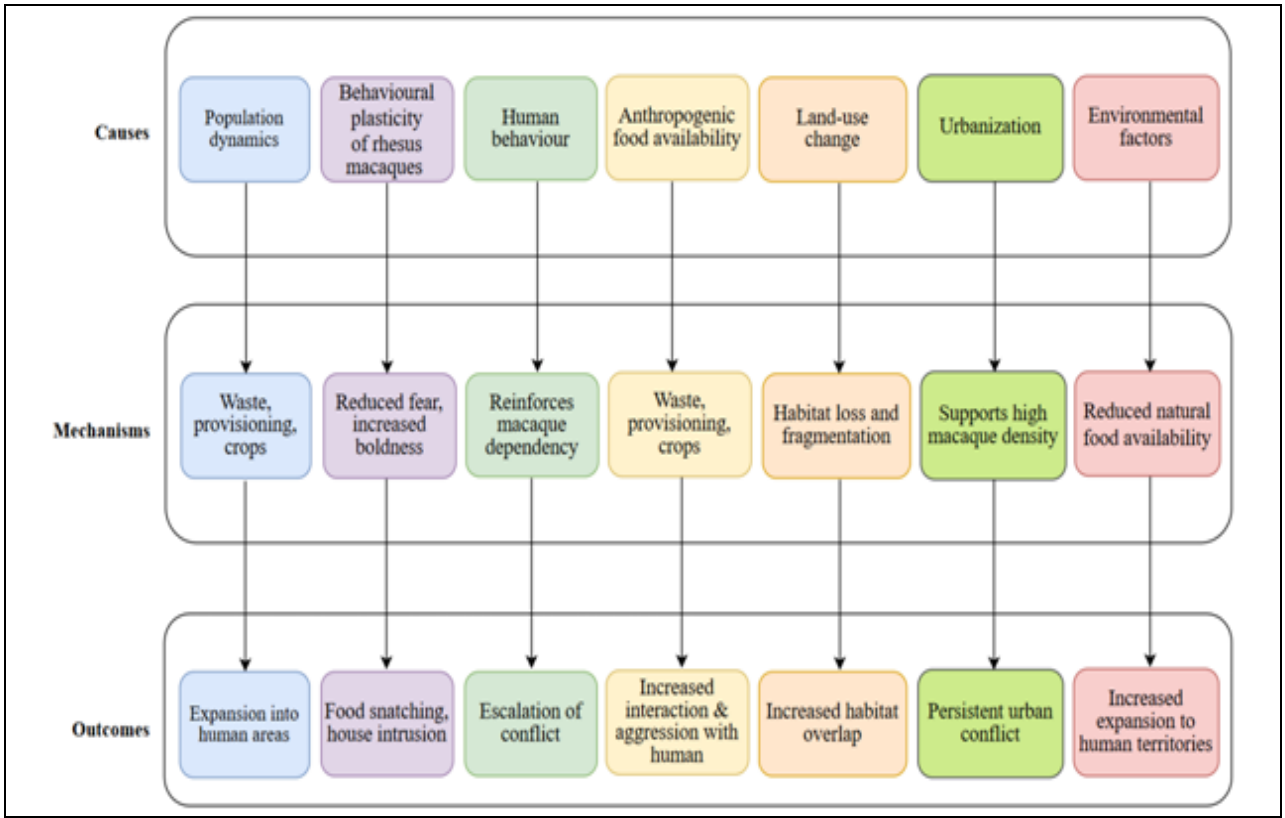

Figure 1: Major causes driving human–monkey conflict involving *Macaca mulatta* (Beisner et al. 2014, Das and Mandal 2015, Ganguly and Chauhan 2017, Ganguly et al. 2018, Shukla et al. 2019, Anand and Radhakrishna 2020, Rathi and Bhatt 2020, Bhuyan 2023, Jayapali et al. 2023, Dutta et al. 2024)

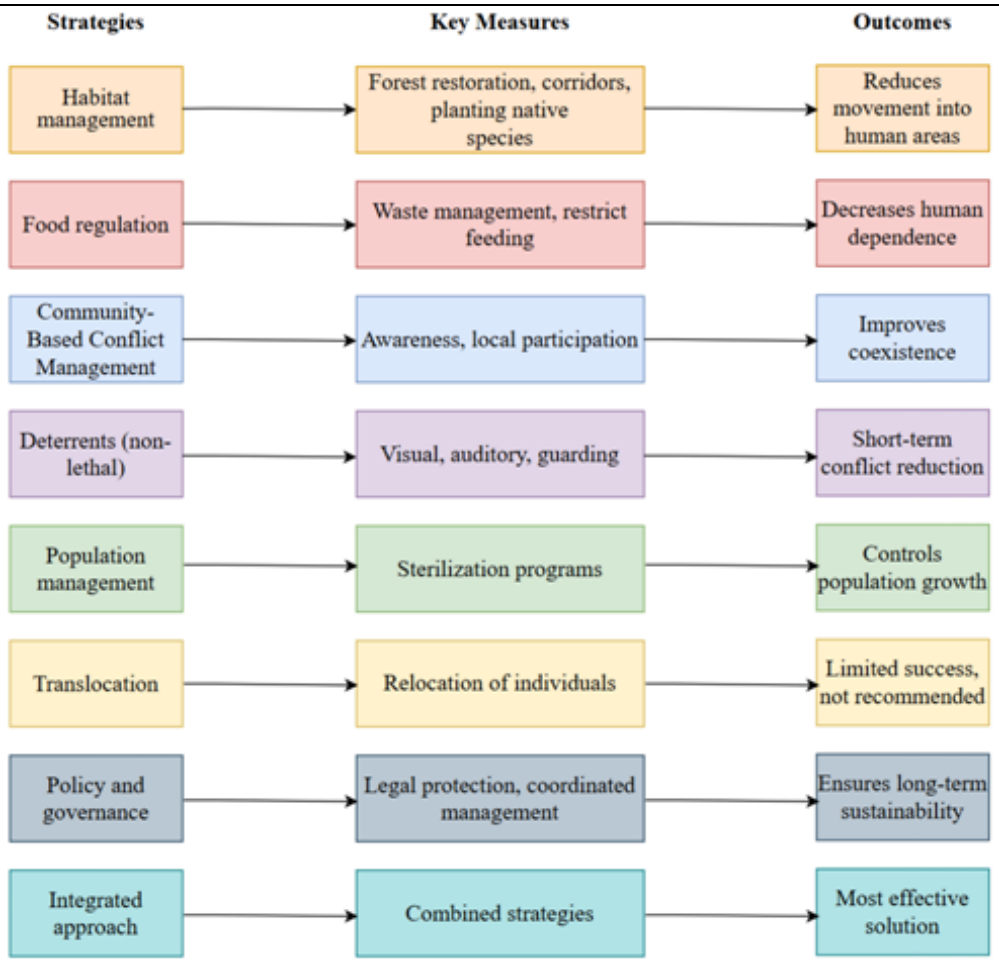

Figure 2: Mitigation strategies for human–monkey conflict involving*Macaca mulatta* (Imam and Yahya 2000, Srivastava et al 2001, Beisner et al. 2014, Mazumder 2014, Ganguly et al. 2018, Shukla et al. 2019, Anand and Radhakrishna 2020, Rathi and Bhatt 2020, Bhuyan 2023, Dutta et al. 2024)