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Analyzing the diverse spectrum of human-wildlife conflict incidents in the Virajpet division around Rajiv Gandhi National Park, Karnataka, India

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Abstract

Human-Wildlife Conflict (HWC) around Rajiv Gandhi National Park has led to notable human casualties and significant crop damage over the past 15 years. From 2005-06 to 2019-20, 66 incidents of human-elephant and human-tiger encounters were reported, resulting in 18 fatalities and 48 injuries, averaging one death and three injuries annually. Peaks in human deaths occurred in 2009-10 and 2019-20, while injuries were most frequent during 2017-18 and 2018-19, with fluctuations largely influenced by varying levels of human-wildlife interactions and an increasing wildlife population. Additionally, crop damage emerged as a major HWC impact, with 96% of surveyed farmers experiencing losses. Property damage incidents around Rajiv Gandhi National Park have significantly increased over the past 15 years, with minimal cases until 2011, followed by a steady rise, peaking in 2019-20 with over 40 reported cases the highest during the study period. Significant damage (> 25% - 50%) affected 85% of respondents, and very high damage (> 50%) affected 9%. Coffee (85%) and pepper (72%) were the most impacted crops, along with jackfruit, banana, ginger, paddy, and others. Official forest department data revealed fewer crop damage cases between 2005-2010, a sharp increase peaking in 2014-15, a brief decline in 2015-16, followed by a rising trend thereafter. These findings highlight the growing severity of HWC in the region, emphasizing the need for community-based conflict management programs, infrastructure support and conflict-sensitive land use policies. Integrating local knowledge with scientific monitoring can enhance early detection and response to wildlife presence, ultimately improving human-wildlife coexistence.

Keywords: Human animal conflict, property damage, livestock predation and crop raiding

Introduction

Human-Wildlife Conflict (HWC) refers to any interaction between humans and wild animals that results in harm to either party or damage to property, including the loss of crops (Agarwal). Such conflicts stem from a variety of direct and indirect negative encounters between people and wildlife. Several factors have fueled the global increase in HWC, such as rapid human population growth, widespread deforestation, forest degradation, and the fragmentation of natural habitats. Changes in land use for agriculture and infrastructure development also significantly contribute to the issue. Other aggravating factors include uncontrolled livestock grazing, poorly planned conservation initiatives, and the effects of climate change—such as droughts and natural disasters like wildfires. Moreover, expanded human access to national parks, biosphere reserves, and wildlife sanctuaries has further intensified human-animal interactions worldwide (Distefano, 2005) [6]. Although human-wildlife conflict has existed for centuries, the modern relationship between people and wildlife has shifted, raising greater awareness and concern. Human influence over wildlife has reshaped how these conflicts are perceived and managed, prompting stronger conservation efforts. Communities living near forest corridors heavily depend on nearby forests for essential domestic and livelihood needs, such as fuelwood, fodder, grazing areas, building materials, medicinal plants, and wild fruits. Residents often face challenges like livestock being preyed upon by leopards and tigers, and crop damage caused by wild boars, elephants, birds, and other herbivores.

Human-wildlife conflict (HWC) is increasingly recognized as a serious conservation and development challenge across the globe, particularly in regions where wildlife-rich areas intersect with densely populated rural landscapes. The growing interface between humans and wildlife is largely driven by anthropogenic pressures, including rapid population growth, deforestation, agricultural expansion, and infrastructure development, all of which fragment and reduce natural habitats (Woodroffe, *et al.*, 2005) [43]. As a result, wild animals are frequently forced into closer proximity with human settlements in search of food and space, thereby increasing the likelihood of conflict (Distefano, 2005) [6]. Such conflicts manifest in various forms depending on species and landscape context, but the most common and widespread impacts include crop raiding, livestock predation, property damage, and human injuries or fatalities. For instance, elephants and primates are notorious for causing extensive crop losses, which directly undermine

food security and rural livelihoods, especially in smallholder agricultural systems (Naughton-Treves, 1998; Hill, 2000) [27, 14]. Large carnivores such as lions, hyenas, leopards, and snow leopards are frequently responsible for livestock depredation, which poses a significant economic burden on pastoral communities (Kolowski & Holekamp, 2006; Bagchi & Mishra, 2006) [20, 1]. In many areas, encounters with wildlife also lead to serious injuries or loss of human life, which fuels fear, anger, and retaliatory behavior among affected communities (Treves *et al.,* 2006; Sillero-Zubiri and Switzer, 2001) [41, 34]. Beyond these direct effects, HWC can exacerbate broader social and psychological stress. Repeated wildlife incursions create a climate of insecurity and can lead to the marginalization of conservation efforts as communities become less tolerant of wildlife presence. When compensation schemes, conflict mitigation measures, or enforcement are weak or absent, local residents may engage in retaliatory killings or habitat destruction, intensifying the conservation crisis (Madden, 2004; Treves *et al*., 2006) [24, 41]. For example, elephants are frequently killed in retaliation for crop damage and human deaths, while predators like leopards or tigers are often targeted after attacking livestock or people. In this context, research into the patterns, drivers, and consequences of human-wildlife conflict is essential. By identifying conflict hotspots, understanding species-specific conflict behavior, and analyzing socio-economic impacts, such studies provide the evidence base needed to design effective and context-sensitive conflict mitigation strategies (Hoare, 1999) [15]. Moreover, these insights support the development of coexistence models that integrate local community needs with biodiversity conservation goals, which is vital for sustainable conservation planning in shared landscapes (Sillero-Zubiri and Switzer, 2001; Woodroffe *et al.,* 2005) [34, 43].

Human-wildlife conflict (HWC) has emerged as a significant conservation and development issue, particularly in regions where human populations are growing rapidly and expanding into formerly undisturbed wildlife habitats. The increasing conversion of natural landscapes into agricultural lands, settlements, and infrastructure corridors has intensified contact between people and wild animals, often leading to adverse outcomes such as crop damage, livestock predation, human injuries or fatalities, and property destruction (Woodroffe, Thirgood, & Rabinowitz, 2005; Distefano, 2005) [43, 6]. These conflicts are particularly severe in developing countries, where rural communities depend heavily on natural resources and have limited capacity to absorb economic losses (Madden, 2004; Naughton-Treves, 1998) [24, 27]. As a result, negative interactions with wildlife contribute to rising hostility toward conservation efforts, with retaliatory killings of wildlife increasingly reported (Treves *et al.,* 2006; Bagchi and Mishra, 2006) [41, 1].Thus, the present study aims to investigate the nature and extent of Human-wildlife conflict (HWC) in the Virajpet division around the Rajiv Gandhi national park focusing on the frequency and impact of crop raiding, human injuries or deaths, livestock depredation, and property damage, with the goal of understanding dynamic of HWC and more equitable and effective mitigation strategies.

Materials and Methods

The study was carried out in the Virajpet division, located in the central Western Ghats of the Kodagu district, Karnataka, with a focus on areas surrounding the Rajiv Gandhi (Nagarahole) National Park managed by the Karnataka Forest Department (Fig. 1). This region, characterized by its dense coffee-based agroforestry landscape, is among the areas most severely impacted by Human-Wildlife Conflict (HWC). Data related to HWC was collected from the Karnataka Forest Department and through direct engagement with residents near five forest range offices: Thithimathi, Shrimangala, Ponnampet, Kallahalla, and Nagarahole, all situated within the Virajpet Taluk. Primary data was gathered by conducting detailed interviews using a semi-structured questionnaire with local farmers (N = 30). The number of occurrences of the human wildlife conflict was enquired. An account on nature of conflict experienced was accounted. It covered nature of conflict (crop raiding, lifting of cattle, injury to cattle, human death, injury to human, damage to assets and causal encounter), animal involved and frequency of occurrence was recorded. During these interviews, information was collected regarding the extent of damage caused by wildlife to livelihoods and the general nature of conflict incidents. Additionally, open-ended questions were included to capture the community's perceptions regarding the causes of HWC events (Ramakrishnan *et al*., 1997; Ramkumar *et al*., 2014) [32, 33]. To analyze the trend of incidents caused by human-wildlife conflict around Rajiv Gandhi National Park, a linear regression analysis was conducted. The purpose was to determine the direction and strength of the relationship between years (independent variable) and number of cases (dependent variable) and suitable interpretation were drawn.

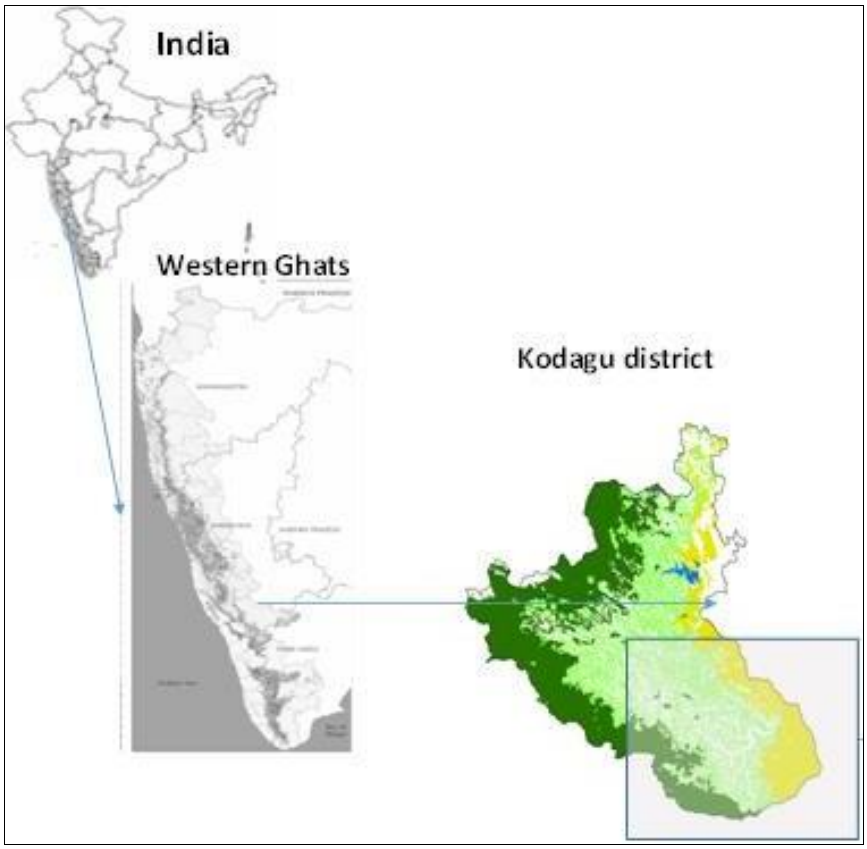

Fig 1: Study area

Results and Discussion

One of the most significant consequences of Human-Animal Conflict (HAC) in and around Rajiv Gandhi National Park is the injury and death of humans due to encounters with raiding elephants and tigers. Although the annual number of such incidents is comparatively low, the impacts on local communities are profound and often traumatic. Between the years 2005-06 and 2019-20, a total of 66 incidents involving human casualties were reported in the study area. These include 18 fatalities and 48 cases of serious injuries, averaging approximately one death and three injuries per year. The highest number of fatalities occurred in 2009-10 and 2019-20, while the greatest number of injuries were recorded during 2017-18 and 2018-19 (Fig. 2 and 3). Data sourced from the Forest Department reveals notable fluctuations in the number of reported incidents over the 15-year period. These variations appear to be closely correlated with the frequency and intensity of human-wildlife interactions, which in turn are influenced by several HAC driving factors. These factors may include habitat fragmentation, seasonal resource scarcity, human encroachment into wildlife corridors, and changes in wildlife population dynamics. Importantly, the data shows a marked increase in human casualties in recent years. This trend could be attributed to the growing population of elephants and tigers within the park, as well as an increase in repeated and close-proximity interactions between humans and wildlife. These encounters often result in significant human injuries or fatalities, posing serious challenges to both conservation efforts and community well-being. This pattern highlights the urgent need for comprehensive conflict mitigation strategies, such as improved early warning systems, better land-use planning, and enhanced community engagement programs. Proactive intervention is essential to reduce risks to human life while ensuring the continued conservation of the region's rich biodiversity.

These figures align with broader trends reported across India, where human-elephant and human-carnivore conflicts have escalated in recent decades, often with devastating consequences for affected communities (Sukumar, 2003; Rajapandian *et al.*, 2022) [37, 31].

The variability in incident frequency over the 15-year period appears to be influenced by a combination of ecological and anthropogenic factors. Habitat fragmentation and the degradation of traditional migration routes have forced wildlife especially elephants and large carnivores into more frequent and often unpredictable contact with human settlements (Sukumar, 1989; Gubbi *et al.*, 2014) [35, 13]. Seasonal scarcity of water and food resources, especially during the dry season, further exacerbates this issue, compelling wildlife to forage in agricultural fields or near human habitation (Madhusudan, 2003) [23]. Additionally, human encroachment into wildlife corridors and buffer zones, driven by agricultural expansion and infrastructure development, has increased the spatial overlap between people and potentially dangerous wildlife (Menon *et al.*, 2013) [25].

The increase in human casualties in recent years is particularly concerning. This may reflect both a rise in the populations of elephants and tigers within the park and a growing frequency of repeated, close-proximity interactions. Studies have shown that growing wildlife populations in isolated or restricted habitats can lead to increased dispersal

behavior, with dispersing individuals more likely to encounter human-dominated landscapes (Goswami and Vasudev, 2017) [11]. In such contexts, even a small number of conflict events can significantly erode community support for conservation efforts and lead to retaliatory killings or demands for animal relocation (Treves & Karanth, 2003; Barua *et al.*, 2013) [41, 3].

These patterns emphasize the need for proactive, science-based conflict mitigation strategies. Early warning systems using real-time tracking of elephant herds and dispersing carnivores have been shown to reduce fatal encounters in several landscapes (Fernando *et al.,* 2008; Wilson *et al.*, 2013) [7, 42]. Additionally, integrating land-use planning that considers wildlife corridors and buffer zones can reduce high-risk interfaces. Community-based education and engagement programs are also crucial for increasing local tolerance and preparedness, particularly when coupled with timely and adequate compensation schemes (Ogra and Badola, 2008) [28].

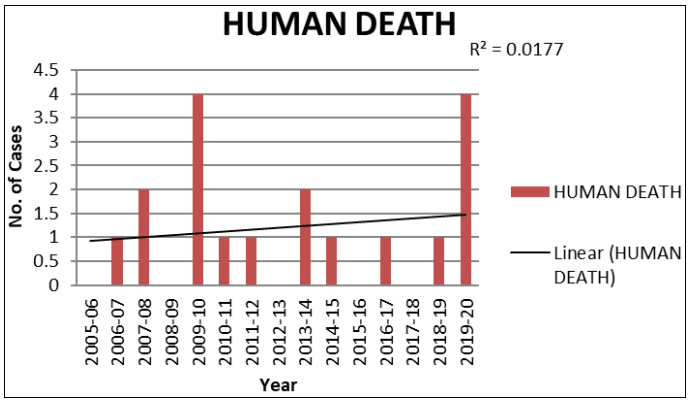

Fig 2: Number of human death due to HWC

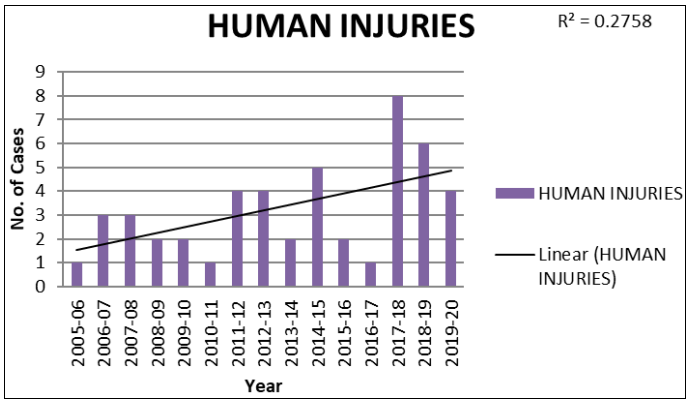

Fig 3: Number of human injuries due to HWC

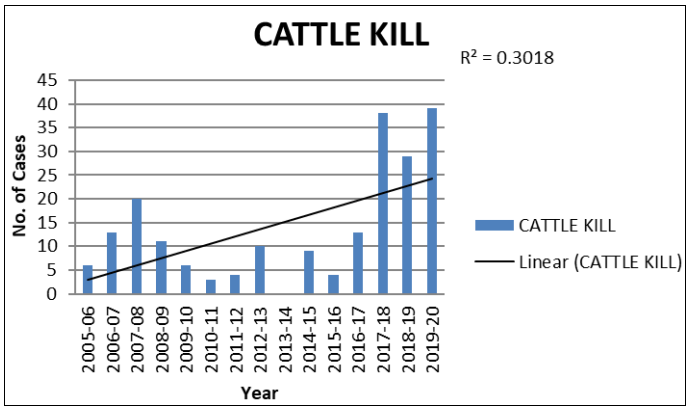

Fig 4: Number of cattle kill due to HWC

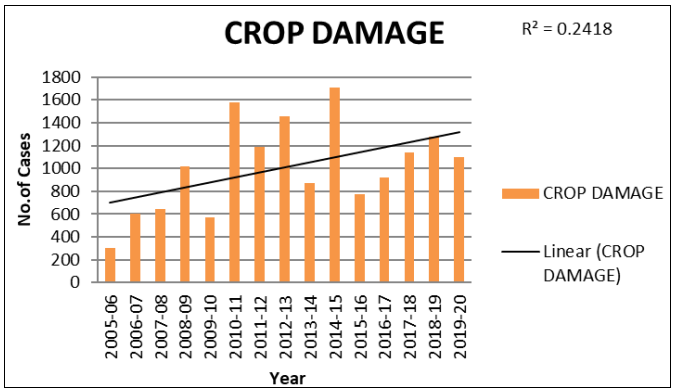

Fig 5: Number of crop damage cases due to HWC

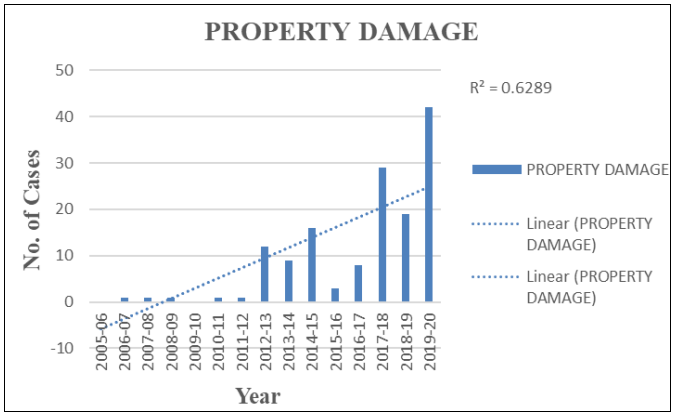

Fig 6: Number of property damage cases due to HWC

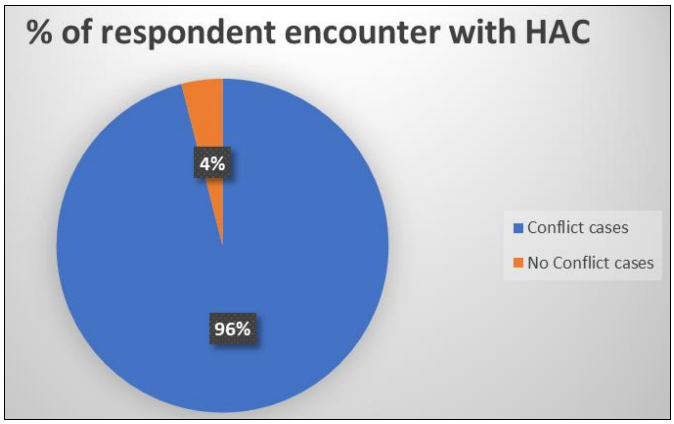

Fig 7: Per cent of respondent encounter with HWC

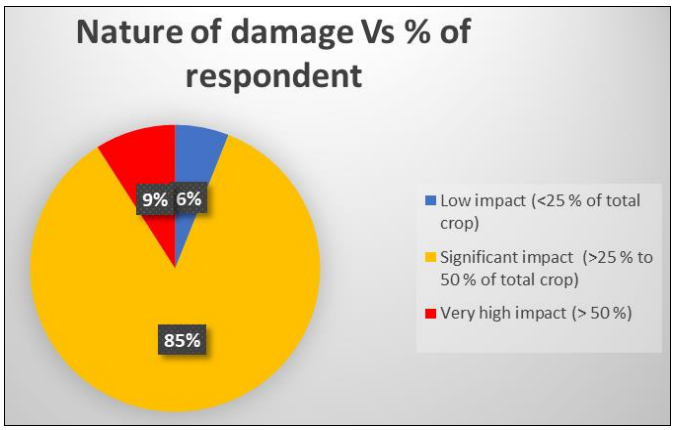

Fig 8: Nature of damage with per cent of respondent due to HWC

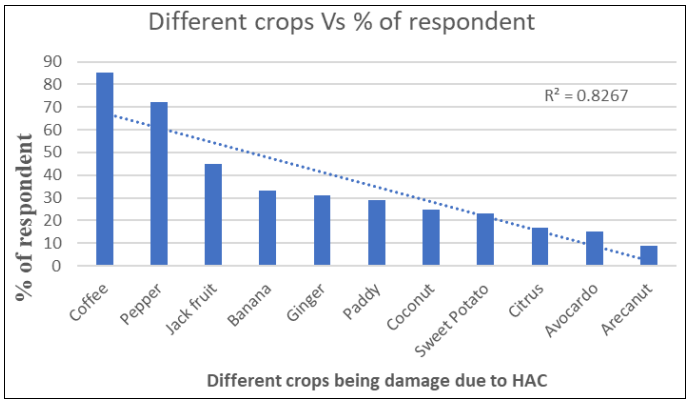

Fig 9: Different crops being damaged with per cent of respondent due to HWC

The analysis of cattle depredation incidents around Rajiv Gandhi National Park over a 15-year period (2005-06 to 2019-20) reveals a clear upward trend in human-wildlife conflict related to livestock loss. The number of reported cattle kill cases fluctuated over the years, with occasional peaks, but showed a marked increase during the latter part of the study period. Notably, the years 2016-17, 2017-18, and 2018-19 recorded the highest levels of conflict, with 36, 40, and 39 cases, respectively, representing the peak in depredation events. In contrast, during the earlier part of the time series (2005-2010), the number of cattle kill cases remained relatively lower, generally ranging between 4 to 20 cases per year. The mid-period (2010-2015) exhibited a temporary decline in conflict, with several years reporting fewer than 5 incidents. However, from 2015-16 onwards, there was a sharp and sustained rise in depredation incidents, indicating an escalation in conflict intensity. The linear trend line included in the chart ($R^2 = 0.3018$) suggests a moderate but statistically observable increase in cattle kill incidents over time (Fig. 4). Although year-to-year variability is evident, the overall trend points to a growing incidence of livestock predation likely linked to factors such as increasing predator populations, habitat encroachment, and changing land-use patterns in the surrounding areas.

The increase in cattle depredation incidents observed around Rajiv Gandhi National Park over the 15-year period highlights an intensifying dimension of human-wildlife conflict (HWC) that directly impacts rural livelihoods and community perceptions of conservation. Livestock killing by large carnivores such as tigers (*Panthera tigris*), leopards (*Panthera pardus*), and occasionally dholes (*Cuon alpinus*) is a well-documented consequence of habitat encroachment and prey depletion in protected areas (Mishra, 1997) [26]. The notable spike in cattle kill cases during 2016-19 is consistent with regional studies indicating increasing overlap between predator home ranges and human-use landscapes. One of the key drivers of this conflict is the expansion of agricultural activities and livestock grazing into buffer zones and traditional wildlife corridors, which brings domestic animals into closer proximity with predators (Madhusudan, 2003; Gubbi *et al.*, 2014) [13, 23]. In addition, declining wild prey populations in some areas due to habitat degradation and competition with livestock may compel carnivores to rely more heavily on domestic animals for food (Bagchi and Mishra, 2006) [1]. The economic consequences of cattle loss are significant, especially for small-scale farmers and pastoralists who often lack insurance or access to timely compensation. This can generate hostility toward wildlife and lead to retaliatory killings, as documented in other parts of India and globally (Treves and Karanth, 2003; Barua *et al.*, 2013) [40, 3]. A study by Karanth also found that perceptions of wildlife among rural communities are strongly influenced by the frequency and severity of livestock depredation incidents. Efforts to mitigate livestock predation have shown some success in India and elsewhere. Predator-proof corrals, community-based vigilance groups, and mobile early-warning systems are among the most promising approaches. Compensation schemes, though widely implemented, often suffer from delays and bureaucratic hurdles, limiting their effectiveness in building tolerance (Ogra and Badola, 2008) [28]. This growing trend in cattle depredation underscores the escalating nature of human-wildlife conflict in the region and highlights the vulnerability of pastoral livelihoods to wildlife incursions. The findings stress the need for targeted mitigation measures such as predator-proof livestock enclosures, timely compensation mechanisms, and community-based monitoring systems to reduce losses and foster coexistence.

Crop damage is one of the most widespread and economically devastating outcomes of Human Wildlife Conflict (HWC), particularly in regions where agricultural fields are located adjacent to or within wildlife habitats. Assessing the nature and extent of these damages is critical for understanding both the intensity of conflict and the financial burden on affected households. In the study area, wild animals such as elephants, wild boars, gaur, deer, and monkeys have been reported as the primary contributors to significant crop destruction. This ongoing conflict has imposed substantial economic losses on local farming communities. According to primary data collected from farmer respondents, 96% reported experiencing some form of HWC (Fig.7). These encounters ranged from crop damage, livestock predation, and property destruction to human injuries and fatalities. Among the various forms of conflict, crop damage emerged as the most common and impactful. When asked about the severity of crop loss, 85% of the respondents indicated that they suffered significant crop damage (25-50%), while 9% reported very high levels of damage (greater than 50%). Only 6% of respondents experienced minor losses (less than 25%) (Fig. 8). These findings underscore the high severity and widespread nature of HAC-related crop damage in the region. The major crops affected include Coffee (*Coffea robusta* and *Coffea arabica*), Pepper (*Piper nigrum*), Jackfruit (*Artocarpus*

heterophyllus), Banana (*Musa paradisiaca*), Ginger (*Zingiber officinale*), Paddy (*Oryza sativa*), Coconut (*Cocos nucifera*), Sweet Potato (*Ipomoea batatas*), Citrus fruits (*Citrus spp.*), Avocado (*Persea americana*), Arecanut (*Areca catechu*) (Fig.9)

Among these, coffee was the most frequently affected crop, with 85% of respondents reporting damage. This was followed by pepper (72%), jackfruit (45%), banana (33%), and ginger (31%). Other crops such as paddy (29%), coconut (25%), and sweet potato (23%) were also impacted, though to a lesser extent (Fig.9). The mode of destruction generally involved trampling followed by feeding, particularly in the case of larger mammals like elephants and gaur.

Historical data obtained from the Karnataka Forest Department regarding crop damage incidents between 2005-06 and 2019-20 shows distinct trends. Crop damage cases were relatively lower between 2005 and 2010, followed by a notable surge in cases between 2010 and 2015, peaking in the year 2014-15. Interestingly, the number of reported cases declined sharply in 2015-16, but began to rise again in subsequent years, indicating a resurgent trend in crop raiding by wild animals (Fig. 5).

These observations emphasize the urgent need for conflict mitigation strategies, including better land-use planning, effective crop protection methods, timely compensation schemes, and community-based wildlife management to reduce economic hardship and promote coexistence between humans and wildlife. Several investigators in Asia (Sukumar, 1991) [36] and Africa (Barnes *et al.*, 1995; Graham *et al.*, 2010) [2, 11] have proposed that, destruction of wild elephant range increases the chances of contact between human settlement and elephants, which eventually increases crop raiding. The elephants raid cultivated crops, when the availability of wild plant within their habitat is no longer sufficient (Madhusudan, 2003) [23]. Predation on livestock was another significant issue that was mentioned by the respondents. Farm animals frequently graze on land that is protected by wildlife sanctuaries (73 per cent) and protected areas (39 per cent) in India (Mishra, 1997) [26]. Therefore, livestock turns into a significant source of prey for predators (Mardaraj and Sethy, 2015) [24]. Although domestic animals were not seen grazing in the forest in this location, the significantly higher density of livestock on the edges of the forest may make them easy prey for larger predators like tigers. However, according to Osborn (2004) [30], agricultural damage from herbivores happens all year round and varies depending on the seasons. The extent of consumption and avoidance can be used to predict the food source choices of herbivores (Iason and Villalba, 2006) [16]. Crop raiding by wild animals such as elephants, wild boars, and deer is a well-documented issue in many parts of India, particularly near protected areas (Madhusudan, 2003; Sukumar, 2006) [23, 38]. Studies have consistently shown that such conflicts lead to severe economic impacts on smallholder farmers, with coffee, banana, and pepper being among the most frequently damaged crops (Chowdhury *et al.*, 2020; Jena and Dutta, 2021) [4, 17]. The situation around Nagarahole National Park mirrors these broader trends observed across similar forest-agriculture interfaces in India (Karanth and Nepal, 2012) [19].

The data reveal a significant increase in the number of property damage incidents caused by wildlife interactions around Rajiv Gandhi National Park over the 15-year period. While the initial years (2005-2011) showed minimal or no reported cases, a gradual escalation began around 2012-13, with a noticeable surge in subsequent years. The most drastic rise occurred in 2019-20, which saw over 40 cases of property damage—the highest recorded during the study period (Fig.6). The trend line with an R^2 value of 0.6289 indicates a strong positive linear relationship over time, suggesting that property damage incidents are increasing at a consistent and concerning rate. The data indicate periodic spikes, such as in 2013-14, 2015-16, and 2017-18, followed by a dramatic increase in the final year. These patterns suggest not only more frequent wildlife incursions into human settlements but also a growing intensity of such events, often resulting in severe structural damage to homes, fences, granaries, and storage facilities (Fig.6). The rising trend in property damage reflects the expanding interface between human settlements and wildlife habitats, driven largely by habitat fragmentation, agricultural expansion, and increasing anthropogenic pressure on forest ecosystems. Large mammals such as elephants, wild boars, and occasionally bears are known to cause substantial property damage when they raid villages in search of food or during migratory movement (Sukumar, 2003; Naughton-Treves, 1998) [37, 27].

Property damage can lead to severe economic strain, particularly among rural and tribal households that lack insurance coverage or access to timely state compensation. The destruction of homes and food storage infrastructure directly undermines food security, exacerbates poverty, and fosters resentment toward wildlife conservation efforts (Barua *et al.*, 2013; Ogra, 2008) [3, 28]. Studies in other Indian protected areas have shown similar trends, with increasing wildlife incursions into peripheral villages due to loss of natural foraging grounds and breakdowns in corridor connectivity (Gubbi, 2012; Goswami *et al.*, 2015) [12, 10]. Elephants, in particular, are responsible for significant damage due to their strength and behavioral tendency to revisit successful foraging sites (Fernando *et al.*, 2005) [8]. The psychological impact of property destruction, often accompanied by crop loss and fear of future raids, further erodes community tolerance. In the absence of adequate mitigation measures—such as reinforced barriers, night patrolling, and early warning systems—conflict escalates and can even turn violent, resulting in retaliatory actions against wildlife or resistance to conservation initiatives (Madden, 2004) [24]. Ultimately, human-wildlife conflict in and around the Rajiv Gandhi National Park landscape presents a complex and evolving challenge. Without comprehensive and inclusive intervention strategies, the frequency and severity of such incidents are likely to increase threatening not only human lives and livelihoods but also long-term conservation goals.

Conclusion

The 15-year analysis of human-wildlife conflict (HWC) around Rajiv Gandhi National Park reveals a clear and escalating trend in incidents, including human casualties, livestock depredation, crop damage, and property destruction. Although human fatalities and injuries are comparatively low (66 incidents, including 18 deaths), their

social and psychological impacts are profound. Livestock kills, especially during 2016-2019, and property damage—with increasing trends (R^2 = 0.3018 and 0.6289, respectively)—point to more frequent and intense wildlife incursions, largely driven by habitat fragmentation, prey depletion, and human encroachment. Crop damage remains the most widespread conflict, impacting over 85% of farmers and targeting key crops like coffee and pepper. The rising trend in cattle kills and property damage underscores the urgent need for integrated management strategies that combine ecological restoration, conflict-sensitive conservation, and active community participation. Landscape-level planning that preserves prey bases and wildlife corridors, alongside community-based conflict management programs, infrastructure support, and land-use policies, is critical. Integrating traditional knowledge with scientific monitoring can enhance early detection and response to wildlife presence, fostering long-term coexistence between humans and wildlife.

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