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Rapid assessment of human–elephant conflict: a crime science approach

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Abstract

An interdisciplinary approach has the potential not only to help solve conservation-centric problems but also to enrich and improve evidence-based scientific research. Crime science, an offshoot of criminology, provides a comprehensive, solution-oriented approach that transcends disciplinary boundaries and bridges science and practice for developing effective conservation interventions to real-life problems such as Human Elephant Conflict (HEC). This paper focuses on HEC as a conservation concern, but the resultant behaviors toward elephants, people, and their property are criminology's concern. Using the Action Research paradigm, a rapid assessment of human–elephant conflict (HEC) in India was undertaken to identify contextual solutions. This study utilized problem-oriented field research methods that enabled the gathering of data on elephant habitat-landscape, villagers' lifestyle (habitat) in the fringe areas, their current approaches in dealing with the conflict, the challenges forest officials face to mitigate HEC, and the assistance provided by district administrators to protect villagers and their corps and HEC-related deaths. The qualitative inquiry, including observation of village-forest fringe areas, focus group discussions with villagers, and interviews with forest officers and rangers, and district administrators/collectors who are handlers, guardians, and managers of the conflict space, provided rich data in identifying situational practical measures and underscored the role of crime science in providing a conceptual framework to gather evidence in addressing HEC in forest areas. The findings of the research suggest that human–animal convergence space is the source (or location) of conflict and criminology-driven situational crime prevention measures, including increasing effort, risks, reducing rewards and provocations, and removing excuses might mitigate the conflict, requiring coordinated efforts by villagers, forest and district administrators, and local law enforcers.

Keywords Interdisciplinary, Crime science, Human elephant conflict, Rapid assessment, Action research, Situation-specific measures

Introduction

The human–elephant conflict (HEC) has escalated into a major conservation concern, particularly in the Asia and Africa regions, which are elephants' natural habitats. The root cause of these conflicts can be traced back to the expanding human population and their encroachment into elephants' territories (see Gandiwa et al., 2013; Gunawansa et al., 2023; Shaffer et al., 2019; Yurike et al., 2021). The resulting spatial convergence between human and elephant habitats and the coexistence has sparked a series of territorial disputes, including crop raiding, human casualties, and retaliatory killings of elephants (see Thant et al., 2021). This escalating HEC poses a significant threat to biodiversity conservation, especially elephants' survival and habitat loss, and jeopardizes the safety, security, and property loss of those residing in and around forest areas. Over the years, HEC has been considered a conservation concern, and conservation scientists have relentlessly undertaken mitigating initiatives

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through their research and policies. It is a human–elephant coexistence issue in an evolving urbanized world demanding an understanding of human behaviors and ecosystems, entailing societal-level solutions to minimize HEC.

Conservation scientists have already recognized the limitations of a single disciplinary approach in solving conservation-centric problems and addressing the complex issue of species and ecosystem losses (Clark et al., 2001). Bennett et. al. (2017) have echoed this sentiment, advocating for an interdisciplinary approach to enrich and enhance conservation, particularly in the social sciences. They have identified 18 social science subfields, each with its unique contribution.[1] However, their comprehensive review has overlooked criminology, a crucial emerging subfield making significant strides in solving conservation problems such as wildlife crimes, illegal logging, and poaching. This paper delves into this subfield, offering a comprehensive, solution-oriented approach that transcends disciplinary boundaries and bridges science and practice which can assist conservation in providing insights into human ecology in dealing with Pohl, (2011). It specifically focuses on a new school of criminology, environmental criminology or crime science, which has pioneered a range of theories (including routine activity, crime pattern, and criminological rational choice) that explain crime events as the interaction between a motivated offender and the environment where crime opportunities are present in space and time (Brantingham & Brantingham, 1984; Clarke, 1983; Cohen & Felson, 1979; Cornish & Clarke, 1986). With four decades of empirical assessment, this criminological approach has successfully prevented and mitigated numerous crime situations (Clarke, 2018).

One of the crime science approaches is Clarke's (1980) Situational Crime Prevention (SCP), which, in contrast to most other crime prevention approaches, focuses on reducing opportunities for crime and disorder. This situational crime prevention effort can take one of five main forms or objectives: increase the difficulties of crime, increase the risks of crime, reduce the rewards of crime, remove provocations and temptations, and remove excuses for crime. To date, 25 different ways of achieving these objectives have been identified (see Clarke, 1995, 2004; Clarke & Cornish, 1985; Cornish & Clarke, 1986, 2003). Using this approach, a handful of crime scientists (they are also known as conservation criminologists) have undertaken studies on elephant poaching, tiger poaching, parrot poaching, and ranger patrols, informing conservation-oriented crime prevention research and policies (e.g. Boratto & Gibbs, 2021; Clarke et al., 2014; Delpech et al., 2021; Kahler, 2018; Kahler et al., 2023; Kurland, 2019; Kurland & Pires, 2017; Lemieux, 2014a, 2014b; Lynch & Pires, 2019; Lynch et al., 2018; Pires et al., 2012; Wilson & Boratto, 2020; Wilson & Clarke, 2019). Kahler (2018) expanded Cornish and Clarke's (2003) situational crime prevention matrix from 25 to 30 techniques for conservation under a new category. This new category, increasing the incentive for compliance, includes (1) local residents as guardians, (2) increased transparency, (3) cooperative extension education, (4) increased economic incentives, and (5) increased risks of detection. Criminology's situational crime prevention perspective can indeed be beneficial in identifying and addressing the specific situational factors that contribute to HEC. While environmental criminologists have used various location-based analyses and applied SCP measures to deal with wildlife crimes, there is scarce literature on criminology's contribution to HEC. This paper is intended to fill the void in the literature.

Driven by the law of human action, environmental criminological theories, otherwise known as crime opportunity theories, emphasize the interaction of person and environment/setting that facilitates crime, suggesting that opportunity-reducing prevention makes the environment harder for anyone to commit crimes. This interaction is fundamental to crime opportunity theories[2] that seek to explain the occurrence of crime rather than simply the existence of criminal dispositions. There are two practical benefits of focusing on opportunities: first, reducing opportunities immediately affects crime and disorders, while addressing the so-called root causes of crime can only produce results in the future, if ever. Second, any agency, whether private or public, can take action to reduce opportunities for a crime problem in its jurisdiction (Natarajan, 2017). Numerous case studies demonstrate the successful application of environmental criminology's situational crime prevention in reducing crime and disorders (Clarke, 2018).[3] Environmental criminologists have developed pathways to holistic solutions and created reliable evidence about 'what works' in preventing crime. They have studied and found solutions

[1] Included social sciences are—sociology, anthropology, political science, geography, economics, history, philosophy, psychology, conservation and development, conservation marketing, environmental and conservation law, environmental and conservation education, human dimensions of conservation, policy sciences, political ecology, science and technology, ecological economics, environmental humanities.

[2] They include Cohen and Felson's (1979) routine activity theory, the criminological bounded rational choice perspective of Clarke and Cornish (Clarke, 1985; Cornish & Clarke, 1986), and Brantingham and Brantingham's (1984) crime pattern theory. Also, see Clarke and Felson (2017).

[3] Over 200 SCP case studies can be accessible, see https://popcenter.asu.edu/content/situational-crime-prevention-database-home.

to prevent wildlife crimes in the past decade. However, it has been acknowledged that analysts are relatively rare in wildlife protection; most analytic capacity is found within the biological monitoring division of an organization, not the law enforcement units (Lemieux et al., 2022). When dealing with the interaction between wildlife and human behaviors in protected forests and fringe areas, conservation scientists could benefit from integrating years of research by environmental criminologists. This integration is necessary in using evidence-based science to integrate transdisciplinary science-stakeholder policy approaches to mitigating human–wildlife conflicts on a larger scale.

Routine activities theory (Cohen & Felson, 1979), a prominent crime science theory, deals with the three essential elements of a criminal event (offender, target, place). Applying this theory to human–elephant conflict has implications for understanding the problem and identifying the concerned stakeholders in reducing the conflicts. Suppose it is assumed that the elephants are perpetrators and the villagers are victims. In that case, the theory will lead to identifying the "handlers," the "guardians," and the "place managers" where the conflicts occur (Felson, 1994). Handlers are people closely associated with the elephants, guardians are the farm owners in the forests' fringe areas, and managers are government officials or village leaders formally authorized to monitor forest and village "convergence" sites where human–elephant conflict occurs.

In sum, in the past few decades, scholars of crime science, informed by environmental criminology, have illustrated proactive approaches to studying and identifying solutions to conservation problems, including HEC (e.g., Kahler, 2018; Lemieux, 2014a, 2014b; Moreto & Pires, 2018; Viollaz et al., 2022).

Background

The issue of human–elephant conflict is a complex, multifaceted problem that negatively affects both humans and wildlife. This conflict leads to trauma, injuries, deaths, and property damages (Dickman, 2010; Gross et al., 2021; Gulati et al., 2021; Karanth et al., 2012; Thakur et al., 2016). Many conservation researchers have made valuable contributions to understanding and mitigating these conflicts (Denninger Snyder & Rentsch, 2020; Evans & Adams, 2018; Gubbi, 2012; Hahn et al., 2017; Hoare, 2015; La Grange et al., 2022; Lenin and Sukumar, 2008; Mayberry et al., 2017; Mumby & Plotnik, 2018; Neupane et al., 2018; Ntukey et al., 2022; Nyumba et al., 2020; Prakash et al., 2020a; Sampson et al., 2019; Shaffer et al., 2019; Venkataramana et al., 2017; Virtanen et al., 2021). For example, Zeppelzauer et. al. (2015) highlighted the importance of a visual detection method for tracking elephants in wildlife videos as an acoustic early warning system using real-time audio data. Studies in African and Asian countries have shown the positive results of using various fences to protect crops involving the local community (Karidozo & Osborn, 2015; Vibha et al., 2021). In Tanzania, chili fences have proven effective in preventing crop-raiding by elephants, as elephants dislike the smell of hot chili peppers (Chang'a et al., 2016; Hedges & Gunaryadi, 2010). Research has also shown that growing chili plants not only dissuades elephants from entering the farms but has become an alternative source of livelihood for local farmers and helps deal with HEC (Pozo et al., 2019). According to König et. al. (2020), fence building has become widespread, "resulting in decreased economic losses from wildlife damage but also in the displacement of wildlife conflicts to new areas" (p. 792). Additionally, recent studies have emphasized the importance of predicting environmental impacts and temporal patterns of land use and land cover change hotspots and human–elephant conflict (see also Chen et al., 2016; Rathnayake et al., 2022; Tiller et al., 2021).

In India, human–elephant conflict (HEC) is a significant conservation issue that conservation scientists have extensively researched. This paper describes the research on HEC conducted in the forest areas of Tamil Nadu, a southern state in India. The research demonstrates the relevance of social science problem-solving methods and offers a promising direction for reducing HEC and its associated impacts, adding to the existing literature. Though the nature and extent of conflict cannot be comparable, Human–elephant Conflict (HEC) has been a persistent problem in many regions across Asia and Africa, and the situation in Tamil Nadu, India, a South Asian nation, is no exception.

Human–elephant conflict (HEC) in India

India is home to an estimated 30,000 wild elephants. In the southern state of Tamil Nadu, around 2760 elephants are found, primarily concentrated in several forest areas surrounded by villages and towns (Project Elephant India, 2017, see Tables 1 and 2). According to the Forest Survey of India (2017), the State's Recorded Forest Area in 2015 was 22,877 sq. km, 17.59 percent of the State's Geographical Area, with an estimated human population of 83.9[4] million. The forests are spread along the Western and Eastern Ghats in Tamil Nadu, and wild elephants are found in three central Tiger reserves. Government estimates of the number of people and animals (including livestock) show that the space available for both groups

[4] Estimate 2024 population of Tamil Nadu (https://www.indiacensus.net/states/tamil-nadu).

Table 1 Elephant population in India. Source: Project Elephant 2017

Indian state	Elephant population	Indian state	Elephant population
Karnataka	6049	Uttar Pradesh	232
Assam	5719	South Bengal	194
Kerala	3054	Tripura	102
Tamil Nadu	2761	Andhra Pradesh	65
Odisha	1976	Bihar	25
Utharkand	1839	Andaman and Nicobars	19
Meghalaya	1754	Manipur	9
Arunachal Pradesh	1614	Mizoram	7
Jharkhand	679	Madhya Pradesh	7
North Bengal	488	Harryana	7
Nagaland	446	Himachal	7
Chattisgarh	247	Maharashtra	6

Table 2 Elephant populations in Tamil Nadu districts. Source: Project Elephant 2017

Tamil Nadu districts	Elephant population	Tamil Nadu districts	Elephant population
Sathyamangalam TR	772	Tirunelvelii	70
Hosur	499	Gudalur	60
Mudumalai TR	294	Kalakadu TR	58
Anamalai TR	237	Nilgiri South	54
Dharmapuri	184	Megamalai	27
Nilgiri North	180	Kodaikanal	19
Erode	113	Kanniyakumari	14
Coimbatore	97	Dindigul	8
Srivalliputhur WLS	74	Tirupattur	1

has declined. Further, due to the lack of suitable forage and water, elephants overcome man-made barriers and regularly emerge from the forests. The result has been an increase in human–elephant conflict (HEC). While these conflicts might qualify for conservation concern because they happen in and around forest areas, the resultant harmful behaviors of personal and property damage by elephants and people in these locations are criminology's concern. When elephants raid crops, in the process, villagers, when defending the crops, get killed and often injured. Their properties are also damaged (see Gross et al., 2021). On occasions, villagers kill elephants in retaliation. Given this large number of elephants and their limited habitat, it is not surprising that conflicts between elephants and villagers frequently cause human and elephant deaths and are reported heavily in the media (see Desai & Riddle, 2015; Ganesh, 2019; Ramkumar et al., 2014).

Despite all the mitigation efforts in India and other Asian and African countries, the Human Elephant Conflict (HEC) continues and will continue to be a critical issue for conservation, especially the changing climate, as an emerging driver among others, including biological, ecological, and behavioral factors of habitat loss and the expanding human settlements in forest fringe areas. In India, where many millions live within a few kilometers of protected areas (Ghosh-Harihar et al., 2019), elephant attacks on people have become lethal, causing injury and deaths, leading to public outcry. Recent data from India shows that between 2009 and 2023, approximately 1300 elephants died due to unnatural causes (Azad, 2023). This highlights the urgent need for practical solutions to reduce human–elephant conflict and protect both the lives of elephants and humans.

HEC results in crop-raiding by elephants, injuries and deaths of farmers, and retaliatory killings of elephants. Though these problems seem interconnected, they are distinctive. For example, crop-raiding of elephants requires measures that are distinct from elephants destroying homes while searching for food and injuring or killing people in the process when villagers go to the forest for cattle grazing or when elephants get killed on the rail tracks. Each of these problems requires specific opportunity-reducing measures geared to the nature of the problem in extending guardianship (Cohen & Felson, 1979; Felson & Clarke, 1999) by increasing efforts and risks. Situational Crime Prevention (SCP) is a well-situated theoretical model incorporating socio-psychological, economic, and cultural contexts, operates under the premises of Action Research that is focused on specific problems by gathering appropriate data to find solutions, especially in developing countries (Clarke & Natarajan, 2018) to mitigate HEC.

The present study

This research uses a case study approach to discuss the issue of human–elephant conflict (HEC) in Tamil Nadu. It aims to demonstrate how criminology and crime science can contribute to transdisciplinary conservation research and understanding of HEC, a problem at the intersection of conservation and human activities. The study also explores the use of Rapid Assessment Methodology (RAM), a comprehensive mixed-method inquiry and an important tool that integrates SCP's Action Research paradigm to improve evidence-based scientific research for developing effective conservation and community-level interventions to address the issue of HEC in Tamil Nadu, India. Essentially, the goal of this study is not to establish universal facts and laws but to gather practical information to find solutions. This study aims,

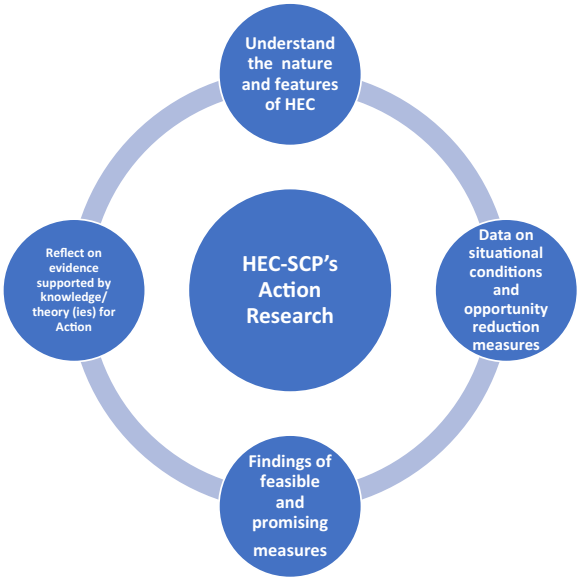

Fig. 1 Addressing human elephant conflict: SCP's action research process for data collection

specifically with the above objectives, to find answers to the following questions:

1. What are the characteristic features of HEC in Tamil Nadu?
2. What measures are in place, and what works to address the problem of HEC?
3. What is more needed to prevent the damage and deaths (both humans and elephants)
4. What actions are needed to safeguard the crops and the forests for elephant and human co-existence?
5. How can crime scientists contribute to conservation science in dealing with HEC?

Methodology

Crime science, especially its situational prevention paradigm, relies on action research (Lewin, 1946) strategies to generate shared knowledge of the causal conditions of the social/behavioral world and its attendant difficulties (Friedman & Rogers, 2009). Clarke (1997, p. 16) states that action research involves specific stages. It is like the problem-solving methodology used in problem-oriented policing and in many other forms of social intervention that can be modified depending on the nature of the SCP project. Figure 1 illustrates the spiraling process of the SCP's Action Research for data collection to address HEC.

Using the SCP's-Action Research, this research also aims to demonstrate the use of Rapid Assessment Methodology (RAM) to forewarn the need to target the "high-risk" space(s) of HEC and to describe the responses that are in place for an action plan to mitigate the harm to people and animals in the forest fringe areas. RAM is an approach to gathering contextual data with three fundamental premises: the participatory approach, methodological pluralism, and action orientation (Ndolamb, 1991). Rapid assessments comprise various qualitative methods to gain rich, in-depth perspectives on complex issues and provide quick insight into the problems to produce findings that can be translated into action for policies and future research. RAM is a rapidly evolving approach to analyzing situations to understand the context in which the problem develops, as this could be critical for the well-being of the affected population and a tool for developing responses (e.g., Beebe, 2005; Given, 2008; McNall & Foster-Fishman, 2007; Natarajan, 2016; Oliveira et al., 2023; Stimson et al., 1999). It has helped integrate SCP's problem-solving methodology, using routine activity theory, into crime prevention responses suitable for specific crime problems (Cherney, 2006, 2009; Natarajan, 2016).

Under the backcloth of the Action Research paradigm, Natarajan (2016) reports that the RAM is interdisciplinary and generates substantial, relevant, and policy-relevant timely data to understand and solve a crime problem at a relatively low cost from small samples of key informants using semi-structured interviews, focus groups, and surveys, especially for cost-effective research in developing countries. Some conservation scientists have employed RAM in their research depending on their needs in developing action plans (e.g., Ervin, 2003; Parker et al., 2018; Schaffer-Smith et al., 2016; Strange et al., 2024; Venkataraman et al., 2017).

Data collection methods

The study gathered qualitative data using a non-random purposive and convenience sampling strategy.[5] It involved naturalistic field observations, focus group discussions with villagers and Adidravidas (Indigenous people living in forest areas), interviews with forest rangers, administrators, and city administrators, and informal dialogues with NGOs. This diverse qualitative data on HEC was collected to minimize limitations in generalizability and evaluate the validity of the results. Structured focus group discussions and interview protocols were separately prepared (refer to study questions in Appendix A) to collect data.

The research followed the ethics code of the researcher's university, requesting verbal consent and assuring anonymity of the participants' locations and names

[5] Combining purposive and convenience sampling enables the researchers to select participants based on specific criteria while considering practicality and accessibility.

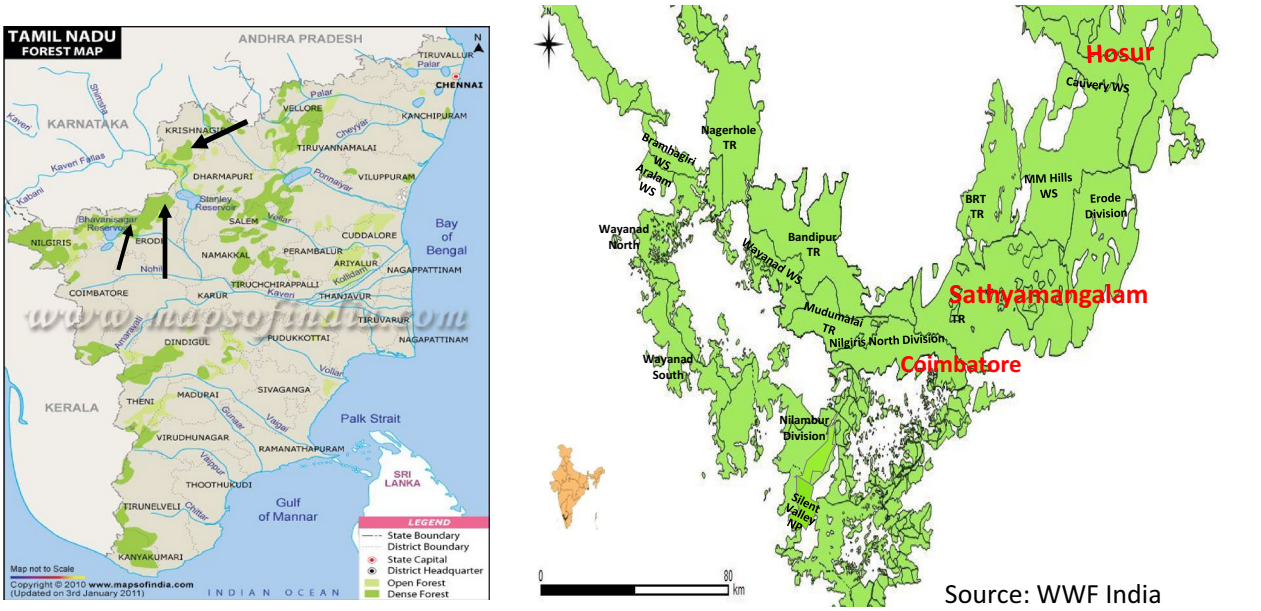

Fig. 2 Study area

to protect their identities. With the official permission of the Principal Chief Conservator of Forests of Tamil Nadu, India, this 2-year study (July 2016–August 2018) was undertaken in three major forest areas: Cauvery North Wildlife Sanctuary, Sathymangalam Tiger Reserve, and Anamalai Tiger Reserve (see Fig. 2).

Observation of the forest areas and the villages in the fringe areas

Field observation research was employed to observe the habitat features of humans and elephants in the study area at four intervals.[6] Using the ride-along[7] and transect walk method,[8] data were gathered by visiting twenty forest locations in the three forest areas/divisions: Coimbatore, Sathyamangalam, and Hosur. Riding along in these forest areas and interacting with conservation experts, forest rangers, local police, and NGOs provided a contextual understanding of the protected and fringe forest sides of the HEC problem.[9]

Focus group discussions

Data were gathered from 16 focus groups (farmers, villagers, and Adidravidas-local Indigenous/tribal people, including men and women) discussions with 110 participants in the three forest areas mentioned above. In some fringe areas, women-only discussions were only allowed, which enabled three women-only group discussions. The data include basic information about crops grown, the frequency of crop-raiding and seasonal variations, measures deployed to deter the elephants, how these are implemented, the perceived usefulness of each measure, difficulties attached to each measure, and limits to their wider deployment. Data were collected at three intervals during the day.[10] The focus group discussions ranged from 4 to 20 participants (an average of 7 participants) and took 30–60 min to complete. The discussions happened on the farms, villagers' front porches, roadsides, and in Adidravidas community open setting gathering rooms. Some participants spontaneously formed a group to speak to the researcher and her field visit team when they stopped for lunch and coffee breaks during the field visits. The researcher, a native, undertook the focus group interviews/discussions in the local language and natural settings, which made the voluntary participants comfortable sharing their views, especially obtaining the gender-inclusive voices on their premises.

[6] August 2016, January 2017, August 2017, and January 2018.

[7] With the local police, forest department staff, conservation specialists, NGOs.

[8] Widely used in observation research, especially when studying social interactions, landscapes, and activities in real-time situations.

[9] The researcher was accompanied by a team including a retired forest administrator, an internationally renowned conservation scientist, and ununiformed local police staff.

[10] Fourteen FGDs were undertaken in January and May 2017; the rest were in August 2018.

Interviews and dialogues

Unstructured interviews were undertaken with three District Collectors, 12 Forest officers, antipoaching staff and rangers, and dialogues with NGOs and conservation scientists.[11] The interview questions included the type and nature of predominant conflicts, the challenges in dealing with them in their respective jurisdictions, and how the forest department has dealt with them over the years. Formal interviews (which lasted an hour despite their busy schedule) were conducted in the offices of forest officials and district administrators with appointments. Dialogues involving NGO conversations happened during the field visits at lunch and dinner.

Results

The primary goal of this study is to enhance the understanding of human–elephant conflict (HEC) as a conservation and human-centric problem and examine it from a criminology/crime science perspective. It addresses research questions related to two main points: the distinct characteristics of HEC in Tamil Nadu and the steps taken by stakeholders to preserve the lives of elephants and humans and protect crops.

Characteristic features of HEC in Tamil Nadu

Elephants require large areas of natural habitat but suffer from habitat fragmentation and degradation (Acharya et al., 2017). The study noted that in recent years, human settlements have increasingly encroached on elephants' migratory paths, extending signs of conflicting spatial situations in and around the forest areas. Also, it was found that the landscapes with higher human density where local people frequently encountered elephants were at higher risk of elephant attacks (see Shaffer et al., 2019; Thant et al., 2021).

As observed, each Indian elephant requires many gallons of water and about 150 kg of food daily. They are herbivores and mainly eat grass, tree leaves, twigs, shrubs, bamboo, roots, flowers, wild fruits, and bananas- because grains are more nutritious than grasses, elephants seek grains when foraging. According to the study participants, elephants also raid agricultural lands, mainly crops such as sugar cane, bananas, and rice, which brings them into conflict with humans. Further, observing the elephant habitat reveals that some parts of the forest areas are rich in edible plants for elephants and have enough water. Consequently, relatively few elephants move out of these forests. However, in some places, for example, near Sirumugai, where the river basins are dry, plants are scarce, and elephants tend to forage in fringe areas where villagers cultivate. The elephants also search for water in these areas, thus causing them to come into conflict with villagers.

Focus group discussions with villagers in the fringe areas and interviews with forest rangers reveal the migratory patterns and the impact of understanding the reasons for the rowdiness of elephants in their regions. Several study participants said:

> *"Elephants migrate primarily for foraging. Female elephants invariably move in groups, but male 'tuskers" are either solitary or move in small groups, which may include other adults and young bulls."*
> *"The elephants frequently raid when crops are ripe from January to May. After that, they may return to the forest, which we call reverse migration, and the distance the elephants cover varies from individual to individual, group to group, and year to year."*
> *"The poachers killing the tuskers (who manage the young ones) had deprived the young males of role models. In the absence of "paternal' guidance, when the young ones find a "food" niche during their migration, they tend to stay put and may become unruly "problem elephants" when humans are in their way."*

Agriculture is the dominant land use and most prominent source of livelihood for a sizable proportion of the Indian population (see the Food and Agriculture Organization (FAO) report—Kumar et al., 2018; Sharma, 2016), and Tamil Nadu is no exception. The study observation found that land close to forests is usually fertile, and wealthy or poor farmers prefer that land for cultivating specific crops. Several village participants in the focus group discussions said:

> *"Farmers prefer high-yield crops, such as sugar, ragi, maize, and bananas (annual crops), which are primarily seasonal because they are low maintenance in terms of human labor and irrigation (if "bore wells" are dug and water is channeled through pipes)."*

The Adidravidas, the Indigenous/tribal people of Tamil Nadu, the study participants who live in the forest areas, said that they know the movement patterns of all animals and take self-measures resonating with Felson and Clarke's (2010) "routine precautions" to protect themselves from animal attacks. Because of the lack of toilets at home, many study Adidravidas participants said they go into the forest for toiletry, especially in the late

[11] The researcher attended a seminar (held under the leadership of the Forest Head at the Advanced Wildlife Management Training Center in one of the research sites) on mitigation measures of HEC in Sri Lanka by a Sri Lankan conservation scientist. It was an informative lecture as part of professional development for the local staff and officers to learn about what other countries are trying to deal with. At the conference, the researcher met a couple of international speakers (who are conservation scientists).

evening and at night. By doing so, they risk being injured or killed by elephants. Further, going into the forest to graze cattle and collect firewood and honey also poses high risks for elephant attacks on humans and cattle by other carnivores. (Please see the photos in Appendix B of the injury caused by the elephant during the field visit).

Some farmers watch their farms during the night in the villages. They may take routine precautions to protect themselves, but wild elephants are very clever and can sense human movements and actions. In a noted incident during the study, a villager was hurt by an elephant, and, according to his account,

> *"When the elephant stamped on me, I did not get up but pretended to be dead. The elephant returned to see if I was alive (moving or not), and since there was no movement, it went away. After waiting for some time, I managed to get help. I am now undergoing treatment for fractured bones (see photos in Appendix B)."*

Gathering firewood for personal use or sale from the forest areas in India is a common practice. Focus group discussions involving only women revealed that despite taking precautions, villagers, especially women and young girls, who are sent into the forest to collect firewood, may still face injuries and even death due to the unpredictable behavior of elephants. In addition to injuries caused by elephants (refer to Appendix A), other carnivores in the forest may completely consume human victims, leaving no evidence of their deaths.

The study findings show that some conflicts occur in towns between hills. In such situations, barriers and checkposts allow people to enter the forest at odd hours. Some drive through the forest on two-wheelers in the late evenings and nights. They may encounter elephants inside the forest areas, thus putting them at risk of elephant attacks. Also, it is important to note that sizable numbers of elephants are purposely killed in retaliation using high-voltage electric fences.

The study revealed that Human–Elephant Conflict (HEC) is a significant issue in Tamil Nadu due to elephants' recent changes in migration patterns from their original habitat. These changes cause the elephants to venture out for food and water. Additionally, the development of human settlements near forest fringe fertile lands has led to elephants raiding the crops grown by villagers, which are attractive to them. The study also found that HEC is seasonal and impacts some fringe areas more severely than others. The attacks by elephants on humans result in loss of life and crop damage. In the same vein, the retaliatory killings of elephants by the villagers are of concern. Furthermore, the study identified economic disparities in how residents of fringe areas cope with HEC.

Measures undertaken by various stakeholders in dealing with HEC

Villagers and Adidravidas measures

The study found that villagers have made use of the following measures to protect themselves and their crops: barbed wire and rope (also chili-coated) fences; bio fences (Agave and Cactus), electric fences; kerosene lamps; fire spears, iron spears; sticks and stones; firecrackers; sound makers (tin-cans-and-stones); flashlights; powerful spotlights; and treehouse watch towers (see photos of measures in Appendix C). Wealthier farmers protect their crops by maintaining fences, finding multiple types of fences depending upon the type of crops, and searching for innovative ways to safeguard their crops. Poorer farmers may have tried the electric fences the forest department gave them, but the study observation showed the need for the proper training, dedication, and finances to maintain them. Some study participants said trenches are unpopular because of their limited deterrent effect. According to them:

> *"Elephants have learned to cross the trenches, and if these are to be used, they must be dug much deeper. If the soil is not suitable, trenches become useless over time; in loose or muddy soil, an elephant can use its trunk to fill the trenches and go across in no time".*

During a field visit, a farmer in a hilly town in the Sathyamanglam forest area reported that elephants had smashed the entire farm and damaged pipes, causing extensive damage.[12] He had just started using multiple measures on a farm he recently leased from another farmer who gave it up due to elephant crop-raiding. His multiple measures included barbed wire, trenches, electric fences, and solar fences. His account in the focus group discussion states:

> *"First, the elephants tried smashing the barbed wire fences, only to encounter trenches they could not cross because they were dug deeper in and around the farm. Beyond the trench, the elephants could see the electric fence. They then gave up and have not returned to the farm in months".*

While this is a success story, the farmer said he is still trying to protect his farm by using several other measures, including chili ropes used in African and other Asian countries (which he learned from the Internet).

The study findings are that while poor farmers are frustrated and discouraged from mending fences, wealthy farmers maintain them and try various other forms of

[12] The damage to the farm was observed in one of the site observation trips.

defense. Some of their fences are tall walls built with heavy stones that would make it very hard for elephants to break, and they also use solar fences to protect their farms. It was claimed in focus group discussions that because of such measures taken by wealthy farmers, poor farmers in adjacent farms get hit by elephants, wondering about the spatial displacement impact of target hardening measures. This would be a fascinating research topic for crime scientists to illustrate the possibilities of displacement and the type of displacement that happens when new measures are introduced. According to a number of focus group study participants,

> *"Elephants smash the electric fences or develop ways to avoid them. They flip the branches from coconut trees on the electric fences and walk on top of the branches to avoid shocks. Once elephants have damaged the fences, we are reluctant to invest in new fences. Even when installed, we are confused about their operations—for example, when to turn on the electricity, how much voltage to use, etc. Sometimes, people and other animals get injured or killed by electric shocks if the fences are set at a higher voltage by mistake. No maintenance or service providers live close by to help us promptly replace or repair the fences.*

In sum, the costs of installation and maintenance, training in adequately operating the fences, and easy access to repair services beg for attention and action.

The study found some issues involving compensation reported by most focus group participants. While villagers welcome the forest department initiatives, they complain that the compensation is often just a fraction of the money they spend on mending the damages. They also criticize bureaucratic delays in receiving compensation, which dissuades them from seeking compensation. The frustration then leads them to take drastic steps, i.e., the retaliatory killing of elephants. Understanding the human psychology of retaliation is vital in finding healthy solutions, such as increasing and releasing compensation promptly. Several of the focus group participants informed that,

> *"The Tamil Nadu Forestry Department has increased compensation for deaths due to elephants (to about $6000 per victim), and the compensation is being delivered to the victims' families quicker than before. However, obtaining death certificates from the village administrators and the investigation by the forestry department and the local police can be very slow."*

Some villagers complained about the bribes to get their cases handled faster, which could be an agenda for criminologists.

Forestry department measures

According to the interviews with the District Forestry Department officers and staff, the following measures have been used to mitigate HEC, including scaring squads, deployment of drummers and distribution of crackers to villagers, removal of problem elephants, use of "kumki" elephants (captive-tamed/trained elephants) to drive away problem elephants, early warning systems, posting danger signs, creating ponds and water sources in the forests. The departments have also created hotlines for the villagers to inform officers if they spot elephants, and, recently, WhatsApp has also been used to alert the authorities if elephants are spotted in the outskirts of the forest. The officers warn villagers about the dangers of grazing cattle and collecting firewood from reserve forest areas, providing them with safety tips. They also advise villagers to be vigilant when sleeping in the nearby forest areas at night.

City administration measures

The city administration claims that it is the job of the forest department to deal with elephants that attack villagers and damage their property. However, all three district collectors interviewed are willing to assist when objective recommendations are made. To deal with HEC, one of the district collectors went beyond his duty call to support a model project subject (involving randomized control design based on the success mentioned above story mentioned earlier) if funding is being obtained.

Situational prevention measures

The study identified a series of situational, opportunity-reducing measures that are in place to address human–elephant conflict (HEC) in the study areas. These measures were organized under the five categories of SCP (increasing the efforts, increasing the risks, reducing the rewards, and removing provocations and excuses for crime) that have immense relevance to minimizing the harm to elephants and humans during conflict situations (see Table 3). Of the 25 SCP techniques of SCP), the measures reported by the study participants and observation fitted the 16 SCP techniques[13] (Clarke, 1997; Cornish & Clarke, 2003). These categories of SCP provide

[13] The 16 SCP techniques are as follows: target hardening, access control, deflecting offenders, controlling facilitators, screen exits, control tools/weapons, extending guardianship, natural surveillance, reducing anonymity: removing targets, identifying the property, denying benefits, reducing frustrations and stress, neutralizing peer pressure, setting rules, assist compliance, control drugs, and alcohol.

Table 3 Human elephant conflict mitigating situational prevention measures

Situational prevention	Measures
Increase the efforts	1. Target harden: "scare-shooting"; chili–tobacco rope fence; elephant proof trenches (EPT); pheromone repellents; plant suramul (*Cylindropuntia ramosissima*) as live fencing 2. Control access to facilities: barbed wire and rope fences; noisemaker fences with tin cans and stones, kerosene lamps; physical barriers; rubble wall; mechanical barriers; fire spear, iron spear; stones and sticks; firecrackers; sound maker; flashlight; salt container outside 3. Screen exits: build watch towers close to regular elephant entry/exit points (known as 'active routes') 4. Deflect offenders: noise and flares; chili-grease fences; plant crops that are not attractive to elephants 5. Control tools/weapons: lighting fires, making loud noises, and throwing stones; Siren's tripwire alarm fence
Increase risks	6. Extend guardianship: male members guarding crops; Introduce African honeybee (a species found in Kruger National Park); crop guards equipped with spotlights and with 2-way radios; bamboo tubes 7. Assist natural surveillance: warning alarms, loud noisemakers, spotlights, and African birds eye chillies (Capsicfrutescens); olfactory and auditory cues of an Acoustic deterrents 'bee threat; Guarding and Patrolling; Trip Wire Alarms 8. Reduce anonymity: use place managers; geolocating through SMS; SMS alert systems at vantage points 9. Remove targets: bio-fence; habitat enrichment; artificial water sources; chemicals; satellite telemetry; aversive conditioning; alternate livelihoods; geo-fence; long awned paddy variety
Reduce rewards	10. Identify property: introduce elephant collars 11. Deny benefits: cultivation of depredation-prone crops (e.g., paddy and millets) away from forested refugia. Plant the crops that elephants dislike
Reduce provocation	12. Reduce frustrations and stress: do not alarm elephants while walking 13. Neutralize peer pressure: relocation of human settlements and agricultural activity; land-use planning community-based natural resource management; insurance
Remove excuses	14. Set rules: scaring squad; removal of elephants drives; translocation; taking into captivity; culling 15. Assist compliance: compensation claims; offer communal insurance schemes 16. Control drugs and alcohol: prohibit alcohol and drugs in the fringe areas

an idea of the role of specific stakeholders in implementing the specific measures (see Table 3). For example, the villagers have a significant role in SCP's *increasing efforts* by making it difficult for the elephants to raid the corps and cause property damage. At the same token, *increasing the risks* requires the contribution of several stakeholders at the community level, demanding collaboration between forest and local law enforcement in patrolling the protected and fringe areas. *Reducing the rewards and removing provocations and excuses* require large-scale state-level forest department and city administration initiatives to deal with the problem of HEC in their jurisdictions. The important finding of this study is that grouping the measures under rational choice and routine activity theory-driven SCP techniques provides a solid foundation for individual studies, reinforcing the various community stakeholders' guardianship role (Kahler et al., 2023) in mitigating HEC.

This study reveals that the identified measures to reduce human–elephant conflict (HEC) are already in place and widely used by local stakeholders. Also, these measures are practical, affordable, and have been in place for a significant period. The stakeholders are open to trying different solutions to reduce HEC, depending on available resources. Some can manage on their own, while others require financial assistance. Villagers exchange information about their initiatives and share stories of success and failure.

This study is the first to categorize the measures and recognize the specific stakeholders' importance in designing, resourcing, and implementing strategies to reduce HEC in particular areas. However, evaluating these measures for their success or failure is essential to establish evidence-based case studies that can effectively address HEC conflicts and save human and elephant lives. This highlights the crucial role of researchers, conservationists, policymakers, and stakeholders in bringing about positive change in managing HEC.

Discussion

Based on the research findings, an interdisciplinary approach is essential for effectively addressing human–elephant conflict (HEC). Understanding the theoretical implications of this research emphasizes the need to integrate environmental criminology-driven situational-prevention measures into HEC mitigation strategies. Furthermore, the practical implications underscore the importance of engaging local stakeholders and communities in designing and implementing long-term solutions to mitigate HEC. This discussion explores how these theoretical and practical implications can inform future research and policy practices in resolving HEC.

Theoretical implications

The study findings revealed three significant themes (convergence space, hot spots, territorial boundaries of conflict) related to HEC locations. These have theoretical

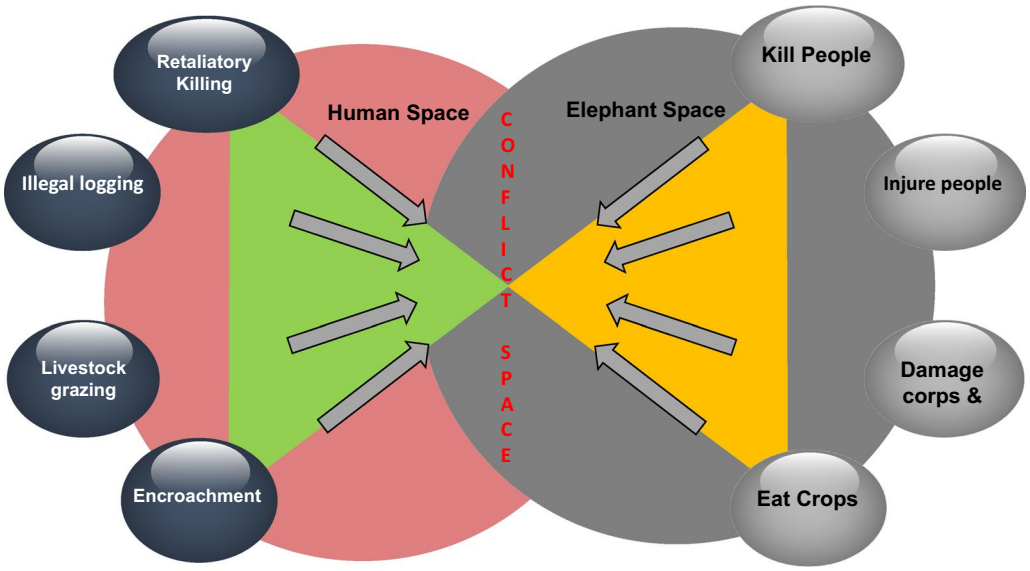

Fig. 3 Human elephant conflict convergence space

implications for minimizing the harms associated with HEC in Tamil Nadu.

Human–elephant conflict space: convergence, hot spots, territorial boundaries

An environmental criminological understanding of how offenders and their targets/victims come together in specific places and times is essential to explaining crime events (Cohen & Felson, 1979; Weisburd, 2015). Figure 3 provides a hypothetical scenario showing the overlap of humans and elephants in certain areas where various activities harm both parties.

The present study's observation of elephants' and villagers' habitats also suggests that villages with higher protected area frontage and unirrigated land were crucial factors leading to conflict. Additionally, a higher risk of elephant attacks is found in landscapes with higher human density (e.g., Gross et al., 2021; Gubbi, 2012; Gubbi et al., 2014; Sukumar et al., 2016; Thant et al., 2021). However, the locations of Human–Elephant Conflicts (HECs) vary considerably. These findings illustrate the importance of conflict areas where villagers and elephants come together, prompting further research to identify and understand the specific problem areas and gather detailed data to measure the issues' size, magnitude, and trend in these convergence spaces/locations.

The literature suggests that detailed spatial analysis of the convergence spaces would help focus on the specific locations and measures to assess what works and where. Recent geospatial analysis of elephant movement patterns (Chen et al., 2016; Das et al., 2018; Tripathy et al., 2021) would shed light on identifying the specific convergence locations for action. This need for mapping the convergence spaces certainly resonates with Brantingham and Brantingham's (1984, 2017) crime pattern theory, which states that crime incidents are not random but concentrated in space and time. The results of such analysis could help identify measures to be addressed by the villagers, the forest department, or the city government. While some NGOs are researching HEC, more context-specific space-based research is needed to resolve these conflicts.

A fundamental principle of situational crime prevention is that crime is highly concentrated on particular people, places, and things; hence, focusing on resources where crime is concentrated will yield the most significant preventive benefits (Clarke & Eck, 2003). This also reflects Pareto's principle, the 80/20 rule,[14] or, as Juran (2004) points out, a small percentage of areas have more extensive problems, and focusing on these areas would help solve a large percentage of HEC. Guided by the SCP, identifying the hotspots or specific convergence areas of HEC locations in the fringe areas in developing measures

[14] Environmental criminologists use this 20/80 principle, which is known as the Pareto principle or J curve. Vilfredo Pareto, an Italian economist (1848–1923) who observed 20% of the income in Italy was received by 80% of the Italian population, and 20% of the population owned 80% of the property. In 1937, Dr. Juran conceptualized the Pareto principle to help separate the "vital few" from the "useful many" in activities.

would give a positive outcome. While conservation scientists have undertaken enormous research for years, the crime science lens will no doubt complement and enhance the outcomes in mitigating HEC.

The discussions reveal that illegal logging, livestock grazing, encroachment, retaliatory killings of elephants and elephants destroying properties, and people harming are considered territorial issues (see also Fig. 3).[15] While climate change and forest degradation force elephants to move beyond their territory, villagers and some wealthy people are encroaching on or legally owning lands on the forest's borders. Also, observation of some convergence areas found that some of the elephants' deaths are hit-and-run accidents due to the railroad crossing of the Tamil Nadu–Kerala State (an adjacent southern state) borders.

A recent study by Blount-Hill and Natarajan (2019) indicated that human societal development may be directly harmful to animal species, thus setting the stage for competition between human development interests and wildlife survival. This study also found that human activities may harm other species due to competition over finite resources. For example, despite the forestry department's warnings and rules, villagers and Adidravidas persist in grazing their cattle in the forest and killing other animals, such as wild pigs, for their meat. Villagers argued in the focus group discussions that cattle are also animals and have the right to be fed in forest areas. To resolve similar arguments, sub-Saharan African countries have begun to explore hydroponic fodder production technology to grow fodder for their livestock near forest areas. Tamil Nadu forest department may also use such technology to grow fodder for their cattle. There should be a concerted effort by the villagers to grow firewood, the use of solar ovens and cookers that do not need firewood, and the forestry department to take an inventory of fodder in the forest areas should be made, including what plants exist and what plants elephants like. For example, the species suggested are *Dalbergia sissoo* (native), *Acacia auriculiformis*, and *Casuarina equisetifolia* (exotic).[16] Though daunting, a program to grow edible plants in forest areas might be considered. NGOs and the district administration could assist in promoting such concepts by demonstrating them to the villagers as part of HEC strategies so that territoriality/turf fights can be minimized. The need for practical solutions reflects the Routine Activity Theory, which emphasizes the importance of forest and township managers, including local police, village, and district administrators, in safeguarding elephants and people in fringe areas.

Integrating SCP's action research and rapid assessment methodology (RAM)

RAM's participatory approach requires the involvement of local stakeholders in data gathering. It combines methods and techniques to gain insights into how to solve the problem. The commonality of Action Research and RAM is that they are both assessment methodologies involving practitioners and stakeholders to assess the situation and find solutions. Guided by SCP's routine activity and rational choice theories, Action Research identifies and deals with the problem in a specific setting (Cherney, 2006, 2009; Clarke, 1997; Natarajan, 2016). Integrating SCP's action research with RAM, which is familiar to conservation scientists, would enhance the action plan and assist in an interdisciplinary approach to advancing the knowledge and solving conservation problems such as wildlife crimes and HEC.

Figure 4 illustrates the RAM's complementarity in gathering rich qualitative primary data to assess HEC. The methodological pluralism, an essential embodiment of RAM, provided validity in this study for the problem assessment in a real-time HEC situation.[17] For instance, observing the habitats helped to see the damaged areas by elephants in the villages and how the villagers managed the conflicts. The focus group discussions helped to see the actual injuries of people and hear about the elephant killing people in the protected area (especially on the day of the field research), the various methods used to mitigate, and all the challenges faced. Simultaneously, the ride along with the forest rangers helped to comprehend the initiatives the forest departments had implemented and their challenges. The interviews with administrators and dialogues with NGOs helped to see the collaborative sense of community involvement in dealing with HEC.

One limitation of this study is that it did not collect any quantitative measures of official forest data on the unnatural deaths of elephants and other animals or the deaths, injuries, and property damages of people in the

[15] While the elephants and humans have territorial resource-sharing issues, this study noted "turf conflicts" between the city and forest departments. For example, though the forest department provides electric fences to help farmers with some validity, the city administration argues that the forest departments should also bear the cost of damage caused by elephants. Compensation for the villagers does happen (see Karanth et al., 2018); the city administration should share the burden of assisting the villagers by providing additional resources and incentives to sustain mitigation efforts.

[16] The literature on HEC in Africa and Asia (see Gross et al., 2017) suggests that growing crops that are unattractive to elephants but provide revenue for farmers could lead to innovative strategies for land use in and around elephant corridors. Also, from personal communication with an internationally renowned conservation scientist, Dr. A. J. T. Johnsingh.

[17] During the study period, two older couples in their 70 s went to the forest late at night, and the elephants stamped upon them, causing injuries that resulted in their deaths. A focus group discussion was undertaken the next day of the incident in that area informed the real incident situation.

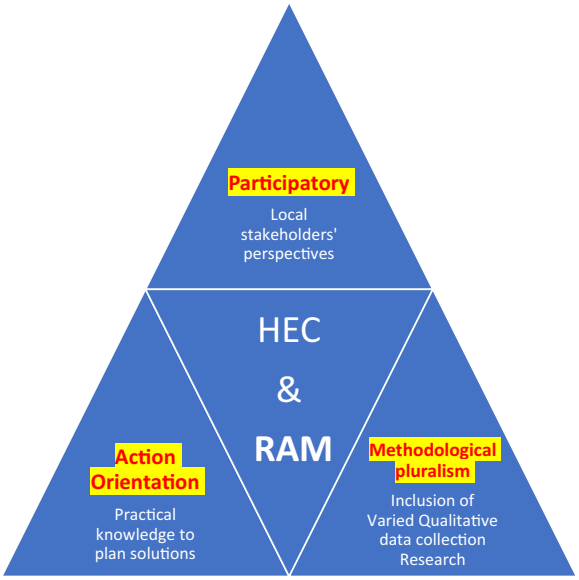

Fig. 4 HEC: integrating rapid assessment methodology (RAM) and action research

forest areas. It also did not measure the proximity length of fringe and protected areas. It also did not survey to quantify and explain the various measures and the factors associated with their applicability in dealing with HEC.

Practical implications

The prior literature, whether in India or elsewhere, indicates that electric fences are working well and seem to be effective in mitigating elephant crop-raiding (Kioko et al., 2008; Neupane et al., 2017, 2018; Ponnusamy et al., 2016; Tsegaye et al., 2023). However, despite financial support from the forest department in installing fences, villagers are reluctant to maintain them. The suggestion is that the forest department may put up the fences, but the villagers should maintain them. The city government can assist the villagers by providing some subsidies to help the poor farmers maintain them. The local banks could also assist with loans with low interest. This again calls for randomized controlled trials as part of the SCP agenda to illustrate the impact of different measures, including the importance of maintenance,[18] so funding from the city and state can be justified. Crime scientists can assist with such evaluation studies; after all, they are trained to identify measures to reduce the damage to people and property and, at the same time, retaliation killings of elephants.

Elephants are the keystone species that help enhance forest biodiversity and are considered ecosystem engineers—seed dispersers, food and water providers to other animals, and habitat modifiers (Fritz, 2017). Providing a conducive ecosystem for elephants is vital as one of the measures to deal with HEC. After all, the elephants wander around villages because there is not enough food or water in their spaces. Also, targeting elephant numbers to conserve biodiversity is essential. If too many are in a forest, the forest departments could work with others to translocate them (Fernando et al., 2012). Suitable habitats should be available to translocate problems or excess animals. Further, forest departments could experiment with camera traps as surveillance (as discussed in Clarke et al., 2014) in crop-raiding areas to help the farmers manage the elephants and their movements. When the forest departments could identify the "rogue or problem" elephants, they could use more of the translocation strategy. Under the SCP framework, crime scientists can assist in surveillance research.

The women-only focus group discussions raised another severe problem concerning missing girls and young women in the fringe areas with suspected foul play of sexual predators. Solving problems such as missing women and girls in and around the forest fringe areas and undertaking surveillance and investigations of accidental vs. intentional deaths of people and elephants are major criminological concerns. Crime scientists can assist the forest departments and the local police in conducting safety audits of forest and fringe areas to solve conservation-related crime and disorder issues.

In sum, forest administration must have an agenda to plant fodder suitable for elephants, continue to dig water holes wherever needed, and explore other ways to protect the elephants in the forests. Farmers and the people living in and around the fringe areas need support from district administrators to protect their farms and themselves. On the other hand, for the district administration, HEC should also be on its agenda because it concerns the welfare of villagers and Adidravidas. Though people who live in the protected and fringe areas take routine precautions against the depredations caused by the elephant, these are not enough. The farmers' and villagers' dependency on forests must be reduced by eco-development programs, as in other Asian and African countries, where criminologists or crime scientists can help develop public safety

[18] A model project on managing electric fences along the following lines is needed: (1) choose a forest fringe area in the study location provide electric fences and develop mechanisms for maintenance: (2) obtain cost quotes from various electric fence builders; (3) assess the electricity and solar options; (4) assist a local fence management team regularly in the chosen conflict area; (5) require 6–12 months to teach villagers about the importance of maintaining the fences; (6) undertake an evaluation using a four-group post experiment: one group with maintenance management (electric and solar); one group with no maintenance; one group with multiple methods (electric fences with trenches); one group with multiple methods (electric fences with trenches) but with no maintenance.

and security programs in and out of the protected areas. The Forest Dwellers Act of 2006 has provided alternate land for those who live in government lands, but it is hard for some to move out to find alternatives, and there is a dire need to assist the families who live in forest areas. It was noted that many have children who do not go to school and are destined to follow in their parent's footsteps, resulting in cattle grazers or woodcutters such as cattle grazing. Overcrowding of families in the forest fringe areas might also contribute to HEC. All of these are not just major conservation concerns but are major social concerns. Integrating social science research will help in alleviating such problems.

Below listed are specific recommendations to deal with HEC in which crime scientists can participate:

- Conducting a systematic inventory of situational prevention measures: as known, HEC results in crop raiding by elephants, injuries, and deaths of farmers, as well as retaliatory killings of elephants. Though these problems seem interconnected and distinctive. For example, crop raiding of elephants requires measures distinct from elephants destroying homes while searching for food and injuring or killing people in the process. When villagers go to the forest for cattle grazing or when elephants get killed on the rail tracks. Each of these problems requires specific opportunity-reducing measures geared to the nature of the problem.
- Promoting constant conservation and criminological education: there is a need to raise awareness of compliance with HEC initiatives for people (who live in fringe areas) and tourists (who visit the forest areas). Criminologists could assist and train local police to patrol village areas where tourists congregate for picnics. This might help prevent tourists from alarming elephants when crossing borders and safeguard them from elephants. Police should prevent people from aggregating in areas where elephants traditionally move in or out of the forest.
- Undertaking location-based research using spatial analyses: the observational analysis indicated that in order to introduce specific situational measures to reduce the damages and casualties, a thorough study is needed of spatial aspects of HEC; temporal aspects (month, day, time, season); type of damage (crop, injury, deaths); perimeter of the conflict situations—the exact spots (the boundary line); the type of crops; and existing measures that forest departments and villagers are currently taking to deal with HEC. The results of such an analysis could help identify measures to be addressed by the villagers, by the forest department, or by the city government.

Based on the research findings, several other suggestions have been proposed to reduce the impact of human–elephant conflict (HEC) in Tamil Nadu. These include collaboratively finding funding and allocating resources by engaging various stakeholders, creating physical pathways to guide elephants away from human settlements, employing aerial surveillance to monitor the migratory paths of elephants, enhancing the resources available to the forest department staff, implementing evidence-based mitigation measures and sharing best practices, organizing interdisciplinary seminars and conferences at regional, national, and international levels on HEC involving both practitioners and academics, establishing an Elephant Conservation Committee to spearhead conservation efforts, and employing robust methods for counting the elephant population (see Hedges et al., 2013) and placing emphasis on effective elephant management to ensure their well-being.

Conclusions

The most significant threat to African elephants is wildlife crime, specifically poaching for the illegal ivory trade. On the other hand, the main threat to Asian elephants is habitat loss, fragmentation, and the resulting human–elephant conflict (World Wildlife Fund.org; Luo et al., 2022; Menon & Tiwari, 2019; Padalia et al., 2019; Prakash et al., 2020a, 2020b). The present study confirms that HEC is concentrated on where human habitats converge with elephants' habitats. Hence, protecting elephants and people within their respective land boundaries is paramount. As stated by a handful of environmental criminologists/crime scientists (see Lemieux et al., 2022; Viollaz et al., 2022), conservation science could benefit from integrating the environmental criminological/crime science framework into its efforts to enhance the capacity to deal with HEC efficiently and effectively.

This research presents an interdisciplinary approach to HEC by integrating crime science and criminology. The study offers practical and sustainable solutions using situational crime prevention framework and action research. The specific measures identified and categorized under SCP taxonomy show promise for resolving conflicts, particularly in the problem conflict space where major human–elephant conflict incidents occur, primarily in developing countries (Clarke & Natarajan, 2018). Furthermore, the research highlights the key stakeholders in developing and implementing these effective techniques (see Table 3).

This case study identified several vital situational factors that contribute to HEC, including the proximity of

human settlements to elephant habitats, inadequate fencing and lighting around crops, and poor management practices. Addressing these factors would require a multidisciplinary approach that involves not only conservation scientists but also criminologists, criminal justice practitioners, urban planners, city and conservation management experts, and other stakeholders. In 2001, Clark, Stevenson, and Ziegelmayer articulated the importance of interdisciplinary problem-solving if humanity is to solve the problem of species and ecosystem loss. Lessons learned from this study certainly have implications for framing interdisciplinary team research (Hoffmann et al., 2017; see also Boratto & Gibbs, 2021) in dealing with HEC but also for designing SCP-informed prospective studies and Randomized Control Trials to assess what works so that the farmers can diffuse the benefits to other farmers in resolving HEC at large. Also, it emphasizes a rapid assessment methodology that is relatively cost-effective, technically eclectic, real-time, and pragmatic in collecting data in designing appropriate culturally sensitive measures and its precursor role in designing RCT in assessing the impact of measures.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) identifies elephants as a "red-flagged" endangered species. It emphasizes the importance of protecting them for biodiversity conservation. Recent studies by Anoop et. al. (2023) and Fernando et. al. (2021) have highlighted the increasing human–elephant conflicts (HEC) as a significant concern for the conservation of Asian elephants. The study emphasizes the importance of collaboration between criminologists and conservation scientists to address complex societal problems like human–animal conflicts. Although conservation scientists have significantly contributed to understanding HEC, there is a need to involve other disciplines, such as criminology, in developing effective solutions.

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Author contributions
I am the sole author of the final manuscript.

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