



## Original Research Paper

# Patterns, Drivers, and Socio-economic Impacts of Human–Wildlife Conflict in Reserved Forest Landscapes of Tiruchirappalli District, South India

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| Key Words                                                                                                                 | Abstract                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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| <b>KEY WORDS:</b><br>Human-wildlife conflict ,<br>Reserved Forests ,<br>Tiruchirappalli District,<br>questionnaire survey | Human-wildlife conflict (HWC) is an effective menace to livelihood and wildlife conservation in the multiuse forest landscapes in India, particularly in the villages located near the reserved forests. This paper examines the trends, causes, and responses of the community towards HWC in peripheral villages around the Reserved Forests in Tiruchirappalli District, Tamil Nadu. To measure the levels of poaching, frequency of conflict, species with high conflict potential, seasonal variability, economic costs and mitigation measures, a set questionnaire survey was given to 474 participants of four forest ranges namely Manapparai, Thuraiyur, Thuvankuruchi and Trichy. This low hunting and poaching frequency (2.3%) and the absence of any significant range dispersion ( $kh^2 = 0.49$ , $df = 3$ , $p = 0.92$ ) were proposed to be effective forest monitors. Conversely, property damage and crop raid were usual, and spotted deer (26), Indian gaur (29), and wild pigs (35) were reported to be the key conflict species. The Trichy and Manapparai ranges became the hot spots of the frequency of conflict, and this fluctuated considerably over ranges ( $kh^2 = 78.7$ , $df = 6$ , $p < 0.001$ ). Primary causes of conflicts were water scarcity and food availability in the forest-agriculture interface that reached the highest in the summer (38%) and post-monsoon seasons (30%). Most households indicated substantial impacts on the livelihood of the smallholder as evidenced by the fact that most households had annual economic losses that fell between 10,000 and 50,000. Electric fencing and noise-based deterrents were the most popular mitigation techniques but others would not be sustainable and safe. To promote the idea of long-term cohabitation between the rural communities, the results provide the need to bring together participatory HWC management approaches that will integrate habitat restoration, seasonal water provisioning, livelihood support, and community-based mitigation |

## Introduction

Human-wildlife conflict is commonly known as an important socio ecological issue whereby high human population live with various wildlife species in more and more fragmented habitats (Barua et al., 2013; Dickman, 2010). In India, land use change, agricultural growth and infrastructural development have increased the human and wildlife interactions that result in the progressive increase in crop, livestock predation and occasional human injury or death (Madhusudan, 2003; Mishra, 1997). Although national parks and tiger reserves are the focus of significant research and policy, many parts of the Indian biodiversity continue to exist in reserves forests and multiple use landscapes that sustain wildlife and human livelihood (Rangarajan et al., 2010). Weaker enforcement and management of these margins are more prone to conflict and expose them to hidden social and psychological costs to the local communities (Barua et al., 2013; Kansky and Knight, 2014).

Growing HWC in agro forest mosaics have been reported around the protected and reserved forests in Tamil Nadu involving elephants, wild pigs, deer, leopards and other species (Madhusudan, 2003; Sukumar, 2006). Past researches have emphasized that one of the leading causes of economic losses and negative perceptions on conservation is crop raiding by ungulates and wild pigs particularly among the smallholders (Madhusudan, 2003; Mishra, 1997). Simultaneously, the lockdowns related to the coronavirus disease 2019 (COVID 19) minimized human mobility and disturbance in most regions of India and was linked with the changes in the use of human dominated areas by the wildlife, which highlights the role of urban and peri urban ecology and regular biodiversity surveillance (Ghosal and Casey, 2020). Nevertheless, little empirical research has been conducted to connect post pandemic wildlife behavior with patterns of conflict at the local level in the reserved forests and the neighbouring villages.

The Reserved Forests of Tiruchirappalli District entail dry forest patches and scrub mixed with agricultural lands where the households are largely relying on crops, which include paddy, maize, and tapioca crops, grown on the edge of forests. Such communities are prone to recurrent crop and property losses caused by wild animals yet they are not given equal institutional and financial resources to mitigate them (Rangarajan et al., 2010). The research paper intends to: (a) evaluate the commonality of poaching and levels of enforcement; (b)

determine the frequency and spatial dispersion of HWC through forest ranges; (c) determine important conflict likely species and seasons of high risk; (d) estimate the economic cost of the damage; and (e) record local prevention procedures and implications on wellbeing and attitudes to wildlife (Barua et al., 2013; Dickman, 2010). With the emphasis put on the reserved forests instead of strictly protected ones, the study can help understand the HWC in the multi-use forest landscapes of India in a more complete manner and provide practical suggestions concerning the community based and socially informed management (Kansky and Knight, 2014; Rangarajan et al., 2010).

## Methods

### Study area

The research was carried out in outlying villages around the Reserved Forests of the Tiruchirappalli District in Tamil Nadu in four forest ranges namely Manapparai, Thuraiyur, Thuvankuruchi and Trichy. These habitats constitute a mosaic of dry forest, scrub and croplands with significant proportions of paddy, maize, tapioca, millets, cereals, cotton and groundnut most of which are quite palatable to the wild ungulates and wild pigs (Madhusudan, 2003). It is a tropical area that has pre monsoon, monsoon, post monsoon and summer seasons that heavily affect water and natural forage of the wildlife (Sukumar, 2006). The lack of forest resources on a seasonal basis exposes the villages that are found at the forest-agriculture border especially to the incursion of wildlife.

### Data collection

A questionnaire survey was carried out in 474 respondents in the peripheral villages of the four ranges in a structured questionnaire survey. The sample was 202 female respondents and 272 male respondents giving a good demographic coverage and minimized age related sampling bias (Newing, 2011). The selection of respondents was based on the households, which are relying on agriculture or near forest boundaries because these are the households that are most directly impacted by HWC (Madhusudan, 2003; Mishra, 1997).

The questionnaire collected data regarding: (a) hunting or poaching; (b) perceived trends in the occurrence of wildlife post COVID 19; (c) species involved in conflicts; (d) frequency of conflicts per season; (e) crops planted along forest edges; (f) seasons of conflict prone seasons; (g) perceived causes of wildlife incursions; (h) economic losses incurred annually in terms of crop and property damage; The design of the survey was based on the principles of known social science procedures of conservation research and the assessment of the

HWC, namely the use of clear questions, ethical involvement, and regionalization (Newing, 2011; Dickman, 2010).

#### Data analysis

Respondent characteristics, the conflict frequencies, conflict prone species, seasonal patterns, and economic loss categories were summarised using descriptive statistics. Chi square tests addressed: (a) variation in reports of ranges of hunting/poaching, and (b) range varying

frequency of conflict encounters per season. The level of statistical significance was evaluated at the level of 5% consistency with what is considered a good practice in ecological and social science research of HWC (Madhusudan, 2003; Kansky and Knight, 2014). The results are displayed in the form of tables and figures that provide a summary of the poaching reports, frequency of conflict, season of conflict, and mitigation..

### Results

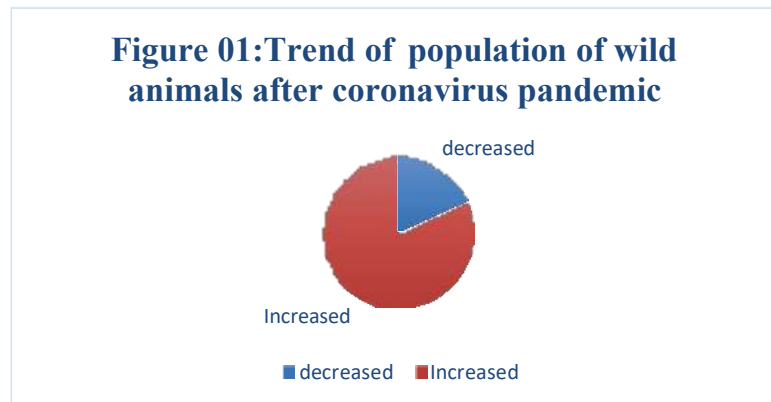
#### Poaching prevalence and enforcement

**Table 1. Chi-Square Test of Hunting /Poaching Occurs in the Study Area**

| Chi-Square Tests   |                   |    |                       |
|--------------------|-------------------|----|-----------------------|
|                    | Value             | df | Asymp. Sig. (2-sided) |
| Pearson Chi-Square | .494 <sup>a</sup> | 3  | .920                  |

Only 11/474 respondents said that they hunted or poached anything in their region meaning that it is seen as an infrequent behavior in the study area. A chi square analysis of the poaching reports between the four ranges did not report any significant difference (Pearson chi square [?] 0.49, df = 3, p [?] 0.92) indicating there

was low poaching prevalence and relatively the same. About 75.1% of those interviewed claimed that their area is monitored by the Forest Department regularly which is probably among the factors that keep the hunting and poaching at the lowest possible levels (Rangarajan et al., 2010)

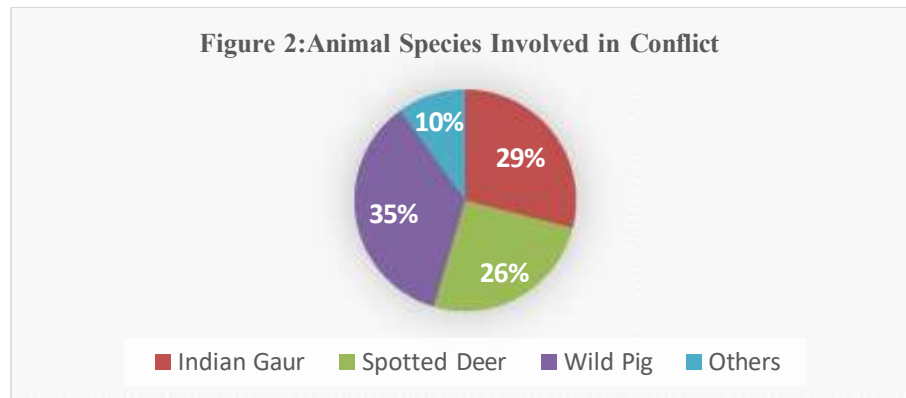


**Fig1. Trend of the population of wild animals after a pandemic**

A high proportion of respondents Figure. 01 indicates that 81.9% had the opinion that the population or sighting of wildlife had risen after the COVID 19 pandemic. They explained it by stringent lockdowns and the decreased human intrusion, which seemed to give more freedom to wildlife to explore areas controlled by humans (Ghosal and Casey, 2020). There are also similar trends of the changed behavior and distribution of

wildlife during lockdowns, which highlight the ability of human-induced changes in human activity to influence the interactions between humans and nature (Ghosal and Casey, 2020). In Tiruchirappalli, this apparent augmented may have led to an amplified frequency of intercourse in the forest-agriculture boundary between individuals and wildlife

### Conflict-prone species



**Fig2. Animal Species Involved in Conflicts**

According to respondents, wild pigs (*Sus scrofa*), Indian gaur (*Bos gaurus*), and spotted deer (*Axis axis*) were the main species that experienced human-wildlife conflict mainly because they are crop-raiders. Wild pigs were reported the most with a percentage of 35 of conflict incidences then Indian gaur with a percentage of 29, and spotted deer with a percentage of 26. About 10 percent of reported conflicts were as a result of jungle cats and

jackals. These species have been well known as significant crop raiders in the forest-agriculture mosaic landscapes in India where they are drawn to the nutrient-rich cultivated crops as a dependable source of food (Madhusudan, 2003; Sukumar, 2006). Their repeated encroachment in to agricultural fields near the Reserved Forests causes continuous- and sometimes substantial- loss of economics to the farmers

### Spatial and seasonal conflict patterns

**Table 2. Frequency of Animal Conflicts in a Season, Range-wise**

|       |  | How often do you encounter animal conflicts in a season? |     |     |             |       |
|-------|--|----------------------------------------------------------|-----|-----|-------------|-------|
|       |  |                                                          | 1-2 | 3-5 | More than 5 | Total |
| Range |  | MANAPPARRAI                                              | 63  | 51  | 11          | 125   |
|       |  | THURAIYUR                                                | 36  | 37  | 31          | 104   |
|       |  | THUVARANKURUCHI                                          | 60  | 7   | 45          | 112   |
|       |  | TRICHY                                                   | 32  | 39  | 62          | 133   |
|       |  | Total                                                    | 191 | 134 | 149         | 474   |

**Table 3. Chi-Square Test of Frequency Animal Conflicts in a Season**

| Range-wise         |                     |    |                       |
|--------------------|---------------------|----|-----------------------|
|                    | Value               | df | Asymp. Sig. (2-sided) |
| Pearson Chi-Square | 78.704 <sup>a</sup> | 6  | .000                  |

### Regional and Seasonal Variation in Conflict Occurrence

As shown in table 2 and table 3, the rate of human-wildlife conflicts differs greatly across different regions. The result of the chi-square test ( $p\text{-value} = 0.000$ ; Pearson  $\chi^2 \approx 78.70$ ,  $df = 6$ ,  $p < 0.001$ ) proves the statistically significant difference between the ranges, which shows that there is a clear spatial variation in the intensity of conflicts. The Trichy range was the conflict prone zone among the four ranges with the next in conflict prone zone being the Manapparai range, and Thuraiyur and Thuvankuruchi had relatively low but significant levels of conflict.

The statistics also indicate that the majority of the respondents had experienced an encounter with the wild animals once or twice per season, but some ranges had more frequent encounters of 3-5 or more times, which can be attributed to the variation in the pressure of conflict. These intrusions normally happen in times when animals leave the Reserved Forests in pursuit of food and water.

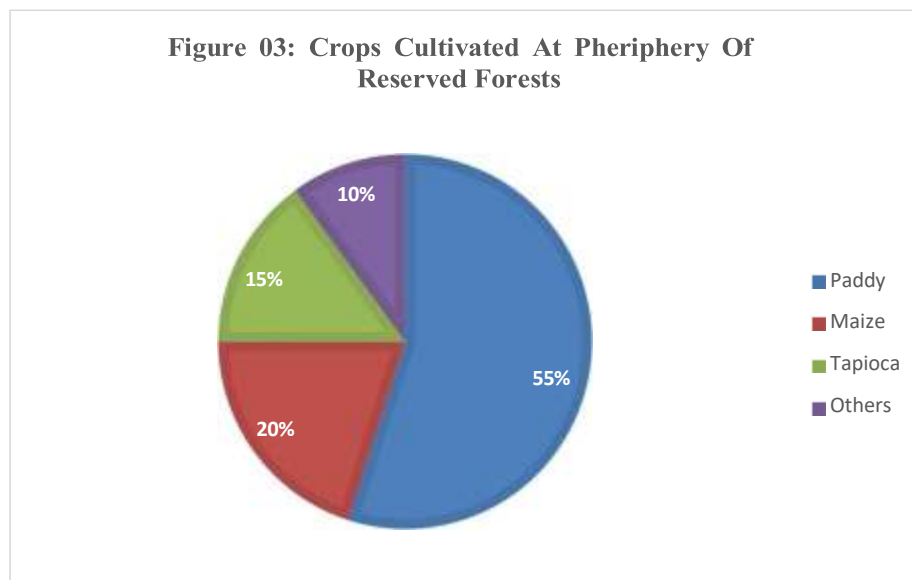
crop availability.

### Crops cultivated and economic losses

Higher incidents of conflicts were recorded at night compared to daytime, probably due to the fact that wild animals do not desire being close to human beings, and they exploit the agricultural fields when humans are busy with other tasks. Consequently, damage of crops is usually witnessed at night.

Conflicts were highest during summer (38 percent of the answers) and post-monsoon (30 percent) than during the pre-monsoon and the monsoon seasons. The dry season experienced during summer in the Reserved Forests forces the migration of the wildlife as they seek water and forage to the neighboring villages and farmlands (Sukumar, 2006). Post-monsoon conflict on the other hand is directly associated with harvesting seasons where standing or newly harvested crops offer concentrated, nutrient-rich food items that draw ungulates and wild pigs (Madhusudan, 2003). These are seasonal patterns that are also in line with the observations of other human-wildlife conflict landscapes where conflict remains strong during resource scarcity and crop availability.

**Fig. 3. Crops Cultivated at the Periphery of Reserved Forests**



On the edge of the forest, paddy occupied approximately 55 percent of the planted land, next were maize (20 percent), tapioca (15 percent), and a blend of millets, cereals, cotton, and groundnut (10 percent). Crops were also often preyed upon by wild animals during and after harvest, when they provide especially good and predictable food. This resulted in huge monetary loss to numerous households, particularly the families that were engaged in agriculture near forest lines.

The economic loss primarily by way of crop and property damage were in two categories as 57.0% of the respondents reported that they lost ₹10,000-₹50,000 each year and 31.4% reported that they lost ₹1,000-₹10,000 annually. The

smaller though significant percentage of (6.8) was that annual losses were above ₹50,000 and the smallest percentage was 4.9% recorded that there were no losses. Alongside direct loss of crops, the respondents reported incidental losses such as trampling of saplings, fences and the occasional losses of huts. These are very high levels of loss and can be compared to other HWC hotspots of India and have the potential to severely impact household income and food security (Madhusudan, 2003; Mishra, 1997).

#### Perceived causes of conflict

**Fig 4. Human Animal Conflict- Prone Season**

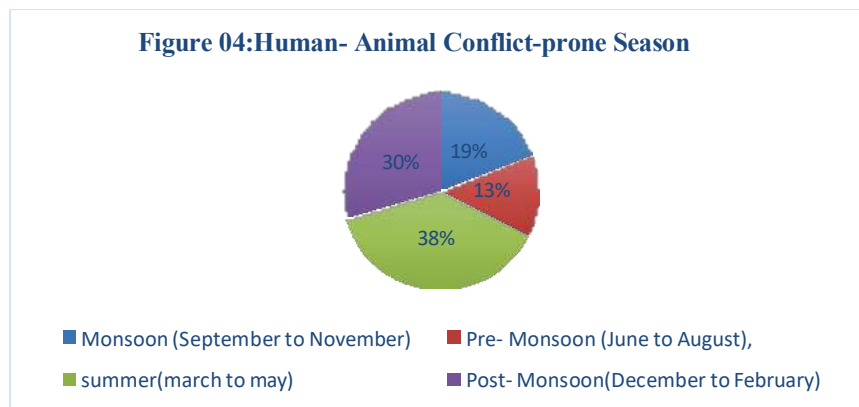
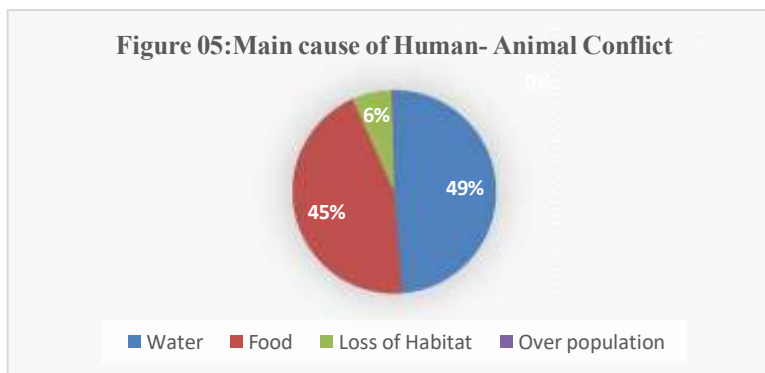


Figure 4 reveals that human-wildlife conflicts are commonest during summer (38) and post-monsoon (30) seasons. The Reserved Forests are in a deplorable state of dryness during the summer season, and the bulk of the natural sources of water are exhausted. This force has made wild animals move beyond the boundaries of forests to find water and food further exposing them to the agricultural landscapes. During the post-monsoon season that coincides with the harvest season, the agricultural fields around the area are rich and full of nutrients,

thus wildlife gets attracted hence increasing cases of crop-raiding.

On the other hand, the level of conflict in the pre-monsoon season and the monsoon season is relatively lower. This has been mainly because there is adequate water and food supply in the Reserved Forests and there is no need to compel the animals to go to regions where humans are already in control.



**Figure 5: Main Cause of Human Animal Conflict**

On the question of causes of wildlife encroaching human habitats, most respondents (49 and 46 percent respectively) cited water shortage and food shortage, with habitat loss or degradation being noted less frequently (5.9 percent). These reactions are focused on proximate factors such as drying water sources and the absence of natural forage, as opposed to more remote land use transformations. Nonetheless, the larger literature suggests that

#### Human injury and mitigation strategies

fragmentation and encroachment of habitats are the real cause of many of these shortages of resources, where the wildlife finds itself depending more and more on crops and other human sources (Rangarajan et al., 2010; Sukumar, 2006). Seasonal drying in the Reserved Forests of Tiruchirappalli, which is accompanied by low foddering and water in the forest, seem to be a major proximate cause of HWC

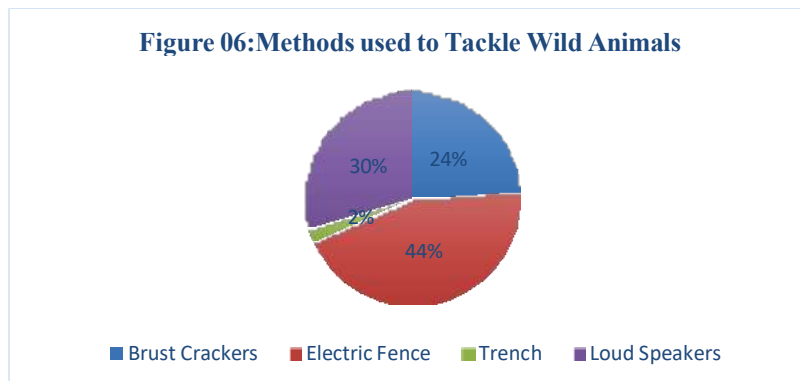
**Table 4. Frequency Table of Damage Cost to Properties by Wild Animals**

| Damage caused to properties by Wild Animals (in rupees) | No. of Respondents (n:474) | Percentage |
|---------------------------------------------------------|----------------------------|------------|
| 1000 - 10000                                            | 149                        | 31.4       |
| 10000- 50000                                            | 270                        | 57.0       |
| 50000- above                                            | 32                         | 6.8        |
| nil                                                     | 23                         | 4.9        |
| Total                                                   | 474                        | 100.0      |

Table 4. indicates that the Wild Animals lead to destruction of the properties (crops). Respondents Financial loss per annum in Indian rupees depicts the fact that approximately 57 per cent of Respondents lose up to 10000-50000 rupees. The Respondents lose about 1000 rupees to 10000 rupees annually and this amounts to 31.4%. 6.8 percent of the respondents indicate that they lose more than 50000 rupees annually due to the crop raiding since they are near the Reserve forests. The Wild Animals do not only destroy crops but also destroy the fence, tramping the other saplings and

at times destroy huts in the surroundings.

The number of reported cases of human injury or death caused by wildlife in the region is only 2. This implies that the war is more an economic and psychological one than a deadly one. The Stakeholders tend to come back to cause the damage as little as possible. This involves certain traditional methods and certain newer methods such as Trenches, Electrical fencing, bursting of crackers, loudspeakers and horns to drive away the Wild Animals



**Figure 6. Different Methods Used to Tackle Wild Animals**

The study area recorded only two cases of human injury or death by wildlife meaning that conflict is more economical and psychological than that involving frequent fatal attacks. However, the constant occurrence of large mammals around communities leads to the fear, stress, and feelings of insecurity among the residents, which are not usually given significant importance in traditional conflict measurements (Barua et al., 2013; Kansky and Knight, 2014).

There was a combination of traditional and modern mitigation in the households. Electric fencing was the most popular (44% of the respondents), then loudspeakers, horns, and sirens (30%), and crackers and fire to scare animals (24%), with only some 2% using trenches. Though such methods can scare away wildlife in the short run, loud music and fire can lead to panic and even unstable behavior that can increase the risk posed to humans and animals (Dickman, 2010). This trend repeats broader results that technical damage mitigation strategies are ineffective and interventions need to take social, cultural, and psychological aspects of conflict into consideration (Barua et al., 2013; Dickman, 2010).

## Discussion

The paper shows that poaching is considered to be low in the Reserved Forests in Tiruchirappalli and the range poaching is relatively homogeneous, probably due to effective Forest Department surveillance (Rangarajan et al., 2010). This is what makes the landscape unlike the other areas in India forest where the issue of illegal hunting is a major conservation challenge (Madhusudan, 2003; Mishra, 1997). Nevertheless, in spite of minor poaching, crop and property disputes are severe and incur significant economic and psychosocial expenses on the rural family, which is consistent with the results of studies conducted all over the world according to which visible damage constitutes only a subset of the costs associated with HWC (Barua et al., 2013; Kansky and Knight, 2014).

Wild pigs, Indian gaur and spotted deer were recognized as the main conflict species, although wild pigs are most evident, in line with evidence that wild pigs are among the worst crop raiders in most parts (Madhusudan, 2003; Sukumar, 2006). Their strong reproduction, dietary flexibility and access to farm lands allow them to be difficult to control only using traditional deterrents like ad hoc fencing or noise. Techniques based on site specific approaches to wild pig behavior, including the design of fences, organizing the community guard,

and in the forest habitat and water management are probably more effective than efforts at the household level (Dickman, 2010; Newing, 2011).

Spatial and seasonal conflict heterogeneity emphasizes the need of interventions being specific. The Trichy and Manapparai ranges which developed as hotspots can have the combination of the nearness of fields to woodland, an increase in the degree of wildlife, and an augmented seasonal scarcity of water that increases the threat of conflict (Madhusudan, 2003). The same space clustering of conflict is seen to occur at the boundary of the protected areas as well as around the movement corridors in other parts of India where the importance of fine scale mapping and range specific approaches is highlighted (Kansky and Knight, 2014; Rangarajan et al., 2010). Summer and post monsoon peaks coincide with periods of resource unavailability in forests and crop availability in fields; so that seasonal water provisioning in forests and increased crop protection during harvest periods would be of value in reducing conflict (Sukumar, 2006).

Reported annual losses of [?]10,000 to [?]50,000 are usually large amounts of household revenue, especially among small-holders who have only a few assets (Madhusudan, 2003). Such losses may discourage conservation at the local level and cause a negative attitude to wildlife in the absence of timely and sufficient compensation or insurance, even when conservation benefits are achieved in the long run (Kansky and Knight, 2014). These effects are further complicated by the psychological pressure of living in massive wildlife, where one is always on guard and costs their life in opportunity costs of guarding (Barua et al., 2013). It is therefore essential to deal with both the visible and invisible costs in order to coexist with the long term.

The use of electric fencing and high-level deterrence is an indication of the efforts made by locals in safeguarding the livelihoods though this creates concerns regarding the sustainability, maintenance, and the potential issues in the welfare of the wildlife (Dickman, 2010). The best practice advice presupposes the integration of technical means with consideration of social attributes, the perception of justice, the confidence in the institutions, and cultural principles (Barua et al., 2013; Dickman, 2010). Participatory planning in Tiruchirappalli with local communities with the assistance of the Forest Department and non governmental organizations may assist in co designing effective, affordable, and acceptable mitigation portfolios, including the enhanced fencing, well-thought-out choice of crops in the regions bordering the forests, and communal early warning systems (Newing, 2011; Rangarajan et al., 2010).

### Conclusion and recommendations

This paper demonstrates that human-wildlife conflict in the Reserved Forests of Tiruchirappalli District is primarily seasonal and resource-based, due to its intensive use of the agricultural landscape by wildlife, and institutional lack of support to its mitigation as opposed to poaching. The perceived post pandemic increase in wildlife occurrence coupled with significant loss of crops and properties has put an increment in pressure to the rural communities and might wipe out long term conservation support unless properly managed (Barua et al., 2013; Ghosal and Casey, 2020).

Successful interventions need ecological, social, and institutional interventions. In the ecological perspective, this could be mitigated by enhancement of habitat quality in the preserved forests by restoration of water bodies, development of fodder plots and preservation of habitat connectivity which will lead to reduced reliance of wildlife to crops (Sukumar, 2006). Socially, ensuring that communities are active participants in the planning and implementation of mitigation can contribute to a greater degree of legitimacy, trust, and matching interventions and local realities (Dickman, 2010; Newing, 2011). At the institutional level, the resilience of rural livelihoods can be enhanced through enhancing the compensation and insurance scheme, providing extension, and attracting civil society organizations to minimize the hidden cost of conflict (Barua et al., 2013; Kinsky and Knight, 2014). These initiatives can be supported by community based early warning systems that use simple technologies like camera traps and mobile alerts that can be used to predict animal movement and minimize unexpected animal interaction during the high-risk seasons (Madhusudan, 2003; Rangarajan et al., 2010). Combined, these actions can bring Tiruchirappalli to a model of coexistence that would protect the wellbeing of the rural communities as well as the wildlife, and the lessons can be applied to other Tamil Nadu and Indian forest-agriculture frontiers.

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