Human Elephant Conflict (HEC): a Contemporary Threat to Rural Livelihoods in Sri Lanka

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Abstract: **Human Elephant Conflict (HEC) has been recognized as one of the key concerns in rural community development including their agricultural activities and livelihoods well. Unrestrained and insensitive clearing of natural forest habitats for human settlements and agricultural expansions have become the major causes for this HEC, which has arisen and reported to be problematic for many years. Being mega-herbivores, elephants necessitate a huge amount of daily feed intake and due to reduced extent of their feeding grounds and migratory drives, they tends to invade human settlements and raid croplands adjacent to their habitats. This phenomenon can be predominantly witnessed in Asia and some regions of Africa where the HEC is reported to be greater. Accordingly, Sri Lanka is one of the Asian countries which deem the elephants as a cultural emblem and also an ominous beast. Capture-transport, driving of elephants in to non-problematic areas, and different forms of elephant barriers particularly electric fencing and make trenches over protected areas are the most appeared tactics in Sri Lanka. In spite of this mitigation of HEC has become a serious concern in Sri Lanka over the decades as the number of reported incidences are still increasing, emphasizing that the emerged approaches are monitored to be ineffective in long-term. Besides majority of these approaches appeared to be less-sustainable and demanding frequent upkeep and energy. Therefore, it is mandatory to explore a technically sound and environmentally viable approach which can sustain over long-term coupled with satisfactory level of control.**

Keywords: **Crop raiding, Habitat destruction, Human Elephant Conflict (HEC), HEC mitigation, Sustainable forest management**

I. HUMAN ELEPHANT CONFLICT (HEC)

Human Elephant Conflict (HEC) is recognized as one of the alarming issues over the entire globe particularly in Asia and defined as the problematic situation in which humans and elephants have overlapping interests. Elephant habitat is being steadily degraded as human population density rises and land-use patterns change. As a result, much of the current elephant range overlaps and stretches into agricultural areas leading in elevated levels of HEC incidences. There are ample evidences that throughout the early nineteenth century, subsistence farmers producing crops in central African woods were losing substantial crop yields to elephants. Equally, food shortages and demographic shifts have been recorded in other places owing to HEC (Graham, 1973; Ville, 1995). In view of that, HEC is not a something new, and crop-raiding has occurred for generations (Nelson *et al*., 2003).

II. ECOLOGY AND BEHAVIOR OF ELEPHANTS

Wild elephants may be found in 50 nations worldwide, including 13 in Asia (*Elephas maximus)* and 37 in Africa (*Loxodonta africana*) (Perera, 2009). Asian elephants (*Elephas maximus)* are one of the a few endangered species (Prakash *et al*., 2020) that also have a substantial level of conflict with humanity (Fernando, 2015) and they are recognized as 'edge-species,' (Fernando and Leimgruber, 2011). Asian elephants come in a multitude of environments, including rain forests, dry thorn forests, and savannahs (Jackson, 1990). Currently they thrive in dry evergreen and thorn-scrub forests in Sri Lanka, having been mostly extirpated from wet zone rainforests by land-use changes during the previous century (Jayewardene, 1994). Elephants are sexually dimorphic (Fernando and Lande, 2000), having adult males weighing roughly 5000 kg and females weighing around 3000 kg. As a result, body size, weight, and metabolic demands indicate greater male home ranges (Fernando *et al*., 2008a). Individual home range size variation is related to variances in resource requirements caused by body size, gender, reproductive status, and sociality thus a huge variation in individual home ranges can be found among Asian elephants (Joshua and Johnsingh, 1995). Sri Lankan elephant home ranges typically extend from 50 to 400 km^2 (Fernando *et al*., 2008a).

Elephants are mega-herbivores, requiring approximately 10 percent of their total weight in food each day (Sukumar, 1989). As a result, they must obtain a huge quantity of food, which implies they cannot be specialist feeders, picking just a limited variety of plants or the most desirable plant components (McKay, 1973). Accordingly, elephants have evolved into generalist herbivores, ingesting a diverse range of plants from over a hundred different plant species (Sukumar, 1990). They habitually devour large volumes of low-quality food and consume for around 17 hours each day (Sukumar, 1992) on a wide variety of plant materials (Steinheim *et al*., 2005) to satisfy their daily dietary and nutritional needs. As a result, for Asian elephants, food is a limited and distributed resource that requires a significant investment in time and mobility to access. Furthermore elephants' social structure is sexually dimorphic, with solitary

adult males (Sukumar and Gadgil, 1988) and female groups with young and their spatial utilization of home ranges are clumped and non-random. The mating system is polygynous and promiscuous, with male-male rivalry and mate hunting (Fernando *et al*., 2008a). Adult males undergo periodic behavioral, physiological and hormonal changes associated with a phenomena named 'musth', generally restricted to a 2 to 3 month period annually (Eisenberg *et al*., 1971). Most HEC incidents are due to male elephants (Sukumar, 1991; Ekanayaka *et al*., 2011; Fernando *et al*., 2011). Males raid croplands in a high-risk, high-gain approach because crops have more palatability and nutritional value than wild plants, resulting in extra nutrition, better growth, and higher reproductive success (Sukumar and Gadgil, 1988). Musth behaviour, including such urine dribbling and extensive roaming, has a significant energetic penalty, and musth-males quickly lose physical health. Musth length is positively associated to physical condition, and those in poorer health do not undergo musth (Baskaran and Desai, 1996). The relatively high roaming during musth is consistent with a strong reproductive payoff and musth is the most visible trait of male Asian elephants compared to African elephants (Fernando *et al*., 2008a). Male reproductive success is intimately linked to access to receptive females, which may be a limiting issue for polygynous males; hence, male spatial organization may be influenced by female distribution (Belcher and Darrant, 2004). Unlike African elephants, Asian elephants often live in low-visibility forest areas and are nocturnal. In reaction to the high prevalence of HEC across their range, they have grown behaviorally evolved to avoid people (Fernando *et al*., 2008a). Numerous studies on HEC have been conducted in Asia (Sukumar, 2003; Jayawardena, 2004; Prakash *et al*., 2020) and Africa (Hoare, 1999; Walpole and Linkie, 2007). Nonetheless, despite of the wide range of measures and management strategies used to mitigate HEC (Nelson *et al*., 2003; Osborn and Anstey, 2007; Fernando *et al*., 2008b), the severity of the problem is clearly intensifying.

III. MAINSPRING FOR HEC; A HUMAN-INDUCED CONFLICT

The potential for conflict has grown as the human population has grown and agricultural lands have expanded (Fernando *et al*., 2011; Köpke *et al*., 2021). Due to intensive loss of habitats (Hoare and du Toit, 1999), elephants have been confined into smaller forest fragments, their habitual migration routes have been restricted and therefore, possibility of direct contact and competition for resources could be enhanced thus resulting a wide range of interferences on human activities including crop raiding, damages to human settlements and fatal conflicts (Hoare, 2000; Mcdonald *et al*., 2009; Santiapillai *et al*., 2010; Liu *et al*., 2017). Human settlements and agricultural fields have proliferated across Asia and Africa, resulting in extensive loss of elephant habitat, deteriorated fodder, diminished landscape connectivity, and a considerable drop in elephant populations compared to their historical size and overall range (Calabrese *et al*., 2017). As humanity alter the landscape, bringing human and elephant populations closer together, the potential of confrontation escalates, with frequently terrible consequences (Shaffer *et al*., 2019). Furthermore, HEC is exacerbated by habitat fragmentation because roads and farms bordering fragmented foraging areas are more likely to cause conflict (Fernando *et al*., 2005).

Elephants, considered non-ruminants, have evolved a gastrointestinal tract that allows them to ingest a vast range of food than in other herbivores. Thus the feeding preferences of wild elephants are diverse, thus they appear to consume the majority of the crops cultivated by farming communities. Limited availability of feeding materials in fragmented forest landscapes could further intensify the crop raiding leading to HECs. The reported trend of elephant destruction in agriculture-oriented regions implies that cultivated crops do have a role in the diet of certain elephants that are serial crop raiders. Additionally, because of their higher nutritional capabilities, farmed crops are even more vital than wild plant materials (Sukumar, 2003). Therefore, crop raiding on agricultural fields to satisfy food requirements in the most prevalent form of HEC over the many regions in the world (Williams *et al*., 2001; Graham *et al*., 2010; Goswami *et al*., 2015; Liu *et al*., 2016). Elephants appear to scavenge in the forest during the day and in farmlands at evenings (Köpke *et al*., 2021). Once the crops are mature and ready for harvesting, wild elephants prefer to ingest paddy. Even if they are safeguarded from elephants, paddy gets devoured after harvesting when it is stacked in households. Elephants have stormed into households multiple times to feast on stored rice, much to the surprise and dismay of the homeowners. They also contribute in a little way to the storage of salt. Because of their fibrous characteristics, coconut trees are also desired (Tudge, 1994). Both Asian and African elephants have been observed to favor banana plants as a source of food (Sukumar, 1990; Barnes *et al*., 2005). Correspondingly, wild elephants ruin the majority of agricultural croplands in their range regions if they are not appropriately managed (Köpke *et al*., 2021).

IV. FALLOUT OF HEC ON ENVIRONMENT AND RURAL LIVELIHOOD; WORLDWIDE PROMINENCE

Impact of HEC can have different forms including crop raiding and economic losses, property damages, injuries and mutual loss of life. Since crop raiding is the most prevalent form of HEC, farmers and their family will be compelled to secure their crops and property throughout the crop raiding season, resulting in a loss of sleep and energy, inadequate employment options, and greater exposure to stressful events. Therefore, HEC has a warm relation with agriculture, which predicts an increase in HEC incidence during cultivation seasons (Santiapillai *et al*., 2010). A number of studies suggested that crop raiding occurs during harvest season, with homicides occurring in response to severe crop losses that endanger agricultural households' livelihood (Chen *et al*., 2006; Graham *et al*., 2010; He *et al*., 2011; Webber *et al*., 2011; Gubbi, 2012; Nath *et al*., 2015). Therefore HEC triggers loss of life in both parties involved. In general, relative

damage to human or elephant life could be caused by the interaction of many considerations, including people's attitudes toward elephant killing, access to and use of approaches that outcome in elephant deaths, penalties for killing elephants and their implementation, and elephant behavior. However the findings of the following studies (Table 1 to 4) depict the severity of human and elephant fatalities due to the HEC have been on the rise in the key elephant range countries over the world.

Table I. Number of Annual Human Deaths Caused by Hec In Asian Countries And Africa (Kenya)

Country	Annual human deaths	Source
India	571	Ganesh, 2019
Sri Lanka	81	Prakash et al., 2020
Bangladesh	37	Islam et al., 2011
Kenya	25	Shaffer et al., 2019
Nepal	18	Acharya et al., 2016
Myanmar	12	Leimgruber et al., 2011
Indonesia	2	Azmi and Gunaryadi, 2011
Sabah (Borneo)	1 - 2	Alfred et al., 2011
Peninsular Malaysia	1	Saaban et al., 2011

According to the findings of above studies (Table 1), the number of human mortality caused by HEC in Sri Lanka is lower than in India but greater than in other Asian and African elephant range nations. Sri Lanka has by far the greatest HEC-induced human death rate per capita, owing to the fact that India's population is 63 times that of Sri Lanka (Prakash *et al*., 2020). As a result, Sri Lanka has the world's second highest number of yearly human deaths from HEC, as well as the highest per capita mortality rate. The situation is mostly similar in the case of elephant deaths.

Table II. Number Of Annual Elephant Deaths Caused by Hec In Asian Countries And Africa (Kenya)

Country	Annual elephant deaths	Source
Sri Lanka	263	Prakash et al., 2020
India	124	Ganesh, 2019
Kenya	50 - 120	Shaffer et al., 2019
Sabah (Borneo)	10 - 16	Alfred et al., 2011
Indonesia	9	Azmi and Gunaryadi, 2011
Bangladesh	4	Islam et al., 2011
Malaysia	1	Saaban et al., 2011

Mitigation of HEC is almost completely concerned with reducing the impact of elephant depredation on people (Fernando, 2015). Therefore, elephants suffer from a variety of human-caused ailments, including having their trunks and legs severed by wire nooses, having their mouths crushed by 'jaw-bombs,' poisoning, falling into wells, electrocution, and being shot. According to the findings of Prakash *et al*., 2020 in Sri Lanka the elephant death rate has recently increased dramatically, hitting 300 for the first time in 2018 and 400 just a year later. The number of fatalities in 2019 is more than double the ten-year average. As a result, Sri Lanka has the greatest number of yearly elephant fatalities worldwide.

Table III. Annual Human to Elephant Death Ratios Caused by Hec In Asian Countries And Africa (Kenya)

Country	Human: elephant deaths	Source
Bangladesh	9.25	Islam et al., 2011
India	4.6	Ganesh, 2019
Malaysia	1.43	Saaban et al., 2011
Sri Lanka	0.30	Prakash et al., 2020
Kenya	0.2 - 0.5	Shaffer et al., 2019
Indonesia	0.2	Azmi and Gunaryadi, 2011
Sabah (Borneo)	0.06 - 0.2	Alfred et al., 2011

Table IV. Annual Male to Female Death Ratios by Hec In Sri Lanka, Tamil Nadu (India), And Bangladesh

Country	Male: female death ratio	Source
Sri Lanka	6.3	Prakash et al., 2020
Tamil Nadu (India)	5.0	Karthick and Ramakrishnan, 2018
Bangladesh	4.2 - 4.5	Sarker et al., 2015

In most Asian countries, the employable population has a significant male bias (Table 4), which is likely to be excessive in the case of crop guarding and confronting elephants (Prakash *et al*., 2020). Moreover, men do seem to be also more certain to be outside after dark, on the road, and drunken (Fernando *et al*. 2011). As a result, men are more likely to come into contact with elephants, whether intentionally or unintentionally, which justifies the male bias in HEC deaths which is more prominent in Sri Lanka among the reported elephant range counties.

V. STATUS OF HEC IN SRI LANKA; CAN WE SUSTAIN?

The conflict between humans and elephants in Sri Lanka is not a recent event. It has been going on since man began agriculture in elephant-infested regions (Santiapillai *et al*., 2010). As a result, the issue is rather old and it is becoming more severe during recent years and poses a significant threat to their conservation in Sri Lanka and across their range (Prakash *et al*., 2020). Interestingly, Sri Lanka has the largest elephant density among range nations, with roughly 10 to 20 percent of the total Asian elephant population inhabiting less than 2 percent of the global range (Leimgruber *et al*., 2003; Fernando and Pastorini, 2011) and has the third largest human population density among the 13 Asian elephant range countries, trailing only Bangladesh and India (Fernando and Pastorini, 2011). Therefore the high density of elephants and people in Sri Lanka has led to the country's high level of HEC, which has become a serious conservation, socioeconomic, and political concern. Besides, Fernando *et al*., 2021 revealed that

local people exist in 69.4 percent of the elephant range in Sri Lanka, implying that the greater mass of elephants frequented terrains that were heavily interrupted for settlements and crop cultivations. Every year, Sri Lanka records approximately 70 human and 200 elephant deaths as a result of HEC (Santiapillai *et al*., 2010; Fernando and Pastorini, 2011). A recent study in Sri Lanka (Prakash *et al*., 2020) found that the HEC intensity varied among geographic locations and years, but it looked to be rising in overall intensity and extent. During the period 2010 to 2019, the country documented a total of 14,516 HEC incidences. Elephants were responsible for 807 human fatalities, 579 human injuries, and 10,532 property losses, as well as 2631 elephant deaths.

Table V. Annual Human and Elephant Deaths Caused By Hec In Sri Lanka Across Different Time Scales

Time scale	Annual human deaths	Annual elephant deaths	Source
1992 - 2001	54	137	Perera, 2009
2005 - 2010	71	200	Fernando et al., 2011
2010 - 2019	81	263	Prakash et al., 2020
2019	121	400	Prakash et al., 2020

These statistics (Table 5), shown that the number of yearly human and elephant deaths in Sri Lanka owing to HEC has been increasing over the last decades, indicating the severity of the problem. Moreover, the number of human injuries and deaths, as well as elephant deaths, was highest in the North-Central and Eastern provinces, and lowest in the Sabaragamuwa province, with the other provinces falling somewhere in the middle (Prakash *et al*., 2020). Similarly, The Eastern, North-Central, and Uva provinces recorded the most property damage, while the Northern and Sabaragamuwa provinces reported the least (Prakash *et al*., 2020). According to the findings of an assessment of elephant fatalities from 1990 to 2000 by Haturusinghe and Weerakoon (2012), the North-Western area accounted for 39 percent of overall deaths, the Mahaweli region (North-Central) accounted for 26 percent, and the Eastern region accounted to only 11 percent. However, according to a recent study by Prakash *et al*. (2020), conflict has lessened in the North-West but expanded dramatically in the North-Central and Eastern areas. HEC was extremely high in Anuradhapura, Polonnaruwa, and Ampara districts and quite low in Mannar, Mullaitivu, Kandy, Nuwara Eliya, Kilinochchi, and Jaffna (Prakash *et al*., 2020). In the same way to the human or elephant fatalities, property damages suggested a high level of conflict in Ampara and Polonnaruwa districts, and a low level in Vavuniya, Nuwara Eliya, Rathnapura, Mannar, and Mullaitivu. Interestingly, Prakash *et al*., (2020) emphasized that toward the end of their study period (2010 – 2018), there was a reduction in property damages in Sri Lanka and suggested that the observed drop is due to the massive number of elephants killed in recent years in high-conflict regions and could be due to a unspecified short-term change caused by environmental, agricultural, or socioeconomic variations.

VI. HEC MITIGATION APPROACHES AND THEIR APPLICABILITY IN SRI LANKA

Agricultural landowners have been using a variety of tactics to alleviate the HEC, including traditional techniques such as noise, fire, bamboo blasters, guarding the field, alarm system, bells, physical barriers including trenches, covered trenches, sharp stones, vegetative barriers consisting unpalatable crops, buffer zones and non-electric and electric fencing. In Sri Lanka, the key efforts for HEC mitigation and elephant conservation involve capture-transport for relocation, encouraging elephant drives, distribution of elephant thunder crackers, establishment of electric fences, and policing laws and HEC mitigation is almost primarily concerned with minimizing the incidence of elephant destruction on humans (Fernando, 2015).

Translocation to protected areas by capture-transport: Translocation by capture-transport has been the primary method used in Sri Lanka to tackle problematic elephants (Fernando, 2010; Fernando *et al*., 2012). Similar action is usually performed in response to human deaths caused by elephants or repeated damage to dwellings caused by elephants scavenging for stored grains. The ultimate focus of translocation is to withdraw the elephant from a conflict zone, and the secondary goal is to ensure the elephant's survival in the environment (Fernando *et al*., 2012). In consequence, efforts to confine elephants to protected areas by herding them into protected areas and fencing them in have been the primary means of HEC mitigation in Sri Lanka for the past 70 years or more (Fernando, 2015). Protests, public uproar, the media, and politicians are being used to place emphasis on the Department of Wildlife Conservation (DWC). However, the fraction of individuals harmed by translocated elephants greatly outnumbers that of non-translocated elephants, and translocated elephants have a higher risk of death (Fernando *et al*., 2012). As a result, transferring problem elephants does not assist to lessen HEC and, in many situations, exacerbates and spreads it. Yet, this effort has entirely failed, and over 70% of elephant range is now outside of protected boundaries (Fernando *et al*., 2021).

Electric fencing over selected threatened areas: When used to keep nuisance animals away of crops, electric fence has been demonstrated to be safe (Poole and McKillop, 2002). Thus they are undoubtedly the most effective strategy for reducing elephant crop damage (Fernando *et al*., 2008b). Massive efforts are made to prevent elephant damage to crops and property, and significant funds are spent on electric fencing (Fernando, 2015). In fact, the DWC Sri Lanka has installed approximately 2500 kilometers of electric fence for HEC mitigation and the chunk of these fences are at the border lines of Wildlife Department protected regions. (Fernando *et al*., 2011). Even these fences are seen to be effective, there are several complications as well. Fences within forests are challenging to upkeep and even become non-functional after a few years. Extensive installation and long-term maintenance costs make larger-scale implementation of these physical barriers difficult, particularly in fragmented landscapes with

high forest-farm exposures (Perera, 2009). On the other hand electric fence is just a psychological barrier (Fernando *et al*., 2008b) implying that they become ineffective as elephants gain knowledge to smash them. However, according to certain research, electric fence, as opposed to traditional labor-intensive crop protection, is a lucrative human wildlife conflict reduction approach (Feuerbacher *et al*., 2021).

Different forms of elephant drives: The primary concern of elephant drives is to pursue the elephant away from the location of the emergency and generally carried out across Sri Lanka's elephant habitats (Perera, 2009; Fernando *et al*., 2015). This mean of HEC mitigation come into play in regions where elephants hide away. The drivers approach the forests from one side and make noises, flares, and elephant thunder/ fire crackers to scare the elephants into fleeing and the elephants are being driven in their home range (Santiapillai, 1996; Fernando *et al*., 2015). Resembling to the electric fencing, elephant drives are not viable over longer time scales. They are notably problematic in terms of both HEC mitigation and elephant conservation. As a result, preventing elephant drives ought to be a prime concern. Assessing elephant herds that have left some or all of their home range owing to drives has revealed that herds do not adjust swiftly to new habitats and suffer from very substantial illness and fatality (Fernando *et al*., 2015). Despite the fact that elephant drives have been implemented across Sri Lanka for many decades, there is not a single setting where elephants have been entirely wiped as a result (Fernando, 1993; Jayewardene, 1994). Drives make elephants non-responsive to them, refractory to being followed, and aggressive towards people by treating them to the same tactics repeatedly.

Driving innocent herds transforms them into problematic herds with a greater tendency of raiding (Fernando *et al*., 2015). When aggressive males are shot, they transform into deadly elephants that attack on eyesight. Furthermore, the induced incidence of gunfire encourages violence in those incidences, with more human deaths as a consequence of elephant aggression and elephant deaths as a result of gunshot wounds. Besides The utility of elephant thunder crackers fosters HEC and violence. Similar to driving, the public's irresponsible and extensive usage of thunder crackers results in elephant habituation and heightened hostility. The DWC and the divisional secretariats in elephant range regions keep giving them to the locals for free. On average over 50 million Sri Lankan Rupees (LKR) is spent each year on elephant thunder crackers (Fernando *et al*., 2011). Preventing the distribution of elephant thunder crackers and replacing them with non-confrontational prevention tactics will prevent HEC from worsening anymore. Conclusively, elevating the carrying capacity of protected areas by forcing enormous numbers of elephants into them via driving and confining them there with electric fences results in elephant starvation and death.

Other types of elephant barriers: Conventional elephant barriers, such as physical fences, elephant trenches, bio-fences, bee-hive fences, and chili fences, are mostly insufficient to prevent elephant depredation because to expense, logistics, and the services that are required for their establishment and maintenance (Santiapillai, 1996; Fernando *et al*., 2008b). In contrast, most of above declared non-natural means are not ecologically sustainable and ethical.

Policing rules and regulations: The elephant acquires distinctive care under the Fauna and Flora Protection Ordinance, which regulates the protection and conservation of all fauna and flora in Sri Lanka and is administered by the DWC and the hurting or killing of an elephant is subject to penalties by a cost of 150,000 to 500,000 LKR or imprisoned for 2 to 5 years, or both cost and imprisoned (Fernando *et al*., 2015). However the general observation is that those who cause elephant discomfort and death are rarely punished.

VII. CONCLUSION AND WAY FORWARD

Despite increased awareness and attempts taken to mitigate the HEC, the situation remains unsolved. In addition, effectiveness of many exclusion methods employed has been questioned as the cost more to construct and can harm wildlife as well. Therefore, the conventional means that we used to mitigate HEC so far are seem to be no longer viable. It thus underlines the significance of site-specific and sustainable management measures in decreasing crop loss, property damages, and possible HECs in order to prevent human and elephant deaths. In other words, if elephants are to survive in considerable numbers outside of the protected area network, novel strategies must be implemented to reduce negative impacts on both parties involved. We must realize that elephant killing will continue as long as people do not value life beside elephants. It can be underlined that the HEC is already escalating, and it may worsen tomorrow. Although it is unclear that the HEC can be completely avoided, every effort must be made to minimize it to manageable levels. Management of those enormous lives must first be completely overhauled if HEC mitigation and elephant conservation are to be fruitful. In conclusion a scientific management strategy should only be used, with recommendations based on facts and evidence rather than outmoded ideas and invalid interpretations.

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