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Human-Elephant Conflict in Sri Lanka: Patterns and Extent

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Abstract. Human-elephant conflict (HEC) has become a serious socio-economic and conservation problem in Sri Lanka. We assessed the overall level of HEC in the country during 2010–2019 and the patterns of conflict in relation to administrative districts. Globally, Sri Lanka had the highest annual elephant deaths and second highest human deaths, due to HEC. Male mortality was higher in both elephants and people. Conflict has greatly increased in intensity and geographic extent from that reported previously. The highest conflict has shifted from the Northwest to the East and North-Central areas, with the Northwest showing a decline in conflict. The changes in different areas were probably related to differences in management actions and developmental activity. Further increase in HEC is likely in the Eastern, North-Central and Northern regions.

Introduction

Asian elephants (*Elephas maximus*) are listed as 'endangered' and human-elephant conflict (HEC) poses a serious challenge to their conservation in Sri Lanka as well as the rest of the range. The density of elephants in Sri Lanka is the highest among range countries with around 10–20% of the global Asian elephant population occupying less than 2% of the global range (Leimgruber *et al*. 2003; Fernando & Pastorini 2011). Of the 13 Asian elephant range countries, the human population density in Sri Lanka is third highest, behind Bangladesh and India (Fernando & Pastorini 2011). The high densities of elephants and people in Sri Lanka have contributed to a high level of HEC in the country, which has become a major conservation, socio-economic and political issue.

The Department of Wildlife Conservation (DWC) is the agency mainly responsible for mitigating HEC in Sri Lanka. Sri Lanka is divided into several administrative regions by the DWC and most previous studies of HEC have been based on these regions (eg. Zubair *et al*. 2005; Fernando *et al*. 2011; Haturusinghe & Weerakoon 2012). However, the number of regions and their boundaries change from time to time. For example the number of regions varied between six and eleven in the period 2010–2018 (see DWC Performance reports).

The frequent changes in the extent and boundaries of DWC regions makes it difficult to assess changes in HEC with time. Also, effective HEC mitigation requires that people and agencies responsible for people's welfare and development become the main stakeholders of HEC mitigation (Fernando 2015). Such an approach requires allocating resources through the development and administrative sectors. Therefore, we analysed HEC based on the administrative sectors in Sri Lanka.

Methodology

Administratively, Sri Lanka is hierarchically divided into 9 provinces, 25 districts, and 331 Divisional Secretariat (DS) divisions. Data on human deaths, elephant deaths, human injuries, and property damages due to HEC from 2010–2018 and the total number of human and elephant deaths in 2019 were obtained from the DWC under provisions of the Right to Information Act No. 12 of 2016 (Right to Information Commis-

sion of Sri Lanka 2018). Monthly data on human and elephant deaths and annual human injury and property damage data was available at Divisional Secretariat level. Gender of human victims was available for 2010–2018 and age for 2012, 2014, 2015, and 2016. Gender of elephants that died was available for 2010–2014. Funds expended by the DWC for main HEC mitigation initiatives were gleaned from annual performance reports of the DWC.

Analysis of Variance (ANOVA) was conducted to assess significance of variation in HEC related factors between months in a year, years, districts, and gender. As human deaths and injuries, and elephant deaths were of a similar scale and low in number, they were lumped together for analysis. Property damages were analysed separately as they were almost a magnitude greater. Minitab 14 statistical software and Microsoft Excel 2010 were used in statistical analyses and graphical presentation. Maps were prepared using ArcGIS software.

Results

Country-wide analyses

A total of 14,516 HEC incidents were recorded in the country during 2010–2019. There were a total of 807 human deaths (Fig. 1), 579 human injuries and 10,532 property damages caused by elephants and 2631 elephant deaths (Fig. 2). The 2631 elephant deaths include those at the Elephant Transit Home and those where the DS division was not recorded.

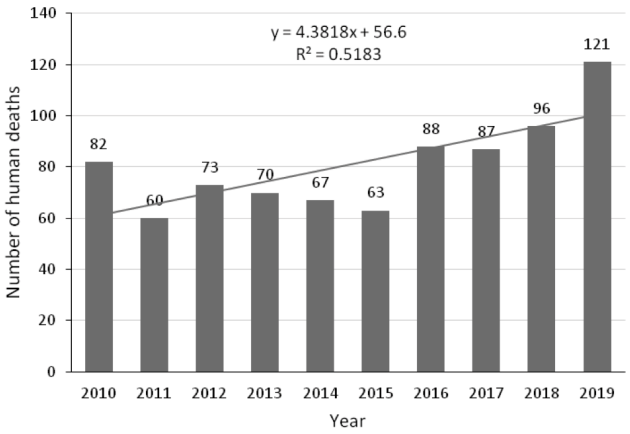

Figure 1. Annual human deaths.

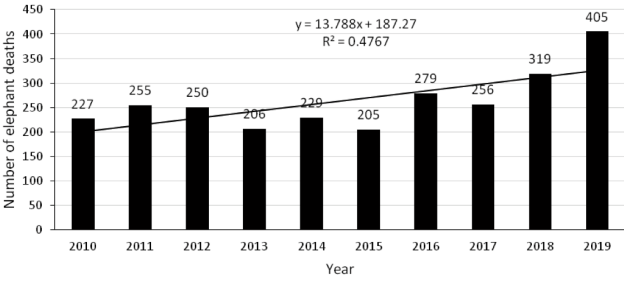

Figure 2. Annual elephant deaths.

Human and elephant deaths did not vary significantly between months of the year. Of 686 human deaths from 2010–1018, in 673 the gender was recorded with 581 being male and 92 female. Significantly more men than women died from the conflict ($F = 191.53$; $p < 0.001$). The mean age of male victims was 52 years (range 4–90 years) and the mean age of females was 53 years (range 7–80 years) (Fig. 3). Of 1167 elephant deaths, in 1033 the sex was identified, consisting of 690 males and 343 females. The male bias was significant ($F = 71.40$; $p < 0.001$).

HEC mitigation by the DWC

Annual expenditure by the DWC for the main HEC mitigation activities is given in Table 1. A total of 2402 km of new electric fences were constructed by the DWC between 2010–2018 (Table 2). A total of 86 multi-day elephant drives were conducted in the same period with the intention of eliminating elephants from a given area. In addition to such drives, the DWC conducted innumerable short duration drives to 'chase' elephants from a given locality, for which no data were available.

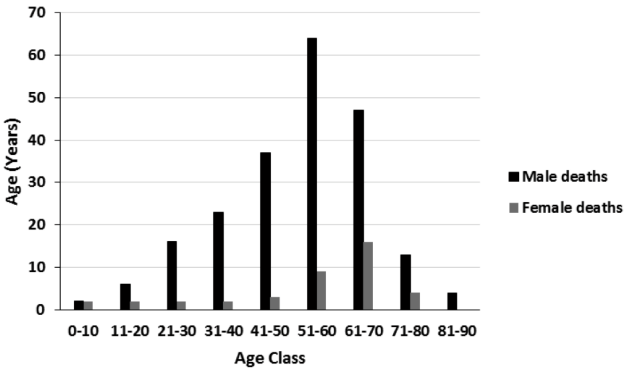

Figure 3. Human deaths due to HEC, by gender and age group.

Table 1. Funds spent (in US$) annually for selected HEC mitigation activities by the DWC.

Year	Elephant thunders	Compensation	Capture translocation	Elephant drives	Total
2010	193,636	214,757	42,131	54,477	505,001
2011	228,117	139,587	1,996	25,990	395,690
2012	240,922	119,408	34,370	33,406	428,106
2013	268,308	172,016	12,196	29,325	481,845
2014	323,189	166,528	16,908	63,125	569,750
2015	420,589	142,580	10,588	40,873	614,630
2016	480,126	123,178	24,669	53,721	681,694
2017	383,952	141,451	23,240	35,441	584,084
2018	714,568	245,431	53,779	54,243	1,068,021

Provincial level analyses

HEC occurred in eight of the nine provinces. HEC incidents showed (human deaths and injuries, and elephant deaths combined) varying intensities between provinces with the North-Central and Eastern provinces showing the highest and Sabaragamuwa the lowest levels (Fig. 4).

Property damages recorded had a similar pattern to HEC incidents represented by injury and death except in the Uva province, which had a relatively higher incidence of property damage (Fig. 5).

The incidence of HEC within a given province varied annually, with increasing trends in some and decreasing trend in others (Figs. 6 & 7). The provinces with the highest HEC incidents as represented by injury and death also showed a recent and rapid increase in the number of incidents (Fig. 6). In contrast, the provinces with the highest property damages showed a recent decrease in the number of incidents (Fig. 7).

Table 2. Length (in km) of new electric fences erected and number of elephant drives conducted by the DWC annually.

Year	Electric fences	Elephant drives
2010	343	11
2011	213	5
2012	232	8
2013	343	10
2014	179	9
2015	226	8
2016	287	16
2017	488	9
2018	91	10

District level analysis

HEC occurred in 19 districts as indicated by both the property damage data and combined data (Figs. 8 and 9). A comparatively high number of HEC incidents were shown by both sets of data in Anuradhapura, Polonnaruwa and Ampara districts while Badulla district had a disproportionately high number of property damages (Figs. 8 and 9).

DS division level analysis

Human deaths due to HEC were reported from 112 DS divisions and elephant deaths from 131 DS divisions, indicating the occurrence of HEC over much of the dry zone (Fig. 10). The mean number of DS divisions reporting human deaths in a given year was 44 (range 35–52) and elephant

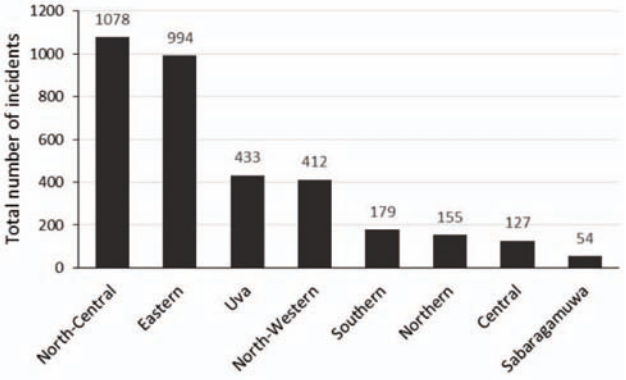

Figure 4. Total number of HEC incidents by province.

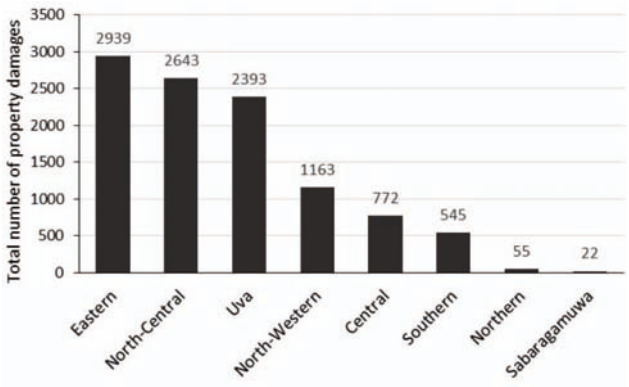

Figure 5. Total number of reported property damages by province.

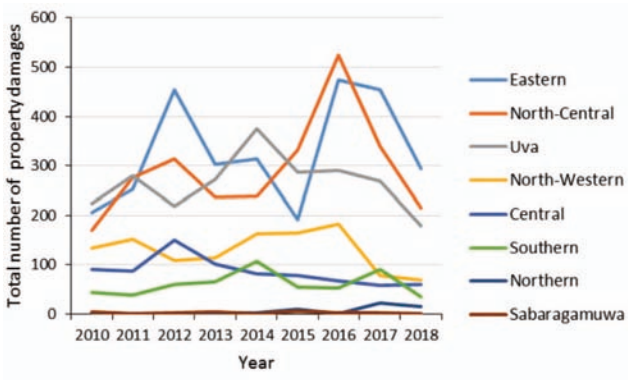

Figure 7. Annually reported property damages by province.

deaths 78 (range 68–86). The number of DS divisions reporting human deaths and elephant deaths in a given year showed an increasing trend (Fig. 11).

Discussion

The study showed that HEC was very widespread in Sri Lanka. The intensity of HEC varied between geographic areas and between years but appeared to be increasing in overall intensity and extent.

The annual human death rate due to HEC from 2010–2019 was 81. In India, currently it is about 571 (Ganesh 2019). In Bangladesh the annual human mortality was 37 (Islam *et al*. 2011), Nepal 18 (Acharya *et al*. 2016), Myanmar 12 (Leimgruber *et al*. 2011), Indonesia 2 (Azmi & Gunaryadi 2011), Sabah (Borneo) 1–2 (Alfred *et al*. 2011), and Peninsular Malaysia 1 (Saaban *et al*. 2011). Thus the number of human deaths due to HEC in Sri Lanka is less than in India but higher than in other Asian elephant range countries. Per capita, Sri Lanka has the highest HEC induced human mortality by far, as the Indian population is 63 times that of Sri Lanka. While HEC is comparatively less in Africa, Kenya has the highest level of HEC in Africa, with around 25 human deaths per year caused by elephants (Shaffer *et al*. 2019). Therefore, Sri Lanka has the second highest number of annual human deaths and the highest per capita death rate from HEC globally.

The average human death rate due to HEC in Sri Lanka was 71 from 2005–2010 (Fernando *et al*. 2011) and 54 from 1992–2001 (Perera 2009). Therefore, the human death rate has increased by about 14% from the previous decade and by about 50% from two decades ago. As the number of deaths in 2019 reached 121, human deaths from HEC appear to be markedly increasing. Annual human mortality in India was 225 from 1998–2001, around 400 in 2011 (Baskaran *et al*. 2011) and 571 between 2015–2018 (Ganesh 2019). Thus human deaths in India increased by around 43% from a decade ago and 153% from

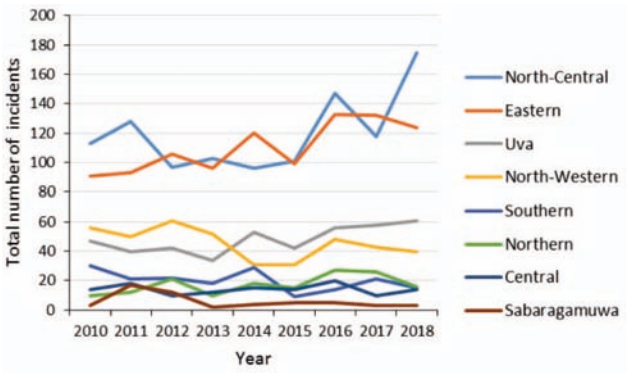

Figure 6. Annual number of HEC incidents by province.

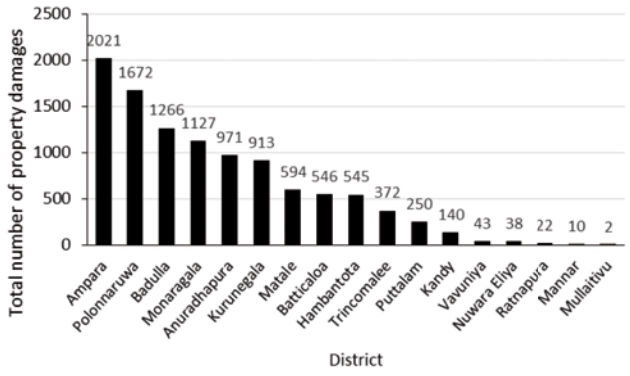

Figure 8. Total number of property damages by district.

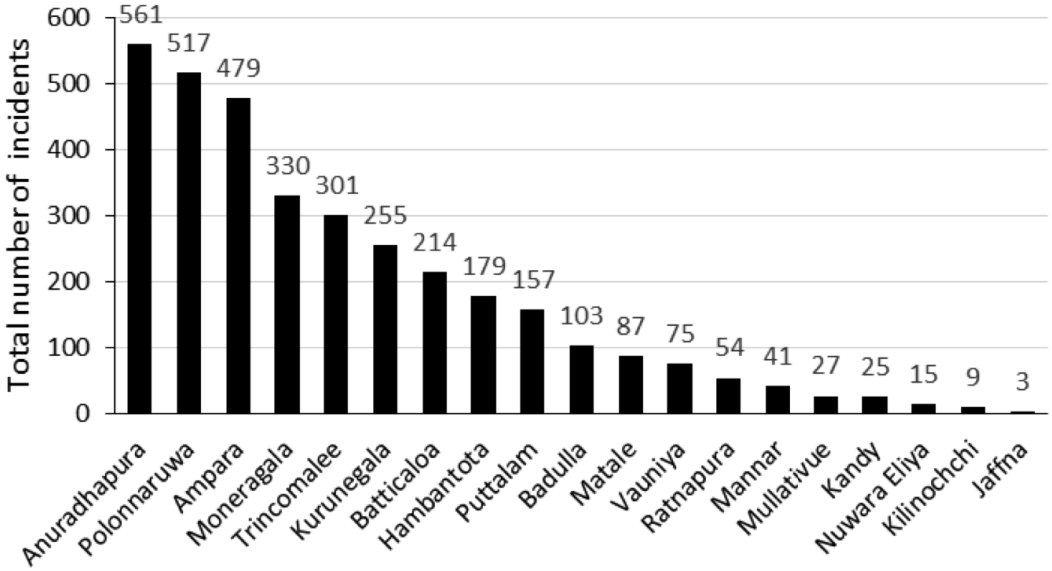

Figure 9. Total number of HEC incidents by district.

two decades ago. The rate of increase in Sri Lanka was less than in India but both show acceleration, symptomatic of the escalation of HEC across the range.

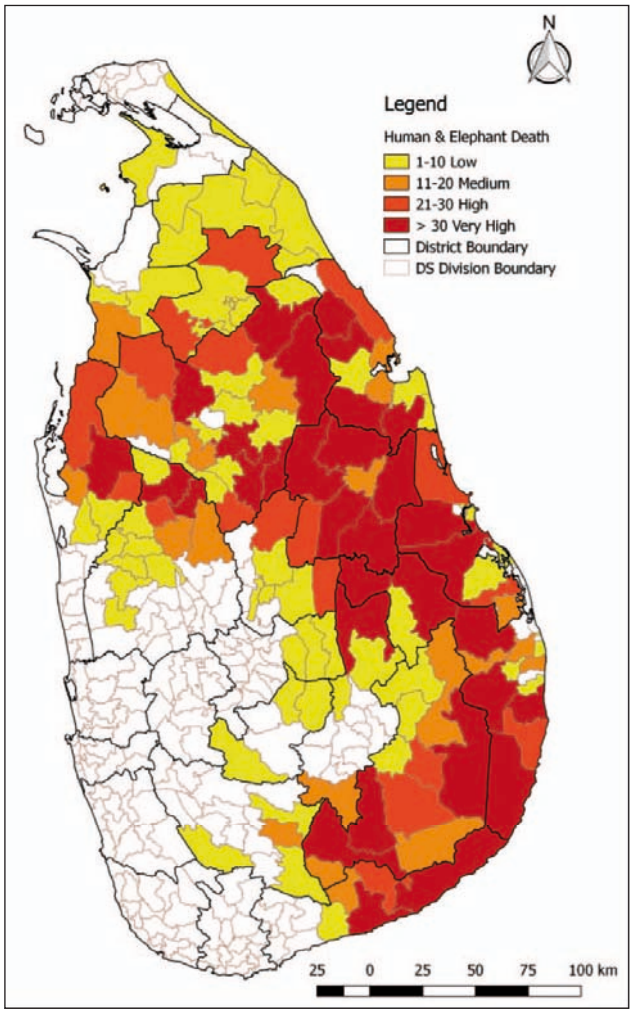

Figure 10. DS divisions with human and elephant deaths.

Annual death rates in Sri Lanka due to motor accidents are over 3000 (Ministry of Transport & Civil Aviation 2019), drowning over 900 (WHO 2014) and snakebites about 400 (Ediriweera *et al*. 2016). While comparatively less in contrast to other causes of accidental deaths, deaths caused by HEC often cause public protests, attracting much media attention. The reaction to human deaths from elephants, appears to be out of proportion to the extent, hence unacceptable psycho-sociologically.

Many deaths due to HEC are caused by irresponsible behaviour of people, such as approaching wild elephants while inebriated, harassing elephants and unnecessarily chasing them. Most human deaths due to HEC are preventable if appropriate precautions are taken. Mass media plays a major role in drawing attention to HEC and shaping public reaction to it. Therefore media should report incidents of HEC responsibly with elucidation and reportage of actual reasons and circumstances causing incidents, rather than sensationalizing them.

While human injuries caused by elephants were similar in scale to deaths, incidents of property damage were more than an order of magnitude greater. Since many cases of property damage are presumably not reported, the actual numbers are likely to be much higher. Most property damage by elephants and some human deaths are related to raiding of grain stored in houses. Alternatives

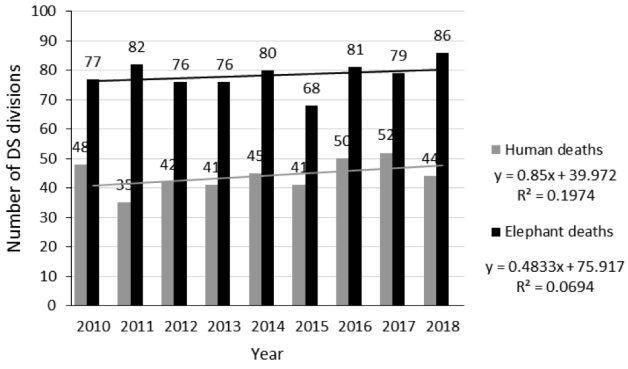

Figure 11. Number of DS divisions reporting human and elephant deaths by year.

to such storage such as sale of the harvest and purchasing the daily requirement, or protection of settlements with electric fences would help prevent such incidents. Purchase of grain by the government at a higher price from areas with elephants could encourage farmers not to store grain in their houses.

We found an annual elephant death rate of 263 from 2010–2019. In 2005–2010 the elephant death rate was 200 (Fernando *et al*. 2011) and in 1992–2001 it was 137 (Perera 2009). Therefore, the elephant death rate has increased by about 31% from the previous decade and by about 92% from two decades ago. The elephant death rate shows an extremely high increase recently, exceeding 300 for the first time in 2018 and 400 just a year after. The deaths in 2019 are double the average from a decade ago. Annual elephant death rates in India are around 124 (Ganesh 2019), Sabah (Borneo) 10–16 (Alfred *et al*. 2011), Indonesia 9 (Azmi & Gunaryadi 2011), Bangladesh 4 (Islam *et al*. 2011), and Malaysia 1 (Saaban *et al*. 2011). In Kenya the annual death rate of elephants is 50–120 (Shaffer *et al*. 2019). Therefore, the highest number of annual elephant deaths globally, is reported from Sri Lanka.

Comparatively many more elephants than people get killed due to HEC in Sri Lanka with a ratio of human to elephant deaths of around 0.30. A similar situation is observed in Kenya, Indonesia and Sabah with respective ratios of 0.2–0.5, 0.2, and 0.06–0.2. In contrast, a higher proportion of human deaths per elephant death occur in India (4.6), Bangladesh (9.25), and Malaysia (1.43). The difference between the two groups is probably due to the interaction of many factors, including attitudes of people towards killing of elephants, access to and use of methods that result in elephant deaths, penalties for killing elephants and their implementation, and behaviour of elephants.

Human deaths and elephant deaths showed an increasing trend within the study period and a major increase from levels reported two decades ago. Annual expenditure on the main activities conducted for HEC mitigation by the DWC increased by around 110% within the same period. On average 267 km of new electric fences were erected annually in addition to maintenance of existing fences, which currently stands at around 4500 km. An annual average of 10 major elephant drives were conducted by the DWC during the study period. Whether the lack of a tangible impact of this increasing expenditure and effort in HEC mitigation is due to the ineffectiveness and inappropriateness of the HEC mitigation methods used (Fernando 2015), or increased conflict due to continued development in areas with elephants is not clear. It is likely that both factors play a part.

HEC has a strong association with Agriculture (Santiapillai *et al*. 2010), which predicts higher HEC incidents during cultivation periods. Sri Lanka has two agricultural seasons. The main season 'Maha' is during the North East monsoon from November to February and the secondary season 'Yala' is from May to August but may vary between years and regions. However, we did not find a relationship between the number of human and elephant deaths and months of the year or agricultural seasons. The lack of correlation maybe due to year-round cultivation with irrigation – especially in home gardens, raiding of perennial crops and incidents due to raiding of grain stored in houses and annual and regional variation in cultivation seasons. Additionally, incidents such as deaths occurring on roads would be unrelated to agriculture. Given that human deaths occur throughout the year, people living in areas with elephants need to be aware of elephant presence throughout the year and take adequate precautions.

Significantly more men were killed by HEC. The male: female ratio of human deaths caused by HEC is 6.3 in Sri Lanka, 4.2–4.5 in Bangladesh (Sarker *et al*. 2015; Hossen 2013) and 5.0 in Tamil Nadu, India (Karthick & Ramakrishnan 2018). In most Asian societies, there is a strong male bias in the economically active population. For example in Sri Lanka, 63.4% of those engaging in economic activities were males (Department of Census and Statistics 2018). Male bias is likely to be extreme in the case of crop guarding and confronting elephants. Men are also more likely to be outside the home after dark, be on roads and to be inebriated (Fernando *et al*. 2011). Therefore, men are more likely to encounter elephants, whether intentional or accidental, which probably explains the male bias in HEC deaths.

We found that the majority of deaths of males due to HEC were of those of working age. Such loss may have serious consequences to the families affected as it may lead to reduced income of the household and create social issues. The highest number of deaths of men was in the age category 51–60 years and in women, 61–70 years. In Bangladesh, 74% of HEC related human deaths in 1989-2012 were of those aged above 30 years (Sarker *et al*. 2015). In Tamil Nadu, India, between 2008 and 2017, the age class of 40–50 was the most affected by HEC followed by 50–60 irrespective of sex (Karthick & Ramakrishnan 2018). Therefore, the observed pattern of middle-aged mortality being the highest is similar to other countries, but with a predisposition towards the old-age group in Sri Lanka. The greater mortality of the middle-age group could be due to higher outdoor activity and the bias towards older-age groups could be due to decreased reflexes and motor impairment with age. The higher life expectancy in Sri Lanka of 73.2 compared to India's 68.0 and Bangladesh's 70.4 (Worlddata n.d.) could also have some influence on the bias towards older age in Sri Lanka.

Significantly more males were represented in elephant deaths also. The male: female ratio of elephant deaths in Sri Lanka was 2.01. A previous study recorded an even greater male bias in North-West Sri Lanka, with a ratio of 2.64 (Haturusinghe & Weerakoon 2012). In Southern India 1531 male elephants and 1189 female elephants died during 1976–2000 (Ecology Center 2019), giving a male: female ratio of 1.29. Most HEC incidents are due to male elephants (Sukumar 1991; Ekanayaka *et al*. 2011; Fernando *et al*. 2011). In India, male elephants entered cultivation about six times more frequently than members of female groups, and males and females obtained 9.3% and 1.7% respectively of their diet from crops (Sukumar 1990). Males raid crops in a high-risk high-gain strategy due to the higher palatability and nutritive value of crops compared to wild plants, obtaining extra nutrition, better growth and higher reproductive success (Sukumar & Gadgil 1988). Thus, the observed male bias in elephant deaths is largely explained by behavioural differences between the two sexes, especially in interaction with humans.

Provincial level distribution of HEC

The number of human injuries and deaths, and elephant deaths combined was highest in North-Central and Eastern provinces and the lowest in the Sabaragamuwa province, with the other provinces at intermediate levels. The highest reported property damages were from the Eastern, North-Central, and Uva provinces while the lowest was from Northern and Sabaragamuwa provinces, with some differences in the ranking of the provinces in the middle when compared with the other indicators. Thus all indicators showed a similar pattern. An analysis of elephant deaths from 1990–2000 based on DWC administrative regions, found the highest with 39% of total deaths occurring in the North-Western, the second highest with 26% in the Mahaweli region (North-Central), while the Eastern region accounted for only 11% (Haturusinghe & Weerakoon 2012). Similarly, a review of elephants and HEC in Sri Lanka from 2005–2010 found North-West and North-Central areas to have the highest conflict but predicted its escalation in the east (Fernando *et al*. 2011). The present study found that conflict has decreased in the North-West and increased markedly in the North-Central and Eastern regions.

District and DS division level distribution of HEC

HEC was very high in Anuradhapura, Polonnaruwa and Ampara and lowest in Mannar, Mullativue, Kandy, Nuwara Eliya, Kilinochchi, and Jaffna districts, as indicated by the combined data. Property damages indicated very high conflict in Ampara and Polonnaruwa, and low levels in Vavuniya, Nuwara Eliya, Ratnapura, Mannar, and Mullaitivu districts. Therefore, the indicators of HEC showed a similar pattern at the scale of districts also. Badulla and Anuradhapura were exceptions to the regular pattern. Anuradhapura recorded the highest conflict in terms of the combined data, but showed an intermediate level with regard to property damages. Badulla showed a mid-level of conflict according to the combined data but a very high level of property damage. The difference between the two data sets may indicate some anomaly in the pattern of cultivation and/or reporting from the particular districts.

More than one third of all DS divisions in Sri Lanka were subject to HEC. The number of DS divisions reporting human deaths and elephant deaths in a given year showed an increasing trend, demonstrating the continued geographic spread of the conflict. Mapping of conflict illustrated that HEC was not recorded due to elephants being absent from a number of areas including the southwest quarter, the Jaffna peninsula and a few small DS divisions in the East and North-Central regions, which were very densely populated (Fig. 10). The only areas with elephants but without HEC were some DS divisions in the North (Fig. 10). The distribution pattern of HEC observed corresponds to the distribution of elephants and HEC indicated by a grid based survey of the island (Fernando *et al*. in press).

Trends in conflict level

The present study shows that the conflict in the North-West has declined and the highest conflict is now in the North-Central and the Eastern provinces. Eastern province showed the greatest increase followed by North-Central, Uva, Northern, and Central provinces in reporting human and elephant deaths and human injuries. The North-Western, Southern, and Sabaragamuwa provinces showed a negative trend. When considering property damages, the North-Central province showed the highest increase followed by Eastern, Uva, North-Western, Southern, and Northern provinces while Central and Sabaragamuwa provinces showed a negative trend. However, a decrease in property damage was observed towards the end of the study period, particularly where the other indicators showed very high conflict. One possibility for the observed decline is the large number of elephants that have been killed in the last few years in the very high conflict areas. However, a decline in property damage was also observed in the North-West where the other indicators also showed a decrease in conflict. Therefore, the recent decline in property damage could also be a short-term phenomenon related to environmental, agricultural or socio-economic changes.

Attempts at limiting elephants to protected areas by driving them into DWC protected areas and fencing them in has been the main approach to HEC mitigation in Sri Lanka over the past 70 years or so (Fernando 2015). However, this approach has completely failed and currently over 70% of elephant range is outside protected areas (Fernando *et al*. in press). In an alternative approach, community-based electric fencing to protect villages and paddy fields has been implemented in the North-West with over 50 community-based fences being implemented by the Centre for Conservation and Research and the DWC in the past decade. In contrast, construction of electric fences on protected area boundaries by the DWC was completed in the North-Central region during the study period (Wickramasinghe AD, DWC pers. comm.). Many such linear fences were also constructed in the East. The decrease in conflict in the North-West and increase in the East and North-Central regions may have some relation to the different approaches to HEC mitigation in the respective areas.

A recent (2020) initiative of distributing guns by the government for ‘HEC mitigation’ in

Anuradhapura and Ampara districts, is likely to greatly escalate the conflict in those areas, with increased human deaths from elephants driven to aggression and elephant deaths from gunshot injuries.

The North, North-Central and the East were also heavily impacted by armed conflict for three decades and many villages and cultivations were abandoned and became optimal elephant habitat (Fernando *et al*. 2011). Since cessation of hostilities in 2009, resettlement of people and increasing human encroachments would also have contributed to the rapid increase in HEC (Prakash 2014).

Therefore, in addition to the continued escalation of HEC in the North-Central and Eastern regions, it is likely that HEC will significantly increase in the North in the near future.

Acknowledgments

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