

## Crop damage by Asian elephant (*Elephas maximus*) in Ekgaloya and Dewalahinda areas in Ampara District, Eastern province, Sri Lanka

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Sri Lanka is one of the Asian countries to support a considerable number of wild elephants mainly in the dry zone of the country. But today elephants have become one of the most seriously endangered large mammals in Sri Lanka and the world as well. Agricultural crop damage by elephants has become a most common and serious problem across the elephant range in Sri Lanka due to negative interaction of people and the elephants. Eastern province is one of such areas where severe crop damage by wild elephants could be observed. In these areas, most of the directly affected families are having low income level. For this common problem, still there is no proper mitigation plans to lower the impacts. Therefore, this study focused on the analysis of economic losses to cultivated crops, identify the most vulnerable crop species and suggest viable control measures to minimize this problem to a certain extent in the area. This study was carried out in two villages within one cropping season under two stages. Household survey including randomly selected 50 villagers from each village was conducted. Highest crop damage incidents were recorded in Dewalahinda area. Of the widely grown crop varieties, maize (*Zea mays*) and paddy (*Oryza sativa*) are subjected to heavy damage in both villages. Paddy and maize were reported as damage crop species by wild elephants in Ekgaloya and 19 households (out of 33) suffered due to that crop raiding incident. Out of 38 crop damage incidents in Dewalahinda, 28 households reported damages in maize and 26 household reported damages in paddy. Wild elephants have shown a least interest on some crop varieties such as chilli (*Capsicum annum*), ladies' finger (*Hibiscus esculentus*) and peanut (*Arachis hypogaea*). But these crop fields were heavily damaged by elephants as they walk across these fields. In both villages, the harvesting period seemed to be affected more by crop damages than other times. However, the post harvesting period was also affected occasionally especially in stored paddy.

**Keywords:** endangered, socio-economic, cropping season, vulnerable crop species, Macroscopic analysis

### 1 Introduction

Elephants are mammalian mega herbivores on the earth. *Elephas maximus* is one of the four living sub species and one of the most seriously endangered species which is found only in 13 countries in Asia including Sri Lanka (Plotnik et al., 2006). According to the historical records the species was widely distributed in Sri Lanka (Santiapillai et al., 1999) but today they are restricted mostly to the low lands in the dry zone and fairly spread in certain areas of North, South, East and North-western, and the highest damages are recorded from areas in the North-central and areas in the South-eastern regions of the country. Asian elephants are generally found in

grasslands, tropical evergreen forests, semi evergreen forests, moist deciduous forests, dry deciduous forest, tropical rain forests and dry thorn forests (Sukumar, 1989).

#### Human Elephant Conflict

Human Elephant Conflict (HEC) is now becoming a considerable social problem and it arise mainly due to the loss, degradation and fragmentation of natural habitats through anthropogenic activities such as agricultural expansion, animal husbandry, logging and various types of development activities (Plotnik et al., 2006). Community in the dry zone of Sri Lanka mainly depends on the agriculture-based economy therefore

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large extent of lands is covered by paddy fields and chena (shifting) cultivations. Reasons for Crop damages could mainly occur in these areas due to cultivated landscapes are located closer to the elephant reserves.

Elephants are both grazers and browsers, so they consume wide range of plant materials belongs to different species. Average daily fresh vegetation consumption by a wild elephant has been estimated as 150–250 kg in Sri Lanka (Bandara, 2010). Some of the wild elephants prefer crops such as banana (*Musa spp.*), paddy (*Oryza sativa*), sugarcane (*Saccharum officinarum*), etc. Therefore, they have become non-insect pests in the agricultural landscapes in Sri Lanka.

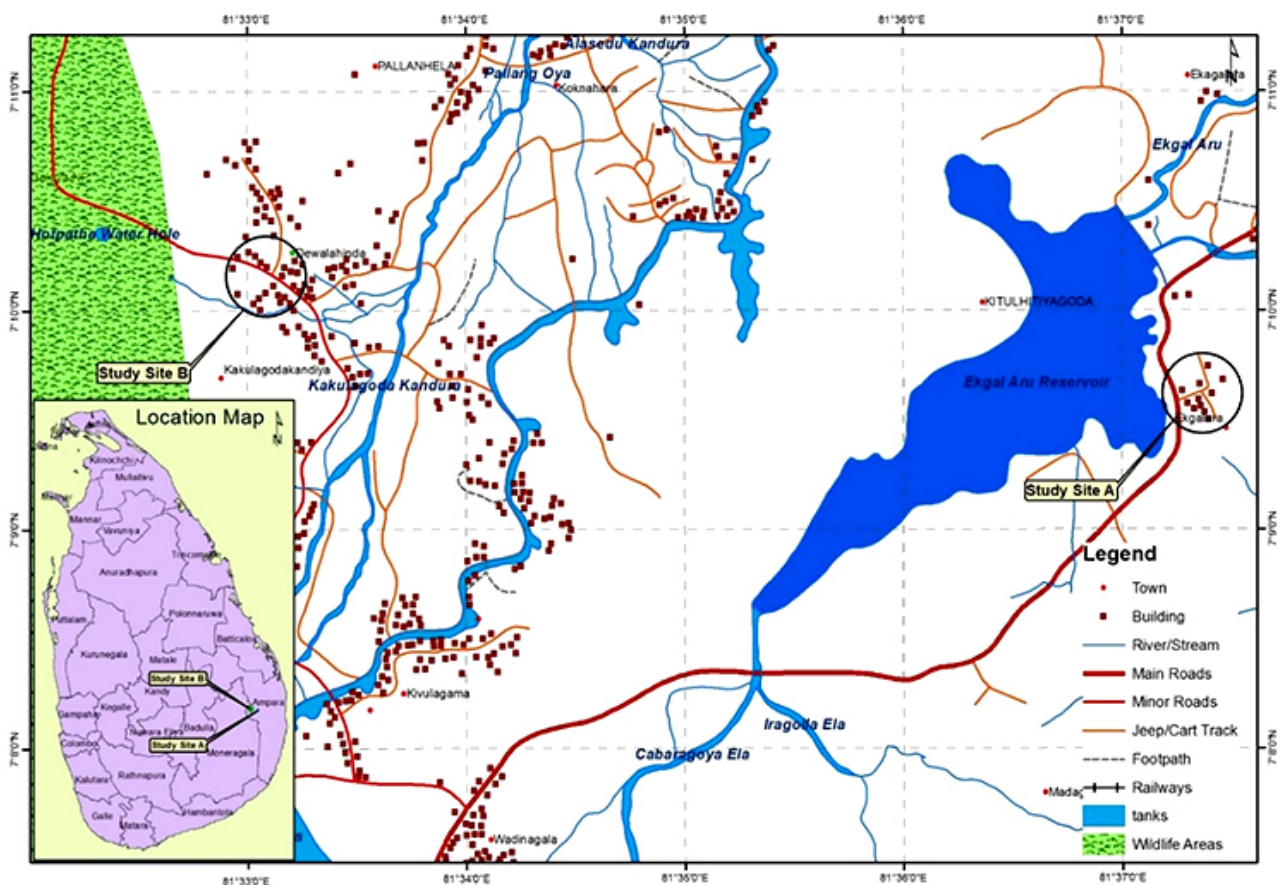
Due to abundance of crop damaging incidents, some researchers have focused their attention to carry out studies to evaluate the crop loss by wild elephants which are mainly affecting rural farmer's economy (Bandara and Tisdell, 2003; Santiapillai et al., 2010). Having large home ranges, they are capable of dispersing seeds over a long distance; Seeds found in elephant dung is providing evidence for seed dispersing by wild elephants (Campos-Arceiz et al., 2016). Therefore, this study is useful to get an idea about the feeding

preferences of wild elephants in the region, to identify the reasons leading human elephant conflict and to suggest controlling measures to minimize them.

### Study area

This study was conducted in Ekgaloya (7° 9' 35.70" N/81° 37' 21.66" E) and Dewalahinda (7° 10' 0.00" N/81° 34' 0.00" E) villages located in Damana Divisional Secretariat, Ampara district, Eastern Province of Sri Lanka (Figure 1). Ekgaloya village is located about 24 km from Ampara-Ekgaloya main road. It includes three chena cultivation areas. Two chena areas are located about 500 m away from the left side of the main road and another one is located about 500 m away from the right side of the main road bordering Ekgaloya tank and Nellikele forest area as well as very close to YSS (Educated Youth Settlement Scheme) village.

The study site Dewalahinda is located about 22 km on the Ampara-Inginiyagala main road and about 500 m away from the trunk road. This study area also included three sites. Two chena lands located about 500 m away from left side of the minor road and another one located about 150 m away from the



**Figure 1** Location map of Ekgal Oya (Study site A) and Dewalahinda (Study site B)  
 Source: Survey Department of Sri Lanka, 1987

right side of the minor road and adjacent to the Galoya National Park.

## 2 Materials and methods

Assessment of crop damage by elephants were carried out using household survey (by questionnaire) and by macroscopic analysis of seeds and germinating unidentified seeds collected from dung piles. Questionnaire was mainly based on the information on cultivations, cultivated crops/s, farming system, pattern of land usage, economic status of the people in the area and major causes for the damages of the harvest.

Household survey was based on two villages covering three cultivated lands (chena areas) in each village. Survey was carried out from July to October 2010, across the cultivated area within one cropping season. Information on crop damages and farmers perception was collected by interviewing people through questionnaire. Interviews were conducted with 50 villagers randomly selected from each village.

Economic losses for different crop varieties were calculated using the formula:

$$Li = Ai \times Yi \text{ (Shrestha, 2018)}$$

where:  $Li$  – loss of a given crop (kg season<sup>-1</sup>) reported by household  $i$ ;  $Ai$  – land area (hectares) for the damaged crop species by elephants as reported by household  $i$ ;  $Yi$  – yield of the given crop (kg hectare<sup>-1</sup> season<sup>-1</sup>) reported by household  $i$

Cost of damage for given crop varieties (EUR season<sup>-1</sup>) were calculated by multiplying ( $Li$ ) with the retail price for the given crop (EUR kg<sup>-1</sup>). Total crop yield (kg season<sup>-1</sup>) for each of crop varieties was obtained by multiplying the values of total cultivated land area with the yield of the

crop (kg hectare<sup>-1</sup> season<sup>-1</sup>) reported by the households in both villages. Cost of damage to crop will be calculated using the retail price values in the local market for the different crop varieties in the area. Crop loss for each crop variety was calculated by multiplying yield of the crop (kg hectare<sup>-1</sup> season<sup>-1</sup>) with the land area for the damaged crop species (hectares) in two villages.

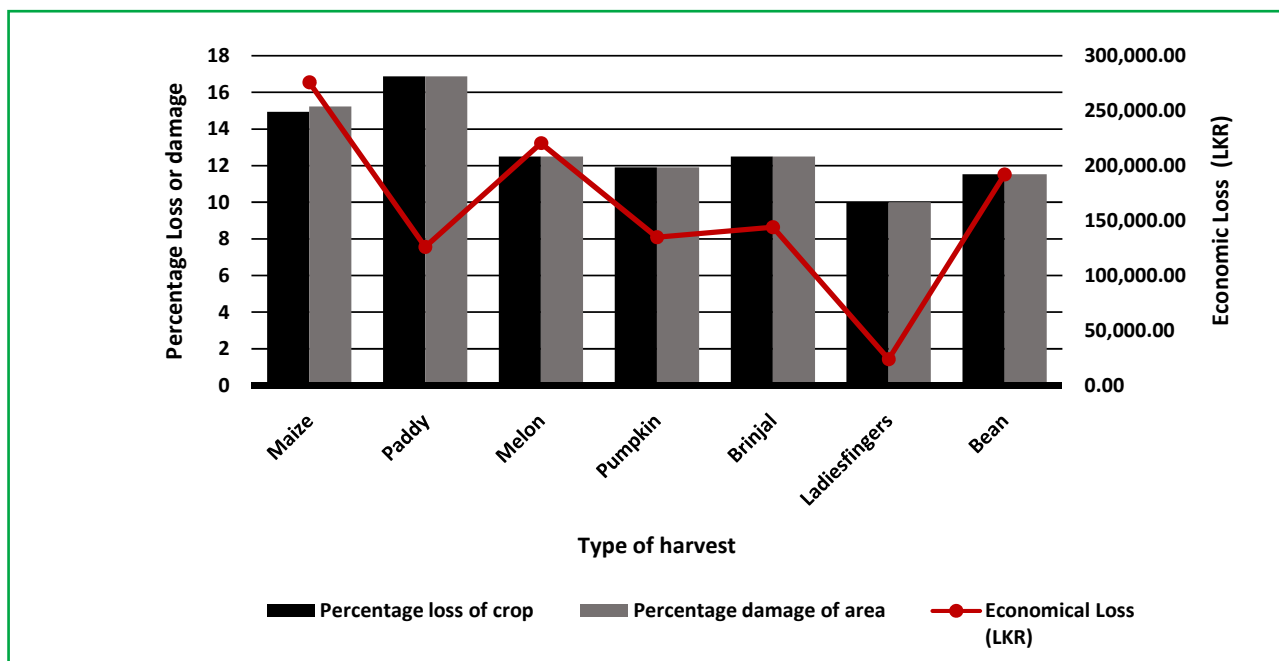
## 3 Results and discussion

Household survey in Ekgaloya revealed that 33 households out of 50 (66%) have faced crop damaged incidents within one cropping season whereas 38 households out of 50 (76%) have faced with crop damage incidents in Dewalahinda. Different crop varieties were identified under threat of elephant damages in both villages (Table 1). According to the information gathered, paddy (*Oryza sativa*) and maize (*Zea mays*) was the most vulnerable crop varieties to elephant crop raiding in both villages. Under this analysis, 37 households reported the damages to maize and paddy in Ekgaloya with 7,800 kg (14.94%) damages in maize and 4,050 kg (16.88%) damages in paddy (Table 2). Similarly, out of 38 households having crop damages 9,750 kg (17.76%) damages in maize and 4,650 kg (16.85%) damages in paddy were recorded in Dewalahinda (Table 3). According to the majority of farmer's response in both villages, "harvesting period" was appeared to be the highest vulnerability for the crop raiding by elephants (Figures 2 and 3).

Cost of damage to crop was calculated using the retail price values in the local market for the different crop varieties in the area. Household survey indicates that within one cropping season, some crop varieties have shown the highest vulnerability to elephant depredation than the other crop varieties in the same area. Maize (*Zea mays*) and Paddy (*Oryza sativa*) were the most widely grown crop varieties in this area and farmers have suffered 14.94% loss of maize and 16.88% loss of

**Table 1** Different crop varieties under threat from elephants in Ekgaloya and Dewalahinda.

Family	Species	Common Name	Local Name
Begoniaceae	<i>Arachis hypogaea</i>	peanut	rata kaju
Cucurbitaceae	<i>Cucumis melo</i>	melon	kekiri
Cucurbitaceae	<i>Cucurbita maxima</i>	pumpkin	wattaka
Leguminosae	<i>Phaseolus vulgaris</i>	bean	bonchi
Malvaceae	<i>Hibiscus esculentus</i>	ladies finger (okra)	bandakka
Poaceae	<i>Zea mays</i>	maize	iringu
Poaceae	<i>Oryza sativa</i>	paddy	vee
Solanaceae	<i>Solanum melongena</i>	brinjal	wambatu
Solanaceae	<i>Capsicum annum</i>	chilli	miris



**Figure 2** Crop damage complain perceived from Closer and Far Ekgaloya villages to the wildlife reserve  
 Secondary Y-Axis of the graph should be relabeled as “Economic loss”

paddy than the other crop varieties when compared to the total crop yield in Ekgaloya (Table 2 and Figure 3). In Dewalahinda, five crop varieties were subjected to damage by elephants within one cropping season in which 17.76% of maize and 16.85% of paddy were the most frequently damaged crop species. In addition, 15% of pea nut (*Arachis hypogaea*), 12.50% of bean (*Phaseolus vulgaris*) and 14.29% of melon (*Cucumis melo*) were the other crop species subjected to damage by elephants in the area (Figure 5).

In Dewalahinda area most crop lands were covered with peanut cultivations mixed with other cultivations

(Figure 3). Because of these peanut cultivations were also subjected to considerable damage by elephants comparable to maize and paddy cultivations.

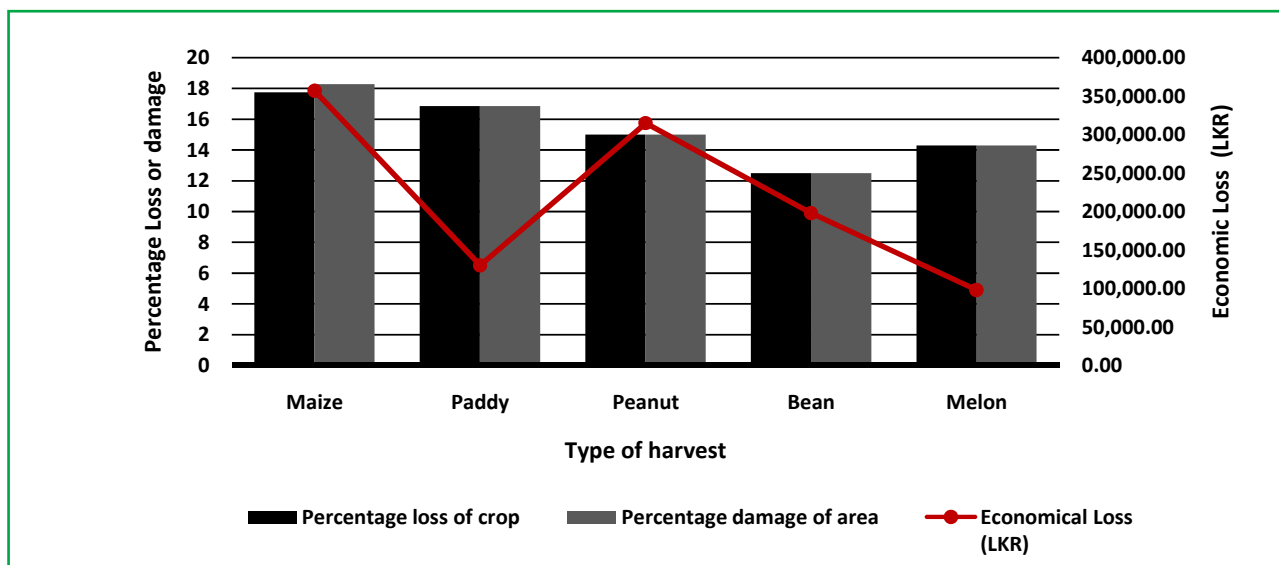
Economic analysis of crop loss for different crop varieties in Ekgaloya showed that maize (14.94%) incurred the highest damage followed by of melon (12.50%) and bean (11.54%). Ladies fingers (*Hibiscus esculentus*) reported the largest damage cost compared to all crop varieties cultivated in the area (Figure 3).

Economic analysis of crop loss in Dewalahinda showed that the highest damage was caused to maize (18%) followed by peanut (16%) and bean (10%). Melon (5%)

**Table 2** Crop damages in Ekgaloya, complains based on different crops

Sample size = 50							
Crop cultivated households = 37							
Crop lost households = 37							
Type of Crop	Damage to the yield (kg)			Area (ha)			Economic loss (EUR)
	total yield	total loss	percentage (%)*	total area	damage area	percentage (%)*	
Maize	52,200	7,800	14.94	16.4	2.5	15.24	1,256.86
Paddy	24,000	4,050	16.88	16.0	2.7	16.88	574.68
Melon	25,200	3,150	12.50	7.2	0.9	12.50	1,004.49
Pumpkin	18,900	2,250	11.90	4.2	0.5	11.90	614.99
Brinjal	19,200	2,400	12.50	4.8	0.6	12.50	655.99
Ladiesfingers	4,000	400	10.00	2.0	0.2	10.00	109.33
Bean	14,300	1,650	11.54	2.6	0.3	11.54	874.66

\*percentage loss or damage of specific items against the it total yield or area

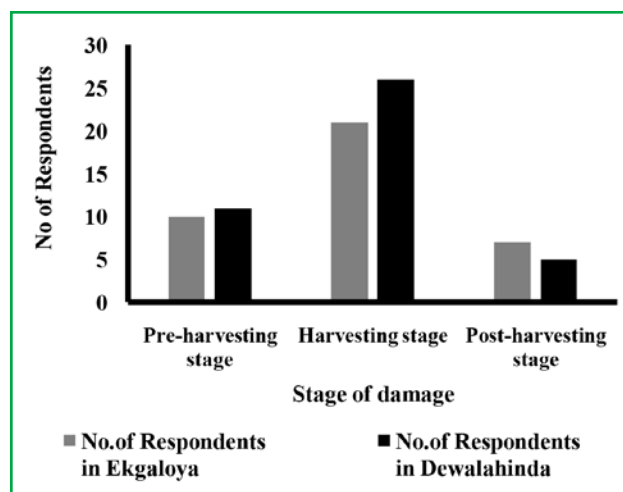


**Figure 3** Crop damage complain perceived from Closer and Far Dewalahinda villages to the wildlife reserve  
 Secondary Y-Axis of the graph should be relabeled as “Economical loss”

has recorded the lowest economic loss compared to all cultivated crop varieties in the area (Table 3 and Figure 3)

In this study crops were categorized into three stages namely pre-harvesting, harvesting and post-harvesting stage. According to the information gathered by household survey “harvesting stage” indicated the highest vulnerable stage for crop raiding incidents in both villages (Figure 4). Minimum number of cases was recorded at the post-harvesting stage in both villages.

Crop raiding incidents were reported during different time intervals in the two villages. A large number of incidents were recorded between 7.00 p.m. to 4.00 a.m. in Ekgaloya (Figure 5). Period between 4.00 a.m. to 9.00 a.m. was also a critical time which elephant move into the crop lands. Highest number of crop damages was reported in Dewalahinda during the time period 7.00 p.m. to 4.00 a.m. (Figure 5).

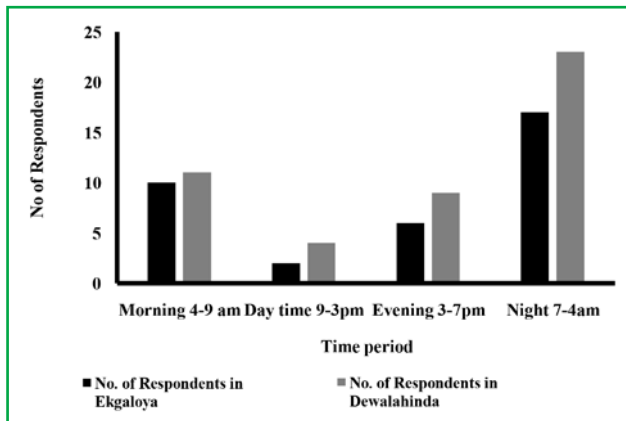


**Figure 4** Growth stages of crops subjected to elephant damage in Ekgaloya and Dewalahinda

**Table 3** Crop damages in Dewalahinda, complains based on different crops

Sample size = 50							
Crop cultivated households = 37							
Crop lost households = 37							
Type of Crop	Damage to the yield (kg)			Area (ha)			Economical loss (EUR)
	total yield	total loss	percentage (%)*	total area	damage area	percentage (%)*	
Maize	54,900	9,750	17.76	18.6	3.4	18.28	1,626.31
Paddy	27,600	4,650	16.85	18.4	3.1	16.85	593.13
Peanut	30,000	4,500	15.00	6.0	0.9	15.00	1,434.98
Bean	13,200	1,650	12.50	2.4	0.3	12.50	901.99
Melon	9,800	1,400	14.29	2.8	0.4	14.29	446.44

\*percentage loss or damage of specific items against the it total yield or area



**Figure 5** Time intervals of crop raiding in Ekgaloya and Dewalahinda

Crop raiding incidents by wild elephants appear to be a major problem along the elephant distribution areas of Sri Lanka (Ekanayaka et al., 2011). Clearance of forest patches for the accelerated new irrigation schemes and establishment of large-scale human settlements are the main causes to aggravate this problem within last few decades in Sri Lanka (Ekanayaka et al., 2011). Ekgaloya and Dewalahinda in Ampara district are also such areas that can be identified as areas where severe crop raiding incidents are frequently occurring. Chena cultivation was one of the major agricultural practices that are frequently exposed to the elephant threats in this area.

Most of the rural people in these areas are having low income level and their livelihood basically depend on the agriculture based (mainly Chena cultivation) economy. Because of that, they can't bare the crop damages that occur even for one cropping season. Crop damages mostly occurred basically due to the consumption of food crops as well as trampling by elephants as they walked across the crop lands at night time. Therefore, large extents of crop lands can be damaged within one night. Such situations were observed in the two villages during the period of the current study. Household data revealed that crops such as green chillies and ladies' fingers were damaged by elephant trampling. Normally, elephants do not eat cash crops like green chillies, because it creates a hot burning sensation in the nose and eyes of elephants (Bandara and Tisdell, 2003). Therefore, some farmers apply a paste made out from crushed chillies on guard fences around the crop lands to avoid elephant threats. Burning chilli mixed dung bricks produce noxious gases which will help to chase away elephants from the crop lands and act as a deterrent for some extent (Hedges and Gunaryadi, 2010).

Farmers are more attracted to cultivate maize (*Zea mays*) and paddy (*Oryza sativa*) (for dry paddy lands) in chena due to low labour cost, easy handling of fertilizer

requirements and easy maintenance up to harvesting stage. Considering crop varieties, maize and paddy lands have experienced the highest damage compared to the other crop lands. Because those two crop varieties were the most commonly grown and most preferable food crops for the wild elephants. During the study period it was found that some of the crop varieties recorded considerable level of economic losses in both villages. Similar studies conducted in countries where human-elephant conflict is prominent also recorded maize (*Zea mays* L.) and beans (*Phaseolous vulgaris*.) are the most frequently damaged crop species by elephants (Poza, Coulson, Mcculloch and Songhurst, 2017). In Sri Lanka paddy (*Oryza sativa*) is a highly preferable food of wild elephants when the plants are ripe and ready for harvesting (Fernando et al., 2011). Not only that, elephants also damage even "stored paddy" after harvesting. Field observations further revealed that banana (*Musa sapientum*) and coconut (*Cocos nucifera*) are the secondary crops damaged by wild elephants in the area.

The abundance of crop raiding incidents involves elephants eating mature food crops which are highly nutritious and palatable (Wang et al., 2007). Therefore, they tend to raid crops that are ripe and ready to harvest (Ekanayaka et al., 2011). Household data and field observations revealed some main food crops such as maize and paddy are having a big raiding risk when they are at the harvesting period. But, there is a possibility to damage crops by elephants, when crops are at pre-harvesting period. And also, some food crops have a big threat when they are stored at different places (as stored paddy) after the harvesting period. According to the (Ekanayaka et al., 2011), elephants have an ability to detect rice and other goods stored inside the houses with the aid of their sensitive smell, knock down the walls and feed them. Crop raiding occurs exclusively at night (Webber et al., 2011). According to our results, night time from 7 p.m to 4 a.m and morning hours from 4 a.m to 9 a.m are the most critical hours that the elephant visits crop fields. Highest damage could be observed along forest edge areas and gradually the threats declines towards the interior of the village. Because large number of human settlements is concentrated towards the interior of the village and most of the chena areas are located along the edge habitats (Bandara, 2010).

This study was based on two villages mainly depending on agriculture based economy (Chena Cultivation). Dewalahinda area recorded considerable crop damage incidents than the Ekgaloya area. This village is located very close to the Gal Oya National park and it is a major habitat of wild elephant in the Eastern Province. As well as most of the encroached lands were located

along the park boundary where agricultural practices (chena cultivation) mostly occur. The vulnerability to crop damage in chena cultivation is reported to be little higher than the other agricultural practices such as home gardens and lowland cultivations (Bandara and Tisdell, 2005). Encroached lands will reduce the park land area and is a disturbance to the Buffer Zone area due to the clearance of natural forest areas. Most of the chena cultivation areas have started in such encroached lands where food crops preferred by elephant are cultivated. This is the main reason especially for the invasion of wild elephants into the village area and crop raiding incidents are also highly recorded in these areas close to the Park boundary. At present, most of the chena (slash and burn) lands are located within the usual home ranges of elephants and most of the encroached lands are also located in these migratory roots of elephants. When forest patches are cleared in a large scale, elephants can't find adequate food requirements within it. Therefore, even at the rainy season, they come out of the forested areas and come across chenas to fulfill their food and water requirements (de Silva, 2010). This type of situation mainly initiates the HEC in these areas.

Further clearance of forest areas for preparing chena cultivations and the illegal human settlements dramatically reduced the buffer zones. Elephants usually need relatively large areas and diversity of environment to forage (Lorimer, 2010). Reduction of such an area will create a direct path for entering elephants into the crop lands. Therefore, distance should be maintained in between elephant habitats and the human settlement areas (Brown et al., 2004). As an important aspect, maintaining a green buffer between elephant reserves and the agricultural lands provide a positive solution for this problem. For example, Neem plants (*Azadirachta indica*) can be grown for this purpose. Because, it is fast growing and drought resistant species that can be easily found in these areas, and have a medicinal value (Santiapillai and Read, 2010).

#### 4 Conclusions

Maize and paddy were the widely grown crop varieties in both villages. Under crop raiding incidents, 31.82% represent the both paddy and maize damages in Ekgaloya considering 19 out of 33 households and 28 out of 38 households having crop damages represent 17.76% of Maize and 16.85% of Paddy damages in Dewalahinda. When comparing the crop raiding incidents in both villages, Dewalahinda has reported the considerable amount of crop loss with 5% of maize (*Zea mays*) and 3% of paddy (*Oryza sativa*) than the other crop varieties. Some crops such as Chilli, Ladies finger and Peanut, have shown least attraction to wild elephants but, they

reported some kind of damage, as elephants walked along the crop lands especially at night.

Dewalahinda area reported frequent crop raiding incidents compared to the other village. The village is located very close to the boundary of Gal Oya National Park and most of the rural people lived in encroached lands at the edge of the Park boundary. Most of the time they have cultivated food crops such as maize, paddy and bean attractive to elephants. These factors are directly responsible for the elephant threats to the area. The highest risk is to damage crops at the harvesting period in both villages and sometimes their damage can be occurred at the post-harvesting period during storage.

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