DEVELOPING AN EVIDENCE BASED POLICY AND PROTOCOL FOR HUMAN ELEPHANT CONFLICT IN OIL PALM PLANTATIONS

A case study of Sime Darby Plantation Berhad

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"Elephant social organisation has shown to be remarkably similar to that of man; in fact, the entire ecology of the elephant is soon to be more similar to that of man than to any other animal. It is therefore not remarkable that man and the elephant are having to face similar and simultaneous crises like survival."

The End of the Game, (1977):

ABSTRACT

Palm oil is arguably one of the most controversial and scrutinised crops by European countries mainly due to their trading resolutions (Palm, 2016). Palm oil has become one of Malaysia's major exports and provides substantial economic support to the livelihood in the country. However, with increased palm oil in rural areas comes increased chances for human-wildlife conflicts. As a result, there have been efforts to increase sustainability of the palm oil industry, which has developed guidelines to help in the management of human-wildlife conflict. The human-elephant conflict (HEC) in oil palm plantations commonly involves oil palm depredation by the elephants as well as reports of property damaged, and in some cases, loss of life for humans and elephants. This research is carried out with the aim to support co-existence between the agricultural society and elephants. Four objectives are determined which are: 1) to systematically review the literature of HEC and mitigation strategies used by palm oil plantations, particularly in Malaysia, 2) to describe HEC in Sime Darby Plantation Berhad operations, including details on the type of conflict and their patterns, 3) to evaluate the effectiveness of the current HEC mitigation measures practiced by Sime Darby Plantation Berhad and 4) to develop a HEC policy and Standard Operating Procedures (SOP) or protocol suitable for management and mitigation in oil palm plantations. The study sites for this research are within Sime Darby Plantation Berhad (SDPB) estates in Malaysia, mainly in Pahang, Johor and Sabah. This study synthesised 102 papers of past mitigation strategies used in the industry, obtained through Google Scholar, Scopus and Web of Science. These papers were reviewed and summarised under systematic themes using Excel. The information on HEC in SDPB Malaysia was acquired from voluntarily reports and past records in the estates. These data include the number of oil palm trees damaged by elephants, age of affected oil palm trees, frequency of HEC occurrence at daily, monthly or annual scale, and location of damage with covariates of mitigation measures such as electrical fencing and crop-guarding. Additionally, a rapid survey was conducted using Google Form for all estates under SDPB Malaysia operations, excluding Sarawak, to assess information of elephant sightings and mitigation used. This research found that 38% (N=102) papers discussed the use of electric fences as mitigation and 9% used crop-guarding. Other methods include carbide, "*bomoh*" (supernatural belief), patrolling, elephant-proof trenching,

improved design fencing, translocation, culling, elephant drive, conservation research and conservation awareness. Overall, 55.15% (N=200,242) of the damaged trees were a year old and the likelihood of trees being damaged reduced significantly after the fifth year. It is common for agriculture plantations, when experiencing Human-Elephant Conflict (HEC), to use physical barriers to prevent wild elephants from entering the plantation areas. The finding that 97% of damages occurred to trees aged 5 years and below indicates that plantations can co-exist with elephants in areas with trees aged 6 years and above, and this can be further explored by future research. The highest intensity of damage was 14,002 trees which occurred in the P2011A field of the estate in Pahang. Between the year 2011 and 2018, the highest frequencies of HEC recorded were 94 times at forest borders of Pahang Estate followed by 90 times at the fields bordering the mangrove forest of Sandakan. The monthly analysis of HEC damage showed irregular patterns for all plantations. The total loss linked to HEC for the eight estates between 2011 and 2018, was RM 24,227,234.70. Logistic regression test demonstrated that some but not all estates which installed electric fencing managed to reduce the number of trees damaged. The company's Saving the Orang Utan Policy which focuses on endangered and protected species, states the commitment to manage human-wildlife conflict responsibly, which is to be improved on and supported by action on the ground. This study records the protocol for managing HEC at SDPB estates for the first time, recommends a potential tool and platform that can be duplicated at other plantations to systematically record and manage their HEC, and has standardised the format to calculate and report financial loss of elephant depredation in the industry. The research achieves its aim by providing data on how plantations can co-exist with wild elephants. However, the data also reveals that this type of coexistence may be applicable to particular conflict areas only, as some plantations had experienced damages to older trees.

REFLEXIVITY AND POSITIONALITY STATEMENT

I acknowledge that being an employee of Sime Darby Plantation Berhad (SDPB) and having worked for more than a decade (2008-present) in the palm oil industry would influence my research process. Therefore, in this and the following parts, I provide an overview of the research context in terms of my personal background and the composition of the personnel that I communicated with internally and externally within the company. The research is guided thoroughly by my two university supervisors, an internal supervisor and in compliance to the university obligations. I have full academic freedom and flexibility to present the results of this research and no one has told me of what to say and not to say. As any organisation, of course there are some of the detail and information that confidential and should not be made public, but it does not affect the research finding; my conclusion or interpretation of my data and thesis reporting for this study.

Briefly, I am also known as Aida Ghani Quilter with the absence of "Nur" on my full registered name. I was born in Lundang, Kelantan in 1982. I grew up in a village that doesn't really experience human-wildlife conflicts, as far as I can remember. Nevertheless, my village is Kg. Badak Mati which can be directly translated as "Dead Rhino Village". My mother used to work for FELCRA office in Kelantan as an account administrative. At present, my elder and younger sisters are serving for FELCRA head-quarters in Setapak, Kuala Lumpur.

In 2000, I applied for a veterinarian course after completing my matriculation, but I was unfortunate. I ended up graduating in Bachelor Science and Food Technology in 2004 from the University of Putra Malaysia. I worked in the chocolate manufacturing industry for two years on quality assurance in the production line. At that time, I put into context that food industry is imperative, as long as people are consuming food, I will always have my job. Little that I know, I will be offered an animal-related work with an English company, as a project facilitator in Zoo Taiping & Night Safari. Initially, I took the job as an escape route from my broken-engagement. It was a turning point in my life that helped me discover a passion for wildlife. My main task in the Zoo was to coordinate a volunteering-programme activity for ex-situ conservation. Our main activities were to

create enrichment in the night dens and exhibit areas, assist zoo curators and veterinarians, as well as, carry out daily animal husbandry with the zookeepers. The species we managed were mainly orang utans, but also Asian elephants, sun bears, tigers, lions, clouded leopards and others when deemed necessary.

In 2008, at the same time I joined SDPB, my husband and I set up a Malaysia-based company named Ecoteer, which later merged to become Fuze Ecoteer. The company promotes "travel with a cause" by combining environmental education with corporate team-building or school expeditions, and connecting participants with conservation research projects all over Malaysia. Meanwhile, my entire career in SDPB has been within the sustainability department. I started with the role to establish manuals and audit ISO certified units, which at that time had expanded to include sustainability certification auditing. I am a certified ISO 14001 Lead Auditor and have successfully completed the High Conservation Value (HCV) assessment course. I was assigned to assist on the HCV criteria includes, but it is not limited to HCV 1 as defined by High Conservation Value Resource Network (HCVRN) which is Rare, Threatened, Endangered (RTE) species and other environmental performance scope. I am appointed as an Honorary Wildlife Warden by Sabah Wildlife Department (2014-2017, 2017-2020).

I don't have any specific political views, but many years I have been casting votes for the sake of my father's favour. He used to be heavily involved in the politics but getting detached slowly. I have never been to any interest-protest or road demonstration although I occasionally support a wildlife campaign through donation and online petition.

In June 2018, I was awarded a scholarship by the Sime Darby Foundation (YSD) to carry out research on human-elephant conflict in SDPB. The scholarship allowed me to take a 1-year sabbatical leave from my work and conduct research as part of the MEME project under the supervision of Professor Ahimsa Campos-Arceiz and Dr. Wong Ee Phin. I was confirmed as a post-graduate student with the University of Nottingham Malaysia on 15 July 2018. The scholarship from YSD covered all the university fees and came with a grant that covered all expenses associated with my research. The grant will bond my service with SDPB for a minimum of 3-years.

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I am truly blessed to have a prominent supervisor like Prof. Ahimsa Campos Arceiz. He has enthused me with his vast knowledge and encouraged me in many ways of the scientific approach which I found is not common in the corporate world that I have been involved in for 11 years. I thank him for his kindness, patience and nurturing. Additionally, I thank Dr. Wong Ee Phin who has always been there to guide me on the finest details of scientific writings and interpretations. To Management and Ecology of Malaysia Elephants (MEME) of which I am proud to be one of the team: Or Oi Ching, my peer who has helped a lot with information of university administration, Praveena, Viviene, Wei Harn who always geared up to assist and not to forget all other members of MEME, former and present. As well as the School of Environmental and Geographical Science, Ms. Sharon and Prof. Chris Gibbin and University of Nottingham, Malaysia Campus (UNMC).

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LIST OF ACRONYMS AND ABBREVIATION

Initial	*Description*
CPO	Crude Palm Oil
CSPO	Certified Sustainable Palm Oil
DWNP	Department of Wildlife and National Park
EC	Energy Commission
FELCRA	Federal Land Consolidation and Rehabilitation Authority
FELDA	Federal Land Development Authority
FFB	Fresh Fruit Bunch
FR	Forest Reserve
GPS	Global Positioning System
HCS	High Carbon Stock
HCV	High Conservation Value
HEC	Human Elephant Conflict
KER	Kernel Extraction Rate
MEME	Management and Ecology of Malaysia Elephant
MSPO	Malaysian Sustainable Palm Oil
OER	Oil Extraction Rate
PRF	Permanent Reserved Forest
R&D	Research and Development
RSPO	Roundtable on Sustainable Palm Oil
RTE	Rare, Threatened and Endangered
SDPB	Sime Darby Plantation Berhad
SOP	Standard Operating Procedure
SPH	Standing per Hectare
SWD	Sabah Wildlife Department
UNMC	University of Nottingham, Malaysia Campus
YSD	Yayasan Sime Darby

1.0 INTRODUCTION

1.1 The palm oil industry

The idea of sustainable development has been, and still is, subjected to criticism, including the question of what is to be sustained in sustainable development (Lippert, 2004). It has been argued that there is no such thing as sustainable oil palm, since there are still on-going issues linked to deforestation (Nikoloyuk, Burns and de Man, 2010; Teoh, 2010). The oil palm (*Elaeis guineensis Jacq*) is native plant from West Africa (Meijaard and Sheil, 2013). The ideal growing conditions for its cultivation are mainly in the tropical climate zone 16° north and south of the equator (Kongsager and Reenberg, 2012). These regions have large areas of tropical rainforest rich in biodiversity on the continents of Asia, Africa and South America (Ripple *et al.*, 2017). The oil palm, which started as an ornamental plant in Malaysia, has made significant contribution to the domestic economy and due to its success, Malaysia has become a main player in the world's palm oil market (Talib and Darawi, 2002). Oil palm plantations cover approximately 4.46 million ha or about 16% of Malaysia's total land mass (A Ferdous Alam *et al.*, 2005). The palm oil industry is the fourth largest contributor to the Malaysian Gross National Income (GNI); and the country aims to achieve RM178.0 billion by 2020 (PEMANDU, 2010). In 2019, Malaysia is the second largest producer of oil palm and exporter of crude palm oil (CPO) in the world. The demand for edible vegetable oils has grown stronger in recent decades and plantations have expanded rapidly in number and size to meet the global demand (Faulkner *et al.*, 2016). Amongst other vegetable oils (i.e. soybean, sunflower and rapeseeds), oil palm is the most scrutinised crop by the European countries (MPOC, 2014). The expansion of oil palm production has contributed to deforestation, peat degradation, biodiversity loss, and forest fires, together with a range of social implications including labour welfare and human rights (Varsha *et al.*, 2016).

1.2 Human-elephant conflict (HEC) in plantation

Asian Elephants (*Elephas maximus*) are edge specialists (Yamamoto-Ebina *et al.*, 2016), and they readily use human-disturbed environments near to forest, including agriculture areas and newly planted rubber and oil palm plantations. Being a mega-herbivore, an adult elephant weighs 1,000-5,000 kg, and needs to eat approximately 10% of its body weight every day (Fernando, 2015). Attracted both by the crops and other early

succession plants, elephants often come into conflict with plantations as part of their natural optimal foraging strategy (Stephens, 1986; Campos-Arceiz, 2013).

One of the challenges to conserving Asian elephants, is the lack of conservation considerations in development and land-use planning, especially around existing wildlife habitats (Johnsingh & Williams, 1999), which in turn exacerbates HEC. Conflict is context-specific, it is crucial to get the information of what, when, where and who (which individual elephants) are involved in the particular HEC areas. Understanding the patterns of elephant depredation will help in formulating mitigation methods and actions. Elephants will visit and consume rich patches of food within their traditional foraging areas; and it is perceived that if oil palm is planted on elephants' traditional routes it is very likely that they would consume it despite preventive measures implemented by the planters (Seidensticker, 1984). Blair (1980) found that on FELDA plantation, the average age of damaged trees was around one month to 10 months old, with less damage for trees five years or older. In Sabah, it was reported that elephants caused most damage in areas planted with young palms (6 months to 3 years of age), potentially destroying hundreds of trees overnight and causing large financial losses (Othman *et al.*, 2019). By understanding what tree age is preferred by elephants, plantations can focus on securing the area from conflict. Yet, this type of information has not been explored in detail, or utilised for greater HEC mitigation context and few studies have been done on patterns of HEC in oil palm plantations.

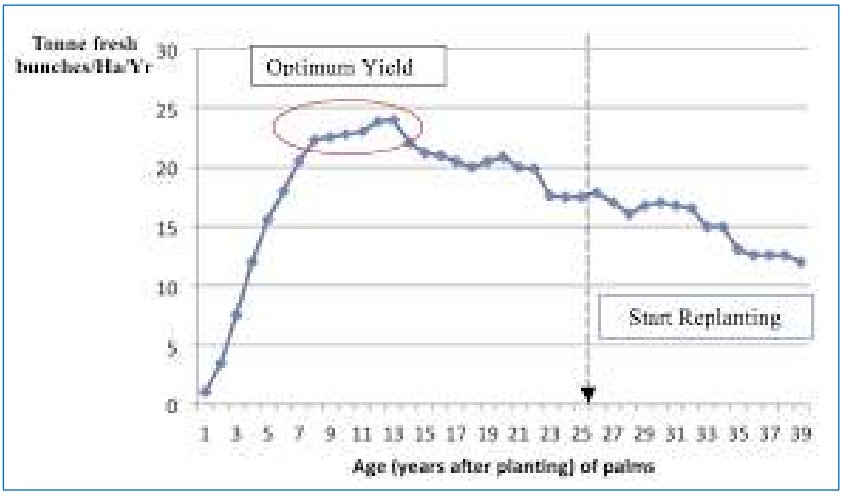


Figure 1: Fresh Fruit Bunch (FFB) tonnage by age of trees, Reference: MPOB

The economics of oil palm replanting suggest that old palms should be retained as long as the yields are reasonable to avoid gaps in the income stream (Corley and Tinker, 2015). The combination of declining yields and increasing height means that replanting is usually necessary at about 25 years after the original planting, though this will vary depending on the vigour of vegetative growth and other factors in respective plantations (Woittiez *et al.*, 2017). *Figure 1* shows that yields tend to decline with age, but usually there is considerable variation between trees (Pohl and Loong, 2016). Oil palm replanting activities includes a land clearing, bole and root mass removal, and shredding of felled trunk, bole, root mass and others. During the shredding of felled trees, elephants are attracted to feed on shredded palm hearts (shoots) and usually stay away after the palms were newly planted (pers. obs. Sime Darby Plantation Berhad). Elephants feeding on shredded palm hearts do not cause economic damage to the plantations. Plantations face economical losses when the newly planted palms' bases grew bigger and the elephants start to predate on the saplings. An elephant can uproot an entire young palm with its trunk and often thrash it on the ground before eating (pers. obs. Sime Darby Plantation Berhad).

Plate 1: Herds of Borneon elephant feeding on the shredded old palm during replanting activities in Tun Tan Estate. Photo credit: Sime Darby Plantation Berhad/Tun Tan Estate/ 2014

In older palms, the damage is confined to pulling and removal of a few shoots with various consequences in terms of tree growth and yield. The cases of depredation by elephants on rubber trees are less common than oil palm (Blair, Boon and Noor, 1979), but when the elephants do attack rubber trees, usually they will strip the bark from the rubber tree. It is assumed that the tree bark contains minerals which are otherwise deficient in the elephant's diet. Some observers in rubber plantations believe that the frequency of attack increases after fertiliser application, which enhances the mineral supply, but this is not proven.

Crop-raiding by elephants has caused large financial losses to plantations in Malaysia (Blair, Boon and Noor, 1979). For example, a rubber plantation company, Plus Valley plantation in Perak experienced a loss of £200,000 between 1925 and 1930. Federal Land Development Authority (FELDA), Federal Land Consolidation and Rehabilitation Authority (FELCRA) and other private companies reported over RM78 million in losses due to HEC between 1975 and 1978 (Blair, Boon and Noor, 1979) for rubber and oil palm. The losses started to decline in the early 1980s when electric fences were introduced to assist in mitigating the problem of elephants raiding plantations (Gunaratne *et al.*, 2017). Electrical fencing has been an effective and efficient mitigation method, since it is not dependent on physical human presence to prevent crop-raiding by elephants, and it will work well as long there is execution of systemic monitoring and maintenance of the fences (Enukwa, 2017) but could create bottleneck for elephant movement if it has been poorly structured (Othman *et al.*, 2019).

FELDA has been constructing electric elephant barriers since 1977 and the cost and effectiveness of these efforts have been assessed by Blair and Noor (1980). The results of their study cover the nature of HEC, extent and cost implications of elephant's damages in oil palm and rubber plantations. When evaluating the damage by elephants on the economic potential of the trees, it is inevitably difficult as various elements need to be identified and incorporated. The formula used by FELDA to calculate HEC cost implication in relation to oil palm destruction (Blair and Noor, 1980) are as follows and are as illustrated in *Appendix; Figure 28 (page 95)*: the calculation of cost per acre includes (i) establishment cost (E), (ii) operational cost (O), (iii) administrative cost (A), (iv) settler

income lost (Y)[1], (v) duty lost (R)[2], and (vi) export value lost (F.O.B)[3] by age of palm at time of damage (months). However, this formula calculated the assumption of market value with no clear information of what has been accounted in the calculation, hence the valuation of crop damage can be overestimated or underestimated. Different plantations may use different formulas for calculating HEC damage, and without a standardised cost evaluation for elephant depredation, it will be difficult to carry out comparison of HEC damages and to justify the cost of mitigation.

1.3 HEC mitigation

A number of data collections have been carried out to understand HEC from various perspectives, however the information has not been synthesised into a summary relevant for plantations. A considerable amount of work has been implemented by plantations on managing and mitigating HEC, but in many instances the effort was conducted in isolation without data collection and coordination between plantations. Therefore, managers are unable to use evidence-based approaches to carry out adaptive management for HEC in plantations. The first objective of this study is to determine what is known and where knowledge is still lacking on HEC mitigation, especially in aspects regarding oil palm plantations. The "Guidelines on the Better Management Practices for the Mitigation and Management of Human-Elephant Conflict in and around Oil-Palm Plantations in Indonesia and Malaysia" was published by WWF more than a decade ago. The guideline (Chong, 2005) recommended and compared the advantage and disadvantage of nine mitigation measures which are 1) land-use planning, 2) protected areas, 3) corridors, 4) buffer zones, 5) electrified fences, 6) trenches, 7) repellents, 8) guarding and 9) translocation. Similarly, the positive and negative impacts of existing HEC mitigations for South Asia were outlined in (Fernando *et al.*, 2008), which conclude that there is an urgent need to put into place well-designed and cost effective HEC mitigation techniques, so that individual projects do not have to keep reinventing the wheel. Increasingly, there is a need to look at HEC mitigation at landscape level, as networks of electric fences in oil

[1] *The average target yield per acre for each year of production is valued at the average price paid to settlers during 1976-1978*

[2] *The average duty levied by Government between 1976-1978 is calculated on a monthly basis*

[3] *On the assumption that all palm oil produced is exported, the average monthly F.O.B price 1976-1978 is used to create a national international market value of the crop lost.*

palm plantations are increasingly restricting elephant movements, as elephants travel from one natural habitat to another. This is often the case of lack of coordination among plantations (Othman *et al.*, 2019). An active inter-disciplinary collaboration between scientists, wildlife managers, policy makers, wildlife enthusiasts and the local communities is required in order to find successful and sustainable solutions to HEC (Perera, 2009).

1.4 Sustainability commitment

Through regulating development such as the voluntary certification of sustainable palm oil industry practices by the Roundtable on Sustainable Palm Oil (RSPO) and public disclosure, producers have made significant progress toward minimising the adverse impacts of palm oil production, but challenges remain (Fitzherbert *et al.,* 2008). The Malaysian government has launched a campaign 'Love MY Palm Oil' and initiated a mandatory national certification scheme of Malaysia Sustainable Palm Oil (MSPO) that requires all plantations to meet a minimum standard of best practices for wildlife by December 31st, 2019. One of the requirements indicated in the criteria is an assessment of the 'status of Rare, Threatened, or Endangered species and high biodiversity value within the area'. In many occasions, the decisions made to manage wildlife in their natural habitat are subjected to the experience or opinion (often with little scientific evidence) of the wildlife managers and authorities (Pullin *et al.* 2004; Sutherland *et al.* 2004; Young and Van Aarde 2011). To support and guide the government initiatives for a wildlife-friendly oil palm industry, there is a need to understand the nature of conflicts in Malaysia backed with evidence and scientific data (Ning *et al.*, 2016).

Sime Darby Plantation Berhad (SDPB) is one of the world's and Malaysia's largest producers of certified sustainable palm oil (CSPO). As part of its commitment to the environment, the company has contributed over RM130 million in funding for nature conservation since 2009 through their philanthropic foundation, Yayasan Sime Darby (YSD). One of SDPB's pledges is to make a sustainable impact and difference in the lives of others, who share resources in the same environment. Currently, SDPB is seeking to improve its operational procedures and protocols to manage the HEC in the plantations, as their current protocols need clearer definition and communication. The existing HEC

mitigation established in SDPB is based on the opinion and verbal consultation exercises conducted with authorities and other related agencies. Therefore, to gather evidence to guide management and as part of SDPB's commitment to lead by example, this master's research is developed as part of Management & Ecology of Malaysian Elephants research project, in the University of Nottingham Malaysia. More importantly, this research is taken up by a Sime Darby Plantation Berhad's employee to build the company's internal capacity in managing HEC protocol and mitigation measure using an evidence-based approach.

2.0 AIM AND OBJECTIVES

The aim of this study is to support and promote co-existence between agricultural societies and elephants within and surrounding oil palm plantations, particularly those of SDPB by using adaptive management and evidence-based approaches.

Therefore, the following objectives are established;

1. to systematically review the literature of Human Elephant Conflict (HEC) and mitigation strategies used by palm oil plantations in the world, but particularly in Malaysia,
2. to evaluate HEC in Sime Darby Plantation Berhad operations, including details on the type of conflict and their patterns,
3. to evaluate the effectiveness of the current HEC mitigation measures practiced by Sime Darby Plantation Berhad and
4. to develop a HEC policy and Standard Operating Procedures (SOP) or protocol suitable for management and mitigation of HEC in oil palm plantations.

3.0 MATERIAL AND METHODS

3.1 Background of Sime Darby Plantation Berhad and Estate Management

The merger of Sime Darby Berhad, Golden Hope Plantations Berhad and Kumpulan Guthrie Berhad (completed on 27 November 2007) established the Sime Darby Plantation Berhad as one of the world's largest palm oil producers. All three companies were members of RSPO before the merger, as per the following commencement dates a) Sime Plantation Sdn. Bhd. 8th September 2004, b) Kumpulan Guthrie Berhad 10th September 2004, and c) Golden Hope Plantation 18th May 2004.

The scope of this study includes oil palm plantations in Sime Darby Plantation Berhad (SDPB), Malaysia with known areas of HEC. The plantations are distributed through 33 strategic operating units (SOU) across East and West Malaysia, consisting of 124 estates. Each estate is managed by one manager, supported by a few assistant managers and local staff (subject to the size of the estates). The estate management team is often rotated based on the head-quarters' decisions and needs. The local staff members who are from the surrounding villages are rarely transferred to other estates and typically assigned for office administrators and field supervisory (mandore) tasks. The field workers are generally comprised of foreign workers from different countries including Indonesia, Philippines, Bangladesh, India and others.

SDPB Malaysia holds a total landbank of more than 348,364 hectares, of which approximately 305,000 hectares are planted areas, including more than 10,000 hectares of rubber plantations in Kedah, Perak, Negeri Sembilan, Melaka and Johor in Peninsular Malaysia. There is no HEC reported in these rubber plantations of SDPB. Therefore, focus has been given to eight estates planted with oil palm and with known HEC records. The history of land use at these estates has not changed since their previous replanting programme. They are monoculture and 100% of the area are planted with oil palm as they were at the time of the three-company merger into SDPB in 2007. All trees planted in SDPB are covered by a premium insurance policy with stipulated terms and conditions.

3.2 Study sites chosen as focus areas

Based on past records of frequent HEC incidents, eight estates were chosen as focus areas for this study. The estates are Tigowis Estate, Tunku Estate, Tun Tan Estate and Sentosa Estate (henceforth addressed as estates in Sandakan), Binuang Estate and Jeleta Bumi Estate (henceforth addressed as estates in Kunak), Mentakab Estate (henceforth addressed as estate in Pahang) and Cenas Estate (henceforth addressed as estate in Johor). The detail of estates are as follows:

Table 1: Details of eight estates with HEC chosen for the research

No	Estate	GPS (office)	Year of establishment	Hectarage
		Sandakan		
1	Tigowis	5°44'59.22"N 118°13'0.93"E	1993	1,879.99ha
2	Tunku	5°42'25.42"N 118°10'52.37"E	1993	2,891.48ha
3	Tun Tan	5°38'16.55"N 118°10'48.83"E	1993	2,775.05ha
4	Sentosa	5°36'19.49"N 118°10'19.91"E	1993	3,208.73ha
			Total hectare (Ha)	10,755.25
		Kunak		
5	Binuang	4°42'2.14"N 118° 4'18.97"E	1979	2,673.02
6	Jeleta Bumi	4°43'48.50"N 117°59'55.91"E	1992 (Oldest Field)	2,771.65
			Total hectare (Ha)	5,444.67
		Pahang		
7	Mentakab	3°28'39.28"N 102°10'56.83"E	1920	2,934.92
			Total hectare (Ha)	2,934.92
		Johor		
8	Cenas	1°54'50.76"N 103°34'50.48"E	1979	1,764.31
			Total hectare (Ha)	1,764.31
			Grand total hectare (Ha)	**20,899.15ha**

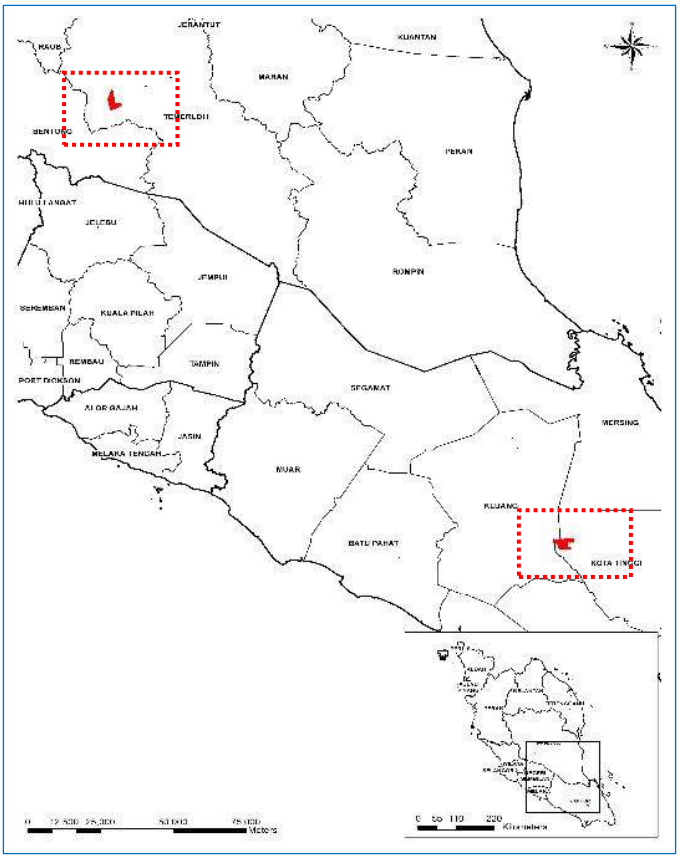


Figure 2: The location of Mentakab Estate in Pahang and Cenas Estate in Johor

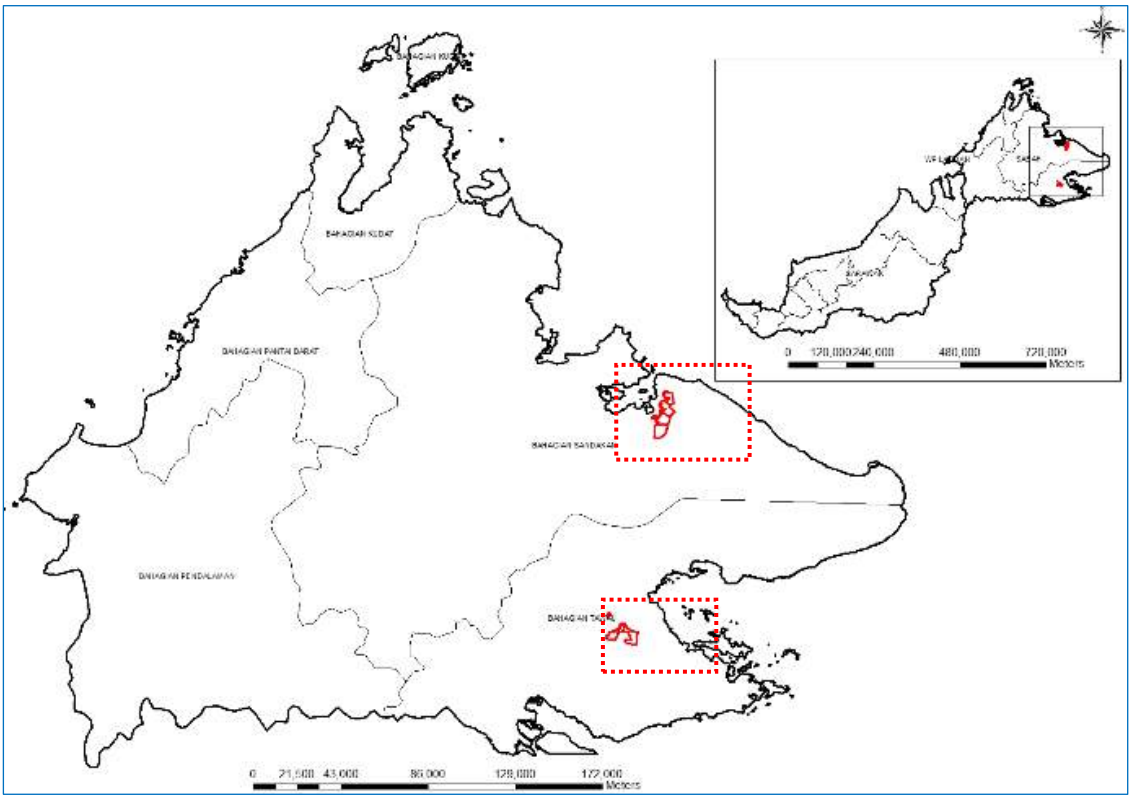


Figure 3: The location of Sandakan Bay Estates in Sukau and Jeleta Bumi and Binuang Estate in Kunak, Sabah

3.2.1 Estates in Sandakan

The four estates in Sandakan are located side-by-side, with the west bordering the mangrove forest of Elopura Forest Reserve (approximately 24,674 ha), and alongside the eastern border there are some patches of smallholders and other oil palm plantations. The four estates were established in 1993/1994. Cases of HEC in the estate have been recorded since the first replanting activities were carried out in 2011 for Sentosa Estate to catch up with plantation age profile. Between 2011 and 2016, the HEC replanting field of Tun Tan and Sentosa Estates have been resupplied with oil palms at multiple times and they did not have any HEC mitigation set in place.

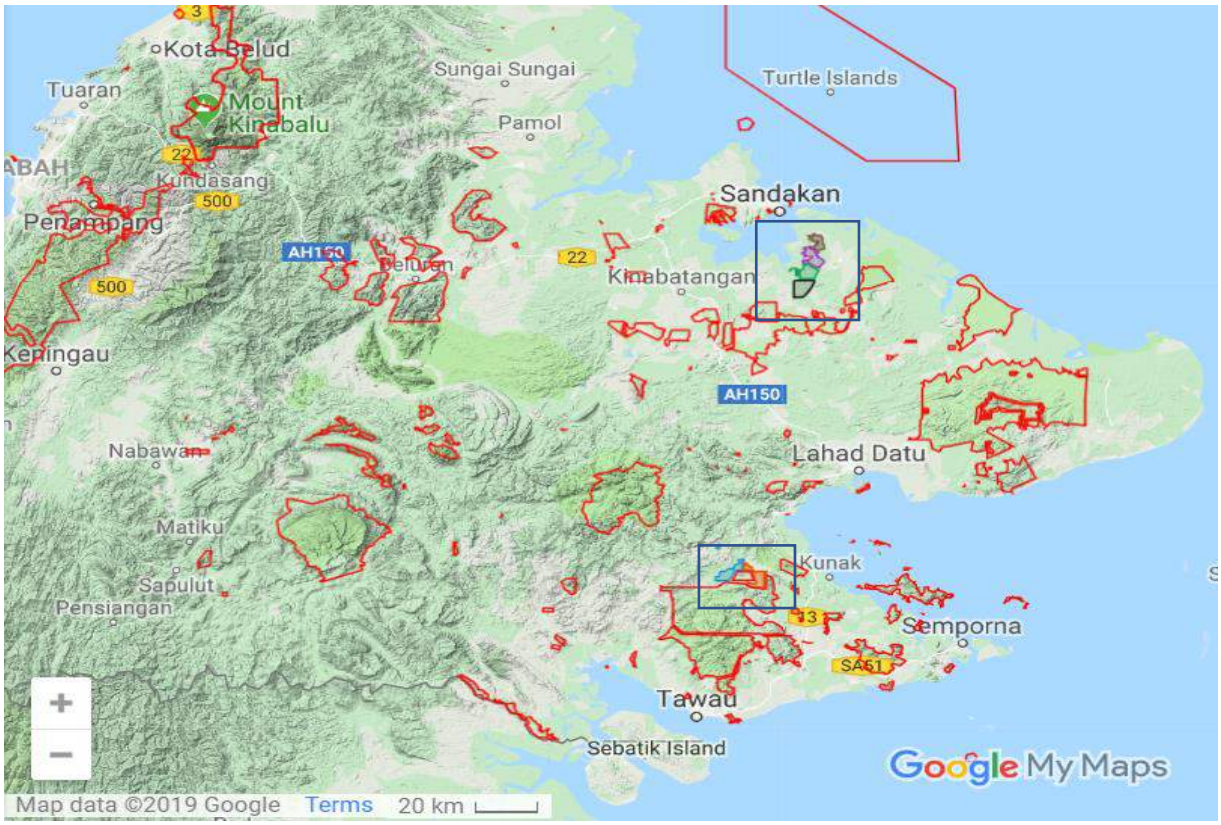


Figure 4: The estates location is layered on google my maps. The box indicated Estates in Sandakan and in Kunak respectively. The red figures are gazetted protected areas extracted from Global Forest Watch data.

3.2.2 Estates in Kunak

Two estates in Kunak are connected by the Madai Baturong reserve of virgin rainforest (VJR, as classified by Sabah Foresty Department). The Madai Baturong reserve was first gazetted in 1932 with an area of about 10,603 ha. The South of Madai Baturong is linked to Ulu Kalumpang Forest Reserve, which was first announced as a forest reserve of about 86,200 hectares in 1956. This reserve is a protected area for the orang utans (*Pongo pygmaeus*), as well as the endangered Bornean elephants (*Elephas maximus borneensis*).

The Kunak estates harbour a few other important habitats, such as the remnants of volcanic craters (locally known as mud-pool) and a hot-spring.

3.2.3 Estate in Pahang

Mentakab Estate is located in Lanchang town, shares a 9.5 km border with Kemasul Forest Reserve (27,088 hectares) on the estates south east and west borders. Cases of HEC in the estate have been recorded since replanting activities were carried out in 2011. The replanting fields of 2011A, B, C have been resupplied with oil palm saplings multiple times due to HEC, when the trees are still immature and there is no HEC mitigation set in place. In the Kemasul Forest Reserve, the State Government of Pahang Darul Makmur, through its Director of Forestry has granted a 60-year lease to Konsortium Perhutanan Makmur Sdn Bhd (KPM), to manage and develop parts of the existing government-owned *Acacia mangium* Compensatory Forest Plantation Project (CFPP)[4] in 2011, for which the information of HEC is not available to the researcher.

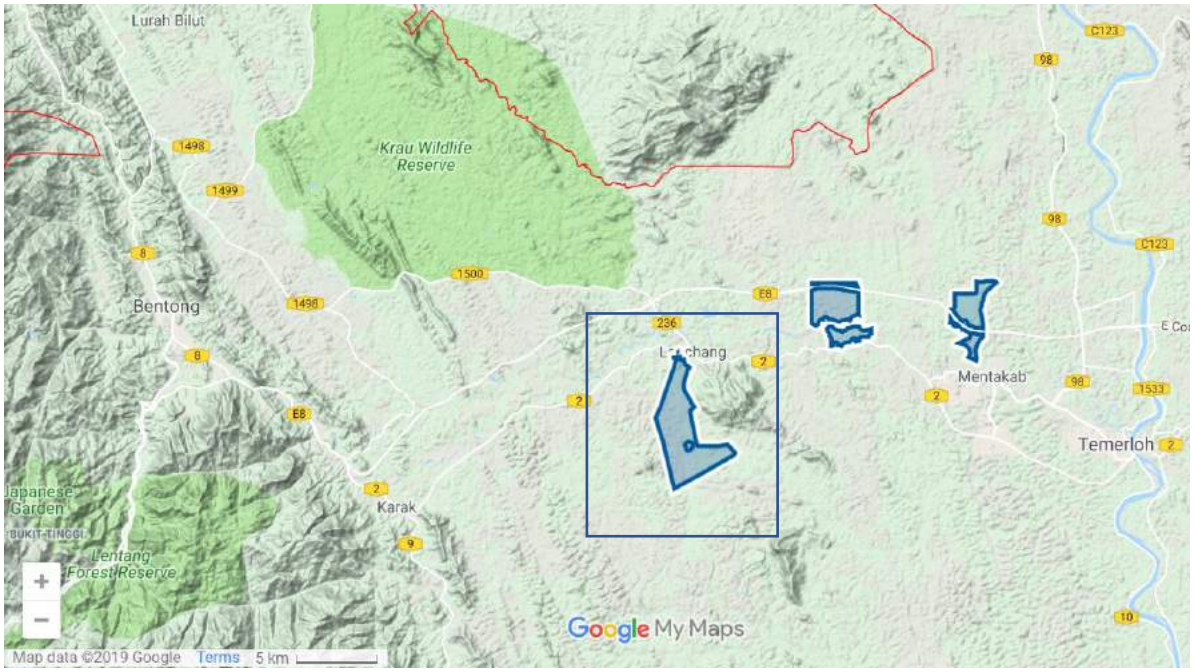


Figure 5: The location of the estate location is layered on google my maps. Blue areas are Mentakab Estate with few divisions. The one in the box is Lanchang division which HEC reported. The red figures are gazetted protected areas extracted from Global Forest Watch data.

[4] *Information from consultation exercise with forestry officer during internal HCV assessment on 29/02 – 04/03/2019.*

3.2.4 *Estate in Johor*

Cenas Estate is located in Bandar Tenggara, west of Sedili, where HEC was most intense in the state of Johor (pers. comm. Perhilitan Johor). The estate has a 7.5km border with the Kluang Tambahan Forest Reserve, a 6,413 hectares state forest land that has been approved by "Majlis Mesyuarat Kerajaan Johor" to become Permanent Reserve Forest (PRF) (pers. comm. Forestry Johor). The estate is located between Felda Bukit Tongkat on the west and Tradewinds Ulu Sibul on the east. Both neighbouring estates established electrical fences on their west and east borders during their replanting programme. Along the forest borders, there is a waterfall flowing from the reserves into the plantation.

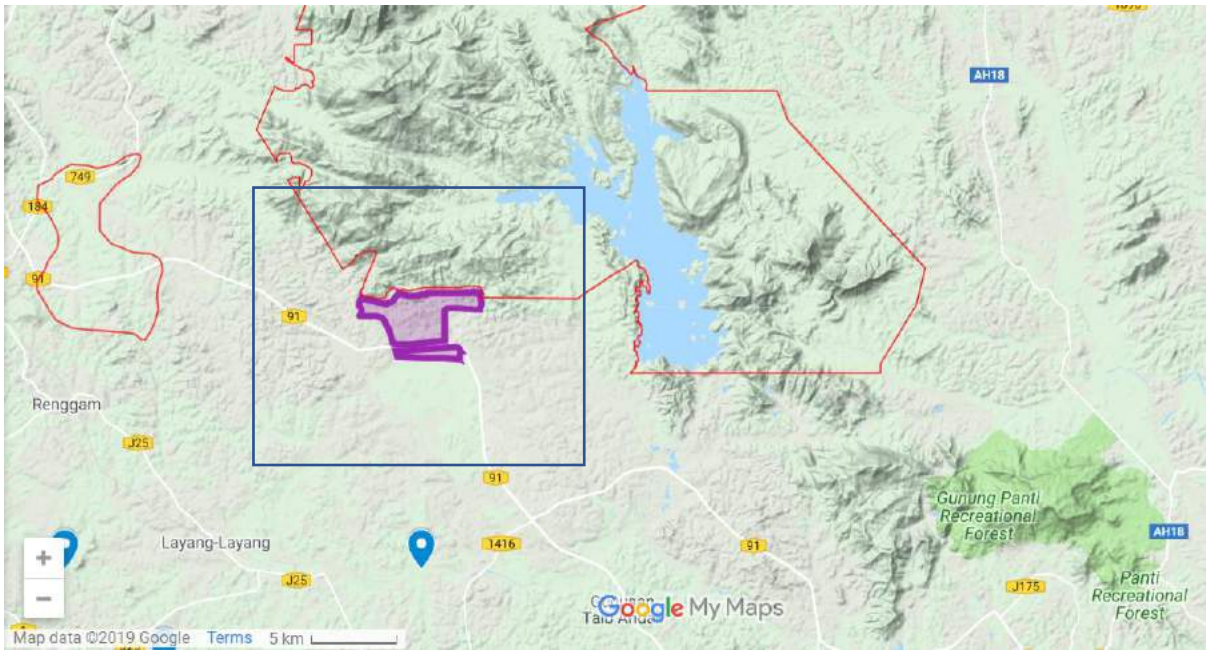


Figure 6: The estate location is layered on google my maps. Purple area in the box is Cenas Estate. The red figures are gazetted protected areas extracted from Global Forest Watch data.

3.3 Data collection

3.3.1 *Literature review*

In reviewing the historical and current strategies of HEC, we carried out several unlimited time period internet-based searches of online cross reference databases namely Google Scholar (2019), Web of Science (2019) and Scopus (2019). Three different combination of keywords used for the search are as follows: "human-wildlife conflict", "human-elephant conflict", "Malaysia", and "crop-raiding". The results of the search are not limited to Malaysia, although publications from Malaysia were prioritised to be selected for review. From the obtained search results, I had selected studies on HEC mitigation and management of elephants. The review analysis excluded studies on other elephant

subjects such as “population”, “occupancy”, “habitat”, “ecology” and others. I have chosen free-accessed articles, conference proceedings, reports and literature review papers, and excluded books and guidelines for the systematic review.

3.3.2 Collating HEC data of Sime Darby Plantation Berhad

This research collected data of oil palm (tree) damage from estates using protocols adapted from guidelines prepared by the IUCN African Elephant Specialist’s Group, Human Elephant Conflict Working Group (Hoare, 2000). The data was sourced from various records such as patrolling (elephant and security) record books of respective estates, records of oil palm re-supply by nursery or Research and Development (R&D) Department, insurance claim records submission to Procurement Department, and internal reporting to Sustainability Department. The data obtained from the estate was available on daily basis. These data were tabled in excel with the following information: month of damage, number of trees damage, and field areas which indicated the age of the trees. Additional data on operational replanting programme and schedule was collected from Replanting Unit and Upstream Malaysia of SDPB management team to use for data verification. All gathered data was consolidated in this study and validated through inter-departmental consultation.

The monthly rainfall datasets were provided by the Upstream Malaysia Department of SDPB. The estates collected and measured rainfall from rain gauges that were set up in the respective estates. This data was combined with damage data in a Microsoft Excel spreadsheet.

The documentations for insurance claims were obtained from the Procurement Department and are as follows (those made available and provided by the estates):

- Duly completed Claim Form (by insurance company)
- Statement of Claim with detailed description of the affected trees / areas / planted date / loss date / quantity and cost
- Copy of Incident Report (police report)
- Copy of Planting Records of the affected trees prior to the incident
- Photographs depicting the damage area/trees
- Copy of invoices and documentation to support the amount claimed

- Copy of Census Report
- Estate layout plan with demarcation of the plots/blocks etc.
- Estate layout plan with demarcation of the plots/blocks etc., with markings/identifications of the affected areas
- Any related documents deemed necessary to substantiate the claim, if any.

A rapid assessment of HEC at Sime Darby Plantation Berhad was carried out for all estates in Malaysia, except for Sarawak region (as there is no elephant distribution in Sarawak), using online survey of Google Form on 11th to 28th March 2019. The objective of this rapid survey is to assess the current status of conflicts for the past three (3) years (2016-2019). Information were collated from the estates' management teams and field teams but not limited to security guards and patrolling team. These questions consisted of a mix of open, close and multiple-choice answers. The questions include: a) estate, name and designation of respondent, b) Have elephants come to your estate for the past three years (2016-2019)?, c) Has your estate experienced Human - Elephant Conflict (HEC) in the past 3 years (2016-2019) and please provide example of crop or property damages? - If they answer "no" for (c), they will proceed to (g) and not be able to access to the rest of questions, d) How big are the groups of elephants that enter the estate? [multiple choice: if groups of different sizes can be seen in the estate, for example if three individual elephants enter in one event and 15 individuals in another event, then respondent can tick both 3-5 and more than 10], e) Have you sighted any juvenile elephants which are 3 years old or younger in your estate? (the question has an attachment of elephant age references as a guide and the submitted photos have been verified accordingly) [respondents asked to share photos of elephants in plantation], f) What human-elephant conflict mitigation approaches have been used in your estate in the past three years (2016-2019)? [multiple choice], g) Any comments or inquiries for Human-Elephant Conflict (HEC) in Sime Darby Plantation? In addition, the survey requested the estate to share images/photos of elephant depredation in the estate's possession to the researcher's email.

3.3.3 *Policies, procedures and protocols*

The company policies and procedures were obtained from the company's website (Sime Darby Plantation, reference[5]) as well as internal documents (both confidential and non-confidential). Additional information was acquired by interaction with the respective estate's management team on the ground during the study.

3.4 Data analysis

3.4.1 *Literature reviews*

The data for literature review was compared descriptively on Microsoft Excel based on the following: published journal, year published, year of study, types of data, collection methodology, geographical distribution of conflicts, types of crops involved, size of the study area, human density and forest frontage (distance of forest reserve and conflict area), type of HEC mitigation, HEC mitigation ownership and effectiveness of HEC mitigation.

3.4.2 *HEC patterns*

The data on tree damages was analysed using Microsoft Excel and open-access statistical programme of R. The age of tree damaged was calculated using the field identifications (ID), which is associated to the year of planting (e.g. Field 2011A). A Pearson correlation was carried out on the number of conflict incidences against monthly rainfall data using Microsoft Excel formula. The data on tree damage was compiled and structured in Microsoft Excel according to estates together with information of fields affected and the year of damage. This information was provided to the regional GIS personal in-charge from the R&D, Precision and Agriculture Unit in Sime Darby Plantation Berhad to produce the HEC spatial and temporal pattern maps. The regional GIS personal in-charge has access to ground surveyed data at respective estates and was able to integrate the HEC and ground survey information using "join the data" function on GPS Trimble. The maps are then prepared by using the ArcGIS License version 2018.1.0.10348 guided by researcher's advice.

[5] http://www.simedarbyplantation.com/sustainability/beliefs-progress/governance/sustainability-policies

The other set of data in the Microsoft Excel was provided to the company's R&D, Data Processing and Management Unit for assessing the effects of existing mitigation in SDPB estates. Binuang and Jeleta Bumi Estate were excluded in this analysis due to inappropriate (sub-standard) fencing established at the estates. The data was arranged in the Microsoft Excel according to Estate, Field ID, Number of damages, Damage (yes or no), Age of tree, Year, Month, Fencing (yes or no), Guarding (yes or no) and Rainfall (mm). The dependent variable used is the number of trees damaged in HEC. The following tests were analysed using licensed software of SAS JMP 14; a) paired T-test to compare the hypothesis of fencing and non-fencing effects, b) chi-square to see the relationship of fencing and damage occurrence by month and c) logistic regression to analyse the non-parametric data of fencing. Additional Sheet was formulated in the Microsoft Excel to run prediction modelling for damages. This sheet is organised to Estate, Number of Damage, Age of trees and Rainfall.

The economic loss of tree damage caused by HEC was quantified and the formula was put together through discussion and debriefing with various department representatives namely Upstream Malaysia Department, Replanting unit, Corporate Finance Department and Sustainability Department. The Corporate Finance of SDPB had calculated HEC loss in 2013 and were able to comment on the proposed formula. The overall HEC tree damage cost data was presented internally for voluntarily review and all comments were addressed.

3.4.3 Policies, procedures and protocols

The integration of management systems via ISO approach was applied in evaluating the performance of existing policies, procedures and protocols in Sime Darby Plantation Berhad. The ISO 14001 standard tool was chosen for the assessment of policies, procedures and protocols as it is a recognised tool with internationally agreed standards, that sets out the requirements for an environmental management system. Although ISO 14001:2004 has been updated to ISO 14001:2015 internationally, the fundamental element remained the same, and at the date of this report, Malaysia has yet to fully adopt the updated version. The standards cover a complete aspect to ensure the system is efficient for compliances from planning stages to the review of system effectiveness. The findings were analysed qualitatively using the Plan-Do-Check-Act (PDCA) approach and

the ten (10) key elements of ISO 14001, with a focus towards wildlife conservation and not on other (general) observation. It is anticipated that the process of managing human-elephant conflict at respective estates needs to be applied using an adaptive management approach (Brown and Senior, 2014).

Figure 7: PDCA approach and process adopted from EMS ISO 14001

4.0 RESULTS

4.1 HEC systematic literature review

A total of 102 papers discussing HEC were collected and reviewed from August 2018 to March 2019. These papers were published from 1993 to 2019, and the studies were carried out using data from the year 1976 to year 2017. The highest number of papers were published in the year of 2017. The journals, Oryx and Gajah, produced the highest number of peer-reviewed HEC papers followed by Plos One and Pachyderm. Other publishers, including Journal of Applied Ecology, Animal Conservation, African Journal of Ecology, Tropical Conservation Science and Biological Conservation, produced an average of 2 to 4 papers.

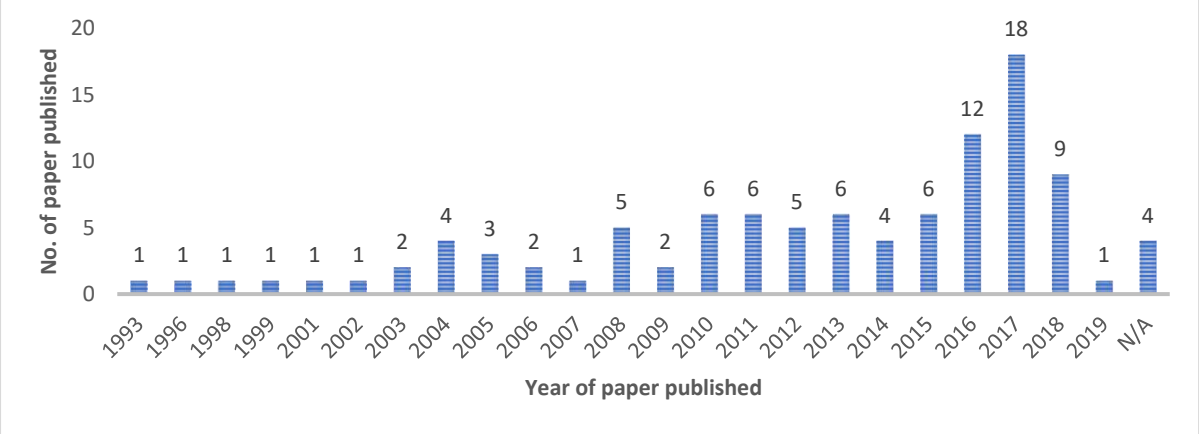


Figure 8: Number of papers published according to the year

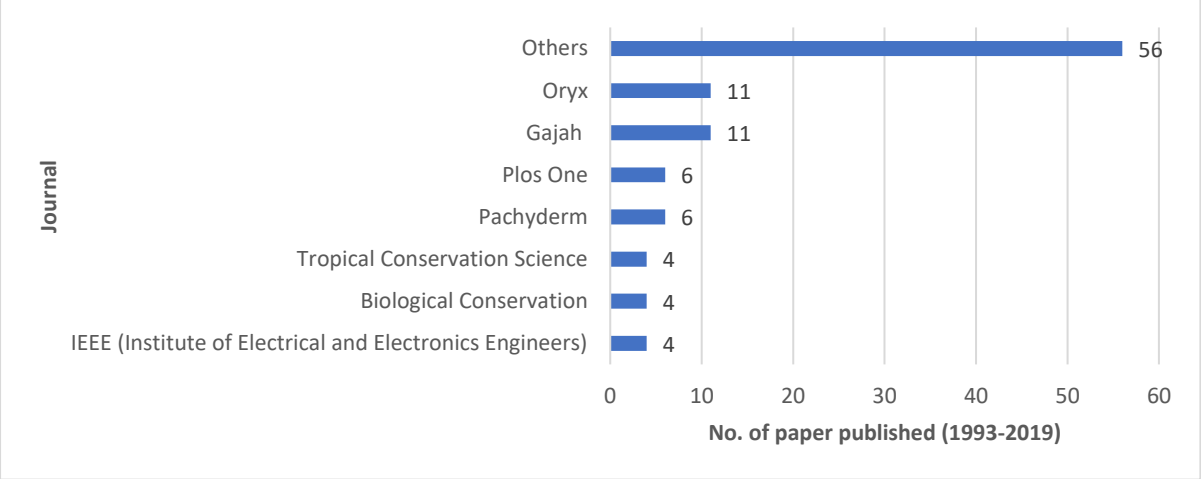


Figure 9: Number of papers published according to the Journal

More than half of the reviewed papers, 57.9% discussed human-wildlife conflict in Asia; which occurred at nine countries namely Cambodia, China, Nepal, Malaysia, India,

Indonesia, Japan, Sri Lanka and Thailand. The following 35.3% of the reviewed papers discussed the human-wildlife conflict in Africa; which occurred at 12 countries namely Cameroon, Tanzania, Ghana, Kenya, Mozambique, Rwanda, Botswana, Congo, Uganda, Zimbabwe, Burkina Faso and Benin. The remaining 6.9% of reviewed papers did not mention a specific country of study.

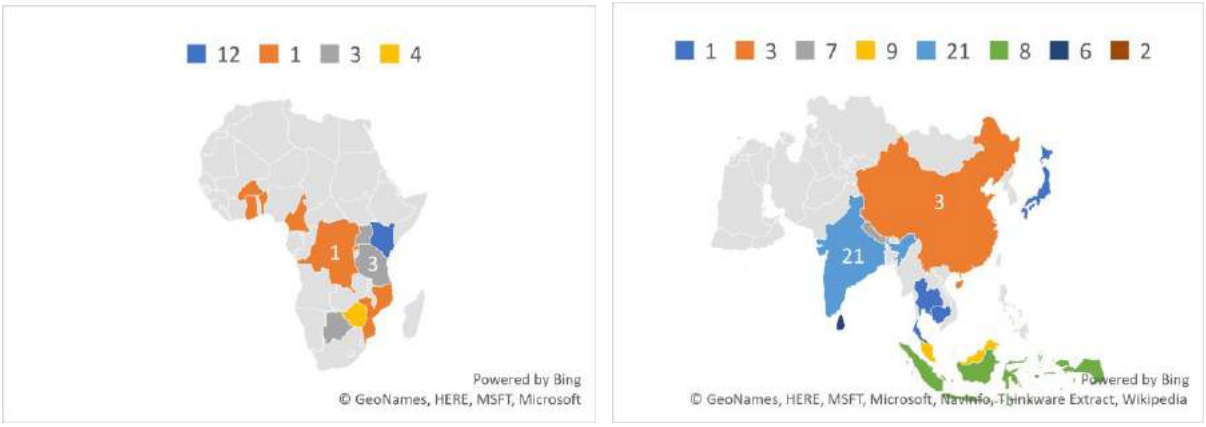


Figure 10: Number of papers published in Africa and Asia regions

The reviewed papers of perennial tree crop such as oil palm, rubber and teak are very restricted in availability with only eight papers found. Only half of these papers discussed the mitigation and management of HEC. The main mitigation approach that has been used at tree crops plantation included carbide, "*bomoh*" (supernatural beliefs), patrolling with use of common deterrent like fire, spotlight, noise and sound, elephant-proof trenching, electrical fencing, elephant capture and translocation, culling, elephant drive, conservation research and conservation awareness. On top of these mitigations, other crops used additional methods such as early-warning technology (predicting hotspot), de-tusking fence breakers, usage of natural elephant barriers, using integrated strategies of academics and local community-level expertise, financial incentives, chilli grease fences, playback of felid growls, bee-hive fences, habitat improvement, and elephant contraception in Asia or Africa.

Others crops studied are mainly seasonal crops such as banana, maize, rice, sorghum, and others which comprised of 46.1% of total reviewed papers. The rest of the papers, 45.1% did not describe any crop depredation in the conflict regardless if the research is crops related or involving other types of conflict (i.e loss of human lives).

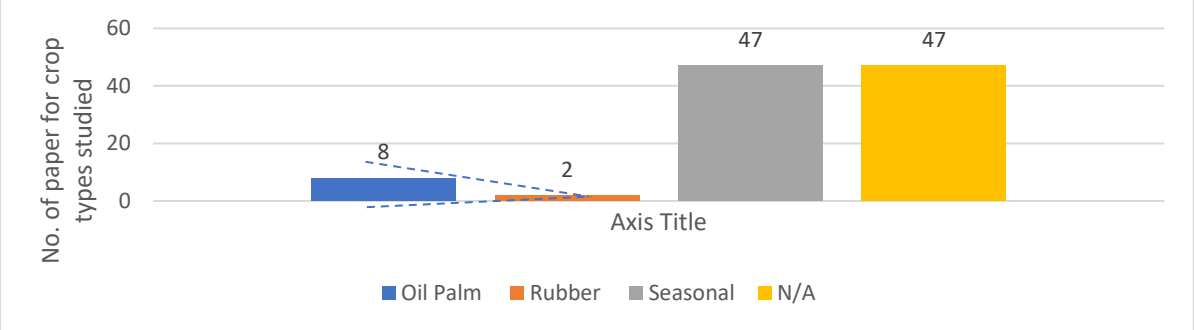


Figure 11: Type of crops studied in the reviewed papers

A total of 15 papers with "titles" mentioning mitigation of HEC were reviewed. In general, the HEC mitigations discussed can be grouped into three categories. The highest percentage of papers, 38.2% (N=102), were on the use of fences as HEC mitigation. These fencing mitigations include few types of material and integrations such as electric fencing, bees, chillies and grease. Mitigation methods that rely on intensive manpower such as active crop-guarding / patrolling were discussed by 31.4% (N=102), whereby 23 cases of guarding are carried out together with fencing. The last group (N/A) covers a variety of mitigation methods including translocation, trenches, de-tusking, raising awareness; whereby most were carried out together with other mitigation measures. Integrated methods were also been practiced. Overall, 16 studies included fencing, guarding and others, five studies with fencing and others, and seven studies with guarding and others.

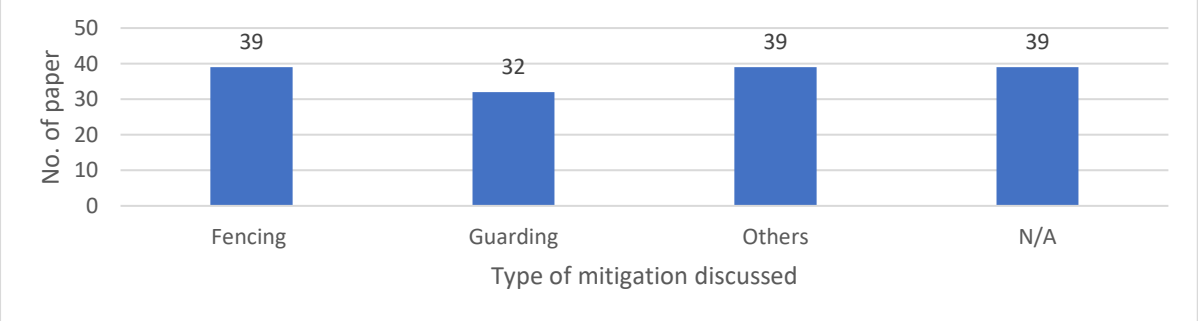


Figure 12: Types of mitigation studied in the reviewed papers

About 54.90% of reviewed papers have not included the HEC mitigation ownership in their studies discussion. Furthermore, 76.5% reviewed papers on HEC mitigation did not discuss HEC mitigation effectiveness. From the remaining 23 reviewed papers that discussed effectiveness of HEC mitigation, 7 were perception studies (interviews), five on improved engineered-design (comparing the number of before and after) and 11 papers of others (schemes such as compensation reports and complaint reports).

Perception studies in Cameroon highlighted the suggestions by respondents on what could be done to minimise crop damage, including shooting the elephants responsible, scaring animals by gunshots, moving the elephants, and fencing, yet most of the respondents had no idea as to what could be done to tackle HEC (Tchamba, 1996). The most common mitigation measure used by farmers in Benin to keep elephants away are the use of noise and fires. However, there were some notable dissimilarities on how these farmers scored the effectiveness of different methods. For example, chilli-grease fences was highly rated by some farmers but not considered effective by others (Djagoun *et al.*, 2017). The similar mitigation methods perceived to be the most effective in India include the use of torches, shouting, banging tins and drums, and the use of chilli (Hoffmeier-Karimi and Schulte, 2015). Nevertheless, these methods are only effective if used in combination depending on the size of elephant herds. The more people involved in chasing the elephants the more effective they are, and the use of an individual method are not known to be effective (Bhagat, Yadav and Jhariya, 2017). These traditional methods are also perceived as the most effective in another part of India, namely Tamil Nadu; of which the most popular mitigation method was screaming (making noise), followed by lighting up fires and fire crackers. On the legal aspect, people were suggesting that elephants can be protected by implementation of strong law enforcement although some respondents opined that the law had never help in the protection of elephants (Jaganathan, Shanmugavadivu and Ganesh, 2018). Protocols deemed essential for mitigating human-elephant conflict as ranked by residents of Western Thailand are forest restoration efforts inside the wildlife sanctuary and patrol teams to chase elephants back into the protected area. Of which, forest restoration efforts at the buffer zone was ranked the highest priority. The study also suggested that the inclusion of the plantation owner in the conservation strategies, specifically providing incentive to mitigate HEC, helped to improve the effectiveness of the HEC methods (van de Water and Matteson, 2018). A predictive model study in Kenya suggested that early detection of elephants as they are approaching farms, increased guarding effort, and the use of active deterrents are fundamental to effective mitigation strategies regardless of the location and the physical attribution of a farm (Sitati, Walpole and Leader-Williams, 2005). Meanwhile, a study on social perceptions of electrified wildlife fence establishment in Laikipia, Kenya found that respondents in communities with more frequent conflicts were less favourable in their rating about fence effectiveness. Other respondents from an array of communities and

livelihoods were positively inclined toward the use of wildlife fences, and that there was a high willingness to pay for properly functioning fences as barriers to HEC (Van Eden, Ellis and Bruyere, 2016). Research in Amboseli, Kenya, found that the presence of protected areas is important in determining the effectiveness of electric fences (Kioko *et al.*, 2008). The results imply that effective non-electrified barriers may equally deter crop-raiding elephants in areas where elephant pressure is minimal. The study did not find an inverse relationship between fence breaking and fence voltage.

In Sri Lanka, current efforts are focused on the deployment and maintenance of the electric fence as a practical solution for addressing HEC. At present, the breakage of fencing is conducted visually with team members walking along and inspecting the fences, this requires a considerable amount of manpower and therefore, the breakages are occasionally left unattended. New designs in fences deploy specially designed nodes along the fence to detect breakage (Tennakoon *et al.*, 2015). Control signals were sent to nodes through the fence wires and this method does not require separate communication infrastructure. The node devices are powered by solar cells, and the breakage detection system are able to recognise whether the fence is broken and to identify its location. This system considerably reduces the maintenance time and the costs for electrical fences (Elvitigala *et al.*, 2015). A study by (Honda *et al.*, 2009) for medium and large mammals in Japan explore closing the gap in fencing between the expanded metal latch and the ground surface, by using a corrugated polyvinyl chloride sheet as an insulating material to prevent animal intrusion through the lower exposed gap in the fence. This particular fence has high practical value for nine targeted mammal species, but excluding elephants.

De-tusking fence-breaking elephants in Kenya was found to drastically reduce elephant attacks but did not prevent elephant depredation (Mutinda *et al.*, 2014). Spotlights, chili fences, and electrical fences seems to be highly effective at preventing crop damage by elephants when used in isolation, but when used in combination with noise their efficacy was compromised (Davies *et al.*, 2011). Community-based chili-grease fence crop-guarding was effective at keeping elephants out of crop fields in 91.2% of attempted raids in Indonesia (Gunaryadi, Sugiyo and Hedges, 2017). The case study from Tanzania found that these chili fences effectively deter crop raiding by elephants at the scale of individual farms, but not at a larger landscape scale (Ndossi *et al.*, 2016). Attempts by WWF-

Malaysia to set up chili-grease fences in Peninsular Malaysia were not successful, which was partly attributed to the high rainfall in this region, making it tedious to reapply the chili grease on the fences (WWF unpublished reports).

Overall, most reviewed papers agreed that the respective HEC areas must adopt a cautious approach and systematically evaluate the actual damage and perceived damage. The management strategies need to be nuanced, research driven and must take account behaviour and ecology of the species (Anand and Radhakrishna, 2017).

4.2 HEC in Sime Darby Plantation Berhad

HEC data was collected by respective estates on a voluntary basis. There is no established protocol or clear recommendation on how and what information should be recorded by the assigned workers. There are differences in guarding strategies between estates. For example, estates in Sandakan have dedicated manpower of between 5-7 people to conduct elephant patrolling during day (8AM – 4PM) and night (4PM onwards), while estates in Johor and Kunak used the auxiliary police team and integrated security boundary patrolling to carry out elephant patrolling in combination with other daily routines. All the estates kept basic records of oil palm damages, which is used for justifying the need of replacement for oil palm saplings and for insurance claims purposes. Most estates lack information about direct sightings of elephants.

From 2011 to December 2018, a total of 200,242 trees were reported damaged by elephants in the eight focus estates. Assuming 1 hectare consisted of 145 trees, the total HEC damage is equal to 1381 ha which is 6.6% of the total 20,899 hectarage of focus area. The HEC patterns are represented by: a) Sandakan Estates (Tigowis, Tunku Tun Tan and Sentosa) in Sabah, b) Kunak Estates (Binuang and Jeleta Bumi) in Sabah c) Cenas Estate in Johor and d) Mentakab Estate in Pahang.

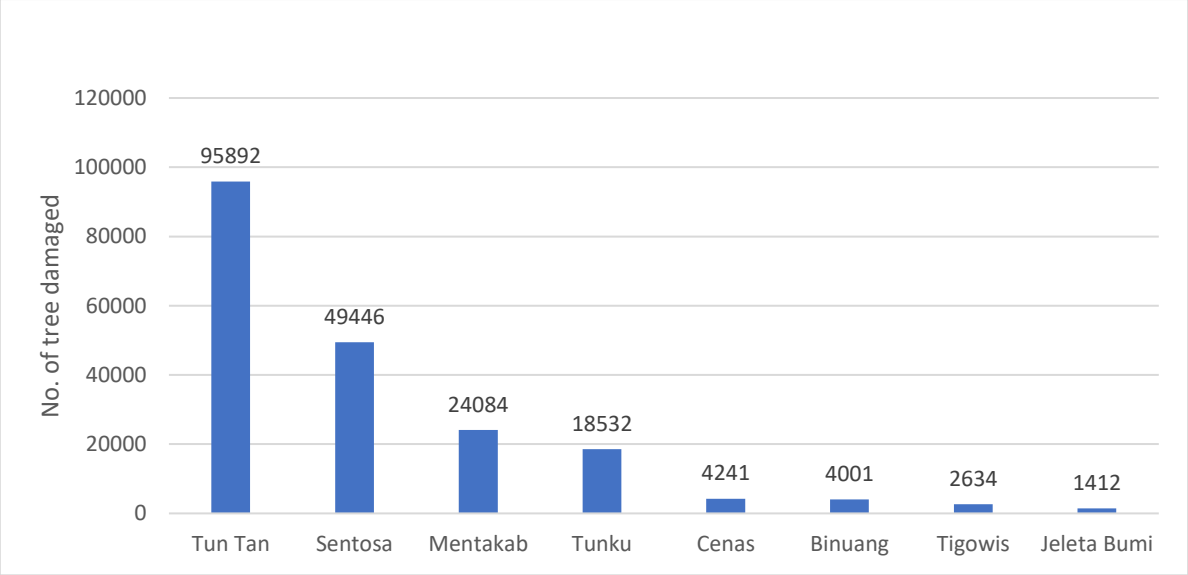


Figure 13: Overall tree damage in 8 estates of SDPB during 2011-2018

4.2.1 Age of trees damaged

The elephants prefer to predate on trees of particular age groups in Sime Darby Plantation Berhad. Overall, 55.2% (N=200,242) of the damaged trees were less than 1-year to 1-year old and the likelihood of tree damaged reduced significantly after the fifth year (mean=2.5 years old, SD=0.04). The age of trees damaged by elephants ranges from 1-year old up to 18-years old. There was moderate negative correlation between number of trees damage and age of trees (r=-0.54, p=0.02). Nevertheless, when the age patterns were analysed by sites, there were differences between estates. In Kunak Estates, one plantation showed that trees age when damaged was between less than a year to four years old. Another estate recorded age of trees affected ranging one-year olds to 15-year olds, and 48.8% (n=1,951) of the damage occurred for trees aged 9 years. The detail of this patterns will be explained further in the discussion. The Sandakan Estates were similar to others, with the highest damage occurred to trees 1-year old and below, whereas the age of trees that have been depredated by elephants in Pahang are between less than a year to five years old, and 81.1% (n=19,542) were 1-year old trees. The age of trees damaged in Johor is between less than a year old and 18 years old, from which 56.5% (n=2,395) are below 1-year old.

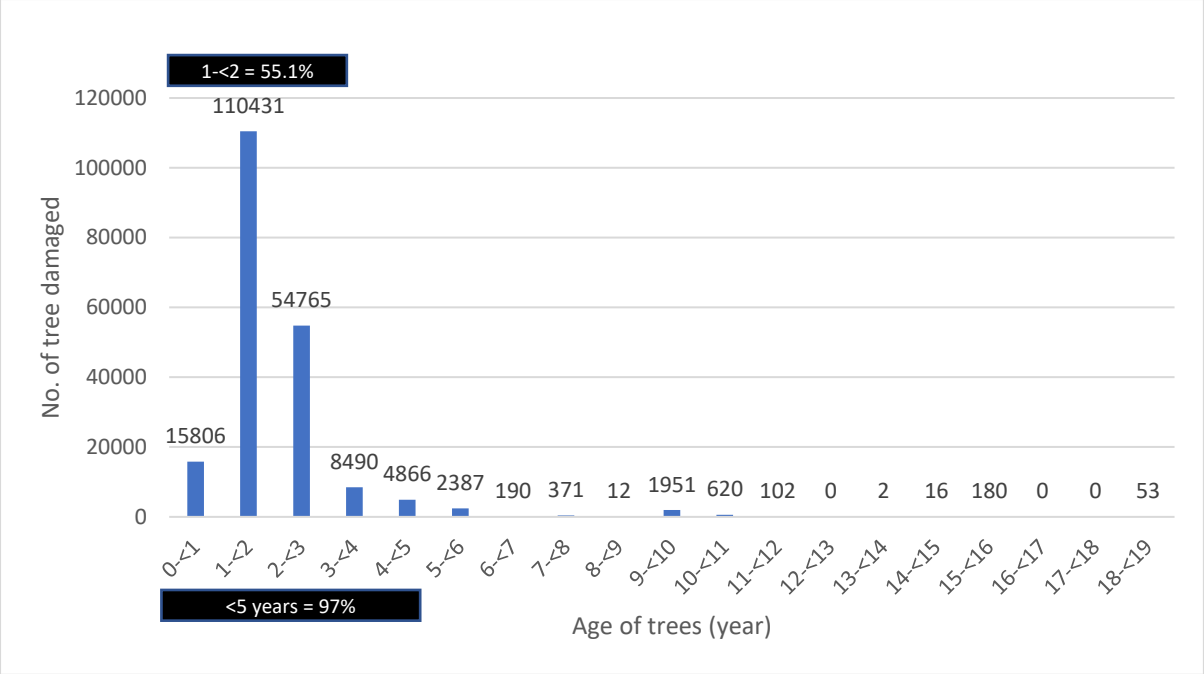


Figure 14: Age of trees damaged by elephant in 8 estates of SDPB during 2011-2018

Table 2: Mean and SD of trees age damaged by elephant at respective 8 estates of SDPB

	Binuang	*Cenas*	*Jeleta Bumi*	*Mentakab*	*Sentosa*	*Tigowis*	*Tun Tan*	*Tunku*
Mean	*7.84*	*7.89*	*1.86*	*1.40*	*2.90*	*3.18*	*2.04*	*2.82*
SD	*3.80*	*6.78*	*1.27*	*0.89*	*2.09*	*1.97*	*1.64*	*1.79*
Median	*9*	*8*	*3*	*1*	*3*	*3*	*1*	*3*

4.2.2 HEC spatial and temporal patterns

The HEC patterns were mapped by intensity of trees damaged and HEC frequency for the four studied areas from the period 2011-2018. Both Kunak and Johor estates have less damage (ranges below 2,000 trees damaged). For the estate in Johor, the highest number of damages occurred in the P2014A field which is located near the waterfall at the forest border. In February 2015, the Johor estate established an electric fence along the forest border. The elephant depredation in Johor estate continues to fluctuate until today. Meanwhile, seven fields in Sandakan Estates recorded more than 7,000 trees damaged; with the highest intensity of damage occurred in the P2015A field, Tun Tan Estate. The former field of 2011-2013 had been resupplied with saplings at multiple times and was re-classified to 2016 due to severe damage by elephants (Figure 17(a)). Overall, the highest number of damages recorded was 14,002 trees occurred in the P2011A field of the estate in Pahang (Figure 17(b)). The former field of P2011A has been replanted and re-classified to 2013E due to severe damage by elephants. No damage was reported at 2013E from 2014 to 2017 but HEC damage re-appeared in 2018. The highest frequencies of HEC that occurred between 2011 and 2018, were 94 times at forest borders of Pahang

Estate followed by 90 times at the fields bordering to the mangrove forest of Sandakan compared to other fields within those estates, and in comparison, to other estates.

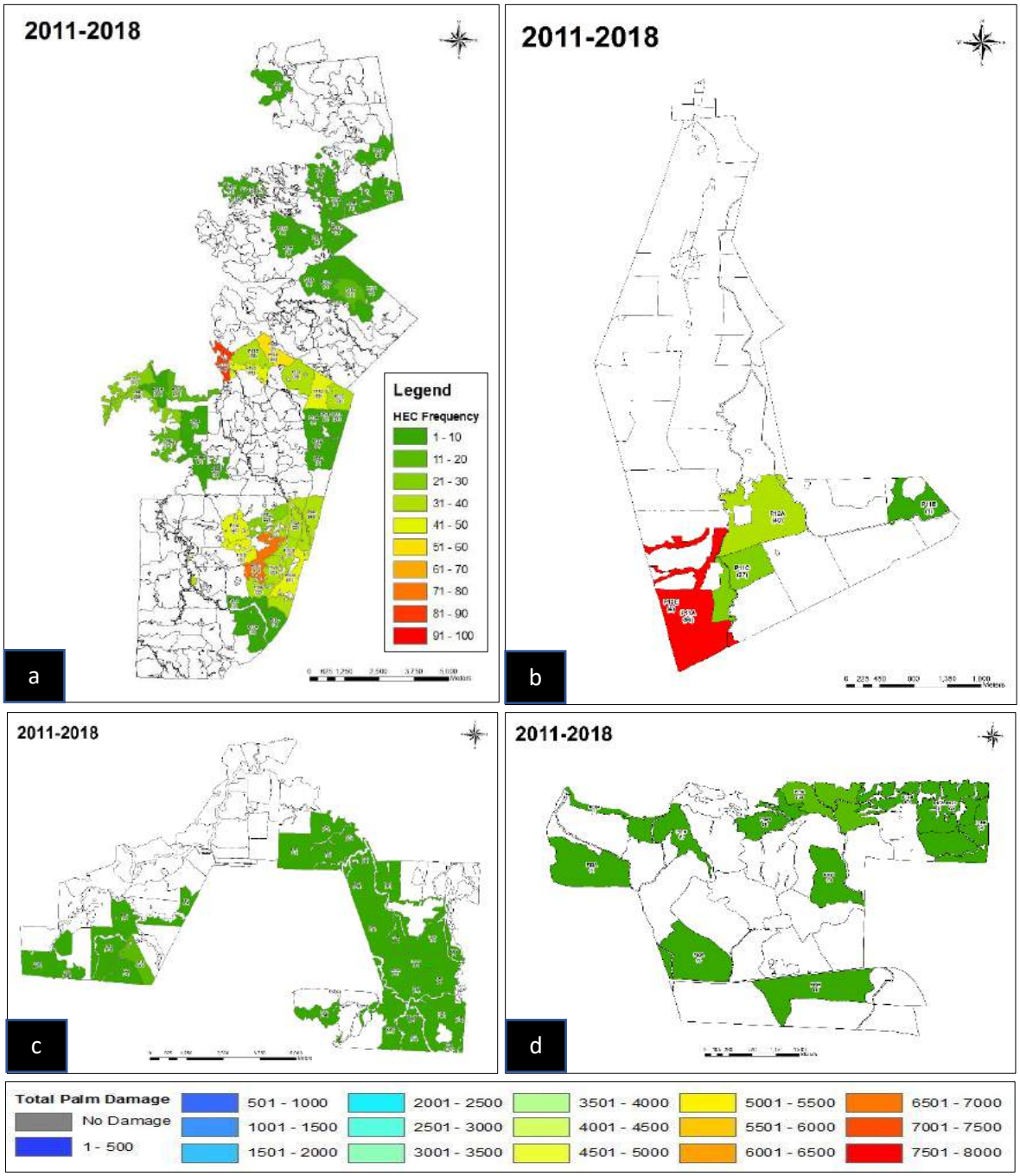


Figure 15: Tree damage frequency; a) Sandakan, b) Pahang, c) Kunak, and d) Johor

The data has shown that the HEC was reported whenever the replanting programme commenced. The illustration of changes in trees damaged according to the scheduled replanting fields are attached in the appendices. For example, figure 17 shown the frequency of damage in Sandakan estates from 2011-2018. The white colour in the map of year 2018 shown the left fields for replanting in 2019 onwards.

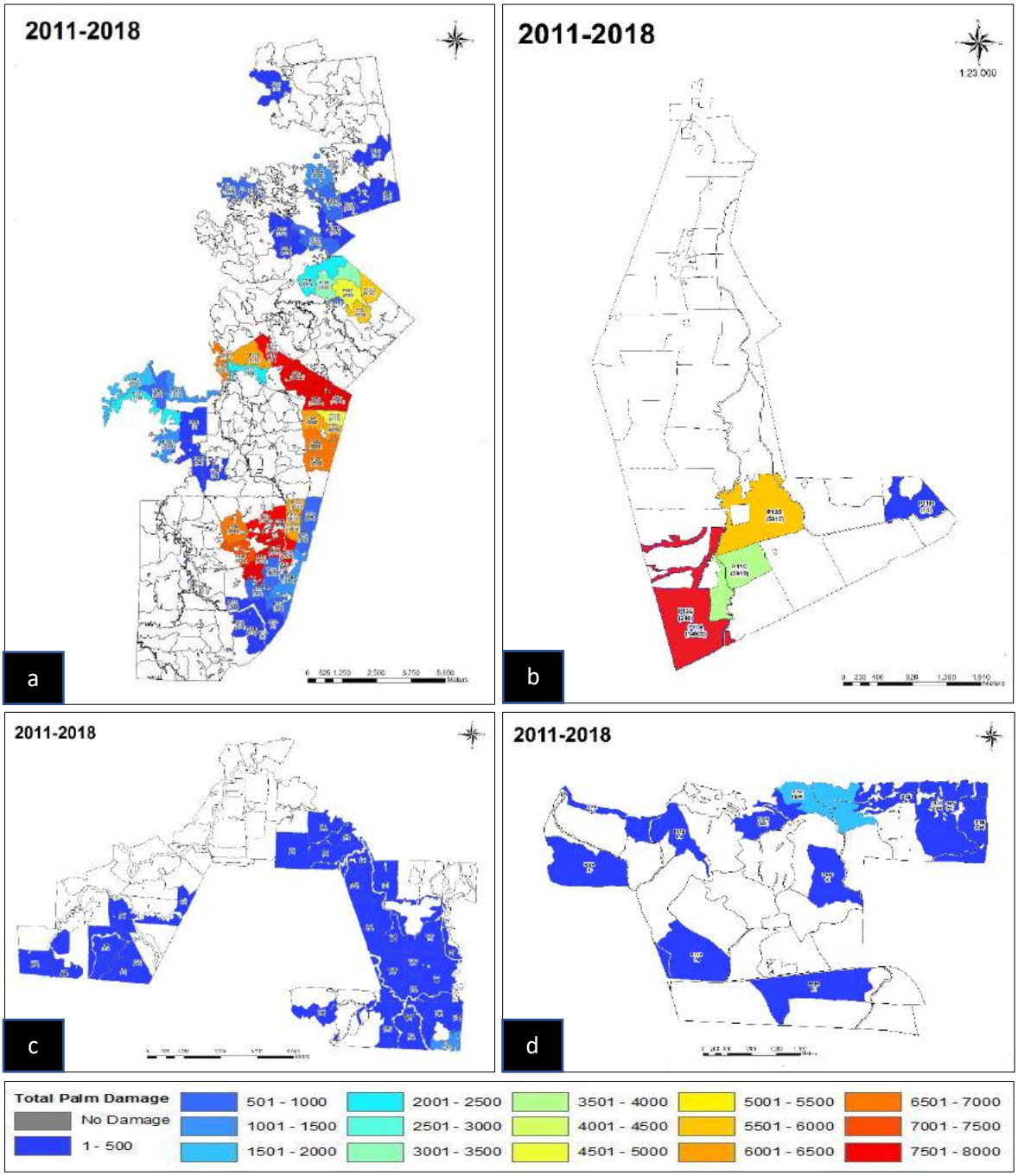


Figure 16: Tree damage intensity; a) Sandakan, b) Pahang, c) Kunak, and d) Johor

The monthly analysis of HEC damage shows an irregular pattern for all plantations. There was no correlation between number of trees damage and rainfall (r=0.08, p=0.81).

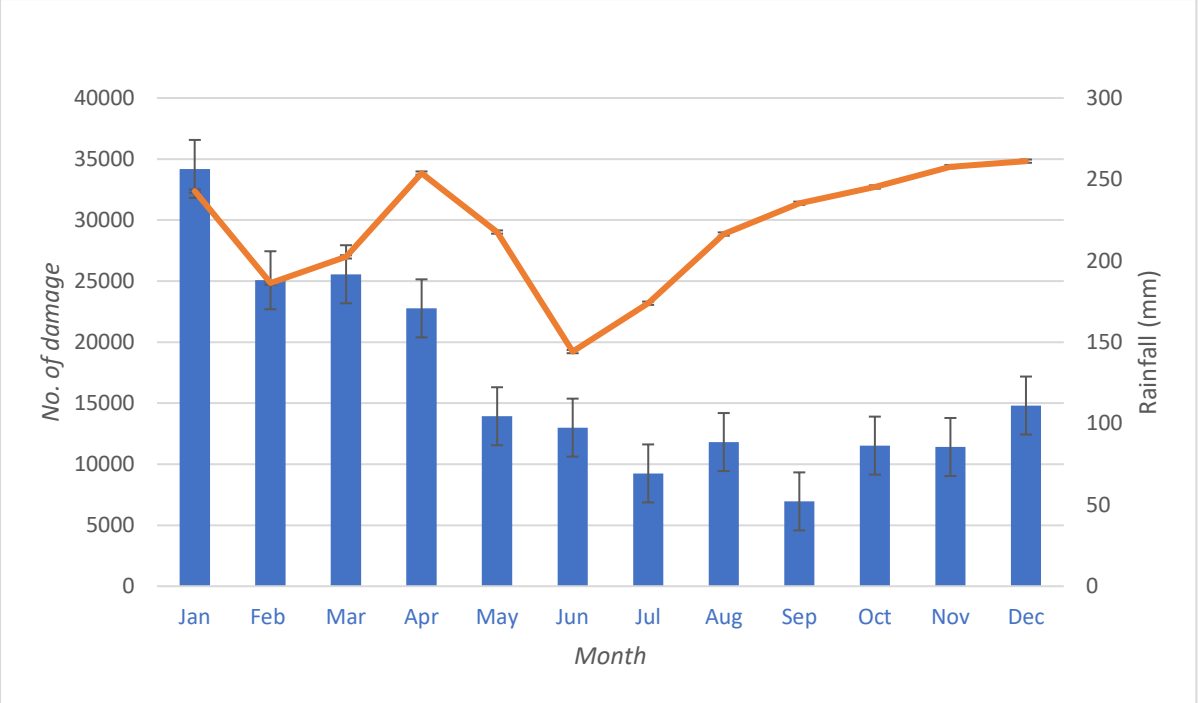


Figure 17: Number of trees damaged and rainfall distribution from 2011-2018

4.2.3 Elephants sightings in estates

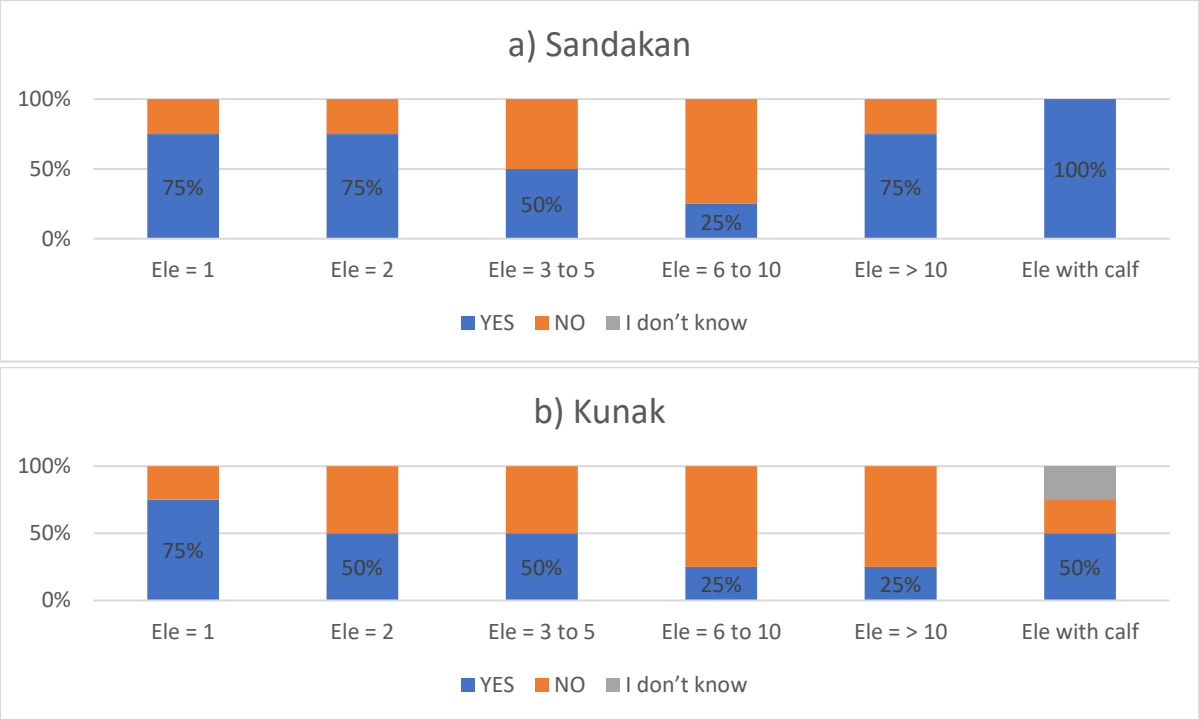
A total of 105 estates of 124 estates (excluding estates in Sarawak state) did the rapid assessment on HEC. There was a total of 143 respondents as some estates replied more than once. The responses were collated and verified through telephone communication with the respondents. All 105 estates provided feedback and we found that six additional estates (Sungang Estate, Tiger Estate, Kempas Klebang Estate, Gunung Mas Estate, North Labis Estate and Tun Dr. Ismail Estate) have HEC but were excluded in the research focus area.

Table 3: Response on number of elephants sighted at respective estates

Estate	Ele = 1	Ele = 2	Ele = 3 to 5	Ele = 6 to 10	Ele = > 10	Ele with calf
			Pahang, N=1			
Mentakab	no	no	no	no	yes	yes
			Johor, N=5			
Cenas	no	no	no	no	yes	yes
Gunung Mas	yes	yes	yes	no	no	I don't know
Kempas Klebang	no	yes	yes	no	no	no
North Labis	no	no	yes	no	no	I don't know
Tun Dr. Ismail	no	yes	no	no	no	I don't know
			Kunak, N=4			
Binuang	yes	yes	yes	no	yes	yes
Jeleta Bumi	yes	yes	yes	no	no	yes

Estate	Ele = 1	Ele = 2	Ele = 3 to 5	Ele = 6 to 10	Ele = > 10	Ele with calf
Sungang	no	no	no	yes	no	I don't know
Tiger	yes	no	no	no	no	no
			Sandakan, N=4			
Tigowis	no	no	no	yes	no	yes
Tunku	yes	yes	no	no	yes	yes
Tun Tan	yes	yes	yes	no	yes	yes
Sentosa	yes	yes	yes	no	yes	yes
YES	50%	57%	50%	14%	43%	57%
NO	50%	43%	50%	86%	57%	14%
I don't know						29%

For estates included in this study, all four estates in Sandakan confirmed the elephant herds that roamed in their plantations had calves. The number of individuals in Johor observed herds varies from larger than ten individuals to smaller herds, with a mixture of bulls and matriarchs. The elephants sighted in Pahang were mostly more than 10 individuals, however in Kunak they suggested more solitary elephants and smaller groups of elephants, between three and five individuals.



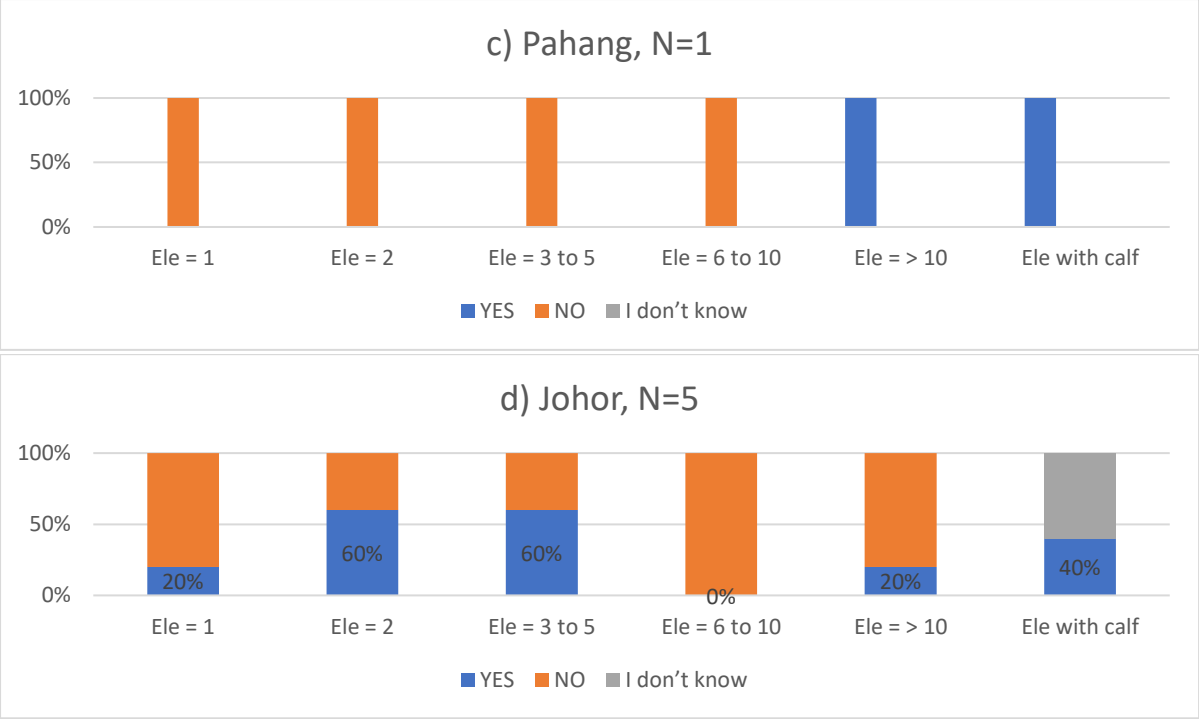


Figure 18: Graph of individual elephant sightings in a) Sandakan b) Kunak c) Pahang and d) Johor as detailed in Table 3

4.2.4 Economic loss and opportunity cost of Human Elephant Conflicts

In order to quantify the losses due to HEC, inputs are obtained from the Planning & Monitoring Unit, Upstream Malaysia and Corporate Finance, the following equations were formulated to estimate HEC cost due to tree damaged by elephant depredation.

Equation 1:

$$\begin{aligned} &Total\ Economic\ Loss\ (L), \\ &\quad = Rc\ (replanting\ cost\ until\ trees\ are\ 3\ years\ old) \\ &\quad + Yl\ (Loss\ of\ potential\ yield) \\ &\quad + M\ (Mitigation\ measure\ capital\ expenditure). \end{aligned}$$

Calculation for Rc (replanting cost) is in turn derived from Equation 2 (see below). Since the data collected from the estates were mainly number of trees damaged, and not the actual size of areas affected, the "Ha of damage" was calculated by dividing the number of trees damaged with the average standing trees per hectare of field, which is 145 trees per hectare. The forecasted immature cost in the calculation for Rc is based on the forecasted cost of inland replants in West Malaysia of Sime Darby Plantation Berhad (see Table 4).

Equation 2:

Rc = Ha of damage (no. of tree / av.145 SPH) x Forecasted immature cost up to the month of attack /Ha (land clearing, material, labour, transport, maintenance)

Table 4: Monthly forecasted immature cost based on West Malaysia operation - inland areas.

Age of Palms (Months)	Monthly Cost (RM/Ha)	To-date Cost (RM/Ha)
Pre-planting	3460	3460
Month of Planting	3650	7110
1	480	7590
2	640	8230
3	150	8380
4	130	8510
5	430	8940
6	240	9180
7	170	9350
8	450	9800
9	100	9900
10	110	10010
11	460	10470
12 (1-year-old)	1070	11540
13	170	11710
14	470	12180
15	120	12300
16	180	12480
17	610	13090
18	370	13460
19	120	13580
20	690	14270
21	80	14350
22	80	14430
23	490	14920
24 (2 years old)	370	15290
25	160	15450
26	640	16090
27	30	16120
28	490	16610
29	100	16710
30	700	17410
31	80	17490
32	500	17990
33	30	18020
34	60	18080
35	640	18720
36 (3 years old)	380	19100

Thus, to calculate Rc, the figure of 200,242 was divided by average 145 trees; Standing Per Hectare (SPH) = 1,380. 98 hectares is affected by elephant depredation. Forecast immature cost for trees below three (3) years old is the sum of the cost for trees less than one-year (109.01ha x RM7,110) + one-year (761.59ha x RM11,540) + two-year (377.69ha x RM15,290) + three-year (58.55x RM19,100). Considering that there is no replacement or supplying of palm carried out after the trees above 3 years old, the forecast immature cost of 4 years and above is calculated as (74.14 x RM19,100). The sum of immature cost per hectare is:

Rc = RM 775,061.1 + 8,788,748.6 + 5,774,880.1 + 1,118,305 + 1,416,074

= RM 17,873,068.80

Calculation for Yl (loss of potential yield) has several factors to be included such as a) potential yield that not to be recovered and loss harvesting period, b) crude palm oil (CPO) production value, c) kernel production value, d) crude palm oil market price, e) kernel market price and f) cost of palm production per metric tonne. The potential harvesting period is calculated up to 25 years of harvesting. This calculation only takes into account for the trees aged 4 years and above and excludes the loss incurred during the delay of harvesting for under 3 years old. The average yearly yield is assumed as 21 metric tonne, average oil extraction rate is considered 21% and kernel extraction rate is considered 5%. CPO and kernel market price are calculated based on the current price on the MPOB website, March 2019 which is RM2170/MT and RM1100/MT respectively.

Table 5: Detail of trees age, hectare, loss and percentage

Age of trees damaged (year)	**No. of trees damaged**	**Hectare (*145/ha)* (a)**	**Loss harvesting period (year) (b)**	**Loss of potential yield (avg. 21)**	**Percentage (%)**
0 (<1)	15,806	109.01	Replace and	Delay	7.91
1	110,431	761.59	delay within	Delay	54.93
2	54765	377.69	1-3 years of	Delay	27.62
3	8490	58.55	recovery	Delay	4.21
4	4866	33.56	21	14,495.21	2.38
5	2387	16.46	20	6,914.069	1.19
6	190	1.31	19	726.4552	0.13
7	371	2.56	18	505.7379	0.10
8	12	0.08	17	0	0.00
9	1951	13.46	16	4,323.972	0.93
10	620	4.28	15	1,346.897	0.31
11	102	0.70	14	565.6966	0.14
12	0	0.00	13	0	0.00
13	2	0.01	12	3.475862	0.00
14	16	0.11	11	25.48966	0.01
15	180	1.24	10	260.6897	0.09
16	0	0.00	9	0	0.00
17	0	0.00	8	0	0.00
18	53	0.37	7	53.73103	0.03
N/A	200,242	1380.98	N/A	29,221.29	100 %

Equation 3:

Calculation for Yl

i) FFB (yield) = Ha of damage (that not to be recovered) x Average yield/Ha/annum (e.g.: 21 MT) x potential loss harvesting period

ii) CPO = FFB x OER (average 21%)

iii) Kernel = FFB x KER (average 5%)

CPO x current price (MPOB average e.g.: RM2170/MT)

Kernel x current price (MPOB average e.g.: RM1100/MT)

Cost of palm product/mt. = [CPO, (2) + Kernel (3)] x RM1,350/MT Palm product (average)

Yl = (4) + (5) - (6)

Yield = (a) x (b) x 21 MT

= 4-years trees (33.56ha x 21 years x 21 metric tonne) + 5-years (16.46x20x21) + 6-years (1.31x19x21) + 7-years (2.56x18x21) + 8-years (0.08x17x21) + 9-years (13.46x16x21) + 10-years (4.28x15x21) + 11-years (0.7x14x21) + 13-years (0.01x12x21) + 14-years (0.11x11x21) + 15-years (1.24x10x21) + 18-years (0.37x7x21)

= 14,799.96 + 6,913.20 + 522.69 + 967.68 + 28.56 + 4,522.56 + 1,348.20 + 205.8 + 2.52 + 25.41 + 260.40 + 54.39

= 29,651.37

CPO = 29,651.37 x 21%

= 6,226.79 x RM2,170/MT

= RM13,512,134.30

Kernel = 29, 651.37 x 5%

= 1,482.57 x RM1,100/MT

= RM1,630,827.00

Cost of palm product / MT = (6,226.79 + 1,482.57) x RM1,350/MT

= 7,709.36 x RM1,350/MT

= RM10,407,636.00

Yl = RM13,512,134.30 + RM1,630,827.00 - RM10,407,636

Therefore, opportunity loss of yield for the trees that were not recovered is **RM4,735,325.30**

The physical mitigation constructed, M, is calculated directly from the money spent on the establishment of electric fences / trenches and excluded maintenance and labour of patrolling. As of December 2018, similar design of concrete electric fences has been approved by the higher management of Sime Darby Plantation Berhad and established at three locations which are in Mentakab Estate, Cenas Estate and Sandakan Bay Estates.

Table 6: Detail of mitigation established at respective HEC estates

No	Description	Mentakab Estate	Cenas Estate	Sandakan Bay Estates
1	Forest reserve (FR) borders	Kemasul FR	Kluang Tambahan FR	Elopura mangrove forest
2	Trenches	Yes	Yes	Yes
3	Electric fences	Yes – 9.7km	Yes – 7.5km	Yes – 45.5km
4	Cost of mitigation measure	RM59,823	RM185,000	RM1,374,017.6
5	Dedicated maintenance team	Yes – 1 people	Yes – 2 people	Yes – 4 to 7 people at 4 different areas.

Hence, the total lost (L) of oil palm depredation by elephant for Sime Darby Plantation Berhad for the respective 8 estates in the duration of 2011-2018 is **RM 24,227,234.70** (Rc = RM 17,873,068.80 Yl = RM4,735,325.30, M=RM1,618,840.6). This amount did not consider the time value of money (DCF), excluded the other 6 estates that not within the scope, excluded the multiple replantings of Tun Tan Estate, Sentosa Estate and Mentakab Estate and running cost of manpower and maintenance of trenches and fencing.

Sime Darby Plantation Berhad has invested and enrolled for the premium growing tree insurance with main coverage for flood, fire and other. A total of 94 claims have been lodged since 2009 until 2018 which 58.51% was completed and reimbursed, 30.85% was rejected and withdrawal due to the submitted claim value was below policy excess and 10.64% was still pending at the time of this dissertation prepared (Mar 2019). The cause of HEC was the highest number of claims submitted which was 33% followed by 32% by flood, 19% by fire, 7% by cattle, 6% by wild boar, and 2% by others. Others are the crop that died due to herbicide application.

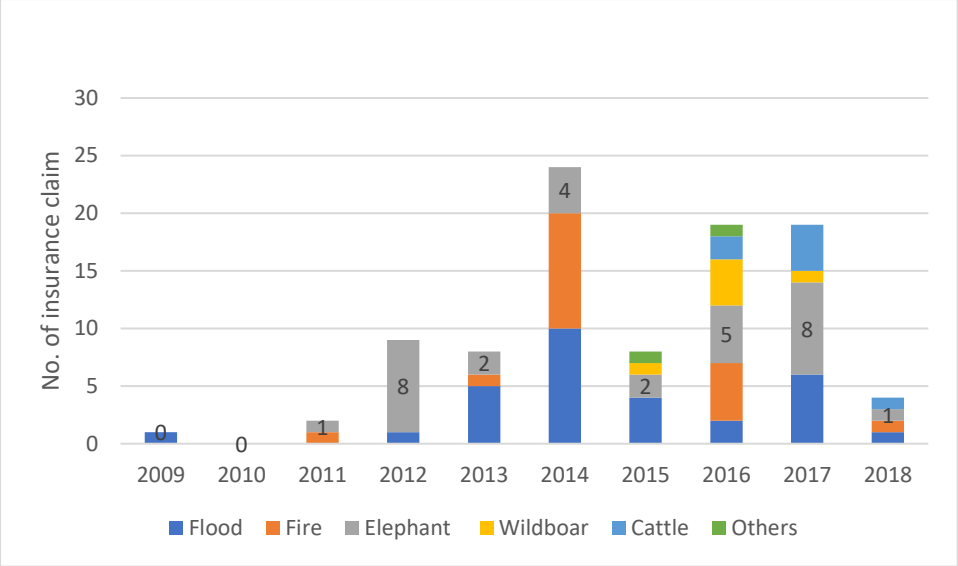


Figure 19: Type of insurance claimed for the duration of 2009-2018

The total value of claims that has been reimbursed for duration of 2009-2018 was RM3,619,620.35. The highest claim paid was 60% for the flood (RM2,157,112.88), followed by 32% for the elephant (RM1,171,436.36), 4% for the wild boar (RM151,491.98) and others.

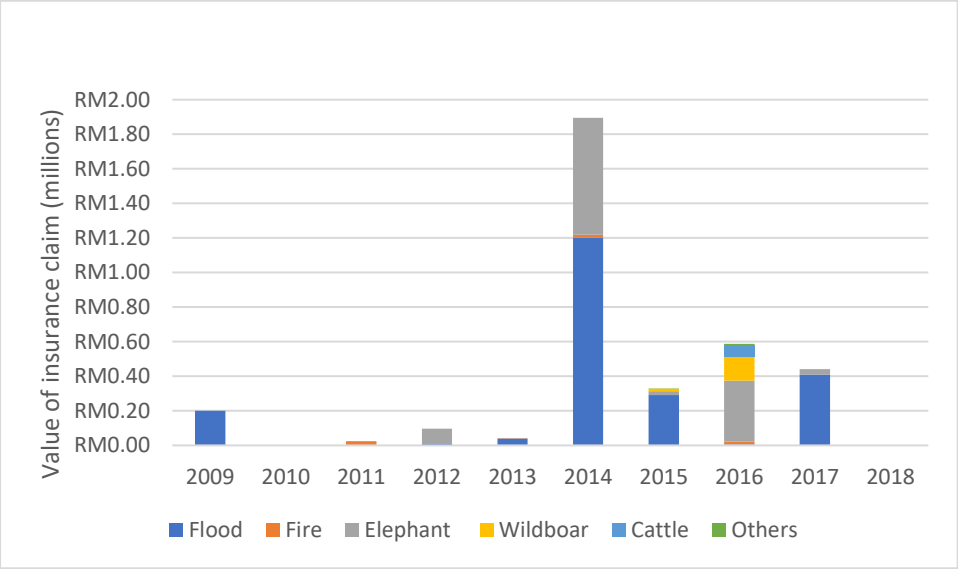


Figure 20: Value of insurance claim for the duration of 2009-2018

4.2.5 Mitigation strategies and effectiveness

The online-survey of 14 estates that confirmed HEC indicated that 57% have established electric fence, 79% constructed trenches, 79% conducted crop-guarding and 7% used chili bomb / chilli scent fogging as their HEC mitigation. Upon establishing the electric fence, most of the estates stated that they have tried various mitigation that has been

recommended by internal and external experts throughout certification audits compliances. These include burning of tyre, placing "hair" in the young palms, planting of banana trees at estate's borders, man-made cannon to produce loud noise, kerosene lamp, and others. During our site visits to the electric fence areas, we noted that decanter cake (by-product) from mill was applied under the fences. The ground team stated that the smell of decanter cake was unpleasant to the elephant.

The electric fence was constructed at three focus areas; 9.7km in Pahang along Kemasul Forest Reserve borders, 7.5km in Johor along Kluang Tambahan Kemasul Forest Reserve borders and 45.5km in Sandakan along plantation borders on the east. Comparison of total damage before constructions of electric fence (2011-2012) and after constructions of electric fence (2013-2018) shows that the number of tree damage reduced by 31% (N=7,398) in Pahang, whereas, there is a 67% (N=111,660) reduction in Sandakan when comparing before (2011-2015) and after (2016-2018). Meanwhile, the total number of damages was greater after (2015-2018) than before (2011-2014) in Johor.

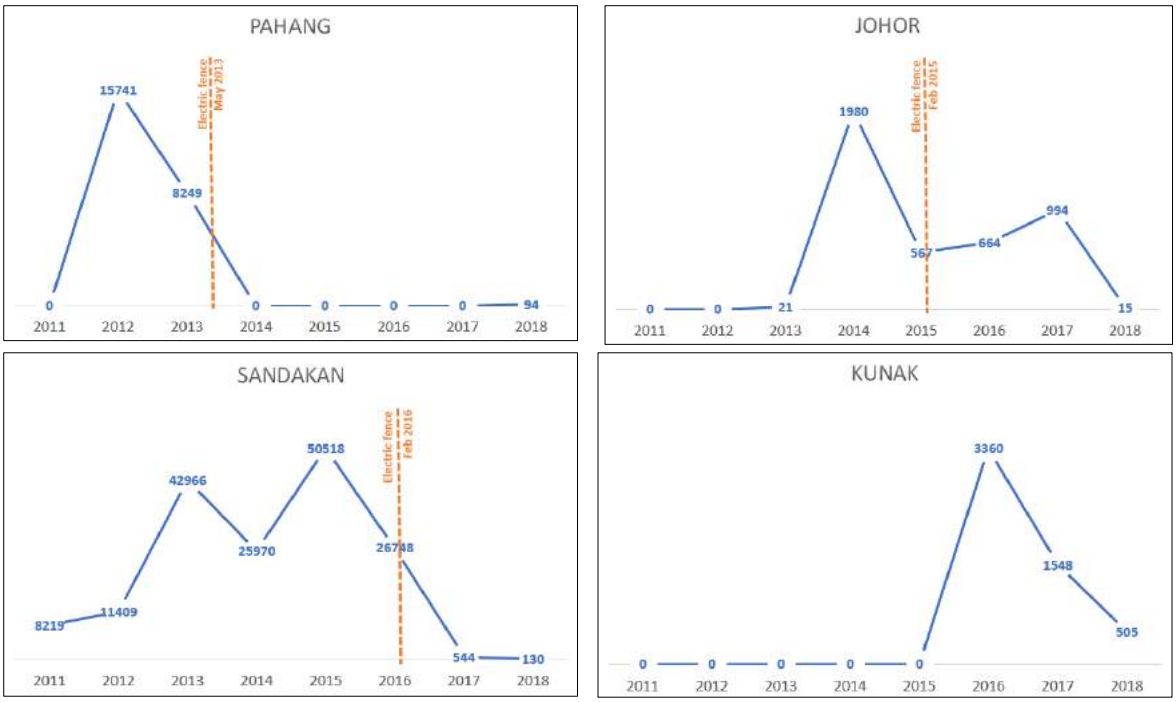


Figure 21: The number of trees depredated by elephant by year

Pair T-test

The result showed that fencing significantly reduced the number of trees damaged overall ($p<0.05$). However, when the analysis conducted separately on respective estates, the results have indicated otherwise for Cenas (t one-tailed = 0.3616) and Mentakab Estate (t one-tailed = 0.1046). In Sandakan Bay, Tun Tan Estate and Sentosa Estate showed a significant reduction in tree damaged after fencing is applied. While Tunku showed a significant increase in damage after the application of fencing (t one-tailed = 0.0456).

Matched Pairs Estate=Tigowis

Difference: Yes-No

Yes	4.33333	t-Ratio	-1.80191
No	215.167	DF	11
Mean Difference	-210.83	Prob > |t|	0.0990
Std Error	117.005	Prob > t	0.9505
Upper 95%	46.6935	Prob < t	0.0495*
Lower 95%	-468.36		
N	12		
Correlation	0.14867		

Matched Pairs Estate=Tunku

Difference: Yes-No

Yes	1498.2	t-Ratio	1.890938
No	355	DF	9
Mean Difference	1143.2	Prob > |t|	0.0912
Std Error	604.568	Prob > t	0.0456*
Upper 95%	2510.83	Prob < t	0.9544
Lower 95%	-224.43		
N	10		
Correlation	0.14933		

Figure 22: Pair-T test result for (i) Tigowis Estate and (ii) Tunku Estate

Matched Pairs Estate=Tun Tan

Difference: Yes-No

Yes	115.952	t-Ratio	-4.9529
No	4450.33	DF	20
Mean Difference	-4334.4	Prob > |t|	<.0001*
Std Error	875.121	Prob > t	1.0000
Upper 95%	-2508.9	Prob < t	<.0001*
Lower 95%	-6159.9		
N	21		
Correlation	-0.1344		

Matched Pairs Estate=Sentosa

Difference: Yes-No

Yes	653.077	t-Ratio	-3.26199
No	3150.46	DF	12
Mean Difference	-2497.4	Prob > |t|	0.0068*
Std Error	765.602	Prob > t	0.9966
Upper 95%	-829.28	Prob < t	0.0034*
Lower 95%	-4165.5		
N	13		
Correlation	0.80934		

Figure 23: Pair-T test result for (iii) Tun Tan Estate and (iv) Sentosa Estate

Matched Pairs Estate=Mentakab

Difference: Yes-No

Yes	456.8	t-Ratio	-1.49476
No	4341.2	DF	4
Mean Difference	-3884.4	Prob > |t|	0.2093
Std Error	2598.68	Prob > t	0.8954
Upper 95%	3330.68	Prob < t	0.1046
Lower 95%	-11099		
N	5		
Correlation	-0.0647		

Matched Pairs Estate=Cenas

Difference: Yes-No

Yes	136.154	t-Ratio	-0.36265
No	190.077	DF	12
Mean Difference	-53.923	Prob > |t|	0.7232
Std Error	148.692	Prob > t	0.6384
Upper 95%	270.049	Prob < t	0.3616
Lower 95%	-377.9		
N	13		
Correlation	0.21158		

Figure 24: Pair-T test result for (v) Mentakab Estate and (vi) Cenas Estate

Chi-square

A chi-squared test of independence shows that there is an effect of fencing on the proportion of trees damaged in HEC, $X2$ (1, N=4510) = 336.177, p<0.001. For trees damaged by HEC, 73.37% occurred in estates without electric fences. While estate with fences, have bigger proportion of trees not damaged by HEC (64.29%). This is supported by fisher exact test which indicated that without fencing the occurrence of damage will increase significantly. The detail of the result by respective estates attached in the appendices.

Contingency Analysis of Damage By Fencing

Freq: N

Contingency Table

Fencing	Count / Total % / Col % / Row %	Damage: No	Damage: Yes	Total
No	Count	1369	496	1865
	Total %	30.35	11.00	41.35
	Col %	35.71	73.37	
	Row %	73.40	26.60	
Yes	Count	2465	180	2645
	Total %	54.66	3.99	58.65
	Col %	64.29	26.63	
	Row %	93.19	6.81	
Total	Count	3834	676	4510
	Total %	85.01	14.99	

Tests

N	DF	-LogLike	RSquare (U)
4510	1	167.88403	0.0881

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	335.768	<.0001*
Pearson	336.177	<.0001*

Fisher's Exact Test	Prob	Alternative Hypothesis
Left	<.0001*	Prob(Damage=Yes) is greater for Fencing=No than Yes
Right	1.0000	Prob(Damage=Yes) is greater for Fencing=Yes than No
2-Tail	<.0001*	Prob(Damage=Yes) is different across Fencing

Figure 25: Chi-square and Fisher's Exact test result for all 6 estates

Logistic regression 1

Regression model 1 used 3 explanatory variables; with the monthly number of damaged trees as dependent variable (damage), and estate, fencing and age as explanatory variables as shown on *Figure 27*.

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	675.5948	28	1351.19	<.0001*
Full	1229.9556			
Reduced	1905.5505			

RSquare (U)	0.3545
AICc	2518.3
BIC	2703.92
Observations (or Sum Wgts)	4510

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Estate	5	5	809.977771	<.0001*
Fencing	1	1	225.613649	<.0001*
Age	22	22	182.910045	<.0001*

Figure 26: Test of logistic regression 1 variables

All explanatory variables had significant impacts on monthly damage occurrence ($p<0.05$). However, interaction between these 3 factors is unknown. Further analysis was conducted by expanding the model to include interaction between all explanatory variables via logistic regression 2 below.

Logistic regression 2

Regression model 2 analysed using the following explanatory variables: a) estate, b) fencing, c) age, d) estate X fencing, e) estate X age, f) fencing X age and g) estate X fencing X age

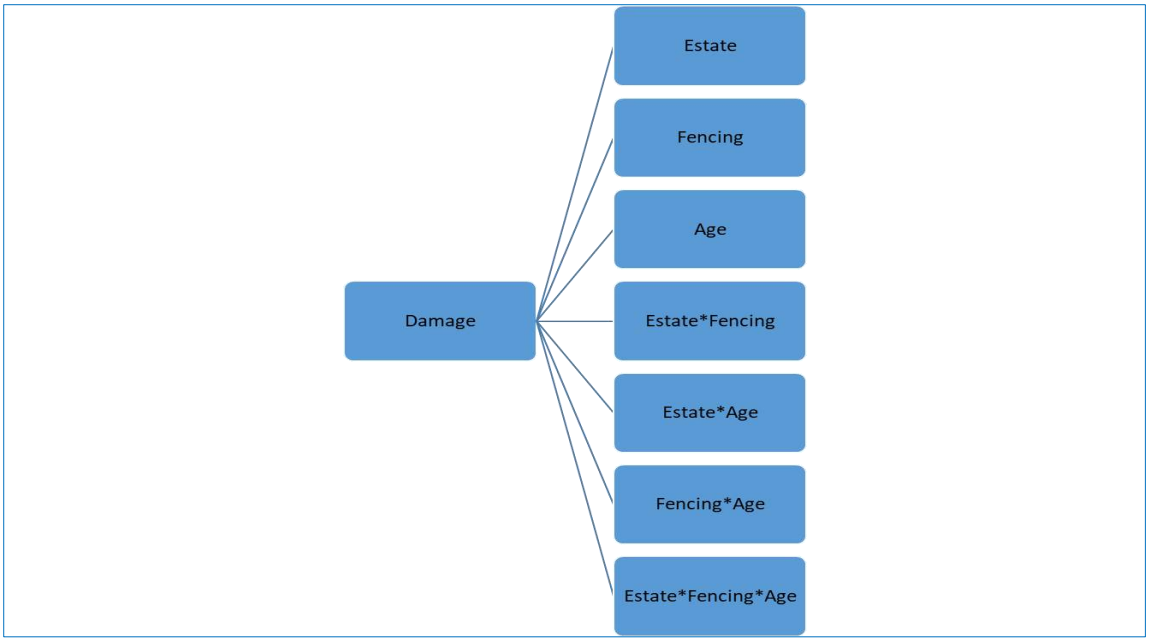


Figure 27: Variables of logistic regression 2

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	803.7897	92	1607.579	<.0001*
Full	1101.7608			
Reduced	1905.5505			

RSquare (U)	0.4218
AICc	2791.64
BIC	4525.8
Observations (or Sum Wgts)	4510

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Estate	5	5	223.881746	<.0001*
Fencing	1	1	3.08946e-8	0.9999
Estate*Fencing	5	5	27.836098	<.0001*
Age	22	22	10.8205323	0.9772
Estate*Age	110	31	123.579092	<.0001*
Fencing*Age	22	12	8.52639754	0.7428
Estate*Fencing*Age	110	16	42.9569713	0.0003*

The model with interactions between Estate X Fencing X Age have significant impact on monthly damage occurrence (df=16, $X2$=42.96, p=0.003). This further explain that all 3 variables have an interaction influence on monthly damage occurrence inflicted by the elephant. However, the AIC and BIC are larger than logistic regression 1, meaning it could be overly more complex without necessarily providing better fit to the data.

Prediction model

The analysis is to predict mean number of damages based on age of the palm. The formula of "$a.Exp\ (b.Age)$" is used, which "a" = scale, and "b" = growth rate;

$$Number\ of\ damage = 295.8e^{-0.17\ Age}$$

Parameter	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Scale	295.79742	77.292041	14.646006	0.0001*	144.30781	447.28704
Growth Rate	-0.169729	0.0730437	5.3993826	0.0201*	-0.312892	-0.026566

By comparing 4 potential model for predicting number of damages, exponential model is the best model base on criteria of low AIC, BIC, MSE and RMSE. This explained that exponential model is the best model in predicting number of damages by using age

component.

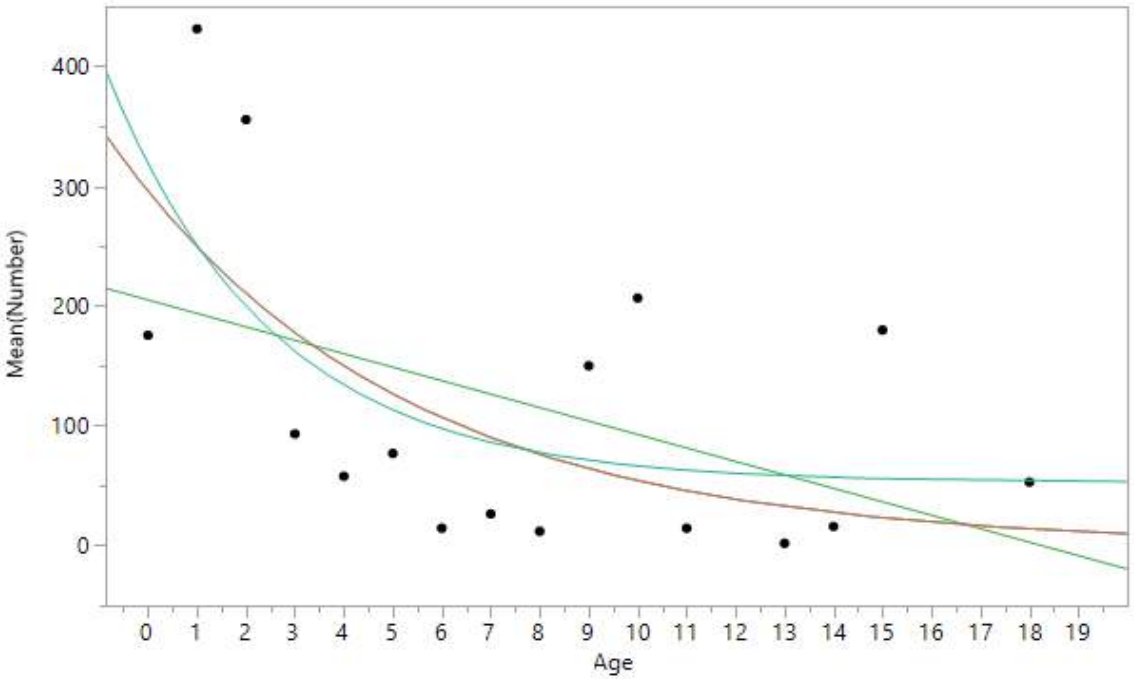


Figure 29: Prediction models

Model	AICc	AICc Weight	.2 .4 .6 .8	BIC	SSE	MSE	RMSE	R-Square
Exponential 2P	200.97082	0.5932229		201.28858	162005.84	11571.846	107.57251	0.3405488
Mechanistic Growth	203.64441	0.1558309		203.09841	152544.99	11734.23	108.32465	0.3790595
Linear	203.65958	0.1546539		203.97734	191651.75	13689.411	117.00176	0.2198739
Logistic 3P	204.60718	0.0962923		204.06117	162005.85	12461.988	111.63328	0.3405487

4.3 Policies, procedures and protocol in SDPB

4.3.1 Plan-Do-Check-Act (PDCA) analysis from MS ISO14001

The element of Plan-Do-Check-Act (PDCA) approach was adopted from MS ISO14001 management system standards to review the wildlife management for Sime Darby Plantation Berhad by the researcher. Table 7 describes the key elements in of MS ISO 14001:2004 standards that can be adopted to manage HEC at individual estates.

Table 7: Review of the wildlife management in SDPB using the PDCA approach elements

No	Key element	Analysis findings
		PLANNING
1	Policy and procedures	Sime Darby has established 3-tier policy which consisted of 16 policies and levelled by Corporate Policy (1), Management Policies (4) and Operational Policies (11).

No	Key element	Analysis findings
		These policies have been made publicly available on their website and throughout their respective plantation operations in Malaysia, Indonesia, Papua New Guinea and Liberia. http://www.simedarbyplantation.com/sustainability/beliefs-progress/governance/sustainability-policies There are two wildlife-related policies found in operational policies; a) Saving the Orang Utan Policy, b) Environment & Biodiversity Policy SDPB is committed in protecting and conserving an endangered and protected species as stipulated in the Saving the Orang Utan Policy. The commitment demonstrated throughout their operation by: • Proper planning of sustainable land-use • Ensuring compliance with all regulatory requirement • Educating and creating awareness about the conservation of endangered and protected species to all employees • Supporting local, national and international conservation efforts • **Establishing, communicating, and implementing responsible and practical measures to resolve human-wildlife conflict** • Prohibiting hunting activities Whereas, commitment on protecting the environment and conserving the biodiversity are specified in the Environment & Biodiversity Policy. These include: • Complying **all with statutory and regulatory concerning environment and biodiversity** • Establishing, maintaining and continuously improving sustainable plantation management system • Eliminating any potential adverse effects • Educating and enhancing awareness about environment and biodiversity • Avoiding deforestation of primary and virgin forest, areas of High Conservation Value (HCV) and HIGH Carbon Stock (HCS) • Prohibition of new planting in peat areas • Support peat forest conservation and rehabilitation efforts The procedures of managing wildlife and biodiversity is not developed internally and yet to be established by the company. By default, the company's practices are to adopt and adapt guidelines and best management practices introduced and commenced by external resources namely High Conservation Value Resource Network (HCVRN) and other certification requirements.

No	Key element	Analysis findings
		The temporary Standard Operating Procedure (SOP) of Human-Elephant Conflict was drafted and circulated as and when deemed necessary by the internal Sustainability Department to respective conflict's plantation. These SOPs are consisted of 4 categories: • SOP of HEC management • SOP of chasing elephant (crop-guarding) • SOP of electric fence house (this is applicable to the area where they have public vehicles passing by the fence) • SOP of wooden electrical fence (there are additional fence that has been constructed in between the Sandakan Bay Estates previously and also on the west side of mangroves reserves adjacent to Sentosa and Tun Tan Estate)
2	Legal and other requirements	The respective plantation has identified and maintain a register of relevant legal laws and other regulations such as Wildlife Conservation Act 2010, Wildlife Conservation Enactment 1997, Wildlife Protection Ordinance 1998, and others. The document is known as Legal and Other Requirement Register (LORR). In addition, the voluntary requirement including corporate standards, and environmental guidance and codes of practice published by professional and industrial bodies to which the organization subscribes also has been maintained throughout plantation operations.
3	Objectives and targets	Generally, plantation operation generates the management objective and target for the Quality, Safety and Environment. However, wildlife and biodiversity-related targets has been developed to fulfil the conditions set by the various sustainability certifications namely MSPO, RSPO, ISCC and others.
		IMPLEMENTATION & OPERATION
4	Management Programs	The wildlife programmes are generally initiated by head-quarters of Sustainability Department in collaboration with related agencies at identified / focus plantation. Sustainability Certifications require all plantation operations to develop actions to achieve objectives and targets for activities that potentially give significant impacts to environment and wildlife. In practice, the programme and plans for wildlife are integrated with identified potential site or value that has been identified by the HCV Assessment Report.
5	Structure and responsibility	Roles and responsibilities for wildlife management have not been clearly defined. Generally, Estate Managers will be accountable for general aspects which at some points includes appropriate human-wildlife conflict management. The responsibilities have not been formalised in existing job descriptions.

No	Key element	Analysis findings
6	Training, awareness and competence	Similar to the wildlife management programme, the training of wildlife conservation is generally initiated by head-quarters of Sustainability Department in collaboration with related agencies at identified / focus plantation. In 2013, Sabah North Region has approved budget for the Honorary Wildlife Warden course to be attended by management and staff of plantation operation. Sustainability Certifications required all plantation operations to carry out the biodiversity and wildlife-related awareness and capacity building. This High Conservation Value (HCV) and Biodiversity training normally been carried out annually by head-quarters or regional team of Sustainability Department and have two different focus group; management team and field workers. The nomination of relevant representatives to attend the training is decided by the respective plantation manager.
7	Communication	Internal communication: A correspondence relating to biodiversity and wildlife management from external to head-quarters being distributed to respective plantation operations. Likewise, respective plantation managers will escalate information to head-quarters on any concern raised by local authority about wildlife conflicts. External communication: Respective plantation operation has established stakeholders list which identified local authorities of wildlife officer's contacts information at site.
		CHECKING
8	Monitoring and measurement	Key aspect of biodiversity and wildlife monitoring in plantation operations is guided by the recommendation of High Conservation Value (HCV) Report. The HCV form is provided by the assessor and is one of the records that has been maintained to fulfil the requirements by sustainability certifications. It was found that there is no approved procedure or protocol to monitor the general wildlife in plantation. Action plan and other documents are developed as on case-to-case basis.
9	Audit	Where appropriate, Sustainability Certifications Audit team has continuously emphasized and highlighted the inclusion of biodiversity and wildlife conservations in the estate's performance. The effectiveness of HCV / Biodiversity Management Plan implementation at estates were occasionally raised by internal and external auditors.
		REVIEW
10	Management review	Quarterly management review meeting is conducted at plantation operations mainly to discuss the estate performance of production. This platform has

No	Key element	Analysis findings
		been integrated to include other concerns like biodiversity and wildlife conflicts as required by Sustainability certifications.

4.3.2 Current Standard Operating Procedure and protocol for HEC

One of eight estates that responded "yes" to HEC occurrence at their plantation commented that SOP is needed to manage HEC in SDPB estates. This response showed that not all are aware of the availability of the interim SOP of Human-Elephant Conflict established in SDPB. Others have commented on the perceived effectiveness of electric fence establishment.

Table 8: Analysis findings of existing SOP in SDP

Standard Operating Procedure (SOP)	Analysis findings	Improvement
SOP of HEC management	The SOP has identified the following: • Objective • Scope • Reference • Definition and type of HEC • Roles and responsibility • Reporting of HEC flowchart (figure) • Appendix of HCV monitoring	The SOP is basic and straight forward. The document coverage is limited to manage existing HECs at respective estates and act as fire-fighting. The procedure can be further enhanced by the information of elephants preferring to damage certain age group of trees. This should include the planning of land-use / replanting programme as one of the mitigation interventions as highlighted in the proposed HEC Charter.

Standard Operating Procedure (SOP)	Analysis findings	Improvement
		The commitment of establishing patrolling teams has not been included.
SOP of chasing elephant (crop-guarding)	Steps that have been detailed in the SOPs are; • Briefing conducted to patrolling teams • Personal protective equipment inspection • Keeping 30-meter distance from elephant • Do not chase elephant to hilly area • Do not run to hilly area when chased by the elephant • Debrief and headcount.	While the SOPs are majorly concern on the safety of patrolling team. Less information of the elephant behaviour. This procedure can be integrated with "Elephant Behaviour Pocket Book" prepared and produced by HUTAN, SWD, Oregon Zoo and DGFC in 2017.
SOP of electric fence house	This SOP is applicable to the area where they have a public vehicle passing by the fence. The caution and steps highlighted; • PPE • Cone and safety / warning signages • Gloves for handling spring gate • Beacon light at night • Do not leave the house unsupervised	
SOP of wooden electrical fence	There is an additional fence that has been constructed in between the estates in Sandakan previously and also on the west side of mangroves reserves. The prepared pictorial SOP illustrated the do's and don'ts of maintaining the wooden fence. This is similar to the electric fence house SOPs.	

5.0 DISCUSSION

5.1 Key points

It is important to use evidence-based assessment to assess the nature of conflict and the effectiveness of mitigation methods for HECs in oil palm plantations. Without data to measure progress, it is difficult to manage the conflict and make well-informed decisions. In that sense, this research work is pioneer and important, not just for SDPB, but in setting the precedence for peer-reviewed research on HEC in the agriculture industry. The lack of data from the systematic literature review has led to the recommendation in the proposed charter that SDPB should commit to collect and analyse HEC data in future.

The main conflict between the agriculture industry and elephants is crop-raiding (Saaban *et al.*, 2011). This is followed by damage to properties that include damages to electrical fencing, resting huts in the field, personal vehicles and depredation on plants growing around housing areas. In Malaysia, cases of human fatality caused by elephants are very rare in comparison to reports of elephant killed by people (Saaban *et al.*, 2011).

This study found that research on human elephant conflict (HEC) is still scarce in Malaysia, particularly to understand the HEC trend in oil palm plantations. Only a few publications are available in the public domain, which made it challenging to determine the best HEC mitigation for plantations therefore more field research is needed in the future. Most of the information collected from the SDPB plantations featured in this study were data prepared for insurance claims and based on case to case basis. There is no standardised protocol or procedure in SDPB on how to document or report human-elephant conflict and observations of elephants, and documentation has been carried out by various leadership in respective estates for the past eight years. The practice of rotation of management team every 3-years duration made it difficult for field staff to maintain the same protocol; for example, some additional data were collected out of the initiative of some management staff, while some reporting was discontinued.

5.2 Systematic review of HEC literature in oil palm sector and the existing strategies

Tree crops like oil palm, rubber, acacia and others are financially important for economy but there is not much research being done or published in relation to HEC. From the

review of publicly available literatures of published papers and internal reports, a common problem in HEC is the lack of reporting of crop-raiding incidents, which could represent a potential source of bias in the measurement of HEC (Pozo *et al.*, 2017). The HEC faced by the oil palm plantations are not a new phenomenon and and they were identified as the main problem in 19th century when Malaysia introduced a rural settlement scheme for national economic growth through FELDA (Gunaratne *et al.*, 2017). Before the current research commenced, it was expected that the HEC information would be abundant and available for reference. It became clear however that not much research has been done or published, although much work and collaboration has happened on the ground. There was a descriptive paper done by (Blair, Boon and Noor, 1979) that was published in the planter's literature that many university researchers cannot access. This is the only paper that described in fine detail HEC in oil palm plantation. This paper describes the nature of agriculture and discuss damage in FELDA schemes in a greater detail. The topics covered include the extent of damage, frequency of attack, age of trees at time of attack and distribution of monthly damage from 1975 to 1978. Since the research was done more than 40 years ago, it is timely to review and update the findings on the nature of HEC in Malaysia and publish the findings via open access platform to make the information more accessible for others and encourage better HEC management.

Other important papers by the Malaysia's Department of Wildlife and National Park (DWNP) Peninsular Malaysia, (Saaban *et al.*, 2011) and (Gunaratne *et al.*, 2017) described that the most HEC affected areas are villages and small-scale oil palm plantations, and mainly occurred in 4 states of Johor, Pahang, Terengganu and Perak (see Table 7);

Table 9: Number of trees damaged by elephant in the 1970S in FELDA, FELCRA and other private companies (Original source: Jalaluddin, 1979)

State of HEC reported	Number of agriculture scheme affected	Number of trees damaged		
		Rubber	Oil palm	Total
Pahang	55	328,361	811,211	1,139,482
Johor	15	-	400,470	400,470
Terengganu	5	-	103,369	103,369
Perak	3	-	81,016	81,016
Total	**78**	**328,361**	**1,395,976**	**1,724,337**

There were no more recent references to understand if the conflict trend increased or decreased after almost 50 years. Today, most of the communities and palm oil companies that operating in these four areas adjacent to forest reserve are still dealing with HEC particularly in the state of Johor. There are a number of known academic and conservation NGOs in Malaysia that are carrying out research or managing HEC, these include MEME working with local communities and aborigines in West Malaysia, Wildlife Conservation Society (WCS) working with oil palm plantations in Johor, World Wide Fund for Nature (WWF) working with oil palm plantations in Tawau and Kunak, Danau Girang Field Centre (DGFC), Seratu Aatai and HUTAN working with oil palm plantations in Sandakan and Kinabatangan. However, not all data gathered by these organisations are available for reference, and hence not included in the review of current HEC mitigation efforts.

This study reviewed 102 of papers and reports related to HEC, whereby only 23 measured the effectiveness of mitigation methods and 46 discussed the ownership of HEC mitigation. More than half of the HEC mitigation papers reviewed in this study reported the use of fencing and crop-guarding in conflict areas. The traditional crop-guarding method is commonly used by individual farmers, while construction of physical barrier like fencing is being used by plantations or projects funded by the Malaysian government or external parties (funds came from outside of the community). Thirty-nine of the reviewed papers on HEC mitigation focused on the use of electric fence as the main mitigation method (which was often used in combination with other methods). Malaysia is one of the pioneers in the use of electric fencing for HEC mitigation but there is no study indicating how much we have learnt or progress in the design of fences. According to Monroe and England (1978), electric fencing has been used to deter elephants in Peninsular Malaysia since 1940. There is not much historical information on electrical fencing establishment in Borneo for HEC mitigation. Most of the actions taken to mitigate HEC are ad-hoc decisions and transient in nature which ignored the needs of stakeholders in the conflict (Alfred *et al.*, 2012).

Although electric fences have been perceived as the best solution in mitigating HEC (Ponnusamy *et al.*, 2015; Enukwa, 2017), more papers are needed to access the effectiveness of this method. The gaps in knowledge still exist and require more research

to document and quantify the effect of HEC, of which future studies should use standardise designs and data collection protocols (Perera, 2009). It seems that at the moment, we cannot recommend the best HEC mitigation method since there is insufficient data and not enough evidence-based approaches utilised in the agriculture sector. Most reports cover only a description of what people are doing, and not in assessing how the mitigation method was successful, failed or made the conflict worst. Of 23 papers that studied HEC effectiveness, half of the papers were using data from compensation scheme offered by authorities or other agencies, and these captured only cases where HEC mitigation failed. These data are very subjective by further factors including the favour of respondents to report and may not represent the actual efficacy.

A conclusion can be made from the literature review is that we should encourage more monitoring and reporting of HEC mitigation effectiveness. Data should be collected and monitored, the output of the findings should be published, and reports and papers should be made available through open-access publications. Another concerned is that the data available today were mostly gathered by third party or external party, and not directly by the HEC affected personnel (agriculture sector). In the palm oil plantations context, there are insufficient experts to advice on the wildlife conservation management and mitigation. Even when a third party collaboratively collect the data with the plantations, there could be a bias mutual agreement; for example, if it is through a consultancy commissioned by the plantation, then the owners' expectations may differ and create some limitation of what can be published and be communicated to the externals and public. Another reason why the third-party collaboration may not work is the lack of or no trust between the parties, thus the collaboration may not reach fullest potential in making improvements to HEC mitigation on the ground. Henceforth, the oil palm plantation should be proactive and promote transparency in sharing information and data, and support to enhance collaboration on wildlife conservation. Potentially, the collaboration of wildlife conservation study in plantations should not be led by a third party but by the plantation sector themselves to promote more ownership of research amongst plantation personnel (e.g internal sustainability team). The WWF-Malaysia's collaboration with Sabah Softwood Berhad serves as an example of a third party collaborating with the plantation; whereby the dedicated plantation representative has partaken an equal amount of ground work and support for the conservation work. The

collaboration has established a wildlife corridor connecting forest patches through the plantation and included other oil palm plantation stakeholders in the working group to mitigate HEC locally. We like to reiterate that it is important for a dedicated plantation representative to be given the responsibility of the project, trained for data monitoring and to publish the HEC information with guidance by scientific expertise locally.

5.3 Human-elephant conflicts (HEC) in Sime Darby Plantation Berhad

5.3.1 Age of trees damaged

The results from this study concurred with past studies (Othman *et al.*, 2019) that elephants prefer to feed on oil palm trees of young age groups; with 55% (N=200,242) of trees depredated by elephants are 1-year old and 97% (N=200,242) of the depredated trees are below 5-years old. Elephants are known to be selective of certain plants' parts and maturation stage for depredation (Chiyo *et al.*, 2005). It is important to note that crop raiding is influenced by crop availability and not by periodic decline in forage quality inside protected areas in Africa (Chiyo *et al.*, 2005).

An important implication of knowing the age of trees depredated by elephants is that SDPB can adjust their strategy for future HEC management and mitigation. The existing perimeters fencing practiced today by large plantations may limit elephants' foraging route and have negative repercussions on neighbouring small and medium growers, especially those who are undergoing planned replanting (pers. obs. Sime Darby Plantation Berhad). Internally SDPB can map out areas in the plantations according to elephant depredation risk; whereby trees above 5 years of age will be deemed less in risk and more crop protection focus can be directed on trees aged 1-year old and below. This information can be incorporated during planning stage so it can be implemented during replanting at potential HEC areas. The usage of land-use planning that incorporates identification of elephant depredation risk can be carried out jointly with others at a larger landscape level as well (Chen *et al.*, 2013).

Plate 2: The 7-years tree damaged by elephant depredation at Binuang Estate

We can expect that damages mostly occur to trees below five years of age and significantly reduces after seven years of age. Two outliers were observed at Cenas Estate in Johor and Binuang Estate in Kunak, with damages that include matured trees up to 18 years old. Based on the estate's management explanation, this is due to patrolling activities by neighbouring estates which have directed and forced the elephants to be cornered in the areas as illustrated in the spatial and temporal maps (see Appendices 8.2-2013). The following years, age of trees damaged is shown uniform between less than a year to four years old after 2014. Whereas in Binuang Estate in Kunak, within three years, almost half of the total damage reported had involved trees that 9 years old and above. This age range of trees attacked is not common compared to the research findings at another estates and data shared by other plantations in the industry. When compared with immature trees, the extent of damage on matured tree shoots has less but it can distort the full potential of trees to grow and to produce expected yields (pers. obs. Sime Darby Plantation Berhad).

Plate 3: The 18-years tree damaged by elephant depredation at Cenas Estate, Johor in 2013

5.3.2 HEC spatial and temporal patterns

Most crop raiding incidents in Africa occurred along the major rivers, reflecting the fact that during dry season, agriculture is limited to the floodplain of the major rivers and their tributaries, where alluvial soils and water are available (Parker and Osborn, 2001). Understanding drivers of HEC at a large spatial scale is an extremely complex topic as spatial correlation in conflict have few trends (Hoare, 1999; Sitati *et al.*, 2003). Overall, this study found that there is no pattern of HEC occurrence that correlated to rainfall in Sime Darby Plantation Berhad estates. In Sandakan Bay Estates in particular, the elephant utilisation distribution (UD) varied significantly between individuals and seasonally. In both seasons of high and low rainfall, the elephants were observed to maintain their UD close to the river (Othman, 2018). However, the opinion that elephants raid crops due to non-availability of food and water within Protected Areas during dry season is incorrect as observed in South India (Gubbi, 2012). Although another study also suggested that there is a tendency of an increase in HEC occurrence during the transitional period of rainy to dry season, and vice versa (Qomariah *et al.*, 2019) the relationship is neither

consistent nor very strong (Blair and Noor, 1980). Elephants target certain crop types and preferred smaller plantations compare to bigger plantations (Hema *et al.*, 2018). The frequency of elephant depredation within plantations is high in areas where elephants have easy access such as areas bordering to forest reserves. However, the information of loss of elephants, crop raiding patterns and economic losses due to HEC in Sabah are not well documented, making it difficult to understand the trends and intensity of the conflicts (Othman *et al.*, 2013).

5.3.3 Elephants in estates

Since every individual elephant has a different foraging strategy (Stephens, 1986), SDPB needs more systematic data collection particularly to records the observation of elephant sightings at HEC areas. The protection of river corridors and strategic small-scale fencing is the way forward to reduce bottlenecks to elephant's home range and movement pathways.

Male elephants may have a tolerance degree to human disturbance (Poole, 1989). The males can cause five times greater damage than females (Hoare, 1999). This can be observed at the west side of Sandakan Bay which the estates found that determined bulls will swim across the mangroves rivers to get into the estates (pers. obs. Sime Darby Plantation Berhad).

The patrolling team reported that they recognised most of the elephants that are roaming in the plantations and had given names to a few individuals. They observed that most of the time, the elephants showed angry behaviour of charging and making noise. They have captured these elephants on videos, but the quality of filming are varies depending on their personal handphone's camera standards and condition of filming. In Sabah, the elephants seek out kaolin clay (usually known as mud-pool volcanoes) like those that occurred in Binuang Estate. It seems the elephants had not come to plantations to feed on oil palm but for other purposes. In previous research (Silva, 1965), the elephants visited salt licks to fulfil their mineral salt needs. They will not only eat the salinated earth, but also scour their massive bodies by rolling in the mud. Perhaps this is one of the main reasons for elephant presence in Binuang Estate? Previously before the replanting programme started, elephant has free access to a "mud pool" in the Estate. In 2010, there

was an elephant that was stuck in the mud pool and the estate launched a successful rescue (see appendix 8.5). Nonetheless, this requires further studies and collaborations with universities and researchers.

5.3.4 Business loss and opportunity of Human Elephant Conflicts

Among all other wildlife present in oil palm plantations, human-elephant conflicts have caused major financial implications. By carrying out this research, the company can understand the patterns of elephant depredation and how much this conflict has cost the operations. Without this knowledge, the company would repeat the same mistakes and continue to suffer avoidable business loss. By understanding the true cost of HEC, the company can also present the case of justifying the higher cost of certified sustainable palm oil to the market. By understanding the nature of HEC and providing capacity building to staff members to manage HEC appropriately, the company can reduce the risk of accidents from improper management of conflict that may tarnish the business image. One estate in Sandakan has spent a total of RM7,359.04 HEC running cost per month for 8 person of ground team. This expense accumulated to RM88,308.48 per estate per year. The breakdown of cost detail in the table below:

Table 10: Running cost for elephant patrolling and maintenance team

No.	***Work***	***Labour***	***Cost/day***	***Cost/month***
1	Fence maintenance	2	RM70.76	RM1839.76
2	Patrolling team	6	RM212.28	RM5519.28
	Total	**8**	**RM282.04**	**RM7359.04**

SDPB market capitalisation is at RM4.89 per share, and the company is worth around RM33.26B (April 2019). The estimation loss of RM 24 million by elephant depredation at 8 estates during 2011-2018 is comparable to 0.01% of company's market capitalisation, which will be much less if the HEC cost is averaged out to approximately RM3 million per year. The 200,242 trees that have been depredated by elephant are almost equal to 1400 hectare, which is about a total hectarage for a divisional estate of SDPB. The cost is equivalent to the management cost of a small or middle grower with a relatively high profit without the presence of elephant conflict. Moreover, the HEC loss per year RM2,172.37 per hectare is two times forfeited when compared to the average profit year to-date estimated RM1200 per hectare.

Whilst the company has no control over the price of CPO for the profit margins, they can manage better the respective trees for a higher yield result. For the six-month financial period ended 31 December 2018, Sime Darby Plantation (SD Plantation) Group registered a Profit Before Tax (PBT) of RM457 million after the company's demerger exercise. Upstream Malaysia registered a recurring PBT of RM176 million, representing a decrease of 57 percent year-over-year from RM414 million in the corresponding quarter last year. The weaker performance was largely due to the lower average crude palm oil (CPO) and palm kernel (PK) prices realised. Average CPO price declined by 28 percent year-over-year from RM2,706 per MT to RM1,939 per metric tonne (MT), whereas average PK price realised declined by 47 percent year-over-year from RM2,694 per MT to RM1,434 per MT. Fresh fruit bunch (FFB) production in Malaysia stood at 1.51 million MT this quarter versus 1.69 million MT in the corresponding quarter of the previous year. This represents an 11 percent year-over-year decline, which was attributable to the bumper harvest experienced in the same quarter last year. Nevertheless, OER increased year-over-year from 20.21 percent to 20.68 percent as a result of crop quality improvements with better agriculture management. Consequently, having had lost over 200 thousand trees matter to the company. This has resulted in the strategic decision of SDPB to insure every individual tree in the operations through Growing Tree Insurance.

Results have shown that although the highest number of insurance claims was related to HEC, the highest value (RM) claim was result of flooding. However, since there are many cases where insurance cannot be claimed as the HEC damage did not reach the threshold permissible for insurance claim. The insurance provider set a policy term requirement of 10% of loss; minimum of RM7,500 whichever is higher, and maximum of RM35,000 on each and every loss. During elephant depredation in plantation, the severity in the loss of trees also hinges on the effectiveness of mitigation at estate operation management. For example, elephants can respond contrarily during elephant patrol encounter. If the patrolling team are trained to understand behaviour of elephants, injuries and further damages to the trees can be prevented or reduced. Although the use of insurance has not been explored much for the HEC mitigation in Malaysia, it has the potential to be one of the alternatives to compensate HEC loss and increase tolerance between the agricultural

societies and wild elephants. SDPB has invested over than RM150 thousand annually for the insurance to cover all planted trees (over 300 thousand hectares) and so far, RM3.6 million has been reimbursed, in which 32% is for the elephant depredation loss (RM1,171,436.36) for the duration of 2009-2018. The effectiveness of insurance payment for HEC mitigation has not been explored in greater detail by plantations within SDPB as we found out during my research that there were lack of awareness of the scheme among estates management in SDPB, possibly resulting as well in many losses not been compensated. Nonetheless, if the insurance provider retains their policy in the future, this could be a fair mechanism to compensate HEC loss. Although the enrolment could be expensive to small-medium growers, but perhaps insurance in future could use landscape models to examine HEC risk and propose collective insurance scheme to stakeholders in the landscape. More funding from the end-consumer of the industry can be invested into this mechanism to mitigate HEC locally to meet the requirement of sustainable agriculture producer.

The need for responsible wildlife conflict management and mitigation in oil palm plantations has been emphasized as one of compliance indicators by mandatory and voluntary sustainable certifications at the national (e.g. Malaysia Sustainable Palm Oil, MSPO) and international (e.g. Roundtable of Sustainable Palm Oil, RSPO) level. While the oil palm plantations are expected to deliver best management practices (BMP), there is no rewards or incentives to encourage plantations to implement. Currently there is no premium fee offered to those oil palm plantations that manage and mitigate the HEC responsibly in effort to coexist with endangered species. It is expensive to establish a wildlife-friendly plantation that promotes coexistence with endangered species. A potential way to encourage coexistence with elephant, is through market incentives that will attract more oil palm plantation companies to go the extra mile to commit towards sustainable and responsible production. These market incentives should come from the end-consumer of palm oil products through a fair mechanism that is yet to be created.

5.3.5 Mitigation effectiveness

This study assessed the effectiveness of electric fencing in individual estates in protecting crops from depredation by elephants. By examining the patterns, we found that, although electric fencing can help in mitigating the conflict, the intended benefits are not being

fully achieved. This is due to the loopholes of few factors, including the maintenance of the fences, the reaction of individual elephants to various types of mitigation, the respective estate's management strategy and decision. A major policy suggestion of this study is the development of further research to investigate why existing electric fencing fails and what the best factors are that influence its success. Electric fences are effective to reduce the number of HEC damages for Tun Tan and Sentosa Estate, but not for all; in Johor the damage trend fluctuates and has not shown any reduction after three (3) years. Other studies found that the methods of electric fence breaking is not the same by all elephants, but is rather learned by individuals (Mutinda *et al.*, 2014). Thus, elephant patrolling team that are able to identify individual elephants would be useful for HEC mitigation decision making.

5.4 Policies, procedures and protocols in SDPB

The levels of conflict model are used as an analytical tool to explore the types and intensity in a conservation conflict context (Madden and McQuinn, 2014). The levels are; a) dispute, b) underlying conflict and c) identity-based / deep-rooted conflict. The first level is an immediate expression of a conflict, mostly observable and palpable, the second level is a history of unresolved disputes which underlying concern masked by the disputants themselves. The third level involves deeply held value, beliefs or socio-psychological needs. Sime Darby Plantation Berhad has a very good opportunity to manage HEC responsibly within their operations and find ways to coexistence with endangered species. The level of conflict is only on the dispute level and there are no deep social issues to deal with. HEC is considered a technical issue that if the company is able to keep to a manageable level, everyone will be on acceptable tolerance with the conflicts. (Agrawal *et al.*, 2016).

This research is proposing a "Human-Elephant Conflict Charter" for SDPB which is committed to a) identifying the affected areas of Human Elephant Conflict, b) mitigating Human Elephant Conflict, and c) monitoring the effectiveness of mitigation practices. The Charter document is attached in the Appendix along with this dissertation. The policy involves the use of an integrated approach beyond physical barriers for a better option in managing HEC effectively at plantation landscape. The effectiveness of HEC mitigation

needs to be demonstrated through the provision of readily clear information of evidence for farmers/plantation to follow (Gunaryadi, Sugiyo and Hedges, 2017). There are no easy solutions to stop elephants from raiding crops once agriculture becomes the principal land use in the vicinity of elephant reserves (Santiapillai and Ramono, 1993). The five strategic phases of intervention suggested for mitigating human elephant conflicts (Lim, 2018) are:

Table 11: Five strategic phases of intervention suggested for HEC mitigation

Phase	Intervention	Appropriate timing
1	Land-use controls	Before a development
2	Barriers to protect people and crops	During elephant raiding
3	Financial tools	After elephant raids
4	Building tolerance	At any time
5	Removal of wildlife	As a last resort

This policy should not be a stand-alone document. It should be supported by operational procedures and protocols on how to implement the commitment at an operational level. It is important to note that while establishing the protocol, there is a need for inputs from the people on the ground who conduct the patrolling and should be created with consultation with others. SDPB has made 16 policies publicly available on their website. The company has developed an existing policy on Saving the Orang Utan which included the statement on their responsibility to protect endangered species in the case of human-wildlife conflict. This particular policy emphasized on "*establishing, communicating and implementing responsible and practical measures to resolve HWC within our operation*". By default, the company is currently adopting and adapting practices from an external document namely High Conservation Value Resource Network (HCVRN), and other best practices recommended by certifications schemes.

Overall, we found that the plantation industry did not develop species-specific policies. The most common policy that related to wildlife is linked to "sustainable" or "environment and biodiversity" or "conservation" policies. My personal observation is that that plantation companies tend to change or update their policy commitment through demand from certifications. For example, many companies started to develop No Deforestation, Peat Exploitation (NDPE) policy when RSPO urged their member to

commit. Another example when an RSPO indicator required Human Rights to be included in the policy, the plantation companies revised their Social Policy, including SDPB. In the context of Malaysia, MSPO certification has set the requirement for plantation companies to develop MSPO policy, which is in the process of development at the time of this research. Fundamentally, the policy should be supported by the procedures on how to implement the committed policy. Sometimes, with several changes in certification requirement and changing demands, policies cannot function effectively and with the danger of them becoming obsolete. This could result in more non-conformance in the company's performance.

Being a profit-making company, palm oil plantation companies prioritised effort in improving the yield and ensure compliances on the necessary legal regulations. Similar to SDPB management, the operation and yield is the highest priority and main Key Performance Index for the operations management team. Aside from that, the safety is one of the top concerns in the company. Safety procedures in the industry has advance tremendously and this has been guided closely by the national regulation, Occupational Safety and Health Act (OSHA) in Malaysia. The reporting of the safety accident has been set for the industry to follow. The procedure of conducting safety practices has been well established at most of the industry players which could be implied for wildlife management. For example, the incidents reporting, the dedicated officer and the compulsory quarterly meeting that can be integrated with the safety compliances. While when it comes to the environment, mill performance was closely monitored by the Department of Environment (DOE), but this is not much applicable to the management in estates apart from Scheduled Waste concerns.

In Sabah, an Environment Impact Assessment (EIA) is mandatory for activities prescribed in the Environment Protection (Prescribed Activities) (Environment Impact Assessment) Order 2005 under section 12 of the Environment Protection Enactment 2002 which is advance than in the West of Malaysia. This prescribed activity is including the planned replanting programme for estate's operation. Any person intending to carry out any prescribed activity shall submit a report on environmental impacts to the Director of Environment Protection Department (EPD) for examination. Sime Darby Plantation has appointed two EPD-listed consultants and complying the requirement by the state

enactment which reviewing our human-elephant conflict management from time to time. According to First and Second Schedules of the Environment Protection Enactment (prescribed Activities) (Environmental Impact Assessment) Order 2005 – Annex I;

Table 12: Schedules of the Environment Protection Enactment (prescribes Activities) in Sabah

1st Schedule: List of prescribed activities requiring Proposal for Mitigation Measures (PMM) Report. (Agriculture)	2nd Schedule: List of prescribed activities requiring EIA (Agriculture)
i. Development of agricultural estates or plantations covering an area of 100ha or more but less than 500ha; ii. Development of agricultural estates or plantations involving change in type of crops covering an area of 100ha or more but less than 500ha; or iii. Conversion of wetland forests into agricultural estates or plantations covering an area of 20ha or more but less than 50ha.	i. Development of agricultural estates or plantations covering an area of 500ha or more; ii. Development of agricultural estates or plantations involving change in type of crops covering an area of 500ha or more; iii. Conversion of wetland forests into agricultural estates or plantations covering an area of 50ha or more; or iv. Agricultural programmes involving the settlement of 100 families or more.

After a number of wildlife incidents in SDPB, the wildlife incidents procedure has been integrated in the safety incident reporting, the "Standard Operating Procedure of Incidents, Accidents and Non-conformance Management", which was revised in June 2019. There are two types of incidents outlined under Class 11 – Environmental Incident which are: a) incident resulting in the accidental release of material resulting in actual or potential pollution to internal and/ or external environment causing adverse effects to the operation, community and the ecosystems, and b) incidents involving the death of Endangered, Rare & Threatened (ERT) species or damages to conservation areas within premise. It seems at the moment the function of policies and procedures of managing wildlife or species have yet to be fully aligned and may not be as optimal and effective at the moment in SDPB. Notwithstanding, in creating the elephant friendly practices also can increase the risk of accidents for workers, thus safety needs to be carefully considered.

During visit to the estates, the patrolling team used the internal application of PDFmap to locate the GPS points of elephant movement. There is a number of digital technologies

that have been explored and used by the people locally. These include the use of mobile apps to monitor the HEC reporting and to initiate fast action plan such as ArcGIS Survey123 and other free application. Sime Darby Plantation Berhad has prepared geo-referencing maps for all their plantation estates which enable the team on the ground to report accurate information at sites. However, this has not been formally used as a HEC reporting tool. At some cases this information can assist the team at head-quarters to monitor information in real-time, long term. In addition, the potential use of camera traps with a long range (LoRa) wireless that enable early detection of elephants, can allow the plantation to deploy their patrolling team to the required site accordingly. Similar to the real-time Spatial Monitoring and Reporting Tool (SMART), the information to guide patrolling would be very helpful for plantation.

The palm oil sustainability certification requires plantation to manage wildlife conflict in an appropriate manner. However currently there is no strict guideline provided. With the business-driven priority to the operation performance, often no budget is allocated to manage the conflicts. The roles of sustainability certification such as MSPO and RSPO have been the main drivers to ensure the compliances and implementation of best practices for wildlife management; not just for the company but for the industry overall. One of the common findings that have been raised during external audits by certification bodies, in relation to wildlife, are mechanisms on wildlife conflict management and the ineffectiveness of species and habitat monitoring implementation.

The Energy Commission (EC) had published a guideline on the installation of electric fences. This guideline is intended to enforce the method of installing the electric fences in order to improve the safety level of the installation according to MS IEC 60335-2-76 standard. This guideline also provides procedures that applicants must be complied in order to obtain approval from the Energy Commission on the installation of electric fences. Therefore, the installation of electric fences needs to follow controls and safety protocols in accordance to the Electricity Supply Act 1990, Electricity Regulations 1994 and other relevant standards. The respective regulations that need to be complied with are Regulation 15, Regulation 65, Regulation 68, Regulation 75, Regulation 110 and Regulation 111. In order for electric fences to be effectively managed for HEC, it is

recommended that the "energizer with 12V input voltage, repeat impulse rate does not exceed 1Hz, and output at least 12 Joule (J) and storage maximum 16J".

In Sabah, the state government has publicly announced by media that stricter laws will be enforced with regard to elephant deaths resulting from HEC. The landowners will be made accountable for elephants found dead in their plantations. Although there has yet to be further action from the announcement, the legal implication will be one of the main concerns of human-elephant conflict management in the plantations. As such, plantations should be proactive and start implementing SOPs that minimise the threats to wild Asian elephants.

This research recommended that SDPB to continue collecting and analysing HEC data and improve on the reporting information especially on the sightings of elephant. The protocols of HEC mitigation should be based on an adaptive approach; doing what is clear now but with some action to improve on areas where information is still uncertain. Feasibly, the first step, is to map elephant depredation risk areas and revise the location of existing electrical fences. Strategically, SDPB should promote connectivity and access to important resources like the mud pool and allow some space in the plantation for the wild elephants to forage and move around. A continuous programme of awareness and engagement need to be carried out among workers and estate management to build up the support for promoting co-existence and as capacity building for staff. Additionally, the higher management should reward and recognise estates management teams that face challenges with mitigation for HEC and promote co-existence. Budget priorities should be given to mitigating conflict with allocation for dedicated guardians and patrolling team. It is suggested that the recognition such as "the most wildlife friendly estates" to be introduced in the SDPB annual dinner and events. These wildlife-friendly concepts also can be made known to all staff by creating a logo that represent the animal at regional level.

5.5 Limitations of the study

There were some challenges in the focus areas of this research. Sime Darby Plantation Berhad estates in West Malaysia are situated on the west side of the peninsula. These areas are mostly developed and are less connected to the large forest reserves or

protected areas in the landscape. Thus, the findings of this study may not represent overall plantations in the states.

Another limitation of this research is that the HEC data collected from estates in this study are not uniform and was based on voluntary reports. Additionally, the regular changes of management team have affected the trend of record keeping or its availability at the respective estates.

5.6 Future studies

The study of spatial and temporal nature of HEC patterns and elephant movements can be expanded to include the analysis of land-use change (LUC). The challenge is to obtain data on land use or land cover, and information on changes over large areas or even at national scale, and that there are large differences in the quality of the data. Despite these uncertainties, the overview of past LUC indicated that large changes in land use have occurred in Indonesia and Malaysia (Wicke *et al.*, 2011).

There is lack of information on the association of elephants in Sabah with the natural occurring mud-volcano areas. The last paper that touched on this topic was in 1968 (Silva, 1965) and the update of this knowledge is overdue. There are also pressing needs to study wildlife conservation methods suitable within oil palm plantations, and for the industry to better manage HEC.

6. CONCLUSION

This research is an innovative study. It provides a scientific synthesis of information on HEC encountered by SDPB Malaysia operations for the duration of 2011-2018. Little is known of the effectiveness of human-elephant conflict mitigation applied for tree crops, particularly for palm oil. As the palm oil industry is important for the livelihood of Malaysia, more research is needed to study HEC mitigation methods that will support elephant conservation. This research suggested that elephant depredation mostly occurs when the oil palm trees are below five years old, and the most damage takes place when the tree is one year old. Other factors such as availability of mud-pools can influence the trees damage pattern. The spatial distribution of highest HEC intensity and damage frequency occurred mostly at the area of entry point at estate borders and some were reduced with the application of mitigation. The temporal pattern of HEC in SDPB suggested that some estates showed clear reduction in HEC when comparing HEC incidents before and after the year of electric fencing is in place but not for all. This concurred that electric fence is useful when applied in the right conditions, but it may not be a solution for all HEC. Further research and observation are needed at respective estates of SDPB. The HEC pattern is not correlated with monthly rainfall. The economic loss of RM24 million is considered very high. It is important to reduce this loss in future with the implementation of right mitigation and to reduce unnecessary expenditure. The enrolment of growing tree insurance by the company can be explored as a HEC mitigation tool as part of the holistic approach. At this moment, SDPB wildlife related policies can be further enhanced and protocol of managing the HEC at operations need to be documented, implemented and communicated.

Overall, this research can be replicated at other plantations to generate scientific information useful for managing HEC and elephant conservation at landscape level. In conclusion, the oil palm sector cannot continue to be known for what it used to be known for (deforestation and depleting the wildlife habitat), and should be promoting co-existence within plantations. The collaboration between private sector, academia and the conservation world is very important and needs to be more transparent and consistent. This research is a part of the process being transparent and pioneering step for SDPB to move towards coexistence with elephants and other wildlife in plantations, by bringing

science that can help the organisation manage the issue, save money and do good for endangered species.

7. REFERENCES

A Ferdous Alam, A. S. *et al.* (2005) *Malaysian oil palm industry: Prospect and problem Developing a Multi-criteria Decision Support System for Urban Disaster Management View project Both of the Above View project WFL Publisher Science and Technology Malaysian oil palm industry: Prospect and* , *Agriculture & Environment*. Available at: www.world-food.net.

Agrawal, P. K. *et al.* (2016) *Human-wildlife conflict*, *Current Science*. Oxford University Press. doi: 10.1093/acprof:oso/9780199687145.001.0001.

Alfred, R. *et al.* (2012) 'Home range and ranging behaviour of bornean elephant (elephas maximus borneensis) females', *PLoS ONE*. doi: 10.1371/journal.pone.0031400.

Anand, S. and Radhakrishna, S. (2017) 'Investigating trends in human-wildlife conflict: is conflict escalation real or imagined?', *Journal of Asia-Pacific Biodiversity*, 10(2), pp. 154–161. doi: 10.1016/j.japb.2017.02.003.

Bhagat, V. K., Yadav, D. K. and Jhariya, M. K. (2017) 'Human-Elephant Conflict and Its Consequences : A Preliminary Appraisal and Way Forward', 6(June), pp. 85–94.

Blair, J. A. S., Boon, G. G. and Noor, N. M. (1979) *Conservation or Cultivation: The confrontation between the Asian Elephant and land development in Peninsular Malaysia*.

Blair, J. A. S. and M. Noor, N. (1980) *The Elephant Problem with particular reference to PM.pdf*.

Brown, E. and Senior, M. J. M. (2014) 'Common Guidance for the Management and Monitoring of High Conservation Values', (September), p. 66.

Campos-Arceiz, A. (2013) 'The Dangerous Myth of the Noble Beast', 38(May), p. 1. Available at: papers2://publication/uuid/B67A5F6A-8A6A-4857-BD40-507F72DBCB1C.

Chen, S. *et al.* (2013) 'Developing a spatially-explicit , sustainable and risk-based insurance scheme to mitigate human – wildlife conflict'. Elsevier Ltd, 168, pp. 31–39. doi: 10.1016/j.biocon.2013.09.017.

Chiyo, P. I. *et al.* (2005) 'Temporal patterns of crop raiding by elephants: A response to changes in forage quality or crop availability?', *African Journal of Ecology*, 43(1), pp. 48–55. doi: 10.1111/j.1365-2028.2004.00544.x.

Corley, R. H. V. and Tinker, P. B. (2015) 'Site Selection and Land Preparation', *The Oil*

Palm, pp. 240–274. doi: 10.1002/9781118953297.ch9.

Daniel Chong Kah Fui, D. N. A. A. B. (2005) 'Better Management Practices Human-Elephant Conflict', (July).

Davies, T. E. *et al.* (2011) 'Effectiveness of intervention methods against crop-raiding elephants', *Conservation Letters*, 4(5), pp. 346–354. doi: 10.1111/j.1755-263X.2011.00182.x.

Djagoun, C. A. M. S. *et al.* (2017) 'A stakeholder assessment of human–elephant conflict in Benin', *Pachyderm*, 2017(58), pp. 161–166.

Van Eden, M., Ellis, E. and Bruyere, B. L. (2016) 'The Influence of Human–Elephant Conflict on Electric Fence Management and Perception Among Different Rural Communities in Laikipia County, Kenya', *Human Dimensions of Wildlife*, 21(4), pp. 283–296. doi: 10.1080/10871209.2016.1149746.

Elvitigala, C. *et al.* (2015) 'Towards a sensor system to tame the human elephant conflict', *SAS 2015 - 2015 IEEE Sensors Applications Symposium, Proceedings*. doi: 10.1109/SAS.2015.7133595.

Enukwa, E. H. (2017) 'Human-Elephant confilict mitigation methods: A review of effectiveness and sustainability', *Journal of Wildlife and Biodiversity*, 1(2), pp. 69–78. doi: 10.22120/jwb.2017.28260.

Faulkner, O. T. *et al.* (2016) *The Oil Palm*, *West African Agriculture*. doi: 10.1017/cbo9781316530122.010.

Fernando, P. *et al.* (2008) *Review of Human-Elephant Conflict Mitigation Measures Practiced in South Asia WORLD BANK-WWF ALLIANCE FOR FOREST CONSERVATION & SUSTAINABLE USE LIST OF TECHNIQUES CONTENTS*.

Fernando, P. (2015) 'Managing elephants in Sri Lanka: where we are and where we need to be', *Ceylon Journal of Science (Biological Sciences)*, 44(1), p. 1. doi: 10.4038/cjsbs.v44i1.7336.

Gubbi, S. (2012) 'Patterns and correlates of human-elephant conflict around a south Indian reserve', *Biological Conservation*. doi: 10.1016/j.biocon.2012.01.046.

Gunaratne, L. H. P. *et al.* (2017) 'Historical review of human-elephant conflict in Peninsular Malaysia', *Gajah*. BioMed Central, 34(1), pp. 1–10. doi: 10.13140/RG.2.1.3701.0088.

Gunaryadi, D., Sugiyo and Hedges, S. (2017) 'Community-based human-elephant conflict mitigation: The value of an evidence-based approach in promoting the uptake of

effective methods', *PLoS ONE*, 12(5), pp. 1–13. doi: 10.1371/journal.pone.0173742.

Hema, E. M. *et al.* (2018) 'Raiding or not raiding? A study of the ecological correlates of human-elephant conflict at Nazinga game ranch (Burkina Faso)', *Revue d'Ecologie (La Terre et la Vie)*, 73(1), pp. 3–11.

Hoare, R. E. (1999) 'Determinants of human-elephant conflict in a land-use mosaic', *Journal of Applied Ecology*. doi: 10.1046/j.1365-2664.1999.00437.x.

Hoare, R. E. (2000) 'Data collection and analysis for Human-Elephant conflicts situation in Africa.', *Resource Africa (SADC)*, 1, p. 30.

Honda, T. *et al.* (2009) 'Effectiveness of Newly-Designed Electric Fences in Reducing Crop Damage by Medium and Large Mammals', *Mammal Study*. doi: 10.3106/041.034.0103.

Jaganathan, V., Shanmugavadivu, M. and Ganesh, S. (2018) 'International Journal of Advanced Research in Biological Sciences Preliminary phytochemical screening and anti-bacterial activity of date seed methanolic extract', 5, pp. 209–215. doi: 10.22192/ijarbs.

Kioko, J. *et al.* (2008) 'Published By: Southern African Wildlife Management Association', *Source: South African Journal of Wildlife Research*, 38(1), pp. 52–58. doi: 10.3957/0379-4369-38.1.52.

Kongsager, R. and Reenberg, A. (2012) 'Contemporary land-use transitions: The global oil palm expansion', *The Global Land Project Report*, 4(January 2012), p. 40. Available at: http://forskningsbasen.deff.dk/Share.external?sp=S76f0064a-6f76-4825-939e-3bd25e8d56d0&sp=Sdtu.

Lim, T. (2018) *HUMAN-ELEPHANT RELATIONS IN PENINSULAR MALAYSIA*, *Unpublished*. doi: .1037//0033-2909.I26.1.78.

Lippert, I. (2004) 'An Introduction to the Criticism on Sustainable Development', *Brandenburg University of Technology, Cottbus*, p. 51.

Meijaard, E. and Sheil, D. (2013) 'Oil-Palm Plantations in the Context of Biodiversity Conservation', in *Encyclopedia of Biodiversity: Second Edition*, pp. 600–612. doi: 10.1016/B978-0-12-384719-5.00340-3.

MPOC (2014) 'www.mpoc.org.my', 11(4).

Mutinda, M. *et al.* (2014) 'Detusking fence-breaker elephants as an approach in human-elephant conflict mitigation', *PLoS ONE*, 9(3). doi:

10.1371/journal.pone.0091749.

Ndossi, H. P. *et al.* (2016) 'Scaling-Up the Use of Chili Fences for Reducing Human-Elephant Conflict Across Landscapes in Tanzania', *Tropical Conservation Science*, 9(2), pp. 921–930. doi: 10.1177/194008291600900220.

Nikoloyuk, J., Burns, T. R. and de Man, R. (2010) 'The promise and limitations of partnered governance: The case of sustainable palm oil', *Corporate Governance*, 10(1), pp. 59–72. doi: 10.1108/14720701011021111.

Ning, H. *et al.* (2016) *MEME-moving towards a science-based conservation of Malaysian elephants*, *Malayan Nature Journal*.

Othman, N. *et al.* (2019) 'Shift of paradigm needed towards improving human – elephant coexistence in monoculture landscapes in Sabah', pp. 1–13. doi: 10.1111/izy.12226.

Othman, N. *et al.* (2013) *Elephant Conservation and Mitigation of Human-Elephant Conflict in Government of Malaysia-UNDP Multiple-Use Forest Landscapes Project Area in Sabah*.

Othman, N. B. (2018) 'Behaviour and Spatial Ecology of the Bornean elephant (Elephas maximus borneensis) in Lower Kinabatangan, Sabah, Malaysia Borneo', (September).

Palm, T. O. (2016) 'Biofuels', pp. 507–518.

Parker, G. E. and Osborn, F. V. (2001) 'Dual season crop damage by elephants in the Eastern Zambezi Valley, Zimbabwe', *Pachyderm*, (30), pp. 49–56. doi: 10.1074/mcp.M111.008490.

PEMANDU (2010) 'Chapter 9 - Deepening Malaysia's Palm Oil Advantage', *Economic Transformation Programme: A Roadmap For Malaysia*, pp. 281–314. doi: 10.1002/047167849X.bio071.

Perera, B. M. A. O. (2009) 'The Human-elephant Conflict: a review of current status and mitigation methods', *Gajah*, 30, pp. 41–52.

Pohl, C. and Loong, C. K. (2016) 'In-situ data collection for oil palm tree height determination using synthetic aperture radar', *IOP Conference Series: Earth and Environmental Science*, 34(1). doi: 10.1088/1755-1315/34/1/012027.

Ponnusamy, V. *et al.* (2015) *ASSESSMENT OF THE SOCIO---ECONOMIC IMPACT OF ELECTRIC FENCE FOR MITIGATING HUMAN ELEPHANT CONFLICT*.

Poole, J. H. (1989) 'Announcing intent: the aggressive state of musth in African

elephants', *Animal Behaviour*, 37(PART 1), pp. 153–155. doi: 10.1016/0003-3472(89)90015-8.

Pozo, R. A. *et al.* (2017) 'Determining baselines for human-elephant conflict: A matter of time', *PLoS ONE*, 12(6), pp. 1–17. doi: 10.1371/journal.pone.0178840.

Qomariah, I. N. *et al.* (2019) 'Conflict between human and wild Sumatran Elephant (Elephas maximus sumatranus Temminck, 1847) in Aceh Province, Indonesia', *Bioviversitas*, 20(1), pp. 77–84. doi: 10.13057/biodiv/d200110.

Ripple, W. J. *et al.* (2017) 'Conserving the World's Megafauna and Biodiversity: The Fierce Urgency of Now', *BioScience*, 67(3), p. biw168. doi: 10.1093/biosci/biw168.

Saaban, S. *et al.* (2011) *Current Status of Asian Elephants in Peninsular Malaysia*.

Santiapillai, C. and Ramono, W. S. (1993) 'Why do elephants raid crop in Sumatra', *Gajah*, 11, pp. 55–58. Available at: http://www.asesg.org/PDFfiles/Gajah/11-55-Santiapillai.pdf.

Seidensticker, J. (1984) *Managing elephant depredation in agricultural and forestry projects*.

Silva, G. S. de (1965) 'Elephants of Sabah', *Sabah Society Journal*.

Sitati, N. W. *et al.* (2003) 'Predicting spatial aspects of human and elephant conflict', *Journal of Applied Ecology*, 4(40), pp. 667–677. doi: 10.1046/j.1365-2664.2003.00828.x.

Sitati, N. W., Walpole, M. J. and Leader-Williams, N. (2005) 'Factors affecting susceptibility of farms to crop raiding by African elephants: Using a predictive model to mitigate conflict', *Journal of Applied Ecology*, 42(6), pp. 1175–1182. doi: 10.1111/j.1365-2664.2005.01091.x.

Talib, B. A. and Darawi, Z. (2002) 'An Economic Analysis of the Malaysian Palm Oil Market', *Oil Palm Industry Economic Journal*, 2(1), pp. 19–27.

Tchamba, M. N. (1996) 'History and present status of the human/elephant conflict in the Waza-Logone Region, Cameroon, west Africa', *Biological Conservation*, 75(1), pp. 35–41. doi: 10.1016/0006-3207(95)00040-2.

Tennakoon, E. *et al.* (2015) 'Sensor-based breakage detection for electric fences', *SAS 2015 - 2015 IEEE Sensors Applications Symposium, Proceedings*, pp. 4–7. doi: 10.1109/SAS.2015.7133589.

Teoh, C. H. (2010) 'THE WORLD BANK Key Sustainability Issues in the Palm Oil Sector'.

Varsha, V. *et al.* (2016) 'The Impacts of Oil Palm on Recent Deforestation and Biodiversity', *PLoS ONE*, 11(7), pp. 1–19. doi: 10.5061/dryad.2v77j.

van de Water, A. and Matteson, K. (2018) 'Human-elephant conflict in western Thailand: Socio-economic drivers and potential mitigation strategies', *PLoS ONE*, 13(6), pp. 1–14. doi: 10.1371/journal.pone.0194736.

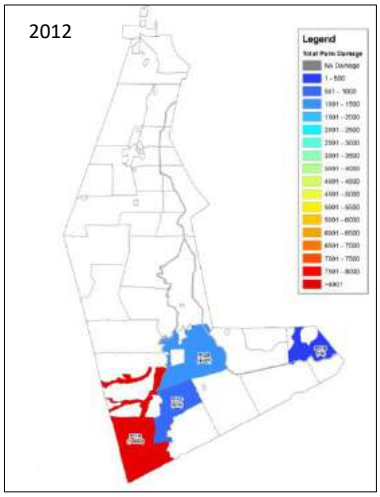
Wicke, B. *et al.* (2011) 'Exploring land use changes and the role of palm oil production in Indonesia and Malaysia', *Land Use Policy*. Elsevier Ltd, 28(1), pp. 193–206. doi: 10.1016/j.landusepol.2010.06.001.

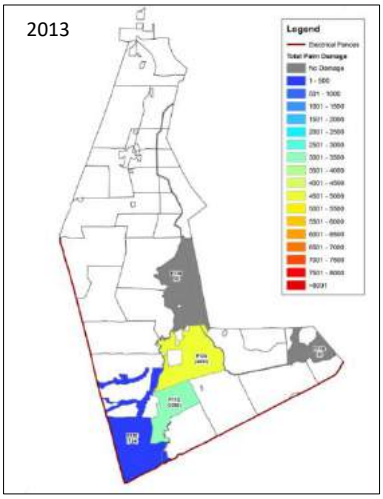
Woittiez, L. S. *et al.* (2017) 'Yield gaps in oil palm: A quantitative review of contributing factors', *European Journal of Agronomy*. Elsevier B.V., 83, pp. 57–77. doi: 10.1016/j.eja.2016.11.002.

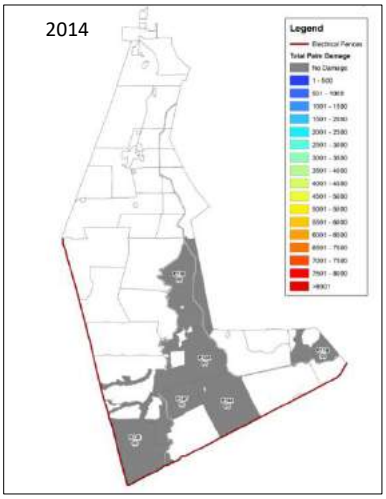
Yamamoto-Ebina, S. *et al.* (2016) 'Food Habits of Asian Elephants *Elephas maximus* in a Rainforest of Northern Peninsular Malaysia', *Mammal Study*. doi: 10.3106/041.041.0306.

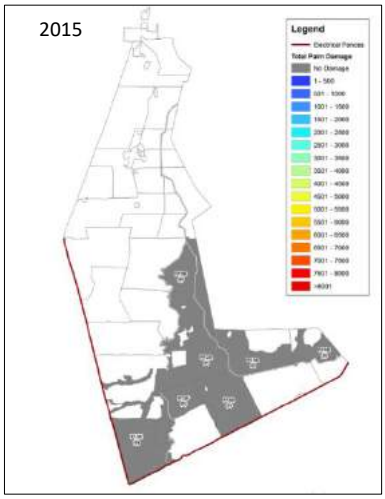
8. APPENDICES

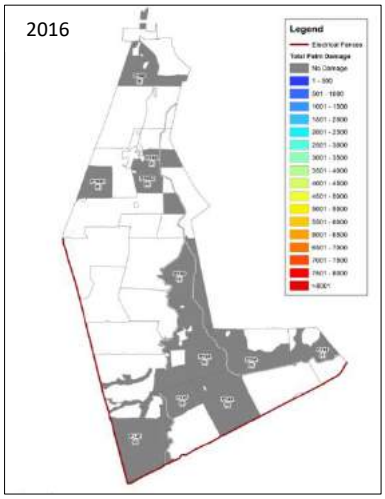
8.1 Replanting map and number of trees damage for Mentakab Estate

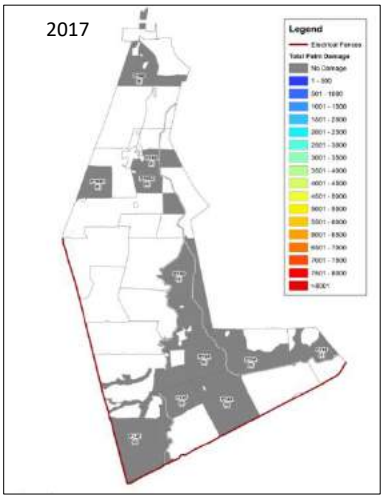


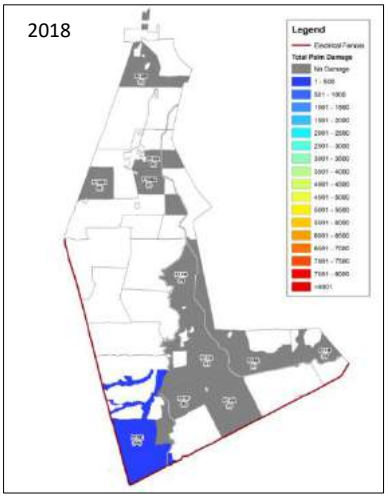




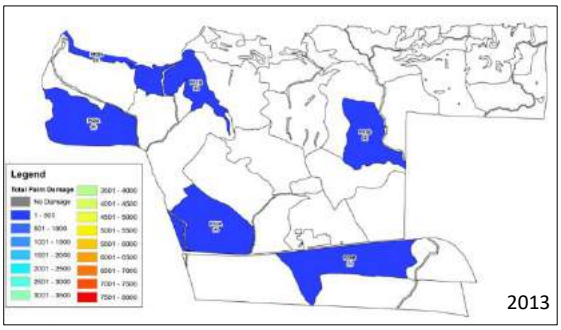


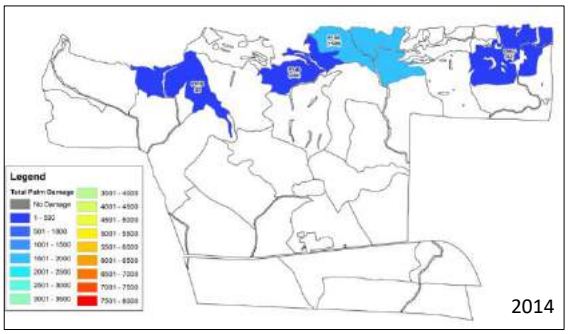


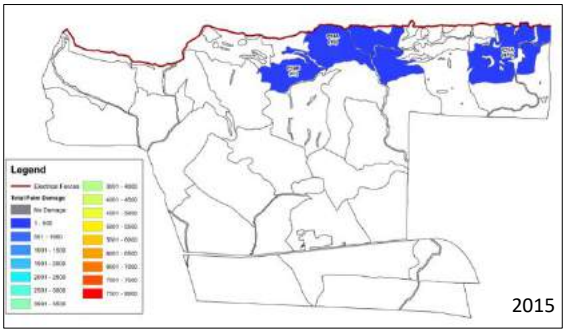


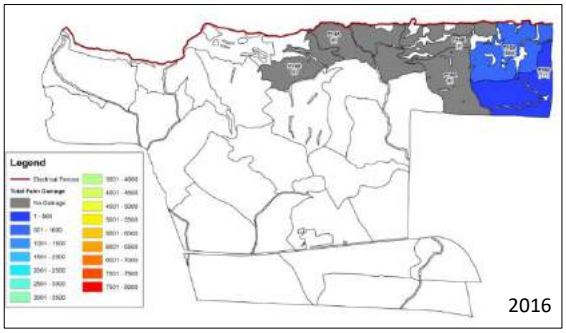


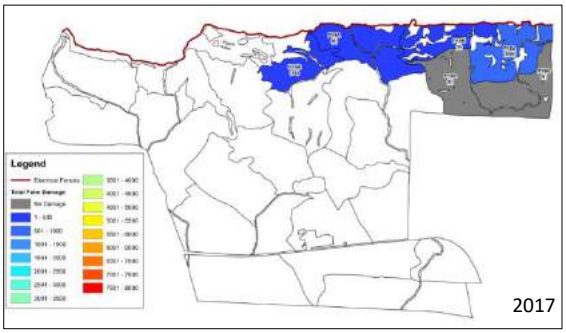
8.2 Replanting map and number of trees damage for Cenas Estate

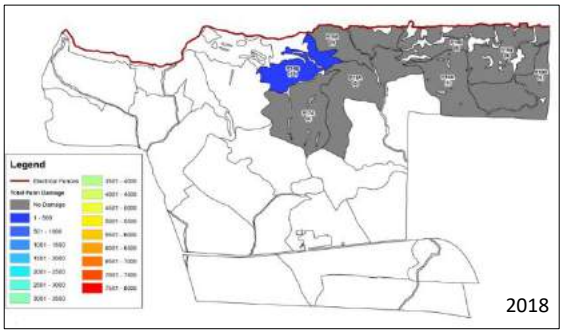




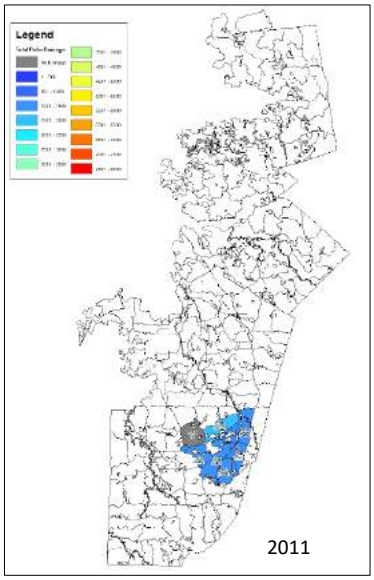


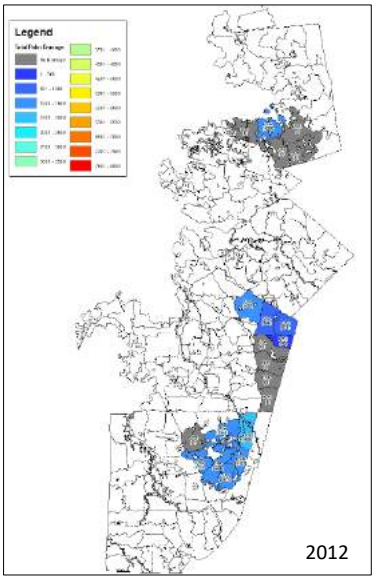


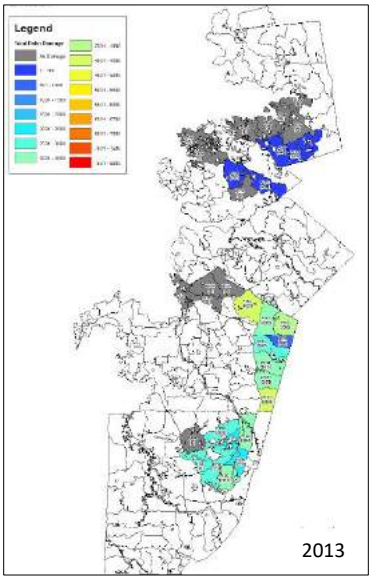


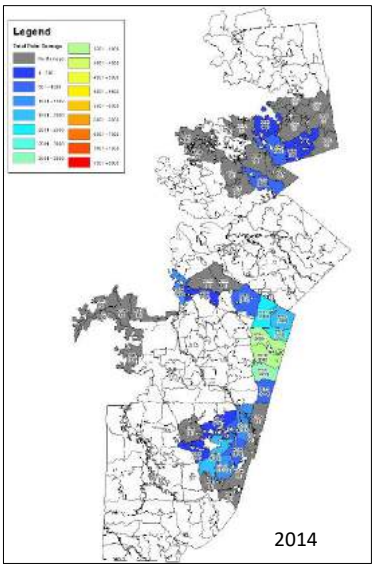


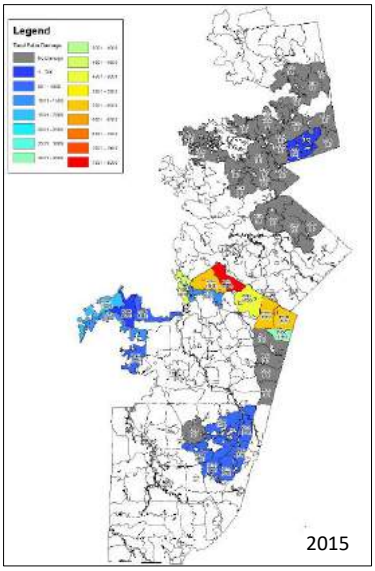
8.3 Replanting map and number of trees damage for Sandakan Bay Estates

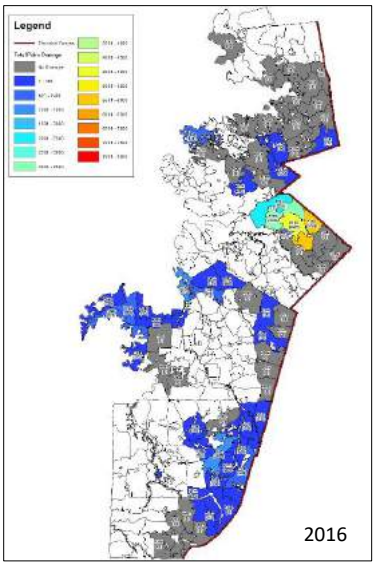


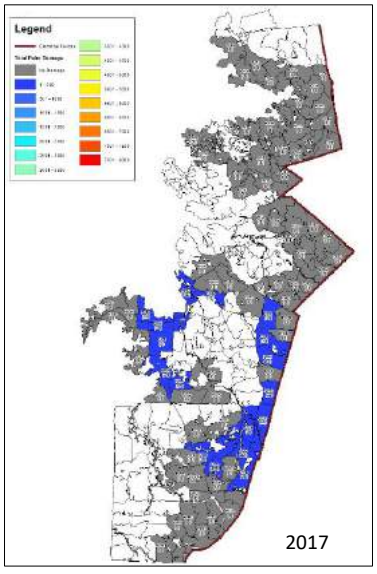


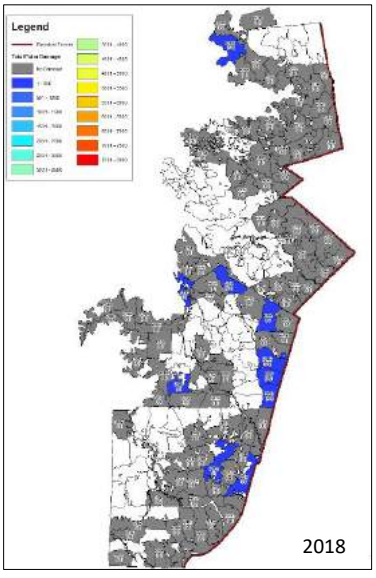




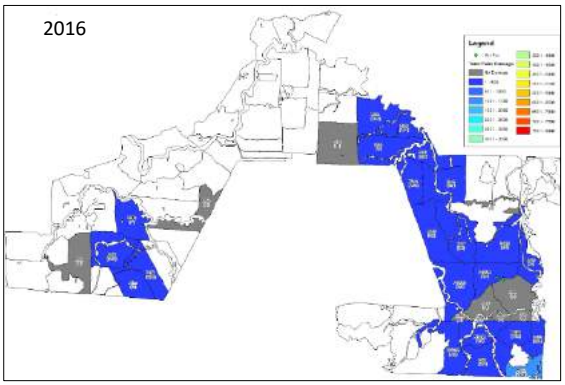


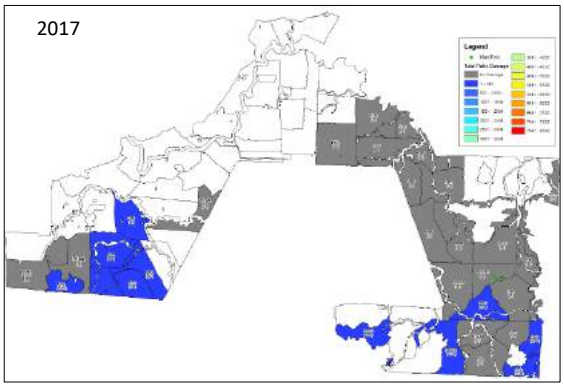


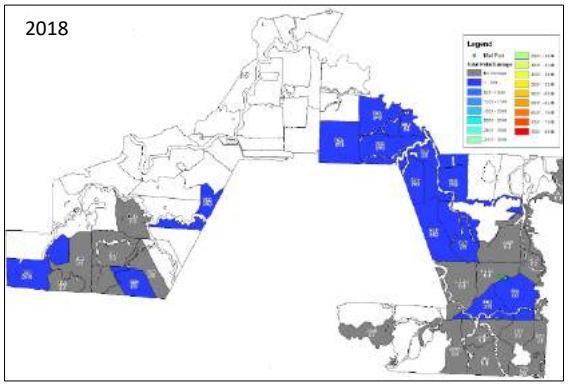




8.4 Replanting map and number of trees damage for Jeleta Bumi Estate and Binuang Estate



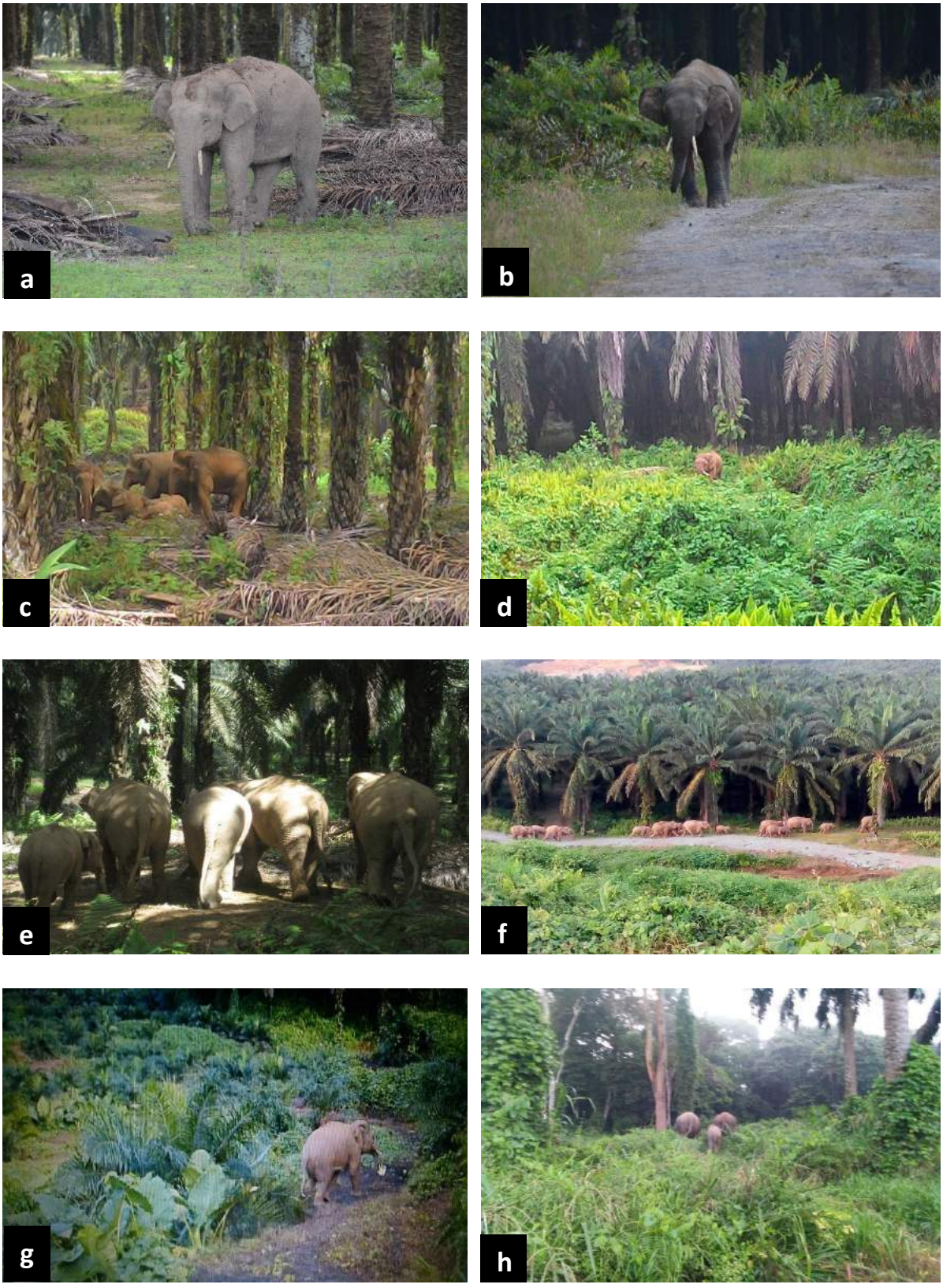




8.5 Elephant rescued in 2010 at mud-pool of Binuang Estate

8.6 Elephant feeding during 2010-2014 replanting at Sandakan Bay Estates

8.7 Elephant roaming in mature area before electrical fencing was constructed



8.8 Cost implication of oil palm destruction by Blair, 1980.

	Cost/Acre ($) by Age of Palms at Time of Damage (Months)						
Items of Cost	**3**	**6**	**9**	**....**	**21**	**....**	**60**
Establishment Costs (E)							
a) Planting material	107.30	107.30	107.30	....	107.30	....	107.30
b) Planting labour	29.00	29.00	29.00	....	29.00	....	29.00
c) Lining	7.00	7.00	7.00	....	7.00	....	7.00
d) Re-opening circles	17.40	17.40	17.40	....	17.40	....	17.40
Sub-total	160.70	160.70	160.70	....	160.70	....	160.70
Operational Costs (0)							
a) Weed control	25.50	51.00	76.50	....	178.50	....	510.00
b) Manuring	8.87	17.74	26.61	....	124.13	....	409.57
c) Pests and disease	1.25	2.50	3.75	....	8.75	....	25.00
d) Castration/ablation	0.00	0.00	0.00	....	12.60	....	18.00
e) Assisted pollination	0.00	0.00	0.00	....	0.00	....	129.60
f) Palm census	0.20	0.20	0.20	....	0.40	....	1.00
Sub-total	35.82	71.44	107.06	....	324.38	....	1,093.17
Administrative Costs (A)	29.61	33.84	38.07	....	54.99	....	109.98
Total E.O.A. Costs	226.13	265.98	305.83	....	540.07	....	1,363.85
Settler Income Lost (Y)[1]	28.55	57.12	85.67	....	1,444.26	....	3,170.80
Duty Lost (R)[2]	16.27	32.53	48.80	....	741.93	....	1,598.49
Export Value (F.O.B.) Lost[3]	57.54	115.08	172.61	....	2,624,79	....	5,655,08

Figure 28: Cost implication of oil palm destruction by Blair, 1980.

9. HUMAN-ELEPHANT CONFLICT CHARTER

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Sime Darby

Delivering Sustainable Futures

Plantation

Human- Elephant Conflict Charter

Sime Darby Plantation Berhad

Human Elephant Conflict Charter

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01 Preamble

02 Scope

03 Commitments

04 Implementation

05 Responsibilities and Reporting

1. Preamble

At Sime Darby Plantation, our core values of Integrity, Respect & Responsibility, Excellence and Enterprise support our commitment to sustainable development which resonates with the Group's brand promise of Delivering Sustainable Futures. We appreciate that the journey to achieve sustainability is not something we can undertake on our own and thus we actively engage with all our stakeholders in order to help us achieve our targets for sustainable development.

We respect the environment by promoting global environmental responsibility through encouraging the development and use of environmentally friendly designs and technologies, committing and devoting resources towards the protection of wildlife ecosystem and strict compliance to statutory guidelines and regulations. This is governed by our Code of Business Conduct and Group Policies and Authorities.

One of the challenges to conserving Asian elephants (Elephas maximus) is to incorporate conservation strategies into development and land-use planning, especially around existing their habitats. Where human elephant conflict arising within our operations, we are committed to establishing, communicating and implementing responsible and practical measure to mitigate the conflicts.

2. Scope

Our commitment extends to all human elephant conflicts within our sphere of influence, which includes all our employees, workers in our operations, counterparties and communities surrounding our operations. We are also committed to working with our counterparties and business partners to encourage them to uphold respect for elephant and wildlife protection and conservation as outlined in our policies.

3. Commitments

3.1 As a responsible global corporate citizen, we shall endeavour to meet standards and practices that are consistent with internationally recognised principles, subject to constitutional constraints and the laws and regulations of the countries and territories in which we operate. When faced with conflicts between local and international norms and/or standards, we aspire to uphold the higher standards, wherever possible.

3.2 We respect the protection and conservation of elephants, within our operations and surroundings our communities through our commitments which include, but are not limited to:

- **Identifying the affected areas of Human Elephant Conflict**
  We will strive to identify the past, present, and future areas with human-elephant conflicts within our operation landscapes.

- **Mitigating the Human Elephant Conflict**
  We endeavour to implement the evidence-based practices to mitigate human-elephant conflicts and promote human-elephant co-existence at estate and landscape level through cooperation with relevant stakeholders.

- **Monitoring the effectiveness of our mitigation practices**
  We seek to promote and establish the efficient mechanism of monitoring and reporting to ensure that our human-elephant conflicts practices are effective and adaptive.

4. Implementation

4.1 Our approach to mitigate human elephant conflicts is based on five strategic phases of intervention:

Phase	Intervention	Appropriate timing
1	Land-use controls	Before a development
2	Barriers to protect people and crops	During elephant raiding
3	Financial tools	After elephant raids
4	Building tolerance	At any time
5	Removal of wildlife	As a last resort

4.2 We commit to monitor our progress in implementing this Charter and to develop, where appropriate, performance indicators and other measurements that assist in determining our progress.

4.3 We commit to periodic reviews and assessments of our business activities to identify both positive and negative impacts on human-elephant conflicts; and subsequently to integrate the mitigating outcomes into our internal control systems where appropriate.

4.4 Through awareness and training initiatives we shall engage and educate all levels of the workforce within Sime Darby Plantation to enable them to understand their responsibility in respect of elephant protection and conservation and to empower them to positively influence and encourage our counterparties and business partners.

4.5 We maintain proactive engagement with relevant internal and external stakeholders to better understand and then to respond to human elephant conflicts issues and concerns. We seek to learn and share good practices through engagement within local and international networks.

5. Responsibilities and Reporting

5.1 The responsibility to respect wildlife resides in all of our operations. The oversight of this Charter is should be led by the Board of Directors through the Sustainability Committee. The implementation and administration of this Charter is the responsibility of the management within Sime Darby Plantation.

5.2 The human elephant conflict mitigation effectiveness should be reported to the Sustainability Committee on a quarterly basis and disclose our progress to external stakeholders through our Annual Reports and Sustainability Reports, where available.

5.3 Within Sime Darby Plantation, there should have established human elephant conflict protocols which should be available to all of our employees and external parties. We commit to investigate all human-elephant conflicts under this Charter's scope.