Impact of land use changes on the human-elephant conflict; Bornean elephant (Elephas maximus borneensis) movements, feeding ecology and associated habitat requirements in North Kalimantan, Indonesia

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Rapid expansion of oil palm is leading to human-elephant conflicts

Submitted as
"Rapid expansion of oil palm is leading to the human-elephant conflict in North Kalimantan Province of Indonesia" to Tropical Conservation Science, 25 February 2017 (manuscript number: TCR-17-0020)
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Abstract

Crop raiding by Bornean elephants (*Elephas maximus borneensis*) is increasing rapidly in North Kalimantan, mainly due to a rapid conversion of swiddens and secondary forest into oil palm plantations. In the Tulin Onsoi Sub-district, the area used by oil palm plantations has grown from 3,302.71 ha in 2001 to 21,124.93 ha in 2014. Particularly from 2006 to 2010 the area covered by oil palm plantations increased rapidly (418%). Preventing further encroachment of, oil palm plantations in elephant habitat and regulating land-use change are keys to stop further population declines and make way for the re-establishment of a viable elephant population in Kalimantan. Crop raiding is a strong determinant of the local people's perceptions of elephants, and risks eroding cultural values that enabled people to coexist with elephants. People's perception and attitude towards elephants are generally negative. Nevertheless, negative attitudes have not led to cases of retaliation in the Tulin Onsoi Sub-district. Public education at the community level could strengthen cultural values and foster coexistence between humans and elephants.

Keywords

Bornean elephant, North Kalimantan, oil palm, human-elephant conflict, crop raiding, human-elephant coexistence

2.1 Introduction

Historically, elephants have played an important role in cultural heritage and local traditions. In local stories, elephants would, for instance, lead people that are lost in the forest back to their homes. Elephants are said to be God's creation and regarded as guardians of humans. Elephants are often called grandparents ('*yaki*' for male or '*yadu*' for female), not only as a sign of respect but also because people believe that they descended from elephants. Attempts to observe elephants in the wild are nevertheless considered to be disrespectful, which proved to oppose a few challenges during the present research.

Changes in land use have however brought fierce competition for space and resources between people and wildlife in Southeast Asia (Kinnaird *et al*. 2003; Nyhus & Tilson 2004; Clements *et al*. 2010), and elephants are particularly vulnerable to land use change (Leimgruber *et al*. 2003; Hedges *et al*. 2005; Rood *et al*. 2008; Rood 2010; Saaban *et al*. 2011). On the Indonesian island of Sumatra, the development of oil palm (*Elaeis guineensis*) and rubber plantations has forced elephants to increasingly compete with humans for available space (Nyhus *et al*. 2000; Rood 2010; Sitompul *et al*. 2010; Sitompul 2011). The human-elephant conflict (HEC) may result in injury and death of humans, damage to crops and infrastructure, and lead to negative attitudes towards elephants among local people (Nyhus *et al*. 2000; Fernando *et al*. 2005; Hedges *et al*. 2005).

Land use change in Borneo is mainly driven by the expansion of large-scale oil palm plantations (Sheil *et al*. 2009; Wicke *et al*. 2011; Gunarso *et al*. 2013). Oil palm plantations in East Kalimantan[1] increased from 116,887.5 ha (since 2000) to 1,102,632 ha (since 2013) (East Kalimantan Provincial Government 2015). The Sebuku area, a part of Tulin Onsoi Sub-district [Figure 2-1], is currently one of the main target areas of the provincial oil palm plantation program (Bureau of Estate of East Kalimantan 2015). Two main oil palm estates are operating in the Tulin Onsoi Sub-district: the *Karangjoang Hijau Lestari* (*KHL*) Group and the *Tirtamadu Sawit Jaya* (*TSJ*) Group, with respectively 20,000 and 7,892.18 ha of oil palms (Bureau of Estate of East Kalimantan 2015). Most oil palm is cultivated in a so-called Nucleus Estate and Smallholder (NES) scheme. In this scheme, villagers transfer a proportion of their land to an oil palm company in return for financial compensation (Rist *et al*. 2010). In other cases, people sell their land directly to a company.

1 East Kalimantan has been split to North Kalimantan Province since 2012.

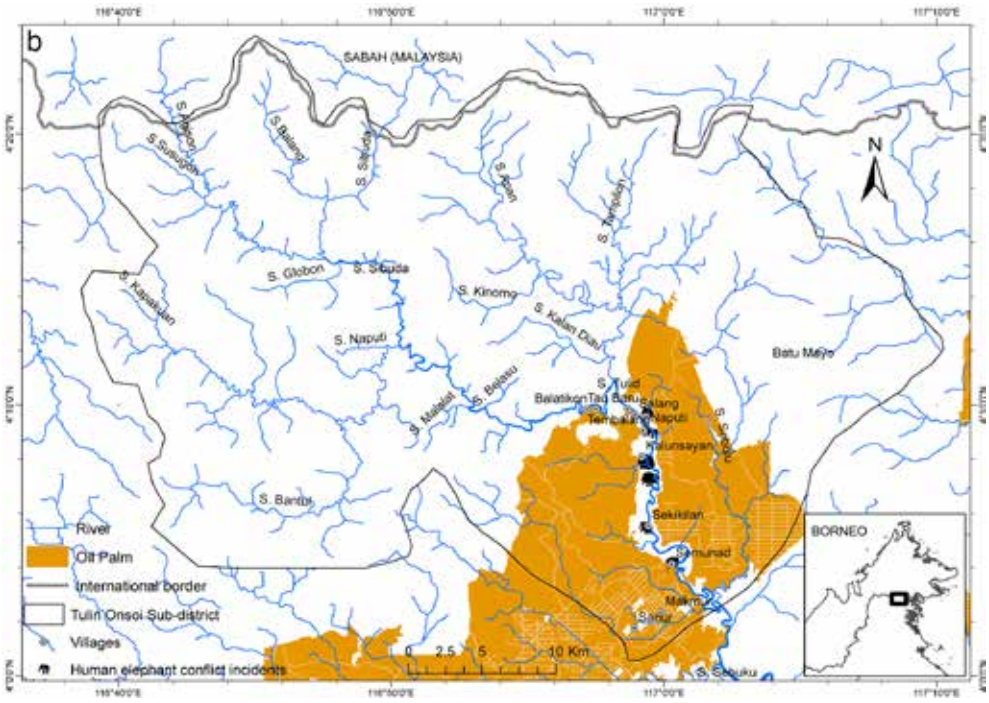

Figure 2-1
Map of the study area showing the Tulin Onsoi Sub-district, North Kalimantan Province and the area that has been allocated for oil palm plantations where human-elephant conflict incident exists

The Asian elephant has a specific significance in the region's history, religion and folklore, which makes it a potential flagship species for forest conservation (Nyhus *et al*. 2000; Fernando *et al*. 2005). However, HEC can undermine these cultural values and erode local support for conservation efforts (Hedges *et al*. 2005). In most cases, the total costs of crop raiding are relatively low, but its impacts on individual farmers can be significant (Naughton-Treves 1998). This chapter identifies patterns and trends in HEC in the Tulin Onsoi Sub-district, specifically in relation to the rapid development of oil palm plantations. The chapter provides a description of current land use changes and analyzes how HEC influences local people's perceptions of and attitudes towards the conservation of the Bornean elephant.

2.2 Methods

2.2.1 Study area

This study was conducted in the Tulin Onsoi Sub-district (split from the Sebuku Sub-district since 2011), which is part of the Nunukan District of North Kalimantan Province (Figure 2-1). The Sebuku forest is one of the most species-rich forests of Borneo in terms of botanical diversity (Jepson *et al*. 2002). However, the forest was logged in the 1990s. Between 1996 and 2003, primary forest decreased from 915,183 ha to 697,695 ha; a 24% decline in 7 years (Lusiana *et al*. 2005; Widayati *et al*. 2005).

This study focused on ten villages in the Tulin Onsoi Sub-district, inhabited by indigenous Agabag Dayak: Balatikon, Tau Baru, Tinampak II, Tinampak I, Salang, Naputi, Tembalang, Kalunsayan, Sekikilan, and Semunad [Figure 2-1]. Around 3,650 people inhabit these ten villages (Profil Daerah Kecamatan Sebuku 2013). The predominant livelihood strategy in these villages is small-scale subsistence farming, nowadays complemented with wage labor for oil palm companies. Crops grown in the area are cassava (*Manihot esculenta*), the staple food crop of Dayak Agabag, rice (*Oryza sativa*), corn (*Zea mays*), legumes, coconut (*Cocos nucifera*), banana (*Musa* spp.), sugar cane (*Saccharum officinarum*), vegetables, fruits, and spice trees.

2.2.2 Data collection and analysis

Land use and land cover change

Remote sensing techniques were used for quantifying land use and land cover changes. Both ground truthing (in February-April 2014 and March-April 2015) and remotely sensed satellite images acquired from the USGS Earth Resources Observation and Science Centre (EROS) at http://glovis.usgs.gov (LANDSAT TM, path 117 row 57) were used for this purpose. Land cover images for the years 2001, 2006, 2010 and 2014 served as a reference to evaluate oil palm land coverage.

We used a land use classification approach based on multistage visual techniques, using ER Mapper v. 7.1 and ArcGIS v. 10.2.2. Following the land use categories defined by Indonesian Ministry of Forestry (MoFRI 2008), ten land-cover categories were identified: upland forest, shrubland, oil palm plantation, dry cultivated land, road network, water bodies, swamp forest, open area, settlements and mixed tree crops (MoFRI 2008). Change matrices were created by comparing maps from different timelines pixel by pixel to identify small scale changes. Patterns in land use change in the study area were also determined through interviews with village heads, traditional leaders, and village elders in the ten villages of Tulin Onsoi Sub-district.

HEC survey

Several social scientific methods were used to assess HEC, and document local people's perceptions of and attitudes towards elephants [Table 2-1]. Household surveys were carried out between January and April 2013 using a pre-structured questionnaire [Table 2-2]. Questions were written and asked in Bahasa Indonesia. The presented results only include interview data for which the respondents have given their consent. Surveys consisted of a systematic sample of 214 households in ten villages of Tulin Onsoi Sub-district. Between 31.7% and 84.8% (average = 56.8%) of the households in the ten villages were sampled. The Agabag represent 77% of all respondents.

Table 2-1
Data collection techniques used for the HEC assessment in the Tulin Onsoi Sub-district

Emphasis of data collection	Method
Village description, settlement history and land use	Interviews with village heads and traditional leaders
Traditional cultural knowledge and value about elephant	Interviews with traditional leaders and village elders, using a snowball sample
Socio-economic and demography	Household survey (systematic sample) and documentation from village heads
Knowledge of and attitudes towards elephants, and information about HEC	Interviews of c. 30 min with one individual (18 years or older) in each household

*Modified from Chartier *et al.* (2011), Nyhus *et al.* (2003), and Sheil *et al.* (2006)

For yes/no questions [Table 2-2, questions no. 12-14], a logistic regression analysis was performed (Freedman 2009; Soto-Shoender & Main 2013), with the ethnic group, age, educational background, year of residence, and prior elephant crop damages as independent variables. The odds of an affirmative answer were modeled to each question for all categories of respondents. Statistical significance was calculated using the Wald χ^2 statistic. Statistical significance was calculated at $P < 0.05$ for all analyses using SPSS v. 23.0.

Table II-2
Summary of the questionnaire used in the interview survey

1. Have you seen elephants? Directly (direct sightings, signs) or indirectly (heard from others)?
2. When and where did you see elephants?
3. Did you recognize elephant's sex?
4. Did elephants ever visit your crop fields?
5. How did you respond?
6. Since when and how often have your crop fields been frequented by elephants?
7. What crops were raided by elephant? What kind of damage did they cause?
8. What could be the reasons for elephants to enter your crop fields?
9. Did elephants cause any other problems?
10. What could cause the decrease of elephant population?
11. How do you feel about elephants?
12. Do you think elephants and humans can live together in harmony? Yes/No/Don't know; Why?
13. Do you know that elephants are protected by local customs or rights? Yes/No; How does it work?
14. Do you know that elephants are protected by Indonesia law? Yes/No; How does it work?

2.3 Results

2.3.1 Land use changes

The multi-temporal analysis spanning from 2001 to 2014 shows a rapid expansion of industrial-scale oil palm plantations in the Tulin Onsoi Sub-district [Figure 2-2a-d]. From 2006 to 2010, the area covered by oil palm plantations increased significantly (418%) [Table 2-3]. 77% of these oil palm plantations were converted from the upland forest.

Table II-3
Land cover classes and their surface area in Tulin Onsoi Sub-district from 2001 to 2014 [Total land size approximately 153,000 ha]

Land cover class (ha)	2001	2006	2010	2014
Upland forest	144,526.96	146,597.02	128,713.09	126,520.57
Shrub land	1,771.99	760.60	3,899.94	2,451.65
Mixed tree crops	2,340.22	–	–	–
Dry cultivated land	–	1,500.77	795.64	1,322.68
Oil palm plantations	3,302.71	3,573.50	18,516.89	21,124.93
Other	1,442.11	1,018.71	1,137.53	1,583.60

Description and landscape context (Gunarso *et al*. 2013; MoFRI 2008):
Upland forest: natural forest, highly diverse species and high basal area, but in this study, upland forest actually represents disturbed forest, with evidence of logging.
Shrub land: open woody vegetation, often part of a mosaic including forest and grassland; well drained soils on a variety of landscapes impacted by logging and possibly fire.
Mixed tree crops: mosaic of cultivated and fallow land with canopy cover between 5-60%.
Dry cultivated land: Open area characterized by herbaceous vegetation intensively managed for row crops; associated with road networks and human settlements.
Oil palm plantations: Large industrial estates planted with oil palm; canopy cover variable depending on age; regular geometry characterized by discernible rows and internal plantation road network, typically in patches greater than 1000 hectares.
Other: swamp forest, bare soil, settlements, and water bodies

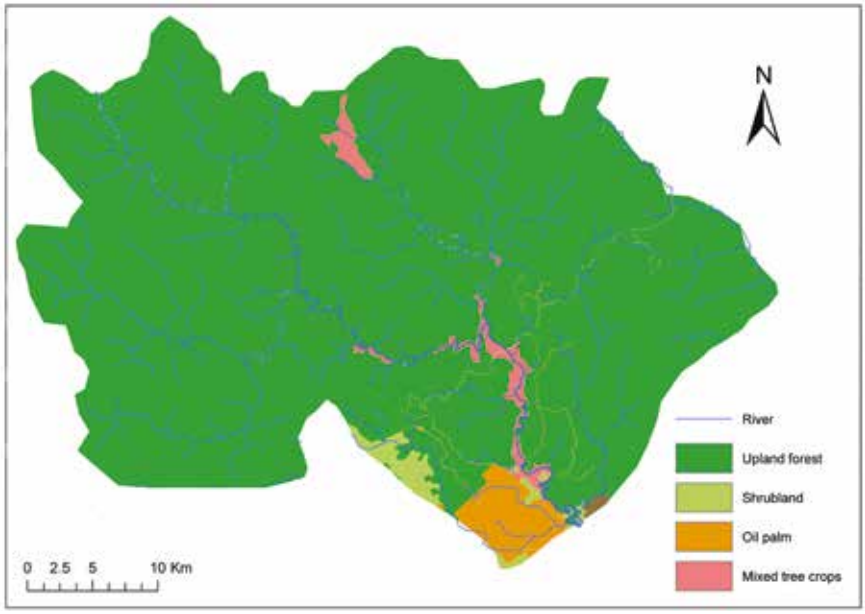

Figure 2-2a
2001 land cover map of Tulin Onsoi Sub-district

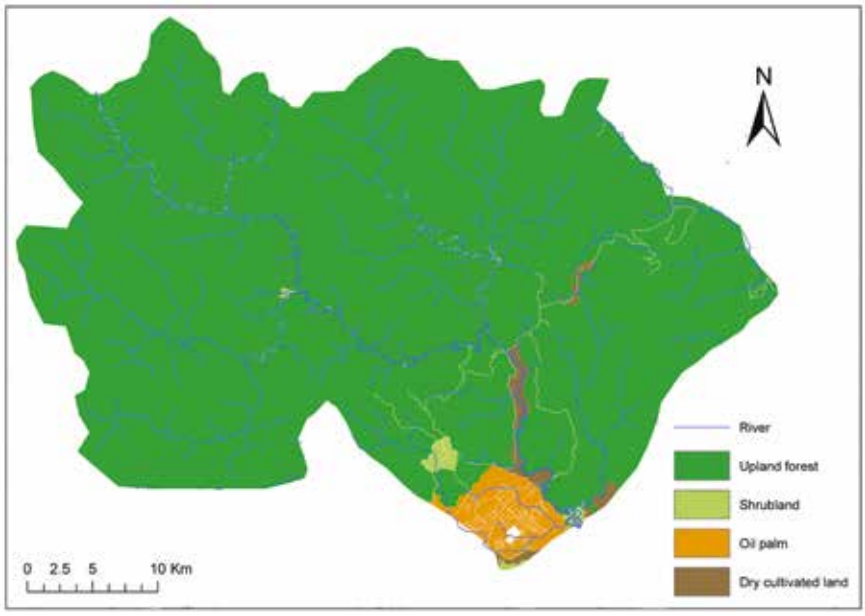

Figure 2-2b
2006 land cover map of Tulin Onsoi Sub-district

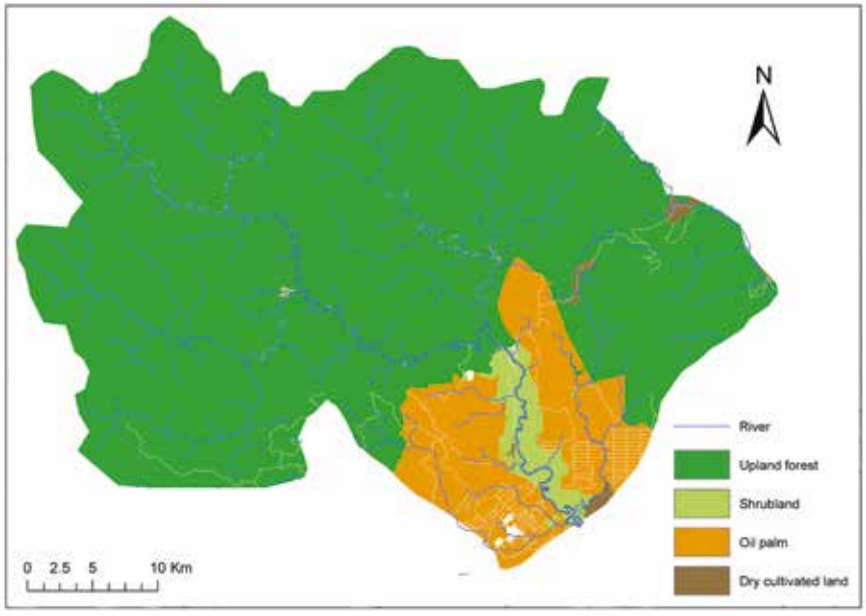

Figure 2-2c
2010 land cover map of Tulin Onsoi Sub-district

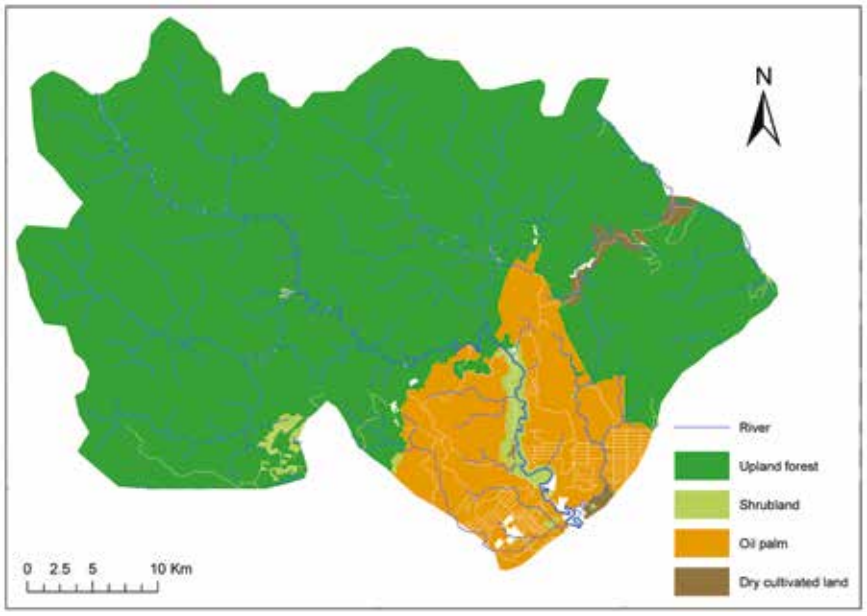

Figure 2-2d
2014 land cover map of Tulin Onsoi Sub-district

In addition to the intensification of several forms of land use [Table 2-3], a general shift in cultivation practices was observed. Between 2001 and 2006, traditional slash-and-burn agriculture adjacent to rivers and streams (the 'mixed tree and crops') was gradually replaced by 'dry cultivated land' which is characterized by an open area with herbaceous vegetation intensively managed for row crops and associated with road networks and human settlements. This was confirmed through our interviews; 52.7% of the respondents indicated that they had changed their traditional farming system to practice sedentary farming instead, and had integrated oil palm in their farming systems at the time of the interview, compared to 6.6% before 2005. The majority, however, transferred their land to the oil palm company in the NES scheme (32.5%) or sold their land directly to the company (14.8%).

The cultivation of important food crops has decreased, such as cassava (from 64.3% to 43.4%), legumes (28.1% to 13.8%), vegetables (17.1% to 9.1%) and rice (21.4% to 7.1%). Insufficient revenue from their traditional crops was given as the main reason for this general decline (54.7%). People stressed they needed to earn more money, and were forced to look for alternative incomes. Other reasons mentioned were government incentives, including local cultivation schemes that provide with seeds and fertilizers to farmers (23.1%); estate incentives that offer a profit-sharing scheme (7.4%); and the proximity to an oil palm mill (7.4%). Some disincentives were mentioned as well, specifically crop raiding by elephants (7.4%).

2.3.2 Elephant sightings and crop raiding

70.6% of the respondents had seen elephants in the wild at some time in their lives. 14.8% had only ever seen indirect evidence of their presence, i.e. tracks, trails, dung, or damage caused by elephants; 14.6% had never seen an elephant. A single individual was observed surrounding village areas in most cases (68.8%) confirming that only solitary bulls raid oil palms [Figure 2-3]. Villagers indicated to observe two peak periods during which elephants visit their village; February-March and August-October. One or two family groups were reported in the vicinity of three main rivers: Apan, Agison and Sibuda in the Sebuku Forest [Figure 2-1]. There is no information of elephant groups that move south of the Tulid River, where most villages are located.

Figure 2-3
Two solitary males of Bornean elephant were spotted during the fieldwork in Semunad village, the Tulin Onsoi Sub-district (left) while feeding on wild bananas, and while crossing the river (right) [Photos by Rachmat B. Suba (author) (left) and Arie Prasetya (right)]

According to the respondents, elephants rarely visited the cultivated lands surrounding the villages before the start of the oil palm program in 2002. Since then, the number of crop-raiding incidents has consistently increased [Figure 2-4]. Out of 215 elephant sightings, 49.3% occurred in villages with oil palm plantations (Tembalang, Kalunsayan, Sekikilan, and Semunad) and 18.6% occurred in villages that are surrounded by other crop types or natural habitat (Salang, Naputi, Tinampak I, Tinampak II, Tau Baru, and Balatikon). According to the respondents (n = 176), oil palm is by far the most frequently raided crop by elephants (59%). When villagers (n = 213) were asked about the reason why they thought elephants enter their fields, 51.3% would refer to some kind of habitat loss, e.g. 'elephants are looking for food'; 'the forest has been depleted'; and 'the forest has been destroyed by the oil-palm estates'.

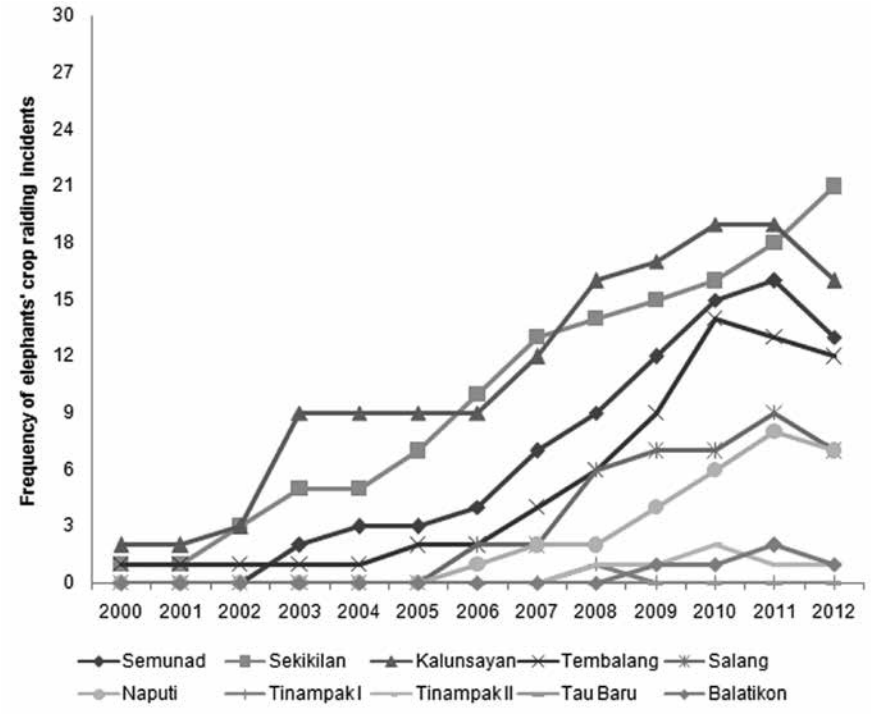

Figure 2-4
Reported frequency of elephants' crop-raiding incidents
in the ten villages of Tulin Onsoi Sub-district based on interviews

2.3.3 Attitudes towards elephants

43.2% of the respondents expressed an outright negative attitude towards elephants, with 'loss of crops' (15.5%) as the main motivation for this negative attitude. 79% of all respondents say that oil palm expansion is the main cause of HEC. About 21% also mention logging operations in the area as a cause of HEC. They claim that logging operations have destroyed some of the natural salt licks in the area and disrupted elephant movements in the Sebuku Forest.

Table 2-4
Percentage of responses (yes, no and don't know) to the question whether elephants and humans can live together in harmony and the elaborated explanation or requirement

Response	Percentage of responses (n=213)
Yes	**32.4**
Folklore (ancestor): 'we need each other'; 'we are related'	9.0
'But elephants should be tamed'	7.1
'If they cause no trouble'	5.7
No further comments; don't know; other	5.4
'They should be respected'; 'if forest destruction stops'	5.2
No	**43.2**
Elephants damage the crops	15.5
People are scared of elephants	11.3
Elephants are wild animals, not pets	8.5
No further comments/other	7.9
Don't know	24.4

32.4% of the respondents believe humans can live in harmony with elephants but only under certain conditions [Table 2-4]. 43.2% believe coexistence is difficult as elephants raid crops. Affirmative answers to our questions regarding human-elephant coexistence are significantly influenced by crop damage ($P = 0.008$). The odds of affirmative answers to whether elephants and humans can live together in harmony were 2.53 times higher for people whose fields were not damaged by elephants [Table 2-5].

73.8% of the respondents answered 'yes' to the question 'do you know that elephants are protected by local customs or rights?' Dayak Agabag are significantly more knowledgeable on elephant protection legislation than other ethnic groups ($P = 0.004$ and $P = 0.02$, respectively) [Table 2-5]. The odds of an affirmative answer to whether they knew about local customs or rights and laws for elephant protection were 3.84 and 4.80 times higher, respectively, for Dayak Agabag as opposed to other ethnic groups. Although the majority of respondents are supportive of elephant conservation in the Tulin Onsoi Sub-district, they claimed that it is currently not directly benefitting them. Most respondents acknowledge that elephants are an integral part of their culture, but people also mention that elephants are causing problems, e.g.: 'the elephants are giving us a hard time nowadays' and that these problems should be tackled by government: 'If government wants to protect elephants, it should implement measures to prevent them from raiding our crops.'

Table II-5
Logistic regression analysis, with Wald χ^2 statistical test, for answers to survey questions 12, 13 and 14 [N (total respondents/households) = 213; n = affirmative answer]

Question/predictor variable	Test statistics					
	Estimate	SE	$\chi 2$	df	P	Odds ratio estimate
12 Do you think elephants and humans can live together in harmony? (n = 69)						
Ethnic group (n = 46 Dayak Abagag, n = 23 other)	-0.67	0.53	1.57	1	0.21	0.51
Age	-0.001	0.02	0.002	1	0.97	0.51
Educational background (n = 17 with no education)						
Basic education (n = 37)	0.78	0.54	2.14	1	0.14	2.19
Further education (n = 15)	0.45	0.43	1.12	1	0.29	1.57
Year of residence	0.003	0.17	0.03	1	0.87	1.00
Prior elephant crop damage (37 absent, 32 present)	0.93	0.35	7.06	1	0.008	2.53
13 Do you know that elephants are protected by local customs or rights? (n = 156)						
Ethnic group (n = 131 Dayak Abagag, n = 25 other)	1.35	0.46	8.47	1	0.004	3.84
Age	0.008	0.02	0.22	1	0.64	1.01
Educational background (n = 34 with no education)						
Basic education (n = 88)	-0.12	0.49	0.06	1	0.80	0.88
Further education (n = 34)	0.37	0.39	0.89	1	0.35	1.45
Year of residence	0.00	0.02	0.00	1	0.99	1.00
14 Do you know that elephants are protected by Indonesia law? (n = 192)						
Ethnic group (n = 154 Dayak Abagag, n = 38 other)	1.57	0.65	5.92	1	0.02	4.80
Age	0.002	0.03	0.007	1	0.93	1.00
Educational background (n = 45 with no education)						
Basic education (n = 105)	0.87	0.73	1.44	1	0.23	2.39
Further education (n = 42)	0.88	0.54	2.59	1	0.11	2.40
Year of residence	-0.01	0.02	0.22	1	0.64	0.99

2.4 Discussion

Negative perceptions of elephants are mainly caused by crop damage. This is supported by Kellert *et al*. (1996) who mention that attitudes towards wildlife may be influenced by past and present interaction. In line with this, human and elephant coexistence in the Tulin Onsoi Sub-district was historically enforced through traditional shifting cultivation systems that allowed for resource partitioning (see Fernando *et al*. 2005; Kumar *et al*. 2010; Pastorini *et al*. 2013). Between 2001 and 2014, the total land area covered by oil palm plantations in the Tulin Onsoi Sub-district increased more than 5 times, from 3,302.71 ha in 2001 to 21,124.93 ha in 2014, leading to increased elephant crop-raiding incidents. As a result, HEC has become a significant problem in the Tulin Onsoi Sub-district and attitudes towards elephants have become negative, despite the deeply rooted respect for elephants throughout history. Efforts to save the elephant and its habitat in the future depend on a local support (Nyhus *et al*. 2000; Fernando *et al*. 2005). HEC can hinder efforts to save the species (Infield 1988), although negative attitudes towards elephants have not yet led to cases of retaliation in the Tulin Onsoi Sub-district. People do worry about the costs associated with damage by elephants and are frustrated about the lack of measures that would protect them from the 'government's animals'.

Providing the needs of elephants from inside their habitat requires restoring habitat and food resources (Oelrichs *et al.* 2016). Therefore, to effectively protect the Bornean elephants and to avoid more severe HEC, it is, therefore, essential to prevent further expansion of oil palm plantations. Improving oil palm yield through better management practices could reduce pressure for expansion (Sheil *et al*. 2009). Maintaining 'buffer zones' between forested areas and human agricultural fields is suggested to aid in the mitigation of HEC (Rood *et al*. 2008; Perera 2009). In the Tulin Onsoi Sub-district, such 'buffer zones' have been assigned at 100 m buffer on each side of the Tulid River (according to the Presidential Decree No. 32/1990 about Management of Reserved Areas). Although mostly degraded, the shrublands and secondary forests of these buffer zones contain a variety of potential food plants for elephants, such as bamboo, wild bananas *Musa borneensis* and grasses *Saccharum spontaneum* (personal observation) [Figure 2-5]. Such plant species could thus serve as 'lure' plants (Nyhus *et al*. 2000) to switch elephants' attraction from raiding agricultural fields. Local conflict mitigation efforts should, therefore, include management of these buffer zones, thereby ensuring that any type of cultivation will be prohibited in such areas, although complicating factors linked to Indonesian legislative issues regarding land ownership and compensation would have to be tackled (Fredriksson 2005). While paying compensation could increase the tolerance level of local farmers towards elephants, it is open to considerable abuse (Tchamba 1996). Successful implementation of any compensation scheme entails careful monitor-

ing of the economic value of crop losses by elephants (Zhang & Wang 2003; He *et al*. 2011) to avoid over-estimation of crop damage.

Figure 2-5
Degraded forest landscapes dominated by wild bananas in the Tulin Onsoi Sub-district could benefit elephants living on the forest – non-forest interface [Photos by Rachmat B. Suba (author)]

The timing of crop raiding and its relation to environmental factors are also important considerations in the design of effective short-term strategies to mitigate HEC (Chiyo *et al*. 2005). By knowing this, early warning and vigilant response can be applied in community-based guarding systems to reduce HEC (Hedges & Gunaryadi 2009; Oelrichs *et al.* 2016). Efforts by WWF-Indonesia to deter elephants from crop raiding in the Tulin Onsoi Sub-district using noise cannons made of bamboo filled with carbide [Figure 2-6] have shown promising results and could thus be integrated into future HEC mitigation strategies. Using a special local elephant control team has shown to be effective in minimizing crop damage during elephant visits to village areas in the Sekikilan village (WWF 2011). Although this method is widely used, it requires specialized training and well-regulated night watch shifts to minimize the risks that arise from direct confrontations with elephants.

Fostering cultural values that enable people to live in close proximity to elephants could help to support elephant conservation (Fernando *et al.* 2005). Education as a tool in the prevention of HEC (Zhang & Wang 2003;

Fernando *et al*. 2008; He *et al*. 2011; Jayewardene 2011) could also assist local mitigation efforts. Reinvigorating the local traditional knowledge and perceptions on elephants could at least serve as a basis to reinstate a sense of common responsibility for the protections of elephants.

Figure II-6
Bamboo cannons filled with carbide are used to deter elephants in the Tulin Onsoi sub-district [Source: WWF-Indonesia Kalimantan Program]

2.5 Implications for conservation

Our study shows that crop raiding by elephants is a significant and growing problem in the Tulin Onsoi Sub-district. Effective mitigation measures are urgently required and if local support fails to actually target the villagers' concerns, attitudes toward elephants could become even more negative and fear could turn into frustration. Traditional beliefs and local knowledge values will then no longer protect the elephants.

Preventing further encroachment of oil palm plantations in elephant habitat is a key to stop further population declines and make way for the re-establishment of a viable elephant population in Kalimantan. Hence the Indonesian Government (national and local) assisted by conservation organizations should ensure that policies that regulate land use change are compatible with the conservation of the Bornean elephant. The recently developed 'Conser-

vation Strategy and Action Plan of Bornean Elephants' includes promising ideas on collaborative protection efforts between the regional government and policy makers in the Nunukan District [The 2011 Workshop on Conservation Strategy and Action Plan of Bornean Elephants in Nunukan District].

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