A Pilot Study of Cultivating Non-Preferred Crops to Mitigate Human-Elephant Conflict in the Buffer Zone of Yok Don National Park, Vietnam

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Abstract. We assessed implementing intercropping with annual and perennial non-preferred crops to mitigate human-elephant conflict in the buffer zone of Yok Don National Park. Annual and perennial crops were intercropped in four experimental models in three areas. Eleven households implemented experimental plots. Another 11 plots with traditional crops were selected as controls. The experimental crops did well and were not consumed by elephants but the control plots suffered elephant damage. The income from experimental annual crops was lower than from traditional crops. However, once the perennial crops reach harvesting, the income is expected to be equal to or higher than that obtained by traditional crops, without worries about raiding by elephants. The pilots are being monitored and evaluated for long-term feasibility.

Introduction

Community participation is an important aspect of effective human-elephant conflict (HEC) mitigation (Gunyardi *et al*. 2017). Community-based approaches have been piloted by a number of HEC mitigation projects including the "Elephants and Bees Project" in Kenya (King *et al*. 2017) and community-based crop guarding in Indonesia (Gunaryadi *et al*. 2017). Planting thorny plant species such as agave, cacti and bougainvillea as biological fences has been tried out in Sri Lanka but has proven unsuccessful (Fernando *et al*. 2008). Similarly planting mauritius thorn in African countries has been ineffective (Parker *at al*. 2007). Chilli fences have been constructed by farmers around Mikumi National Park in Tanzania (Chang'a *et al*. 2016). Alternative crops have been tried in African and Asian countries (Parker & Osborn 2006; Gross *et al*. 2016, 2017; Wahed *et al*. 2016).

We propose non-preferred crop cultivation as a method of reducing HEC in the Yok Don National Park buffer zone. We initiated a pilot study to assess its feasibility in January 2018. The objectives of the study were to identify areas with HEC and assess the possibility of intercropping with long- and short-term non-preferred crops, in the buffer zone of Yok Don.

Materials and methods

Study area

Yok Don National Park (YDNP) with a 115,545 ha area, is located in the Dak Lak Province in the Central Highlands of Vietnam. It is bounded in the north by Ea Bung and Cu M'Lan communes of Ea Sup District, in the south by Ea Po and Dak Wil communes of Cu Jut district of Dak Nong province, in the west by the Cambodian border, and on the east by provincial road No. 1 and the Srepok River. The buffer zone of the park covers an area of 133,890 ha. It includes seven communes in three districts of Dak Lak and Dak Nong provinces, situated to the north, south, and east of the park. The Drang Phok village is located inside the park. The buffer zone at its widest is about 26 km and at its narrowest is about 1.6 km. The study area was the farming areas of the Drang Phok village and the neighbouring villages in the buffer zone belonging to the Krong Na commune, Buon Don district, Dak Lak province, amounting

to approximately 336 ha (Fig. 1). The climate of YDNP is dry and hot with two distinct seasons. The rainy season is from May to November with a rainfall of about 76% of the annual rainfall. The dry season is from December to April.

Around 70–100 wild Asian elephants (*Elephas maximus*) are resident in the park (Dak Lak Elephant Conservation Centre 2018), making it the largest elephant population in the country, representing around 75% of the elephants in Vietnam. The Krong Na commune was farmed by the M'Nong, Ede and Lao ethnic minority groups, who faced crop damage by elephants.

Field deployment

A workshop for 14 stakeholders, consisting of rangers, technical staff of YDNP, head of Dak Lak Elephant Conservation Centre (DECC), head of the Agriculture Agency of Buon Don District, Krong Na commune leaders and heads of villages, was held in YDNP on 9th March 2018 (Fig. 2). They were informed of the research and their cooperation requested.

Figure 2. Stakeholders workshop in YDNP.

Secondary data was obtained from reports on farming, elephant tracking data using SMART, documents in YDNP, elephant tracking and annual DECC reports, reports on economic and social development and crop damage reports in Krong Na commune people's committee.

Discussions were held with nine groups of 40 participants each, consisting of leaders, technical staff and forest rangers, to identify elephant distribution, movement and areas of HEC. Interviews were conducted with occupants from 15 households who suffered losses, about the occurrence of elephants and damage, and farming practices.
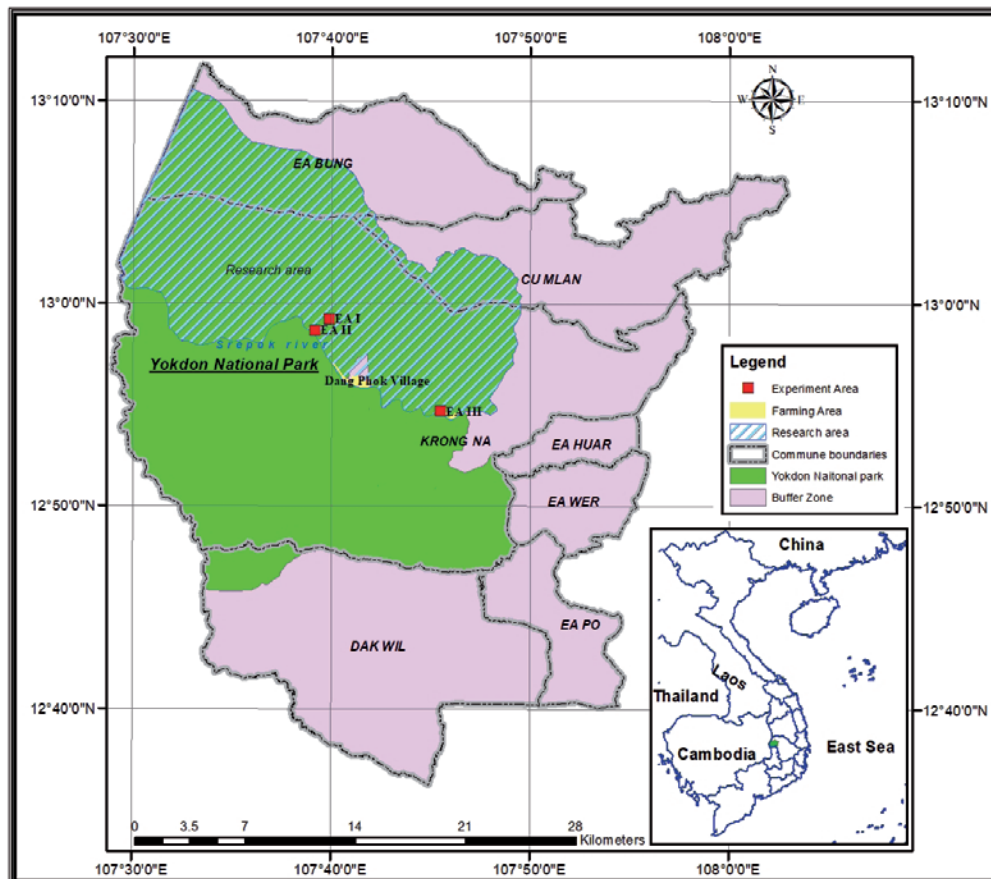
Figure 1. Map of Yok Don National Park and study sites.

Based on the results, three areas for implementing the pilot models were identified.

Two group discussions were held with the participation of 20 households from Drang Phok, Ea Mar, Ea Rong and Buon Don villages, to design pilots based on Participatory Technique Development (Fig. 3).

Pilots were set up in the three areas with 1–3 intercropping models in plots of 1600 m^2 repeated 2–3 times in each pilot. Pilot models were planted in June 2018 (Fig. 4). The growth of annual crops was measured once a month and at harvest. Growth of perennial crops was measured every three months. At each survey elephant sign and HEC incidents were also recorded.

Results

Elephants were present over the entire park. Six farming areas had damage from elephants (Fig. 5). Elephant herds and males were observed in the farming areas during the rainy season and caused damage in areas I – III and VI. In the dry season, there were only 1–2 males and they caused damage in areas II – VI.

Experiment areas

In the areas selected for the pilots, people cultivated annual crops such as corn, rice and cassava once a year. There were differences in HEC levels and farming practices between the areas. Experimental area (EA) I had several sugarcane fields. There were no protective fences and damage by elephants was common. Single elephants and herds occurred every year. Crop damage in particular fields ranged from 60–100%. Five of seven households did not cultivate for three years from 2015–2017 because of elephants. EA II had sugarcane and cashew cultivations. Several farms had simple barriers but elephants still caused damage. Single males occurred every year and sometimes elephant herds. Crop losses ranged from 30–50%. Two of ten households did not cultivate from 2015–2016 due to elephants. Many fields were also not cultivated because the productivity of crops was not high. EA III had cashew, coffee and banana cultivations. Temporary fences protected farms and YDNP rangers helped drive away elephants. Single males appeared regularly every year. Crop damage was less than 30%. Households continued cultivating, but were afraid of elephant raiding. Some fields were uncultivated because the productivity of crops was not high.

Crop species and experimental models

Annual crops selected were taro (*Colocasia esculenta*), turmeric (*Cuscuma longa*), chili (*Capsicum* sp.) and eggplant (*Solanum* sp.). Perennial crops selected were teak (*Tectona grandis*), tamarind (*Tamarindus indica*), pomelo (*Citrus maxima*) and jujube (*Ziziphus mauritiana*). Four experimental models were designed with a perennial crop + annual crop/s with replicates planted in 1600 m^2 plots. Eleven households were selected to deploy the experimental models. One household in EA I implemented two models (Table 1).

The combination of tamarind + taro and tumeric (M) was chosen by 8 households in all three EAs because tamarind has wide adaptability, its care is simple, does not need irrigation in the dry season and has a good market. As the models of
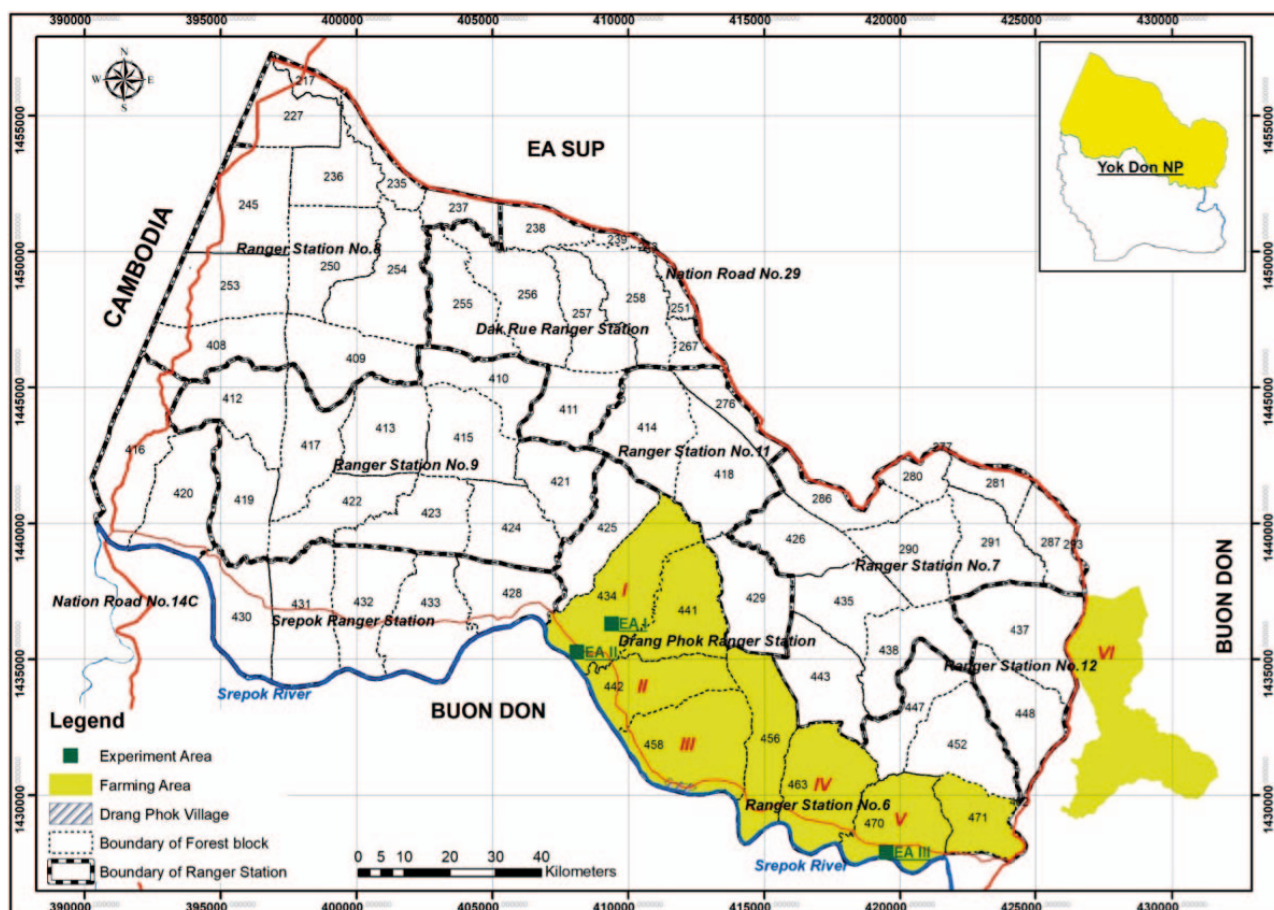

Figure 3. Discussion in Drang Phok village

Figure 4. Providing the seedings to the farmers.

Figure 5. Map of farming areas and experiment areas.

pomelo (B) or jujube (Ta) + chilli and eggplant required more tending and required irrigation, their implementation was only possible in EA III (one household each). The model with teak (T) was selected only by two households with fields in EA I because of issues with soil suitability.

Eleven control plots were set up adjacent to the experimental plots, with previously cultivated crops such as cassava and corn. Two of the control plots had huts and banana plants. There was no difference between experimental and control plots with regard to fences or guarding.

Perennial crops

After 13 months from planting, the average survival rate of teak was 87%, pomelo 93%, jujube 86% and tamarind 70 ± 31.2%. The average height of teak was 211.5 cm, pomelo 129.9 cm, jujube 143.8 cm and tamarind 67.1 ± 19.6 cm. The average diameter at the base of teak was 39.1 mm, pomelo 31.9 mm, jujube 20.8 mm and tamarind 16.4 ± 5.4 mm.

The estimated time from planting to harvest for teak is around 12 years, for tamarind and

Table 1. Intercropping models, number of plots and area planted in the three EAs.

EA	Model	Crops	# plots	Area (m²)	# households
I	T	teak + taro	2	3,200	2
I	M	tamarind + taro, turmeric	4	6,400	4
II	M	tamarind + taro, turmeric	3	4,800	3
III	M	tamarind + taro, turmeric	3	4,800	1
III	B	pomelo + chilli, eggplant, turmeric	3	4,800	1
III	Ta	jujube + chilli, eggplant	3	4,800	1
Total			18	28,800	11

pomelo 5 years and jujube 4 years. The expected income per 1000 m^2 of tamarind is about US$ 226, pomelo about US$ 250 and jujube about US$ 227. For teak, the total expected income at harvest is about US$ 4348, so the average income will be US$ 362 per year.

Annual crops

Cultivation times (planting to harvest) for taro was 6 months, turmeric 7–8 months, eggplant and chilli 2 months. The average survival of taro was 90 ± 6.1%, chilli 85 ± 7.1%, eggplant 90 ± 7.1% and turmeric 65 ± 20.8%. The average yields per ha obtained were taro 6.4 ± 0.0 tons, turmeric 6.8 ± 4.0 tons, eggplant 6.9 ± 0.3 tons, chilli 1.8 ± 0.0 tons. The average income per 1000 m^2 of cultivation was taro US$ 174, turmeric US$ 53 ± 52.3, eggplant US$ 44 ± 6.7, and chilli US$ 50 ± 5.3.

For traditional crops, time from planting to harvest were; corn 4 months, cassava 6 months or one year, rice 3–5 months depending on the variety, sugarcane 12 months but harvested for 3 years then replanted. The average yields reached per ha were, cassava 6.2 tons, corn 5 tons, rice 6.5 tons and sugarcane 50 tons. The average income per 1000 m^2 of cultivation was cassava US$ 450, corn US$ 600, rice US$ 35, and sugarcane US$ 217.

If raided by elephants, fields of corn, sugarcane and rice are usually almost completely damaged and cassava fields damaged 20–80%. In the last three years cassava has also been infected with leaf mosaic virus, with many households suffering 100% damage.

Elephant occurrence and damage in EAs

Over 14 months (June 2018 – August 2019) elephant herds and individual males occurred nine times near and in EA I. On three occasions they raided the control plots, consuming corn, rice and cassava. The experimental plots were not broken into. In EA II, elephants appeared twice, once a herd of over 20 individuals and once a single male. Both times they entered the control plots planted with sugarcane and cassava,

but did not break into the experimental plots. Lone males came twice to EA III during the dry season, both times breaking into the control plots and destroying a hut and consuming bananas and corn. They passed through the experimental models III.B and III.Ta bending and breaking some branches of pomelo and jujube in their paths, but it did not affect tree growth and they did not consume any crops.

Discussion

Our results suggest that both the planted perennial and annual crops did well under the conditions of cultivation and care by local people in the study area. The income from experimental annual crops was initially low, but they were not raided by elephants. Therefore, in view of the risk of raiding traditional crops, the experimental crops could be a viable alternative. Moreover, the plan is for intercropping with short-term crops only in the first 5–6 years of the models, to take advantage of land and space while waiting for maturing of the perennial crops. When the perennial crops are harvested, the households will have a high income, equal to or higher than that obtained by traditional crops over the same period, without worries about being raided by elephants. Considering that many fields were not cultivated due to fear of destruction by elephants, cultivation of non-preferred crops is a viable alternative.

We found that there was no depredation of the experimental crops, but that elephants broke into the control plots with traditional crops. Some damage occurred in the experimental plots due to elephants moving through them and breaking or bending branches of pomelo and jujube trees. However this did not negatively impact growth of the trees. The short-term crops taro, turmeric, chilli and eggplant were completely unaffected by elephants. According to Fernando *et al*. (2008) in Sri Lanka, teak was not previously eaten by elephants, but when teak plantations became abundant, elephants began eating the bark, uprooting and destroying many teak trees. Therefore, monitoring the experiment models inter-cropped with teak will be continued to assess the long-term viability.

The experimental models are still being monitored and evaluated for feasibility, especially in the case of the long-term crops. If it is concluded that the tested non-preferred crops are a viable alternative, then it could be applied to farms that have been severely damaged by elephants and those not cultivated because of elephants. The cultivation of crops such as rice and corn are long-standing practices of the local people, both as a source of food and income. Similarly cassava is planted because of the simplicity of its cultivation and the product can be sold on the spot. Therefore the local farmers may not give up planting of traditional crops immediately. Completely giving up traditional crops will require time and should be attempted in association with land use planning that takes into account the status and level of HEC in each locality. In addition, there is also a need for mechanisms, policies and coordination of stakeholders to support farmers throughout the process.

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