

Land Use and Human-Elephant Conflict in the Sigiriya Sanctuary, Sri Lanka

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Abstract. Human dominated habitats are an integral part of the Sigiriya Sanctuary, making human-elephant conflict a major issue. We studied the extent and patterns of agriculture, conflict and mitigation, based on a grid-based questionnaire survey. The main agricultural practices were dry season highland onion cultivation, and wet season lowland paddy cultivation. Seasonally alternating cultivation allowed elephants and people to share resources, but also led to year round conflict. The fine scale habitat heterogeneity in Sigiriya made coarse separation of human and elephant areas ineffective. Community and farmer based permanent and seasonal electric fences maybe a more effective approach to mitigating human-elephant conflict in Sigiriya.

Introduction

Sigiriya is a place of great historical and archaeological significance and is a UNESCO 'World Heritage site' within the 'Cultural Triangle' of Sri Lanka. The 200 m high Sigiriya rock situated in the center is famed for the palace that was built on top in 477 AD, the lion gateway, mirror wall and the frescoes of ladies on the rock face. It was surrounded by landscaped gardens and was the center of a planned city. Sigiriya is one of the major tourist attractions in Sri Lanka.

Although best known for its archaeological aspects, the Sigiriya Sanctuary also forms part of a large landscape with Asian elephants (*Elephas maximus*) in north-central Sri Lanka as elephants occur in and around the Sigiriya Sanctuary. The eastern edge of Sigiriya Sanctuary is close to the Minneriya National Park where more than 400 elephants annually congregate in the dry season and on the western side it lies in close proximity to the Digampatana Forest Reserve, which is also frequented by elephants. By serving as foraging grounds, refuges and linkages in landscapes that support elephants, areas such as the Sigiriya Sanctuary play an important role in the conservation of Asian elephants (Fernando & Leimgruber, 2011).

Sigiriya was declared as a Sanctuary in 1990 under the Fauna and Flora Protection Ordinance. 'Sanctuary' carries the lowest level of protection among the protected areas under the Department of Wildlife Conservation Sri Lanka. As with other such Sanctuaries, the Sigiriya Sanctuary consists of state and privately owned lands and human activities are a prominent aspect. Human-elephant conflict (HEC) has intensified in the Sigiriya Sanctuary over the past few years. Identifying the underlying local causes and patterns of HEC is important for its mitigation (Fernando *et al.* 2005). The aim of this study was to understand the relationship between land use patterns and HEC in the Sigiriya Sanctuary and thus contribute to mitigating the conflict.

Methods

The Sigiriya Sanctuary covers an area of approximately 5122 ha and is situated at N 7° 57' 23.07" E 80° 45' 34.47". Some areas of the sanctuary are natural habitats, while others are human habitats consisting of croplands and settlements. There are 38 minor fresh water irrigation reservoirs scattered over the Sanctuary. Being situated in the dry zone of Sri Lanka, the rainfall is seasonal with most of the annual precipitation occurring during the northeast

monsoon from October to December. The main cultivation season or 'Maha' coincides with the monsoon and extends from about November to March. The secondary cultivation season or 'Yala' occurs subsequently during the dry season.

Land use at a coarse scale was estimated with Google Earth imagery and demarcating 'forest' and 'developed area' polygons done by hand from visual assessment. Field data collection was done from January to July 2013. A questionnaire was used to collect information from villagers. The questionnaire survey was based on a 1 km² grid aligned with the 25 km² UTM National Grid. In each grid, three residents chosen in an *ad hoc* manner were interviewed.

To find out about the nature of the conflict, questions were asked about landownership; the extent, type and timing of cultivation; extents and patterns of losses from elephants; and social groupings of elephants causing damage. Additional data for conflict incidents, human and elephant deaths, and HEC mitigation actions were obtained from records maintained by the Local Government Administration and the Department of Wildlife Conservation.

Results

Land use patterns

Of the Sigiriya Sanctuary, 55% of land remains as forest cover (2902 ha), while the balance (2334 ha) has been developed for settlement, agriculture and other infrastructure (Fig. 1). Analysis of Google Earth imagery showed a high level of fragmentation of natural habitat with convoluted and scalloped edges suggesting historical and on-going encroachment.

Respondents

In total 115 persons were interviewed. Of the respondents 60% were males and 40% females, aged between 21-90 years, with the largest group being in the 31-40 year category. The mean size of a household was 4.32 persons (± 1.28 SD, range 1-7). The mean period of occupancy of the sanctuary by respondents was 31.41 years

(± 16.3 SD; range 10-83). The majority (92%) of respondents were farmers and the rest worked in the government and private sectors as teachers, drivers, laborers and tourist guides.

Cultivation patterns

Two main types of cultivation were done, lowland and upland. Of those doing lowland cultivation 72% owned the land they cultivated. The mean size of lowland cultivation plots was 1.91 acres (± 1.22 SD; range 0.25-7) in the Maha season and 1.23 acres (± 0.7 SD; range 0.25-3) in the Yala season. Of the respondents 21% and 80% cultivated lowland plots in the Yala and Maha seasons respectively. All lowland plots were cultivated with paddy.

Of those doing upland cultivation, 77% owned the land they cultivated. The mean size of upland areas cultivated was 1.34 acres (± 0.92 SD; range 0.5-3) in the Maha season and 1.28 acres (± 0.81 SD; range 0.25-4) in the Yala season. Of the respondents 81% and 11% cultivated upland plots in the Yala and Maha seasons respectively. The main crop in upland cultivation was onion. Other vegetables such as maize and chilies were cultivated in a small scale.

Income and expenditure

Yala cultivation provided an income ranging from Rs. 12,000-2,500,000 (US\$ 120-25,000)

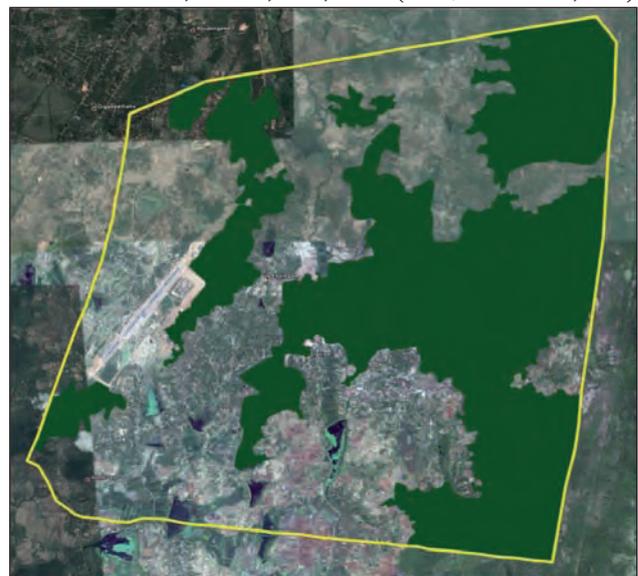


Figure 1. Land use pattern in the Sigiriya Sanctuary based on Google Earth imagery.

per farmer with a mean of Rs. 411,115. Maha cultivation provided incomes ranging from 6,000 - 600,000 (US\$ 60-6000) with a mean of Rs.124,642.

HEC

The majority of respondents (85%) perceived HEC as a major problem and 10%, 4% and 1% as moderate, minor and not a problem respectively. The incidence of crop raiding experienced by respondents was 2.4 incidents/km² in 2011 and 2.8 incidents/km² in 2012. Of the respondents 77.6% said crop damage was the most common form of HEC. Crop damages were experienced in both seasons by 47% of respondents and in the Yala season only by 43% and by 8.6% in the Maha season only. During the period 2008-2012 there were 41 incidents of property damage, 4 human deaths and 3 injuries within the Sanctuary.

The majority of the respondents (91%) felt that the measures to reduce HEC should be mainly taken by the Department of Wildlife Conservation. When asked about the methods they currently used to prevent crop depredation by elephants, 99% of respondents said they used shouting, 98% firecrackers, 97% flashlights, 93% thunder-flashes (large firecrackers); 83% lighted fires; 6% shot at elephants and 4% set up trap guns.

When asked what more needs to be done to mitigate HEC, 95% of respondents said that electric fences that protect their crops and villages are necessary. When asked whose responsibility it would be to maintain such electric fences, 88% of respondents said that it is the responsibility of the villagers. Of the respondents, 95% were willing to set-up societies and contribute manpower, for construction and maintenance of electric fences. Most (95%) of respondents were willing to pay for such electric fences and 55% expressed willingness to pay Rs. 1000 (\$ 10), 28% Rs. 5000 (\$ 50), 10% Rs. 10,000 (\$ 100) and 2% Rs. 25,000 (\$ 250).

When asked which social groups of elephants caused crop damage, 97% of respondents said single adult males, 89% said groups of less than 5 without juveniles or babies and 18% said

groups of more than 5 individuals with juveniles and babies caused damage. During 2008-2012 HEC resulted in the death of 9 elephants in the Sanctuary. Of these, seven were male and two were female elephants. The causes of death consisted of 6 due to gunshot injuries, 2 from electrocution, and 1 by falling into a well.

Current management actions

Compensation for property damage: The total loss of property due to HEC increased from 2008 - 2011 and decreased somewhat in 2012 (Fig. 2). In the period 2008-2012, the total property loss was estimated to be Rs 1,708,239 (US\$ 17,082) and Rs, 1,033,740 (US\$ 10,337) were paid out as compensation by the Department of Wildlife Conservation.

Providing thunder flashes: Thunder flashes are very large firecrackers approximately 25 cm in length, which are thrown at elephants to chase them. Supply of thunder flashes was done throughout the year by the Department of Wildlife Conservation. The total number of thunder flashes distributed by the Department of Wildlife Conservation was 4158 in 2011 and 4037 in 2012.

Electric fences: The Department of Wildlife Conservation constructed three electric fences (Fig. 3) in different periods within the Sanctuary to mitigate HEC: The Mahasengama fence (20 km) in 2008, Wewela-Diyakepilla fence (5 km) in 2010 and Diyakepilla fence (5.2 km) in 2012. Of these the Diyakepilla fence was constructed

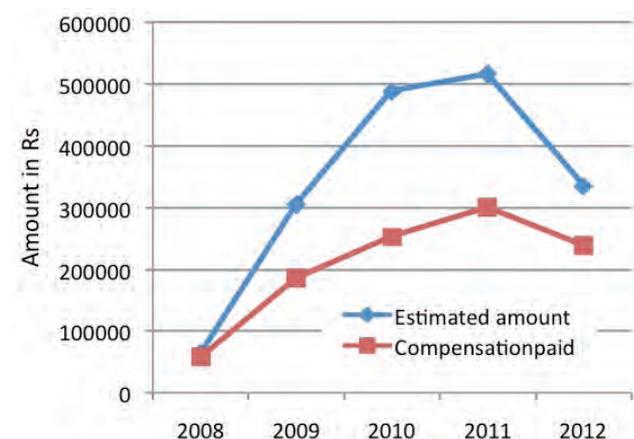


Figure 2. Property damage and compensation paid (2008-2012).

around a community but included the seasonally cultivated fields. The fences were previously maintained by the Department of Wildlife Conservation, but since 2012 they are being maintained by the Civil Defense Department.

Discussion

As the questionnaire survey was based on a grid system covering the entire Sanctuary, the respondents were representative of all the villages located within the Sanctuary and the people living there. Consequently the information obtained is representative of the Sigiriya Sanctuary. The majority of people resident in the Sigiriya Sanctuary were farmers and most of them owned and cultivated lowland and upland plots.

By monitoring crop damage incidents on the ground, Ekanayake *et al.* (2011) found the incidence of HEC in southeastern Sri Lanka to be 2.2 incidents/km². Thus the annual HEC incidence of 2.4-2.8 incidents/km² from interview of only 3 residents/km² in Sigiriya indicates an extremely high level of HEC.

The major crop in the main season or Maha was paddy and in the secondary season or Yala it

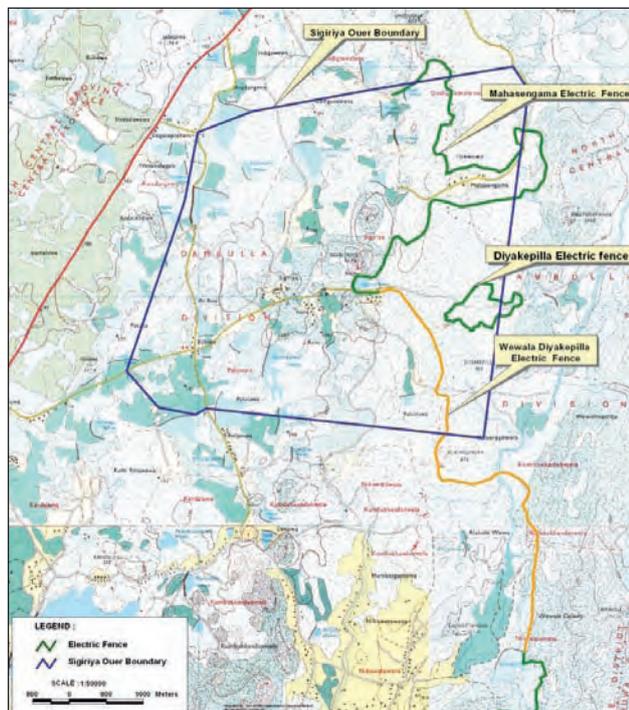


Figure 3. Existing electric fences at Sigiriya Sanctuary.

was onions. Unlike in other parts of Sri Lanka, where farmers obtained their main income from Maha season paddy cultivation, the farmers in Sigiriya received a much greater income from the Yala season onion cultivation. Cultivation in the Sigiriya Sanctuary was mainly commercial rather than subsistence in nature.

Upland plots were mainly cultivated during the drier Yala season as there was too much water in the wet season to grow onions. The lowland plots were mainly cultivated with paddy during the monsoon in the Maha season. The alternation between the upland and lowland cultivations in Yala and Maha seasons meant most plots were cultivated only one season per year. This resulted in grass and scrub growth in fields during the uncultivated period.

Growth of natural vegetation following harvesting in agricultural areas provides a large amount of fodder for elephants and amounts to habitat enrichment for elephants that benefits them greatly (Pastorini *et al.* 2012). While in most areas such regenerative growth of natural vegetation was limited to the dry season when fields were not cultivated (Pastorini *et al.* 2013), in Sigiriya it occurred in both wet and dry seasons due to the alteration of upland and lowland cultivation between seasons. Therefore, as well as areas of natural vegetation, elephants utilized uncultivated agricultural lands seasonally throughout the year. The cultivation patterns in Sigiriya Sanctuary benefitted elephants but also led to high HEC year round. Therefore the spatial and temporal land use pattern has a significant effect on HEC in Sigiriya Sanctuary.

In most situations fragmentation of forest by agriculture causes loss of elephant habitat and increases HEC (Hedges *et al.* 2005; Fernando *et al.* 2008). Similarly fragmentation in Sigiriya Sanctuary resulted in elephants raiding the abundant crops in close proximity to their forest and scrub refuges. Demarcation of the remaining natural areas within the Sigiriya Sanctuary with boundary posts would prevent encroachment and further fragmentation, therefore check further spread of HEC and loss of natural habitat.

The main cause of HEC in Sigiriya was found to be crop raiding by single males and male elephant groups. A similar finding was reported by Ekanayake *et al.* (2011) in Southeastern Sri Lanka. However, many elephant management actions for HEC mitigation do not differentiate between males and female groups (Fernando *et al.* 2005). Activities such as distribution of thunder flashes and payment of compensation imposed a heavy burden on the Department of Wildlife Conservation and had limited effectiveness in mitigating HEC. They tended to reinforce the culpability of the Department of Wildlife Conservation for elephant damage and in the case of thunder flashes, elephants became non-responsive to them after a while or reacted with aggression. To be effective and minimize detrimental effects on elephant conservation, elephant management in HEC mitigation needs to focus on problem causing males rather than elephants in general.

The alternating single season cultivation of lowland and upland areas created a dynamic landscape with crops, re-generating vegetation and uncultivated areas interspersed with each other in a fine-scale mosaic. The spatial and temporal landscape heterogeneity in Sigiriya Sanctuary does not allow easy demarcation of elephant and human use areas at a coarse scale. Electric fences previously erected in Sigiriya Sanctuary to effect such coarse separation obstruct elephant movement across the Sanctuary and is likely to encourage fence breaking by elephants. Additionally, as the Mahasengama and Wewela-Diyakepilla fences are linear fences and not enclosure/exclosure fences, elephants are found on both sides of them. Such fences lead to increase in HEC not its resolution (Fernando *et al.* 2005).

The Diyakepilla fence, which is an exclosure fence, is a better approach. However, the fine-scale heterogeneity in elephant and human habitat in Sigiriya Sanctuary severely limits the application of this approach if the fences are to be constructed and maintained by the Wildlife Conservation Department or other government agency and not the people. Farmer-based seasonal electric fences to protect seasonal

cultivations and community-based permanent electric fences to protect settlements will be a more effective approach in mitigating HEC in Sigiriya Sanctuary. The high level of interest and willingness to construct, maintain and pay for such fences expressed by villagers in the Sigiriya Sanctuary, suggests that such an approach would be successful.

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