A Spatial Analysis of Human-Elephant Conflict in the Tsavo Ecosystem

Robert J. Smith and Samuel M. Kasiki

Executive Summary

A. Human-elephant conflict and GISs

1) Conflict between humans and African elephants (*Loxodonta africana*) occurs wherever the two species co-exist, especially in the interface between the elephants' range and agricultural land. Most human-elephant conflict (HEC) incidents involve crop-raiding animals that consume or destroy food crops and injure or kill those people trying to protect their fields.

2) As well as directly affecting some of Africa's poorest people, HEC influences the attitudes of people living nearby. These communities often resent the presence of elephants and the conservation authorities and protected areas (PAs) that help to maintain elephant numbers. This can lead to the failure of elephant and biodiversity conservation measures that rely on the support of local people.

3) The Human-Elephant Conflict Taskforce (HETF) was formed in 1997 with the aim of understanding HEC and identifying suitable mitigation measures. Part of this process involves collecting standardised data to quantify levels of HEC and assessing the impact of any mitigation strategies. In addition, the HETF aim to analyse these HEC data to identify which factors determine its occurrence.

4) HEC is a spatial phenomenon and so it is important to investigate the effects of spatially explicit factors on its distribution. Therefore, the HETF have recognised that geographical information systems (GISs) should play an important role in the analysis of HEC. These systems allow the integration and manipulation of a range of spatial data and can be used to predict the effects of HEC mitigation measures.

5) This report describes a GIS-based analysis of HEC data from a region in East Africa. It was completed at the request of the HETF to act as a case study for understanding HEC in savanna ecosystems. In addition, this report aims to comment on the applicability of the proposed HETF database for this type of analysis and to develop a standardised methodology for further research.

B. Human-elephant conflict in Taita Taveta district

1) The Tsavo ecosystem, which is an area of approximately 43 000 km^2 in the south east of Kenya, had an estimated elephant population of 8 100 in 1999. This population had increased dramatically during the 1950s and 60s but a period of drought, followed by extensive poaching, reduced this by 85%, leaving 5 600 elephants in 1988. The control of this poaching has since led to a steady increase in elephant numbers.

2) Taita Taveta district is an area of 5 000 km^2 that makes up part of the Tsavo ecosystem. It is surrounded on three sides by Tsavo East and West National Parks (NPs) and shares 80% of its perimeter with these protected areas (PAs). In 1997 the estimated human population in the ecosystem was 393 250 and the annual growth rate was 3.8%.

3) The recent increase in both the human and elephant populations has led to a similar increase in HEC. During a three year period from July 1994 to June 1997 there were 1448 such incidents in Taita Taveta district, most of which involved crop-raiding elephants.

4) The majority of the crop-raiding elephants travelled in family groups of 6 or more which were often accompanied by mature bulls. Similar studies from Zimbabwe and India found that most crop-raiding elephants were lone bulls and so the factors that determine spatial patterns of HEC at these sites may differ from those of Taita Taveta.

5) In 1996 an electric fence was built to reduce HEC in Taita Taveta at an estimated cost of US $324 000. The fence is 30 km long and is situated along the PA boundary in the north-east of the district, where HEC was most prevalent.

C. The factors that determine HEC in the Taita Taveta

1) Three years of incident data were used to find the factors that determined the spatial pattern of HEC in Taita Taveta. This analysis involved dividing Taita Taveta into 31 study blocks that ranged in size from 8.5 km^2 to 426 km^2. A GIS was used to calculate the HEC incident density and spatial characteristics of each study block and the data were analysed using general linear models.

2) The efficacy of the fence was investigated by using a paired t-test to determine whether the HEC densities in the study blocks were significantly different before and after its construction. In addition, a linear regression model was used to test whether those blocks that were most separated from the NPs by the fence experienced a corresponding reduction in HEC levels.

3) HEC incident density in the study blocks was significantly and negatively related to their mean distance to permanent water, mean elevation and the perimeter that they shared with the NPs. The same three factors were significant when looking at annual patterns of HEC, as well as patterns recorded in the low HEC season, the high HEC season (when crops were ripe), the dry season and the rainy season.

4) HEC levels were significantly lower in those study blocks that bordered the NPs. This suggests that local people and the Kenya Wildlife Service (KWS) are using strategies that are successfully mitigating HEC. KWS tend to focus their problem animal control in these areas and the residents have stopped growing crop types that particularly attract elephants.

5) The significance of distance to permanent water, even during the rainy season, was probably partly due to its correlation with human, crop and elephant density. However, the significance of this factor in all five models, despite large fluctuations in food and water availability, suggests that another, unmeasured factor, may have been responsible for determining the observed spatial patterns.

6) One unmeasured factor could be distance from elephant migration routes as there is a similarity between their position (as identified by previous researchers) and the pattern of HEC. These migration routes tend to avoid steep slopes and higher ground which explains the significance of elevation (which was correlated with slope) in the regression models. It appears that elephants follow these routes throughout the year and crop-raid in neighbouring areas whenever food is available.

7) There was no significant difference in HEC density in the six months before and after the construction of the electric fence. Total levels of HEC were unaffected, as were the HEC densities in those study blocks that were separated from the NPs by the fence.

8) Depending on the interpretation of these results, HEC could be mitigated in Taita Taveta either by manipulating the position of artificial water-points or by allowing elephants to follow their traditional migration routes whilst preventing their access to crops. Further research is needed to identify which of these interpretations is more relevant and so ensure the success of any mitigation measures.

D. Recommendations for the analysis of HEC data

1) The arbitrary delineation of HEC zone boundaries can have a dramatic effect on HEC density calculations. Therefore, it is important to set these boundaries using a standardised methodology to allow comparisons between HEC zones. One recommended method uses a GIS to divide each study area into a series of grid squares and defines the HEC zone as those squares where HEC had occurred in the previous five years.

2) HEC data should be analysed at two different spatial scales. The first should be at the continental or regional scale and would treat each HEC zone as one data point. This type of analysis would investigate the influence of funding and mitigation strategies on HEC.

3) The second type of analysis should be at the HEC zone scale and would investigate factors that determine patterns of HEC within a zone. Any analysis at this scale should avoid spatial autocorrelation by using a GIS to divide the zone up into a series of blocks and grouping the HEC incident data accordingly. It is suggested that this type of analysis should adopt the grid system used to define the HEC zone boundaries.

4) The co-ordinates of each HEC incident should be recorded using a GPS unit so that these data can be grouped at a later data for analysis at the relevant scale. This could either be done as soon as the incident was recorded or at a later date by someone who would relocate the incident site by following written instructions. This second approach would allow one trained person to visit all the incident sites and so limit the number of GPS units needed to collect this information.

5) The present HETF conflict zone attribute data sheets should be amended so that data are collected for each grid square used in this analysis. Data should also be recorded on the presence and length of any electric fencing in each grid square, the percentage of the square that is cultivated and the mean distance of the square from water and PAs.

6) The HETF should use Landsat 7 TM satellite imagery as a consistent source of the spatial data that is needed for the analysis of HEC. These images would need to be processed by someone with remote sensing skills, working in conjunction with local experts. The resultant GIS coverages should be stored and documented centrally to avoid their loss or unnecessary duplication.

7) If comparisons are to be made between HEC zones then it is important that the data should be analysed using the same set of factors collected at the same scale. In addition, it is important to use the same statistical tests and it is suggested that general linear models should be used in preference. However, this test is not suitable for analysing data from HEC zones where HEC has not taken place in many of the grid squares and in this case logistic regression should be used instead.

8) Experience from Taita Taveta shows that a great deal of information on traditional elephant migration routes can be obtained by consulting with long-term local residents. This information could be mapped by asking people to identify portions of the route and recording the position with a GPS unit. The proposed routes could be validated in the field and this information would be invaluable when planning the position of fences and other HEC mitigation measures.