Human–elephant conflict outlook in the Tsavo–Amboseli ecosystem, Kenya

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Abstract

We examined the extent of human–elephant conflict in the area between Amboseli, Chyulu Hills and Tsavo West National Parks in south-western Kenya. Standardized questionnaire interviews administered to 880 residents showed that crop farming has intensified in the last 3 to 10 years, with many Maasai people practising crop farming, a departure from their traditional pastoral lifestyle. Incidents of crop damage by wildlife were common and elephants were reported as the most problematic animal. Incidents of elephant crop raiding were high in the dry season and at night, linked to the wetlands, with bull groups being the dominant crop raiders. Incidence of elephant crop raiding in areas under electric fences was significantly low. Elephants preferred maize *(Zea mays)*, a crop farmers consider the most important for their livelihood. Elephants caused few livestock deaths and injuries. Among the households interviewed, 6% had had a family member killed or injured by elephants between 1999 and 2004, and elephants had caused more deaths and injuries than other wildlife species. Residents' perceptions on the importance of having elephants within the area were highly negative. The patterns of attitude towards elephants were associated with the residents' ethnic background, gender, form of land use, benefits accrued from wildlife, level of elephant crop damage, and response of the wildlife authority to problem-elephant reports.

Additional key words: crop raiding, electric fencing

Résumé

Nous avons examiné l'importance des conflits hommes-éléphants dans la région comprise entre les Parcs Nationaux d'Amboseli, de Chyulu et de Tsavo-ouest, dans le sud-ouest du Kenya. Des questionnaires standardisés proposés à 880 résidents ont révélé que les cultures se sont intensifiées au cours des 10 dernières années et que de nombreux Massais pratiquent l'agriculture, en rupture avec leur mode de vie pastoral traditionnel. Les dégâts aux cultures sont fréquents, et les éléphants sont les animaux qui causent le plus de problèmes. Les incidents causés par les éléphants sont nombreux en saison sèche et de nuit, liés aux zones humides, et les groupes de mâles sont les principaux ravageurs. Les raids des éléphants dans les plantations entourées de clôtures électriques étaient significativement moins nombreux. Les éléphants préfèrent le maïs *(Zea mays)*, la culture que les fermiers considèrent comme la plus importante pour leur subsistance. Les éléphants ont causé la mort et des blessures à quelques animaux domestiques. Dans les foyers interrogés, 6% avaient eu un membre de la famille tué ou blessé par des éléphants entre 1999 et 2004, et les éléphants avaient causé plus de morts et de blessures que les autres animaux sauvages. Les impressions des résidents quant à l'importance d'avoir des éléphants dans la région étaient très négatives, et le schéma des attitudes envers les éléphants était associé au background ethnique des résidents, à leur sexe, à la façon dont ils utilisaient les terres, aux bénéfices accrus retirés de la faune sauvage, au niveau des dommages causés par les éléphants et à la réponse des autorités de la faune sauvage aux rapports des problèmes des éléphants.

Introduction

Coexistence between elephants *(Loxodonta africana)* and humans in Africa is facing a serious challenge (Leaky and Lewin 1996). Conflict between local people and wildlife is a serious problem in areas adjacent to protected areas (Newmark et al. 1994). The form of land use is usually an important component of the relationship between elephants, humans and other wildlife species (Kangwana 1993). In most rural areas human population largely depends on agriculture for survival (Fratkin 1994). The increase in human population and associated expansion of land under cultivation poses a major threat to the conservation of elephants (Tchamba 1996). In Kajiado District, land under crop cultivation has gradually increased, doubling from 40,000 ha in 1989 to 90,000 ha in 1994 (Awere-Gyekye 1996). Although human–wildlife conflict is not with elephants alone, elephant crop damage has overshadowed that by other wildlife species (Hill 1998). Although elephants cause catastrophic damage to crop farms, their forays are rare, localized and seasonal (de Boer and Ntumi 2001; Parker and Osborn 2001). In the Tsavo–Amboseli ecosystem, land use has progressively shifted from pastoralism to crop farming (Campbell et al. 2000; Kioko 2005). We examine the scale and characteristics of human–elephant conflict in view of the evolving socio-economic dimensions in the area.

Tsavo–Amboseli ecosystem

The Tsavo–Amboseli ecosystem is an area of approximately 5000 km^2 (Western 1982) and includes about 2000 km^2 covered by Kimana and Kuku Group Ranches and their environs. These two group ranches lie directly between Amboseli, Chyulu Hills and Tsavo West National Parks (fig. 1). This arid to semi-arid area receives 300–900 mm of rainfall annually (Berger 1993). A 'short' rains season occurs between November and December and the 'long' rains from March to May. The geology and hydrology are strongly influenced by Mt Kilimanjaro to the south. Highly permeable volcanic rock forms regionally distributed aquifers that are important sources of water in the area (Omenge and Okello 1992; Smith 1997). Maasai pastoralists, who have for centuries occupied the area, used the swamps and slopes of Mt Kilimanjaro as dry-season pasture grounds for their livestock. Wildlife including elephants also use this area. The land has been administered as communal property under the Group Ranch Act. In the recent past, some of the group ranches have been subdivided and regrettably, critical elephant habitats like the swamps and Kilimanjaro slopes have now been apportioned for crop cultivation. Agriculturists have occupied the slopes of Mt Kilimanjaro since the 1960s with a notable influx of immigrants into the area in the 1980s. Additional crop cultivation has started in the wetlands within the group ranches (fig. 1). Kimana and Namelok fences, 38 km and 24 km long respectively, enclose 42 km^2 of irrigated farmlands south-east of Amboseli National Park. The two electric fences established to minimize elephant crop damage were completed in 2000 and are managed by the farmers through fence committees.

Methods

We mapped the farming clusters using a geographical positioning system (GPS), and determined areas occupied by the crop fields using ArcView GIS. To assess opinions on human–elephant interactions, we randomly conducted 880 interviews to residents within Kuku and Kimana Group Ranches and environs. Three field assistants fluent in Maasai, Swahili and English were trained in interviewing techniques, and together with the authors interviewed 291 crop farmers, 426 mixed farmers and 163 pastoralists. There were 518 (58.86%) males and 352 (41.14%) females interviewed.

Inside the Namelok fence, 66 farmers were interviewed and 154 farmers inside the Kimana fence. One interview was conducted per Maasai household 'boma' among the pastoralists, and the farm owner was interviewed among the farmers. Data on daily elephant crop raiding, extent of crop damage and stage of crop growth when damage occurred were gathered as described by Hoare (1999). The levels of elephant crop damage were calculated following Hoare (1999, 2001), where damage score (< 5 = low, 6–8 = medium, > 9 = high) is the sum of age value, quality value and damage value for all the crops. Age value is classified as 1 = seedling, 2 = intermediate, and 3 = mature; quality value as 1 = poor, 2 = medium and 3 = good; and damage value as 1 = < 5%, 2 = 6–10%, 3 = 11–20%, 4 = 21–50%, 5 = 51–80%, and 6 = > 80%.

We monitored incidents of elephant entry into farms inside Kimana and Namelok electric fences and in farms nearby but outside the fences. We noted the

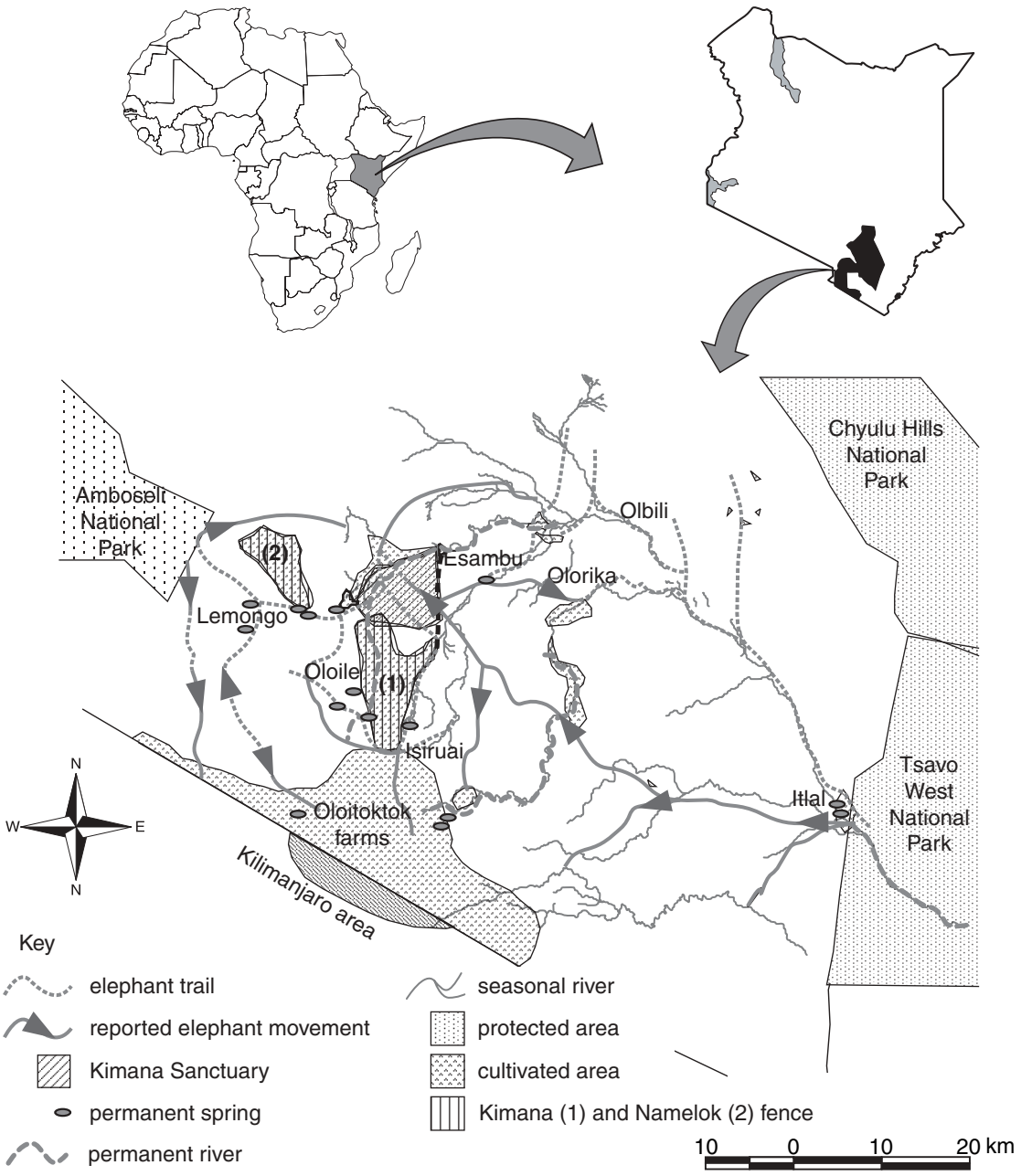

Figure 1. Location of crop farming, Kimana and Namelok fences, and Kimana and Kuku group ranches within Tsavo–Amboseli ecosystem.

number of days it took to repair the fences after elephants broke through as a measure of the fence repair regime. To determine the crop-raiding group types, the first author drove at night with the Kenya Wildlife Service (KWS) Problem Animal Control team and using a powerful spotlight identified elephant group types. Elephant group type was defined as bull(s) or mixed (bull(s) and female(s)) (McKnight 2004). Information on reported incidents of wildlife-caused livestock injury and death was analysed from occurrence books managed by KWS at various outposts. Data on elephant spearing for the period

1987–2004 were acquired from the Amboseli Elephant Research Project that has kept a long-term database on human–elephant conflict in the Amboseli area.

Results

Level of crop farming

While the Maasai are still predominantly livestock keepers, most have also now taken up crop farming. Farming is dominated by immigrant tribesmen from other parts of Kenya and Tanzania (table 1). A notable influx of immigrants occurred in the 1980s after Kenyan farmers left Tanzania following the collapse of the East African Community in 1977. Most farmers (53%, $n = 390$) have been cultivating in the area for the last 3–10 years; newcomers lease, buy or cooperate in farming with the Maasai owning the land (crop sharing). Irrigated agriculture occupies about 7% (95.8 km^2) of two Maasai group ranches (Kuku and Kimana) that directly connect Tsavo West, Chyulu Hills and Amboseli National Parks; 5% of this land (42 km^2) was enclosed by electric fences (Kimana and Namelok). On the slopes of Mt Kilimanjaro (Oloitokitok farms) about 200 km^2 was under rainfed agriculture. Most farmers (70.9%, $n = 521$) cultivated 1–4 acres (0.4–1.6 ha) ($\chi^2 = 479.45$, df = 2, $P < 0.001$) and 62.0% ($n = 449$) grew crops both for consumption at home and for sale. The common crops grown were maize 57% ($n = 227$), onion (*Allium cepa*) 25% ($n = 120$), tomato (*Lycopersicon esculentum*) 11% ($n = 52.8$), and beans (*Vigna faba*) 7% ($n = 33.6$). Farmers considered maize, a food and cash crop, as most important for their livelihood ($\chi^2 = 294$, df = 3, $P = 0.001$).

Level of elephant crop damage

Most farmers 98.3% ($n = 691$) reported that wildlife damaged crops on their farms. The elephant was regarded by most farmers 75.7% ($n = 496$) as the most destructive wildlife species and was reported by 76.6% ($n = 418$) to prefer maize ($\chi^2 = 780.74$, df = 3, $P < 0.001$). Elephants did not eat chillies (*Capsicum annuum*) or tobacco (*Tabacum* sp.). Elephant crop damage per single raid was medium 69.1% ($n = 249$), high 20.5% ($n = 74$) and low 10.5% ($n = 38$) ($\chi^2 = 211.75$, df = 2, $P < 0.001$). In most raids (40.1%, $n = 144$) < 5% of an acre (0.4 ha) was destroyed; in a few raids (7.8%, $n = 11$) elephant damage was more than half an acre (0.2 ha). Elephants mainly destroyed mature crops (64%, $n = 233$) rather than crops that were young or at the middle stage of maturity ($\chi^2 = 207.31$, df = 2, $P < 0.001$). Most farmers (81.5%, $n = 401$) reported that elephant crop destruction was common in the dry season ($\chi^2 = 15.81$, $P < 0.001$) and 89.3% ($n = 461$) said destruction occurred at night. The raids were, however, insignificantly related to monthly rainfall ($r = 0.48$, $P = 0.1$).

Crop-raiding elephant group size and types

The group size of elephants that invaded different farms differed in dry (Kruskall Wallis, $t = 213.77$, $P < 0.001$) and wet season (Kruskall Wallis, $t = 232.83$, $P < 0.001$). The mean group size ranged from 1.07 ± 0.06 SE to 7.8 ± 1.34 SE. The mean group size of elephants was larger in farms farthest away from protected areas ($r^2 = 0.674$, $P = 0.01$) (fig. 2). The groups ($n = 137$) that the Problem Animal Control team pursued from farms were entirely bull groups.

Livestock deaths and injuries by elephants compared with other wildlife species

Most of the residents (62%, $n = 406$) had experienced livestock injury or death associated with elephants in the period 2002–2003 ($\chi^2 = 38.17$, $P < 0.001$). The aggregate number of sheep and goats killed by wild-

Table 1. Main economic activities among residents within Tsavo–Amboseli ecosystem

Ethnic group	Composition of households interviewed (%)	Involvement in various livelihoods (%)		
		Semi-pastoralists	Crop farming alone	Both farming and semi-pastoralism
Maasai	55.4 ($n = 486$)	98.1	5.6	72.3
Kikuyu	11.2 ($n = 98$)	1.9	41.1	19.0
Kamba	1.8 ($n = 16$)	0	25.4	7.0
Tanzanians	7.3 ($n = 64$)	0	24.0	1.3

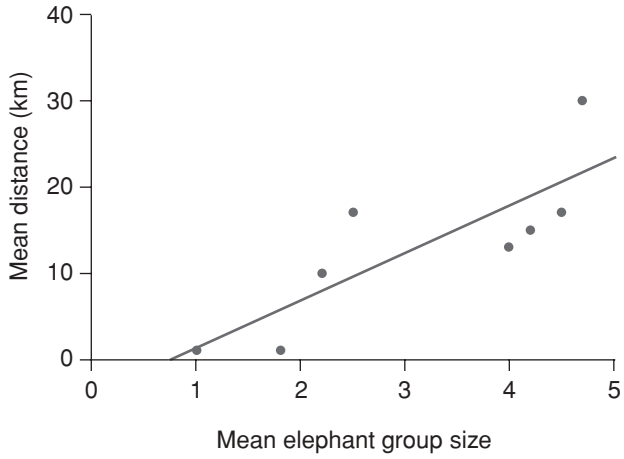

Figure 2. Relationship between mean elephant group size and location of the farms raided by elephants from the nearest protected area.

life among the respondents was (mean = 6.01 ± 0.53 SE, median = 3.00, mode = 1) and cattle (3.16 ± 0.36 SE, median = 2, mode = 1). Elephant-caused livestock deaths and injuries (6%, $n = 6$) were fewer than those caused by hyena 8% ($n = 7$), leopard 10% ($n = 9$) or lion 62% ($n = 57$). Data from the Amboseli Elephant Research Project showed that more cattle (77.4%, $n = 48$) than goats and sheep (22.6%, $n = 16$) were killed by elephants from 1997 to 2003 ($\chi^2 = 18.64$, $P < 0.001$). While there was a positive correlation between reported incidents of carnivore-caused livestock deaths and the amount of rainfall ($r = 0.424$, $P = 0.169$), most incidents associated with elephants occurred in the dry season.

Direct human–elephant interactions and attitudes towards elephants

The number of people who had experienced wildlife-caused deaths and injuries (7.6%, $n = 57$) for the period 1999–2003 was significantly low ($\chi^2 = 543.2\%$, $P < 0.001$). Information from KWS outposts showed that elephants had caused the highest number of human deaths and injuries in the period 1994–2004 (fig. 3). There were 75% ($n = 15$) human deaths and 53.3% ($n = 24$) human injuries associated with elephants. Buffaloes had caused 23.8% ($n = 6$) human deaths and 26.7% ($n = 12$) human injuries. A lion caused one human death and a hyena an injury.

Incidents of speared elephants were high in the dry season (63.6%, $n = 28$) compared with those in the wet season (36.4%, $n = 16$). There was no significant difference between the number of female (55.1%, $n = 27$) and male elephants (44.9%, $n = 22$) speared between 1993 and March 2004 in Amboseli National Park and adjacent areas ($\chi^2 = 0.51$, $P < 0.47$).

While many residents (46.6%, $n = 301$) said that they did not harm elephants that came in the vicinity of their homestead, 31.6% ($n = 204$) scared them away and 21.8% ($n = 141$) sought cover in fear ($\chi^2 = 60.33$, df = 2, $P < 0.001$). Most residents (66.7%, $n = 455$) were of the opinion that having elephants within the group ranches was not important ($\chi^2 = 75.33$, $P < 0.001$). The semi-pastoral Maasai (37.3%, $n = 163$) were more likely to concur that having elephants in the area was important than were the agriculturalists ($\chi^2 = 24.03$, df = 2, $P < 0.001$). More residents who kept livestock (52.6%, *n*

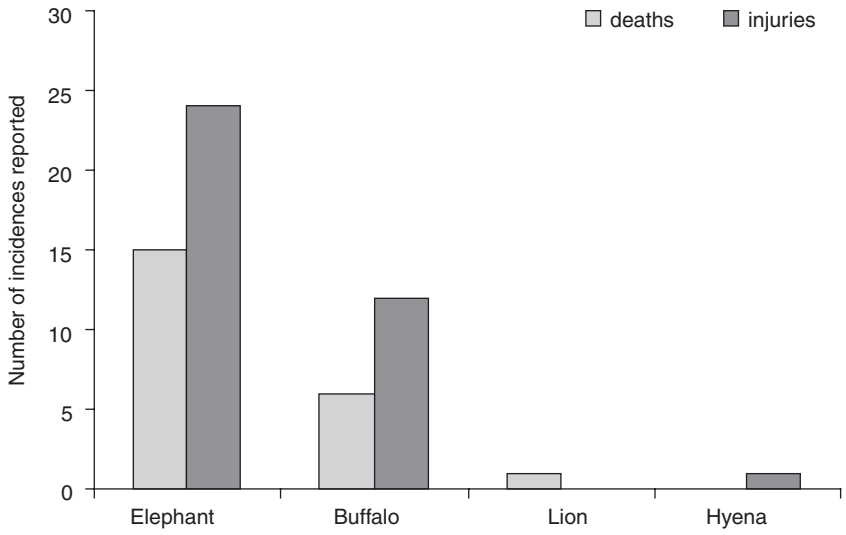

Figure 3. Relationship between elephant- and other wildlife-related human deaths and injuries reported between 1994 and April 2004.

= 81) felt that 'having elephants was important' than those who practised crop cultivation alone (28.8%, n = 51) (χ^2 = 30.20, df = 2, P < 0.001) (table 2).

Most of those whose crops had been damaged by elephants did not sustain the view that having elephants in the ecosystem was important. Only 19.2% (n = 147) of those who had experienced elephant crop damage felt that having elephants was important (χ^2 = 98.00, P < 0.001). Most farmers (74.5%, n = 149) who had not been satisfied with the Problem Animal Control team's response to problem elephant reports did not consider that having elephants was important (χ^2 = 3.11, P = 0.078).

There were 36.7% (n = 212) who said that they received wildlife benefits. The benefits were considered education bursaries for group ranch members, employment through tourism-related activities, and profits from the sale of curios to tourists. Most of those who had received wildlife benefits (70.3%, n = 149) felt that having wildlife in the ecosystem was important compared with 12.3% (n = 45) who did not receive benefits (χ^2 = 202.43, P < 0.001). The level of education did not appear to influence the respondent's perception of whether having elephants in the group ranches was important (χ^2 = 0.469, df = 2, P = 0.79). A higher percentage of females 74.6% (n = 208) than males 59.8% (n = 244) felt that having elephants was *not* important (χ^2 = 16.01, P < 0.001).

Effect of electric fencing in mitigating human–elephant conflict

Farms not enclosed by an electric fence had their crops raided by elephants more frequently than those inside the fences (F_3 = 39.67, $P \leq 0.001$). In the fenced areas elephants raided the crops of 42% of the farmers (n = 93); the crops of all those (n = 294) cultivating in the adjacent unfenced areas were raided. Most (93%) farmers in the fenced areas felt that the level of elephant crop raids on their farms had declined since the electric fences were established (χ^2 = 163.53, $P \leq 0.001$). Farmers in fenced farms perceived that they have lost USD 24.7 ± 4.84 SE per hectare per season worth of maize crop yield to elephants compared with USD 105.7 ± 23.42 SE by those in the unfenced area. The fences were poorly maintained and frequently vandalized and some fence parts were stolen. Once broken by elephants, it took fence attendants 7 ± 1.5 days to repair Kimana fence.

Discussion

Human–elephant conflict in the Tsavo–Amboseli ecosystem largely manifests itself in the forms of crop damage and of livestock and human death and injury. The conflict is commonly linked to elephant movements during the dry season. The advent of crop farming in what formerly was a predominantly pastoralism area is posing a foremost threat to elephant conservation in the dispersal area. The ease in acquiring land for cultivation has led to an influx of farming immigrants from other parts of Kenya and Tanzania over the last 10 years. In the semi-arid environment, crop farming is confined to the few wetlands and high-potential areas on Mt Kilimanjaro slopes—areas key to elephants, other wildlife and Maasai livestock dispersion in the dry season and during drought periods.

While crop raiding is not limited to elephants, they are an important crop pest. Maize, the most important staple crop, was the crop elephants most preferred. They persistently invaded maize fields after the cobs had formed but before the crop was ready for harvesting. At maturity crops are likely to be more nutritious and palatable (Sukumar 1994). Such elephant foraging behaviour was evident in other crops; for instance, they fed on onion bulbs but left the leafy upper part, dug sweet potato and cassava

Table 2. Relationship between land use and resident's perception that 'having elephants in the Kimana and Kuku group ranches is important'

Perception	Livestock keepers (22.16%, n = 154)	Crop farming alone (25.47%, n = 117)	Mixed crop farming and livestock keeping (52.37%, n = 364)
Having elephants 'is important'	52.6% (n = 81)	28.8% (n = 51)	28.3% (n = 103)
Having elephants 'is not important'	47.4% (n = 73)	71.2% (n = 126)	71.7% (n = 261)

(*Manihot esculenta*) roots, and sought pumpkin (*Cucurbita maxima*), watermelon (*Citrullus lanatus*), bananas (*Musa* sp.), fruits and sugarcane (*Saccharum officinarum*). Elephants progressively moved along an altitudinal gradient as the dry season progressed in search of green crops and trees up on the slopes of Mt Kilimanjaro. In the irrigated areas, crops were grown throughout the year and provided a constant supply of forage for the invading elephants in the dry season. These findings are consistent with Chiyo et al. (2005), who found that the large fluctuations in forage in the savannas largely determine temporal variations in elephant crop-raiding patterns.

Elephant groups with young were not observed to invade farms far away from the protected areas, probably due to the long distances and the risks it would pose their young ones. The crop raiding was nocturnal. Elephants avoid humans by invading settlements and other areas with high human activity at night (Kangwana 1993). Even where the farms were guarded, it is likely elephants had learned that by raiding the farms at night they increased their chance of evading the farmers.

Though elephants caused more human deaths and injuries than other wildlife species, the incidents were relatively few and were common near or within settlements, farmlands and wetlands. Elephants' antagonistic behaviour toward humans may have risen after persistent harassment (Sukumar 1994) and increased contact with humans. The changes in land use from keeping livestock to farming crops present the elephants with a hostile environment. In the dry season, the wetlands become important watering and foraging grounds for livestock, elephants and migratory wildlife species. The growing human settlement is not only a physical barrier to elephant movement but also creates a potential for elephant harassment.

Culturally, the Maasai viewed elephants in some ways as similar to humans and gave them a respectful distance (Kioko 2005). The young warriors, however, occasionally killed elephants to prove their manhood. The minimal show of hostility towards elephants combined with the fact that livestock keeping does not involve direct conversion of vital habitats such as wetlands is a chance for managers to integrate livestock keeping with elephant conservation.

Although the Maasai are for the most part livestock keepers, they are gradually embracing crop cultivation. The change in land use is worrying. Given the fact that farmers were less willing to accept the presence of elephants within the group ranches, there is the possibility that crop farming may permanently displace elephants.

The local people's attitude towards conserving elephants is important considering the changing cultural and socio-economic situation within local communities. There is a strong argument (Emerton 2001) that wildlife costs people their livelihoods. The existing land-use policy helps to explain the loss of wildlife in rural areas. In this study, the attitude of a resident in the Amboseli region towards wildlife conservation depended on cultural background, gender, land use, and the costs and benefits associated with interaction with elephants. Negative interaction was mostly due to crop damage. The minimal benefits households received from wildlife apparently created the highly negative perceptions of the importance of elephants to the group ranches. Maasai livelihood strategy, largely dominated by livestock, is less in conflict with elephant presence in the area. Elephants caused only a limited amount of injuries and deaths to humans and livestock.

Recommendations

While the immediate benefits of electric fencing have been realized through reduced crop damage, the future of the fencing project as an elephant barrier is uncertain judging by the extent of vandalism and the poor maintenance regime by the local community. While farmers are the key beneficiaries, other stakeholders (such as agriculture-dependent businessmen, conservation agencies, tourism investors) have a major interest in elephant conservation and thus should provide material and technical support towards managing the fences.

More effective response to human–elephant conflict situations, specifically elephant crop raiding, is required. This will entail additional Problem Animal Control workforce and enlisting the support of local people. Farmers should be empowered with appropriate mitigation tools and training so that they can deal with elephant crop raiding on their own.

In the long term an elephant management strategy is needed that aims to reconcile the needs of humans and of elephants, in particular seeking ways to increase acceptance of elephants by most inhabitants in the ecosystem and community-based approaches to conserve the critical but dwindling elephant habitats.

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Erratum

In an article entitled Elephant numbers and distribution in the Tsavo–Amboseli ecosystem, south-western Kenya by John Kioko et al. *(Pachyderm* 40: 62–67), all the game reserves mentioned in figure 1 are actually game ranches.