An Assessment of Human-Elephant Conflict in the Western Serengeti

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Acronyms

AfESG	African Elephant Specialist Group
DAO	District Agricultural Officer
DC	District Commissioner
DED	District Executive Director
DGO	District Game Officer
DICE	Durrell Institute of Conservation & Ecology
FZS	Frankfurt Zoological Society
GIS	Geographical Information System
GR	Game Reserve
GPS	Global Positioning System
HEC	Human Elephant Conflict
IUCN/SSC	World Conservation Union/Species survival Commission
MMNR	Masai Mara National Reserve
NP	National Park
PAC	Problem Animal Control
SCIP	Support for Community Initiated Projects
SNP	Serengeti National Park
SRCP	Serengeti Regional Conservation Programme
TANAPA	Tanzania National Parks
TAWIRI	Tanzania Wildlife Research Institute
TWCM	Tanzania Wildlife Conservation Monitoring
UTM	Universal Transverse Mercator
VC	Village Chairman
VEO	Village Executive Officer

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Executive Summary

- A multi-institutional team of consultants, representing TANAPA, the Wildlife Division, FZS, Grumeti Reserves and Serengeti District Council conducted an independent assessment of elephant crop raiding in the district in June 2004, after an apparent upsurge in the problem over the past 6-8 months. The team was tasked with evaluating the extent of the problem and developing recommendations for monitoring and mitigation. This report is a record of that exercise.

- Crop raiding by elephants is a recent phenomenon in Serengeti District, that has emerged within the past 3-4 years as a result of increasing cultivation on the boundaries of the elephant range, increasing elephant numbers in the ecosystem, and increased security in the Game Reserves bordering SNP that has resulted in greater incursions of elephants into settled and cultivated areas.

- Crop raiding has escalated since November 2003, and has become a significant issue for both village and district authorities. Data on crop raiding have been collected at both levels, which enabled a more detailed assessment of crop damage than had been expected. In particular, it was possible to elucidate elephant crop preferences and to make broad estimates of the magnitude of losses. Crop raiding takes place between November and June. Elephants clearly preferred grain crops, such as sorghum, millet and maize, to root crops such as cassava and potatoes, and rejected cotton, a minor cash crop in the district.

- However, limitations in the methods and uniformity of data collection across the district are evident. In particular, relying on farmer's reports of crop raiding may lead to overestimates of loss. Equally, the nature of the records taken by each village differs, and they contain little or no spatial or temporal information. This makes it difficult to obtain more than a basic picture of crop raiding.

- Currently, farmers do little to defend their crops from elephants, and believe that their simple guarding and deterrent methods do not work. This is partly due to a lack of experience of dealing with elephants and partly due to a lack of early warning systems that enable detection of elephants prior to their entry into fields. Instead, farmers rely on TANAPA and Grumeti Reserves to respond to reports of crop raiding by sending vehicles and rangers to chase the elephants away after they have begun to raid crops. However, such post hoc interventions are always going to be of secondary importance to effective front line deterrents.

- Attitudes towards conflict mitigation differ between farmers and district leaders. Whilst the former wish to see more intervention and support from wildlife authorities, those at the district level are keen to explore land use planning, reduced cultivation in elephant-adjacent areas, and research. A Grumeti Reserves proposal to erect an electric fence along the boundary of the protected areas has received some support locally but remains controversial, and may not be appropriate at the present time.

- Where elephants coincide with cultivation, it is unlikely that crop raiding will ever be completely eliminated. However, by developing an integrated programme of monitoring, research, participatory mitigation using small-scale and cost effective measures, and education, it is likely that crop raiding will be significantly reduced to more tolerable levels. A series of recommendations are made.

1. Introduction

1.1 Background

Human-elephant conflict (HEC), and particularly crop raiding, is a perennial conservation problem that appears to be increasing wherever elephant range overlaps with human settlement and cultivation. In Serengeti District to the west of the Serengeti National Park (SNP) and associated game reserves (GRs), elephant crop raiding is a relatively recent phenomenon that appeared to reach epidemic proportions early in 2004. Complaints from villages escalated, and the district council, with support from Grumeti Reserves (that holds the concession for Ikorongo and Grumeti GRs, and owns Sasakwa ranch), organised an internal survey and district meeting to explore the issue and potential solutions. An initial picture of the problem was developed and a number of potential mitigation methods were proposed.

As a follow-up to these activities, Frankfurt Zoological Society (FZS) agreed to fund an independent survey and evaluation of the problem. An external consultant with HEC expertise was contracted to lead a small team of representatives from Tanzania National Parks (TANAPA), the Wildlife Division and FZS, together with local representatives from Grumeti Reserves and the district council (see Appendix I for terms of reference, and Appendix II for photographs). This report is a record of that exercise.

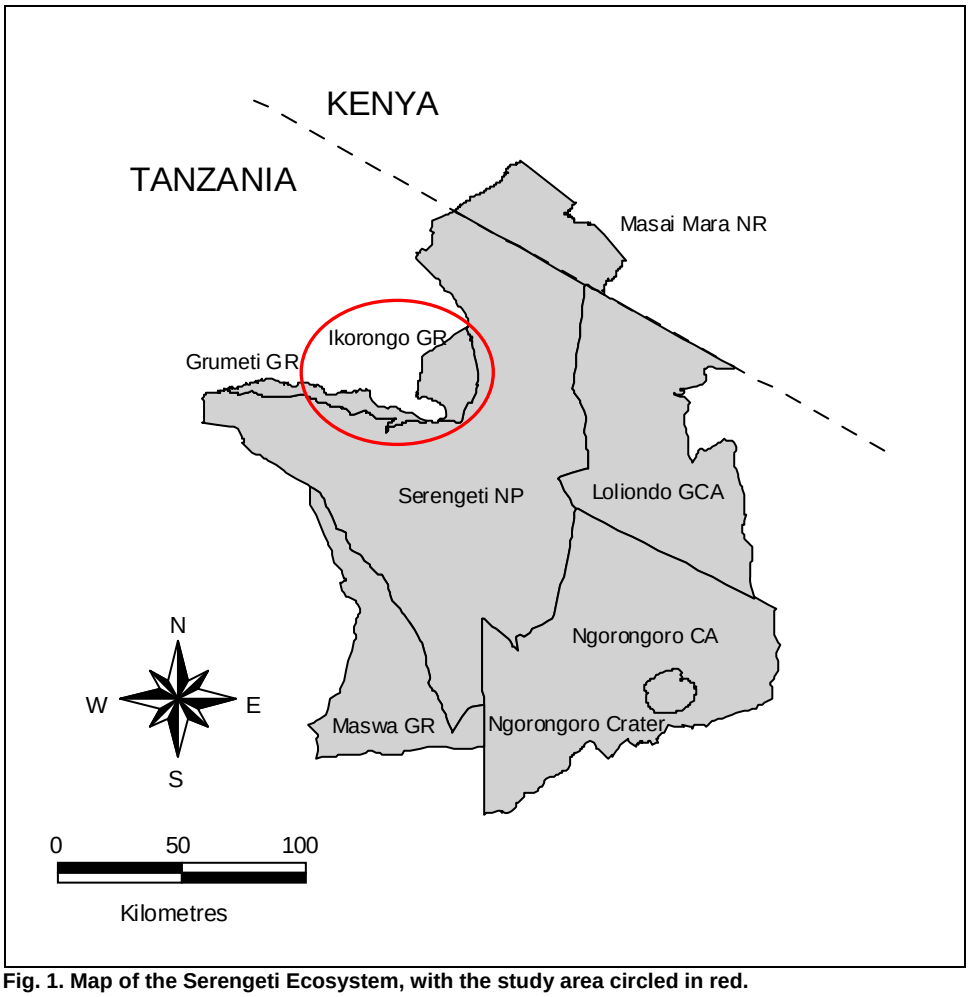

Fig. 1. Map of the Serengeti Ecosystem, with the study area circled in red.

The evaluation took place in the eastern and southern parts of Serengeti District that border SNP, Ikorongo and Grumeti GRs within the Serengeti Ecosystem in Tanzania (Fig. 1). This is an area of increasing human-settlement and agro-pastoralism.

The human population in Serengeti District was over 176,000 in the 2002 national census, and has been rising at an annual rate of around 3.3% (although official figures suggest the rate is 2.8%, a recalculation from 1988 and 2002 census data revealed the higher rate). Although finer scale data were not accessible during this assessment, it is believed that growth rates at the boundary of the protected areas are greater than this.

A lack of land tenure and planning regulations, subsistence lifestyles and relatively low soil fertility all favour the encroachment of agriculture into sparsely settled areas adjacent to protected areas. Between 1978 and 1993 the border of Maswa GR on the southwestern side of SNP was allegedly changed three times to accommodate the encroachment of agro-pastoral settlement, and an area has since been formally degazetted. Equally, part of the northern area of Ikorongo GR is now settled and cultivated, despite some people having been resettled outside the reserve in 2000.

To date there have been no human deaths or injuries as a result of elephants in the district. Recently, three people were killed in Bunda District, to the west of Serengeti District, and so the Wildlife Division had to shoot theelephant. Equally, last year in Tarime District, to the north of Serengeti District, a woman from Gibaso village was killed by an elephant in the early morning whilst travelling to her farm.

1.2 Methods

The evaluation team visited the district from 30 May – 5 June 2004. Visits were made to the offices of several district officials and a number of locally based wildlife authorities, including TANAPA, Ikorongo and Grumeti GR offices, the Serengeti Regional Conservation Programme (SRCP), Grumeti Reserves, and FZS. Interviews were held with key officials, and relevant reports/data were collected where available.

Ten villages on the boundary of the protected area were also visited. In each, meetings were held with village officials and other representatives to gather village-level information and perceptions regarding HEC. In addition, at least one nearby farm in each village that had recently been raided by elephants was visited with the farmer, and a semi-structured interview conducted to gather details regarding the circumstances of the elephant raid. In total, 12 farms were visited in this way.

The locations of villages and farms were recorded in UTM coordinates using a handheld Garmin GPS satellite navigation unit (Garmin Corp., Ulathe, KA). Spatial data were mapped using the ArcView v.3.2 geographical information system (GIS) software package (ESRI, Inc., Redlands, CA). Quantitative data were collated on computer and analysed using SPSS v.10 (SPSS Inc., Chicago, IL).

2. Long-term changes in elephant numbers and distribution in the Serengeti Ecosystem

In living memory, elephants apparently only moved into SNP in the late 1950s (SEMP, 1988). Aerial counts of elephant numbers within SNP are available from 1961. Detailed reports of six censuses conducted in the past two decades exist (TWCM 1986 1992, 1994, 1998; TAWIRI, 2002, 2003). These surveys used a standard aerial photographic method (Norton-Griffiths, 1978) applied to the whole of SNP and parts of adjacent protected areas, although the total area covered varied between years. The survey area was divided into to some 21 distinct blocks (Fig. 3) to enable analysis of spatial as well as temporal trends.

2.1 Temporal trends

Elephant numbers in the ecosystem rose from around 500 in 1961 to over 2,500 in the late 1970s. This dropped to some 500 by 1986 as a result of poaching. It is estimated that around 1500 individuals were illegally killed in SNP, with a further 500 or so moving north into the more heavily protected MMNR (Dublin & Douglas-Hamilton, 1987; Dublin, 1995). Since 1986, elephant numbers have steadily increased and exceeded 2000 individuals by 1998 and remained at that level in 2003, although the total appeared to be lower in 2000 (Fig. 2).

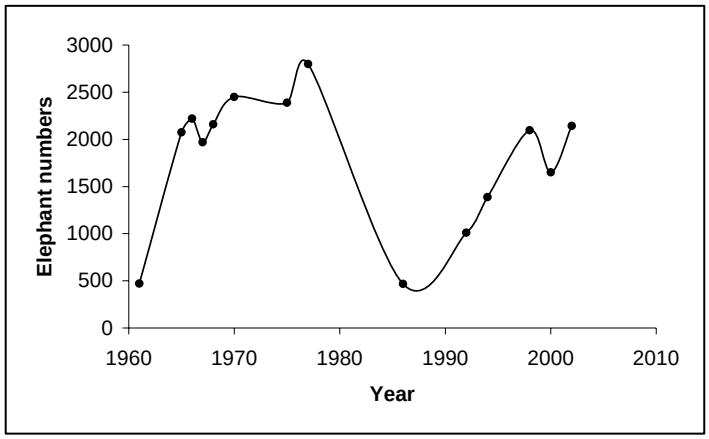

Fig. 2. Serengeti elephant population trend (1961 – 2003).
(Source: total aerial counts by TANAPA and FZS)

2.2 Spatial trends

The relatively crude nature of the census (one count every 2-4 years, using survey blocks with a median area of 900 km^2) makes it difficult to discern any detailed trends in elephant distribution over time. However, a visual examination of the distribution maps from each survey suggests that the population recovery since 1986 has been accompanied by a range expansion (Fig. 3). Initially the population appeared concentrated into two populations, one in the central north of SNP, and the other in the south. In the mid-1990s some expansion east into Loliondo was observed, and by 2000 the population has also expanded to the west, although this appeared to have diminished in 2003. A total of only 21 elephants was apparently recorded in the Ikorongo GR during the aerial census in May 2003 (TAWIRI, 2003).

More recent survey and monitoring activities by the Grumeti Reserves, however, demonstrate that elephants are resident within both the Grumeti and Ikorongo Game Reserves in significant numbers. An aerial census in September 2003 counted 355 elephants, mainly in the eastern parts of these Reserves bordering the Serengeti (Goodman, 2003). Continuous monitoring between September 2003 – April 2004 suggests that elephants are using much wider areas of these Reserves as well as surrounding unprotected areas during times of crop

raiding (Fig. 4). Many of the groups of elephants seen have high proportions of young animals, suggesting that the population is expanding.

It should be stressed that, currently, very little is known about the way that elephants utilise the Serengeti Ecosystem, or about the behaviour and propensity to crop raid of specific elephant groups or individuals. Such information, were it to be available, would be valuable in improving our understanding of HEC in the Serengeti and our ability to mitigate it.

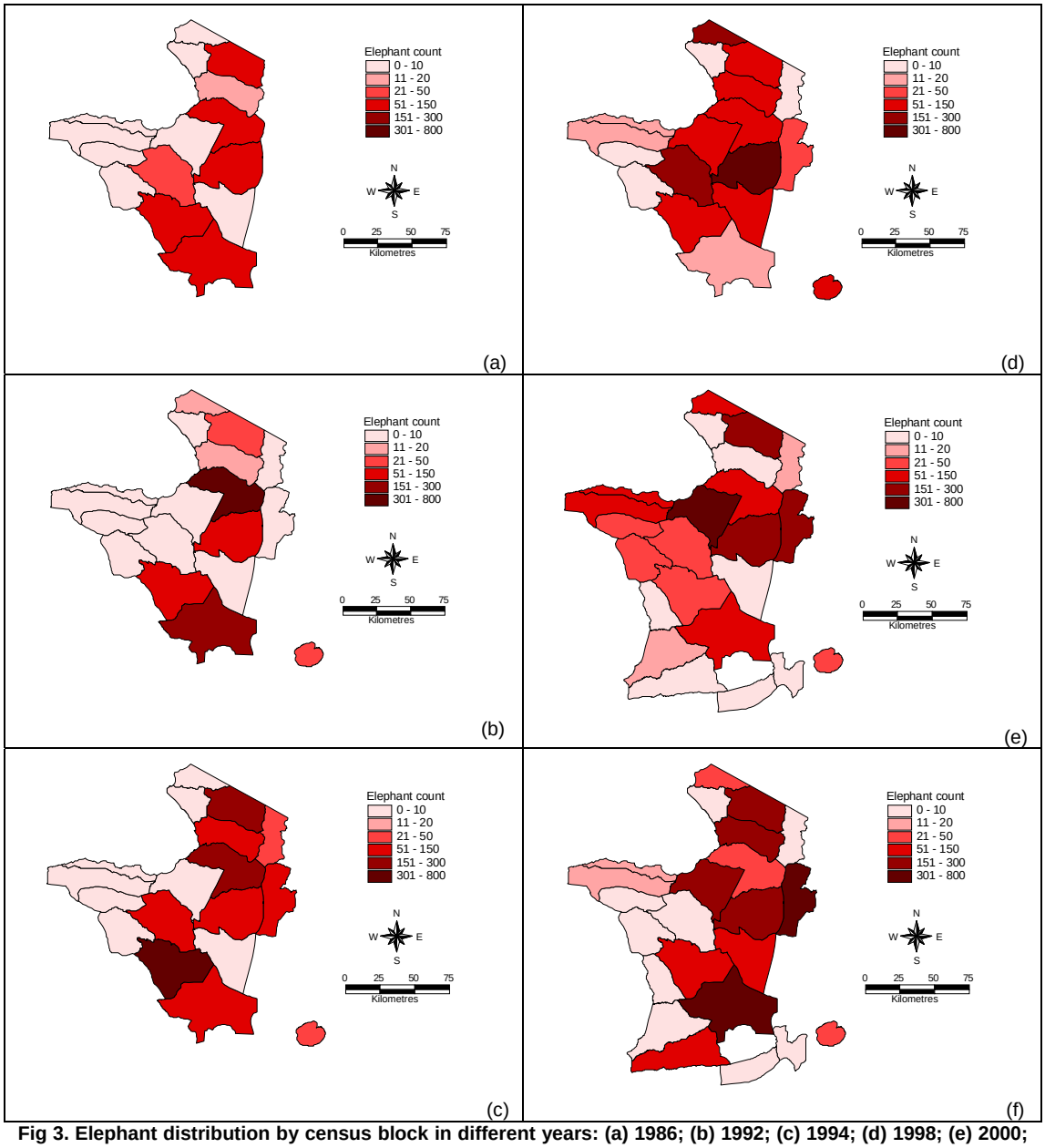

Fig 3. Elephant distribution by census block in different years: (a) 1986; (b) 1992; (c) 1994; (d) 1998; (e) 2000; (f) 2003. (Source: total aerial counts by TANAPA and FZS)

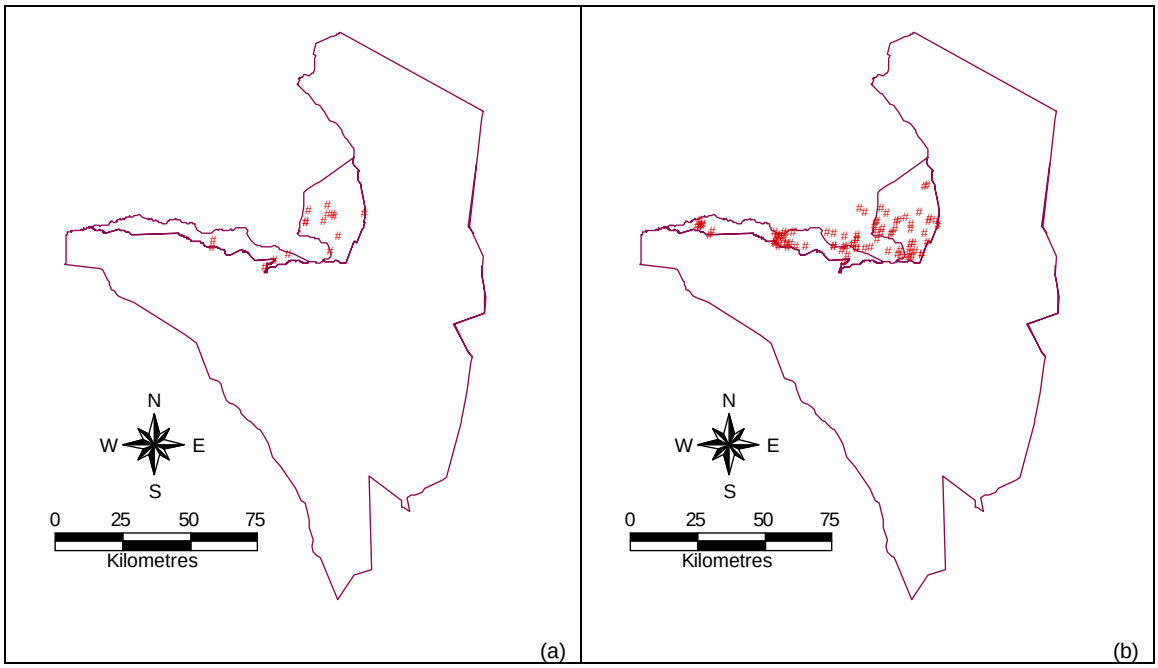

Fig. 4. Distribution of elephant sightings in and around Grumeti and Ikorongo GRs: (a) Sep – Oct 2003 (before crop raiding); (b) Nov 2003 – Apr 2004 (during crop raiding). Source: Grumeti Reserves.

3. Assessment of crop damage caused by elephants and other crop raiding vertebrates in Serengeti District

3.1 Data available

Two principal sources of quantitative information on crop raiding were gathered. The first was a detailed report from the Department of Crops and Production of Serengeti District Council (Bitala, 2004). This described the results of an intensive survey of crop raiding in several villages in January 2004. The report included a summary of crop damage by crop and by ward, and a partly complete appendix detailing the amount of damage recorded at the farm level. The report suggests that detailed independent measurements of raided fields, and the amount of damage inflicted thereon, were undertaken during the survey. This suggests that they are likely to be relatively accurate.

The second source of information was the administration of each village. Farmers' reports of crop raiding have been recorded by VCs or VEOs in several villages, and these reports, mainly from 2003/04 but including some reports from previous years, were made available to the review team. The data are variable, but usually include the farmer's name, crop and amount of damage. Some reports also include the date and the size of raided fields. Since these records rely on unverified 'self-reporting', they may be less accurate than independent surveys, but do cover a longer time period. An attempt was made to assess the accuracy of these reports by comparison with the district survey, personal observation, and known levels of damage elsewhere.

Data were entered into SPSS for statistical analysis. District and village data on crop planting, yield, and market prices (augmented with June 2004 wholesale market price data available from http://www.foodnet.cgiar.org/market/Tanzania/Prices/dar_weekly.xls) were used to assess elephant crop preferences, relative damage and economic losses. Additional data from TANAPA and Grumeti Reserves were used to assess local benefits from the Serengeti and their potential to offset the costs of living with elephants.

3.2 Location of crop raiding

Like many other areas, crop raiding in the western Serengeti is confined to a narrow band of around a dozen villages bordering SNP and its buffer zone Game Reserves (Fig 5). Moreover, upon visiting these villages, the farms to which the review team were taken to view recent crop damage were almost all at some distance from the village centres and mostly in the direction of the protected areas, i.e. closer to the elephant range. Although a detailed map of the location of all raided fields was not available, these findings are consistent with the general observation that elephants are excluded from areas of higher human density (Hoare & du Toit, 1999), and thus only penetrate into the margins of human habitation. Equally, where elephants undertake forays into cultivated areas from a protected area, there is usually a 'front line' of farms to which crop raiding is generally confined.

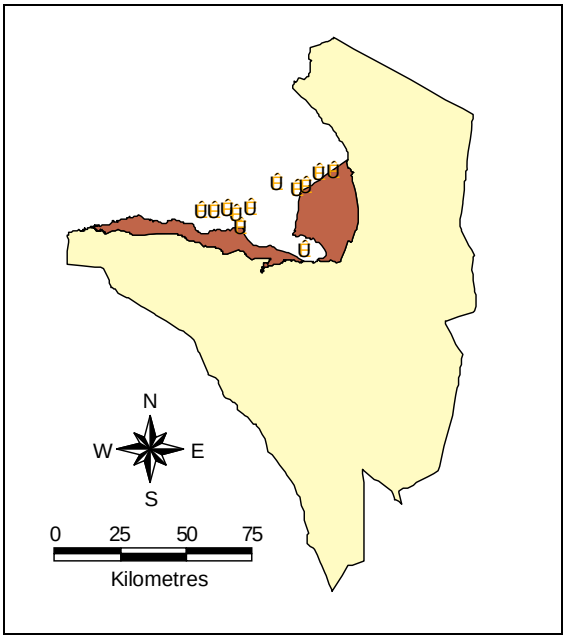

Fig. 5. Villages with elephant crop raiding.

3.3 The general pattern of crop raiding

Crop raiding appears to take place between November and June each year, and most particularly in Dec – Jan and Apr – May which are the two periods when crops are ripening prior to harvest. Within this period crop raiding is not continuous. Usually, a group of elephants will visit the area of a particular village for 1-3 nights, raiding a number of farms within this 'foray'. They may then disappear for many days or weeks before returning again (Box 1).

Box 1: Elephant crop raiding in Bonchugu village.

Between February and May 2004, seven incidences of elephant crop raiding were recorded in Bonchugu village. On 2-3 Feb, elephants raided 42 farms. They returned again on 16 Feb, 22 Feb, 30 Mar, 3 Apr, 11 Apr, and 27 Apr, each time for 1-3 nights. In total, 480 acres of crops were reported to have been destroyed, much of it Sorghum and Cassava.

3.4 The magnitude and distribution of elephant damage

The district survey of elephant crop raiding in January 2004 revealed a total of 192 ha (407 tons) of damage (Table 1). Village records for the period Nov 2003 – May 2004 revealed a total of 569 ha (1408 tons) of damage. However, the latter, although not a complete record of every damage incident, represents unverified self-reporting, and there is some evidence that farmers estimates of damage are over-inflated.

Mean damage per field recorded during the district survey in January 2004 was significantly lower than that recorded by villages themselves (t_{1950} = -11.6, $p < 0.001$). Indeed the latter (mean = 0.55 ha) was 1.71 times greater than the former (mean = 0.32 ha). This pattern was maintained when the data were analysed separately by crop, with cassava (2.3 times) and sweet potatoes (2.5 times) receiving particularly higher village estimates. When dividing the data by ward, three wards (Manchira, Kyambahi and Ikoma) revealed village estimates of crop damage that were 2.5 – 3 times greater than those of the district survey ($p < 0.001$). There was no significant difference in estimates for Natta Ward ($p > 0.5$), however the data from the district survey appears less reliable for Natta than for other wards. There were not enough data to compare results for Issenye and Machochwe.

Using the difference in mean values of damage per field for each crop it is possible to recalculate crop damage from village estimates. This suggests that, for the villages visited, elephants inflicted some 323 ha (732 tons) of damage in the 2003/04 season (Table 1). The most damage was inflicted to sorghum and maize, although village estimates also suggest a relatively high proportion of cassava damage compared with the district survey.

	District Survey		Village records 2003/04		Adjusted village records	
Crop	**Damage (ha)**	**Damage (tons)**	**Damage (ha)**	**Damage (tons)**	**Damage (ha)**	**Damage (tons)**
Sorghum	119.1	164.3	233.2	321.6	152.9	211.0
Maize	46.1	137.7	116.2	347.1	64.0	191.3
Cassava	16.8	84.6	117.2	590.0	50.9	256.3
F/millet			40.3	40.3	23.5	23.5
S/potatoes	5.7	17.0	11.6	35.0	4.6	13.8
Beans	4.2	2.5	10.3	6.0	11.7	6.8
Cotton	0.4	0.5	20.1	25.2	3.7	4.6
Other (mixed fields)			20.4	42.8	11.9	25.0
Total	**192.2**	**406.5**	**569.4**	**1408.1**	**323.3**	**732.3**

Table 1. Magnitude of crop losses to elephants in Serengeti District, 2003/04.

3.5 Temporal patterns

Data from Robanda village were available for three years (2002 – 2004). These suggest that there has been no change over time in the annual number of reported incidents (mean = 118), the estimated amount of damage (mean = 64.1 ha), or the average amount of damage per field (mean = 0.54 ha). However, on a district level, the fact that many other villages appear to have only suffered crop raiding in the past one or two years (Section 4.2) suggests that conflict has spread and increased over time.

In total, 174 farmers in Robanda reported crop raiding between 2002 and 2004. The annual number of complainants increased from 87 in 2002 to 115 in 2004. However, the mean amount of damage reported by each declined from 0.78 ha to 0.55 ha.

Throughout the 2003/04 season, estimated crop damage for sorghum and maize increased from January to mid April, and then declined. Damage to cassava appeared to peak in February (Fig. 6). However, the DGO reported that the major crop-raiding month was May, although he conceded that few detailed records were currently available due to the relatively recent onset of the problem.

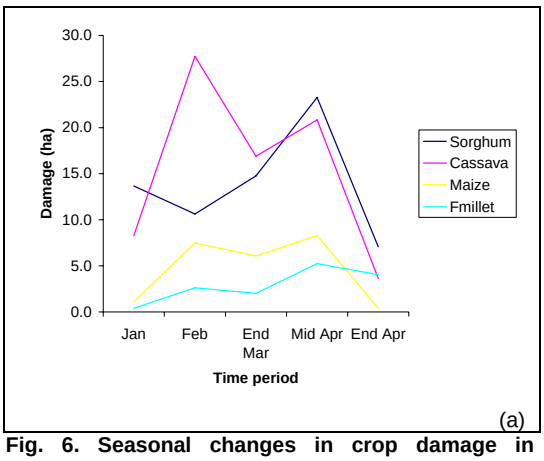

Fig. 6. Seasonal changes in crop damage in Bonchugu village.

3.4 Spatial patterns

There are noticeable differences in the intensity of crop raiding between wards and villages. Using the district survey data, the western part of the crop-raiding zone, in Issenye and Natta Wards, appears to experience more severe crop raiding than the eastern part of Kyambahi, Ikoma, Manchira and Machochwe Wards (Fig. 7.). Robanda village, which is virtually surrounded by elephants, appears to suffer relatively high conflict, although independent survey data for this village were unavailable.

Since this was a relatively brief survey, it is unclear whether the spatial pattern observed is seasonally robust, or whether it would change over time. Further monitoring is necessary to discern this.

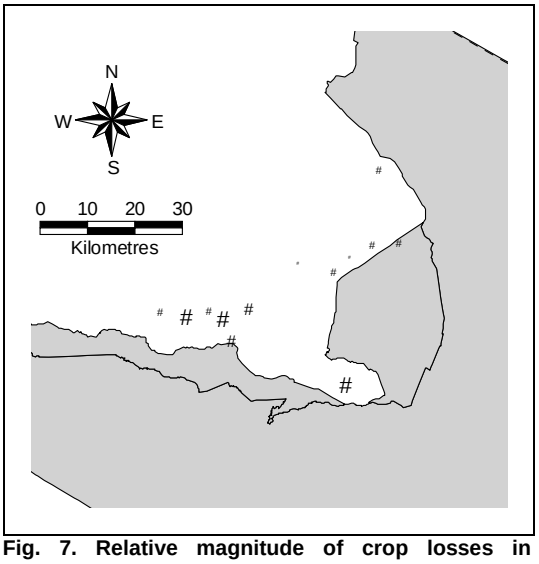

Fig. 7. Relative magnitude of crop losses in different villages adjacent to the protected elephant range. Source: District survey, January 2004.

3.7 Elephant crop preferences

Elephants do not raid all crops equally, and some are more favoured than others (Table 2). The most favoured crops, in terms of the amount taken per unit area planted, were sorghum and finger millet, followed by maize. These are all tall crops with easily accessible grain (see pictures in Appendix II). Note that sorghum was 2-3 times more likely to be raided than maize. Beans, sweet potatoes and cassava were less favoured. The latter two have underground tubers, which are less accessible than the grains of sorghum, millet and maize. Finally, cotton, a cash crop, was rejected, and cotton damage was usually incidental, caused by trampling as elephants moved to and from other crops, rather than by feeding. Two preference calculations, using district and village level data on planting and crop damage, yielded very similar results (Table 2).

Crop	Preference ratio (Maize = 1)	
	District survey	**Village data**
Sorghum	3.40	2.16
F/millet	-	1.67
Maize	1.00	1.00
Beans	0.49	0.56
S/potatoes	0.37	0.20
Cassava	0.27	0.45
Cotton	0.03	0.07

Table 2. Elephant crop preferences.

3.8 Economic losses

Reported crop losses represent around 0.3-0.5% of the district total expected yield, but are a higher proportion, some 2.4%, of the yield of affected villages. However, losses to individual farmers are much more significant. Data on field size were only available from Nyakitono village (*n = 135*). Here, 66% of crop damage estimates indicated that entire fields were destroyed by elephants, and some 88% of damage estimates were equal to or greater than 50%. However, as previously, these may be over-estimates; comparable data from Transmara District across the border in Kenya revealed a median of 37.5% damage per field (Sitati, 2003).

3.9 Mismatched benefits and costs

The losses from elephants within Serengeti District are confined to the villages bordering the protected elephant range. Moreover, within these villages, the distribution of losses is not even. In Robanda, for example, there were 115 complainants out of a total of some 250 households, suggesting that 46% of households suffered crop raiding this year (although even this may be an overestimate if some complainants were from the same household). Moreover, of the 174 farmers who reported crop raiding in 2002 – 2004, 24.1% had suffered crop raiding in at least two of these years, and 21.8% had suffered losses in all three years. This suggests that elephants are returning to specific farms within each village, and these are most likely to be those that are most accessible, i.e. the front line farms between the villages and the protected elephant range.

A total of 406 farmers were recorded as having suffered crop damage during the January 2004 district survey (excluding Robanda). This represents 7.9% of all households in the affected villages. Thus, losses to elephants are relatively concentrated, with a small proportion of the population suffering the majority of losses.

Tanzania does not subscribe to a policy of compensating farmers for crop or livestock losses to wildlife. However, districts bordering protected areas do benefit from benefit-sharing schemes. TANAPA's SCIP fund injects resources into community-based projects such as schools and roads. These community projects do not offset individual losses from wildlife. Equally, of the c.US$ 47,500 that was dispersed to Serengeti District in 2002/03 (the latest year for which records are available) only around 30% of this went to villages that suffer crop raiding. Thus communities bordering SNP could be forgiven for feeling that they are paying more for the existence of the park than they receive back. Having said that, TANAPA do make every effort to respond to reports of crop raiding, sending vehicles and rangers to deter elephants where possible (see below).

The establishment of a conservation and development fund by Grumeti Reserves, however, has made a significant difference to the level of community benefits from wildlife in the district, injecting some US$ 1.5 million over the past 2-3 years in various projects, many of them aimed at villages on the borders of the protected elephant range. Part of this assistance has included the deployment of a helicopter for elephant conflict mitigation activities, as well as the training of village game scouts. Much of this input, however, remains somewhat invisible to individuals, being in the form of infrastructure and equipment, and is not yet viewed in any way as an incentive to tolerate elephants or other wildlife (see below). This is partly an awareness issue among communities, and partly a failure of the authorities to reduce or offset individual's costs.

3.10 Other vertebrate crop pests

When asked, village officials listed a number of other vertebrate crop pests. The most commonly listed pests were baboon, monkey and bush pig that were all listed by 70-90% of respondents. Other species listed by 10-20% of respondents included wildebeest (seasonally during migration), other antelope, porcupine and ostrich. However, none was perceived by villagers to be as significant a problem as elephant, although the DAO suggested that recurrent losses to these smaller species was just as significant as losses to elephants. No data exists on the damage caused by these species, although rigorous assessments elsewhere in East Africa have suggested that crop damage by these species, and by livestock, exceeds that caused by elephants (Naughton-Treves, 1998). The contribution of rodents and other small mammals to crop losses was beyond the scope of this evaluation, but is according to the DAO a problem throughout the district.

4. Local perceptions of elephant crop raiding in Serengeti District

4.1 Source data

Visits were made to ten villages, where meetings were held with the VC, VEO and other representatives to gather village-level information and perceptions regarding HEC. In addition, at least one nearby farm in each village that had recently been raided by elephants was visited with the farmer, and a semi-structured interview conducted to gather details regarding the circumstances of the elephant raid. In total, 12 farms were visited in this way.

4.2 Perceptions of crop raiding

There was a general consensus that elephant crop raiding was a relatively recent phenomenon in the district. In some villages it had begun in the last 2-3 years, in others this was the first year that it seemed to have been witnessed. All agreed that this year had been the first time that crop raiding had become a serious problem. This was despite the fact that elephants had been seen passing close to some villages for several years; people believe that elephants have suddenly gained a boldness for crop raiding, perhaps due to improved wildlife security and reduced hunting/poaching, and are visiting farms in large herds of up to 100 animals without showing any fear.

Village estimates of damage were greater than those measured during the district survey. There could be several reasons for this. First, people may perceive the problem as greater than it really is, due to the fact that any loss is a bad loss for subsistence farmers, and because elephants are large and dangerous, and the increased risk associated with them increases perceptions of damage (Naughton-Treves *et al*., 1999). Second, people's estimates of the area of damage may be inaccurate. To many local farmers, an acre is an area of land that takes two days to plough, and is thus measured more broadly in time rather than space. This may make it difficult to accurately estimate area. Third, the area damaged may not always reflect the loss of yield. For example, if a group of elephants damages half an acre, there may still be salvageable crops within that area. One farmer stated that half of his field had been destroyed by elephants, but when prompted went on to say that his expected yield of 20 bags of sorghum had been reduced by three as a result of the elephants. In this case, an estimate of 50% damage by area translated into only 15% loss of yield. This highlights the need for careful assessment and accurate measurement of damage.

4.3 Perceptions of current mitigation methods

Ten out of twelve farms visited were unfenced, and those that were fenced used sisal, which appears to attract elephants and is itself eaten by them. Most farmers instead used shouting, drums, and sometimes fire as methods to deter elephants. However, the majority felt that these methods no longer worked as elephants had become used to them. More importantly, elephants were rarely detected until they were already within fields, and sometimes not until the next morning when the damage had been done and the elephants had moved on. Under these circumstances it is almost impossible to deter elephants. Research elsewhere has shown that success is much more likely where elephants are detected prior to entering fields (see Box 2).

A further observation was that many farmers are (understandably) quite scared by elephants, and will abandon their guarding posts if elephants are detected. They believe elephants to be very dangerous and are sceptical that traditional methods will do anything but attract them. One or two farmers, however, do believe that concerted efforts at communal guarding, noise and light do deter elephants, if only temporarily.

Most farmers report crop raiding the following day, and await follow-up from the district, TANAPA, or Grumeti Reserves. However, there is an increasing realisation that such assistance, if it comes, is often too late to be effective since the elephants may well have moved on by then. As a result, according to several VEOs, some farmers are no longer bothering to report crop raiding when it occurs.

4.4 Proposed solutions

When asked what were their favoured solutions to HEC, district officials gave 17 responses, village officials gave 24 responses and farmers themselves gave 13. The most commonly proposed solutions were ranger posts along the boundary of the protected areas, a dedicated mobile ranger force to scare elephants from cultivated areas, and technical assistance and expertise from elsewhere, although killing problem elephants and fencing protected areas were also suggested more than once (Table 4).

Suggested Solution	District officials	Village officials	Farmers	Total
boundary ranger posts		6	2	8
Ranger force to scare elephants	1	4	1	6
Technical assistance/expertise	2	3	1	6
Killing elephants		2	3	5
Electric fence around park		2	2	4
Traditional methods	2	2		4
Reduce cultivation near parks	3			3
Empower village game scouts		1	1	2
Compensation		2		2
Government intervention		1	1	2
Burning pungent materials	1	1		2
Improved communication	1		1	2
Buffer crops	2			2
Research	2			2
Enclosure around block farms (barriers or houses)	2			2
Food assistance			1	1
Increase productivity to reduce farming	1			1
Total	**17**	**24**	**13**	**54**

Table 4. Frequency of proposed solutions to HEC suggested by district officials (*n=5*), village officials (*n=10*) and farmers (*n=12*) in Serengeti District.

There were clear (and unsurprising) differences in the solutions proposed by district officials and respondents from villages affected by HEC. Whilst the former were more likely to propose village land use planning, buffer zones, and a reduction of cultivation near park boundaries, the latter were more likely to request direct intervention from the authorities in one form or another. The current perception among villages is that elephants are someone else's responsibility, and that they themselves are currently unequipped to deal with the problem. This is understandable given their lack of experience of dealing with elephants and the acute concentration of losses to elephants in a small proportion of farms and villages without any perceived correspondingly targeted benefits.

Some of these answers are likely to have been influenced by a district meeting held in February 2004 at which crop raiding was discussed. The conclusion from that meeting was that in the short term the various authorities should collaborate to undertake boundary patrols, and that elephants should be scared using noise (blank ammunition) and other deterrents (burning pungent materials). In the longer term, the district was to consider the offer by Grumeti Reserves to erect an electric fence (see Appendix III).

5. Mitigation techniques to reduce human-elephant conflict in the Serengeti Ecosystem

5.1 Current HEC mitigation efforts

Few methods are currently in place to defend farms. This is in large part because this is a relatively new phenomenon in Serengeti District, and people are unaware of how to defend their crops against elephants. According to both the DGO and DED, in communities in other areas of Tanzania where HEC is an established problem, people work harder to defend their crops and to develop novel mitigation methods. In Serengeti District, the usual response of farmers is to report the problem to the authorities. This section considers some of the mitigation methods currently in place in the district.

Barriers around fields

None of the farms visited during the assessment were fenced in any way. Many fields appeared to have been established somewhat randomly in the bush, at some distance from other fields and with no protection whatsoever. In other areas fields were clustered into farming blocks, but most were unfenced. Some used sisal as a form of hedge or boundary marker, but this was actively targeted and eaten by elephants.

Guarding by farmers

There did not appear to be any real effort at guarding and pre-emptive defence of farms. Although some fields were near to family compounds, and others had small huts adjacent to them for guards to sleep in, there did not appear to be any active patrolling. Indeed, guard huts adjacent to remoter fields had been abandoned due to a fear of elephants.

Chasing elephants away

The most common approach to crop raiding is for villages to request assistance from either TANAPA or Grumeti Reserves. TANAPA usually send a vehicle, if available, with a driver who is authorised to use a gun loaded with blank ammunition. Rangers are rarely sent since their field allowances are high (TSH 25,000/pp/day). The driver collects a group of residents who together guard farms overnight, chasing elephants with the vehicle, using its horn and firing blanks to scare them away. Since this method only temporarily displaces the elephants a short distance, it is usually necessary for the vehicle to remain in place for 2-3 days to keep displacing them when they return.

Two vehicles are intermittently available from TANAPA. Records suggest that one vehicle from Fort Ikoma spent 36 days assisting villages between January and May 2004. Of these, 23 days were spent at Robanda, seven at Park Nyigoti, and a further six at villages further west. A second vehicle spent seven days assisting villages further north along the Ikorongo GR boundary. Whilst this method appears successful, it is only ever a retrospective effort for those farmers that are raided first, as there is a lag between elephants arriving on one night and the rangers being deployed (if indeed they are, which is not always the case) some time later.

According to the DGO, an effort was made last year to move some 300 elephants from one of the open areas back in to Grumeti GR. Vehicles and the Grumeti Reserves helicopter were used, along with the firing of blank ammunition, to encourage the elephants to move. This exercise was successful, but did not prevent the elephants returning soon after. One of the problems is that such exercises can only be conducted during the day, whereas elephants raid crops almost exclusively at night.

5.2 Other potential mitigation methods

On Feb 5 2004, a meeting was held in Natta-Mbisso, organised by the DC, to discuss the apparently worsening elephant situation and discuss some possible solutions. The meeting was attended by village chairmen, VEOs, ward EOs, various district officials and other stakeholders. Various possible solutions were discussed and some recommendations made (for a brief report and minutes of the meeting, see Appendix III). This section considers those recommendations and others made by respondents during the current evaluation, and also describes methods used elsewhere in Africa.

Establish a ranger force dedicated to HEC mitigation

As an indication of the commitment of the authorities to combating HEC, a dedicated, combined ranger force (with TANAPA, Grumeti Reserves, the GR authorities and others working together) is likely to be politically a very valuable tool. Properly trained and equipped for mobile rapid response, and with an effective communication system in place between villages and authorities, such a team or teams would also be of value in assisting villages once elephants have appeared, as has been shown already in the district. Having a dedicated and equipped team would speed up response times from current levels. However, as has been described above, this would still only be a retrospective method of defence, and would encourage continued dependence on the authorities by villages. Thus it should be considered as a secondary method to support effective front line defences implemented by villagers themselves (see below).

An associated and popular suggestion among villagers was for manned ranger posts along the boundary of protected areas. However, the long boundary between protected areas and settled areas will be almost impossible to render impermeable, and the construction of several ranger posts will be expensive and unlikely to result in fewer elephant incursions. Manned ranger posts at each front line village would be more effective in providing accessible manpower, but given the relatively low number of elephant incursions to each village this would not be cost-effective in terms of man power and materials compared with one or two mobile ranger patrols on 24 hour standby.

Guarding farms: empowering village game scouts

Guarding fields against elephants is the most common mitigation strategy. Lack of any form of active defence had been shown to lead to increased HEC (Lahm, 1996). However, investment in guarding does not always appear to reduce crop loss to elephants (Naughton-Treves, 1998). This may be due to ineffective guarding methods; many local communities deploy adequate guarding effort. This is partly economic – a subsistence farmer cannot afford to employ guards for his fields, and so must use family members, often children, who are not equipped to deal with elephants. As a result, communities often feel that guarding is ineffective. However, a recent study in Kenya revealed that increased guarding effort did reduce crop raiding, but it was critical that elephants were detected and deterred prior to entering farms; once they were inside a field it was very much more difficult to remove them (Sitati, 2003; Walpole *et al*., 2003).

Several authors have noted the need for greater numbers of trained HEC and PAC personnel to deal with HEC mitigation (Lahm, 1996; Kasiki, 1999). A more direct and effective measure than the ranger force described above would be to train and equip teams of village game scouts or their equivalent in each area to act as a village-based mitigation force. Such a scheme in Transmara District, Kenya, has been very successful (see Box 2).

Scaring elephants away using noise and burning pungent materials

The use of noise and light to scare elephants away are leading short-term mitigation strategies (Tchamba, 1995, 1996; Lahm, 1996; Mubalama, 1996; Ekobo, 1997). Common among these are beating drums, barrels and tins, lighting fires, using torches and throwing sticks and stones. Trained PAC personnel also use thunder flashes and blank or live bullets to scare away elephants (Ngure, 1995). These methods are quick and cheap to implement and many can be implemented by communities themselves without training or specialised equipment.

Such methods can and do work as short-term solutions. In terms of burning pungent materials, the use of oil or rubber may not be considered environmentally sound. However, natural alternatives may be appropriate. Burning of sheep dung and elephant dung has been tried in Cameroon, because people believed that the elephants did not like the smell (Tchamba, 1996; Ekobo, 1997). However, this proved ineffective. A better chemical deterrent may be something more pungent like tobacco or chilli essence (see below for more on this).

Fires of any sort alongside noise and concerted human presence are the most effective combination of active deterrents and should form the basis of any mitigation toolkit. There is always the issue of habituation if elephants begin to perceive that the deterrents being used are essentially 'bluffs' that pose no real threat to them. Combating such habituation relies on using a shifting combination of novel methods that is harder to habituate to, and ensuring that some of the methods used really are unpleasant for elephants. Chilli falls into this category, and is discussed further below.

Chilli essence

The use of chilli as an elephant deterrent has received a great deal of publicity in recent years due to its irritant properties and apparent success at keeping elephants out of fields. It has been used in a variety of ways, including being burnt on fires (Hillman Smith *et al*., 1995), turned into an aerosol spray and fired at elephants (Osborne & Rasmussen 1995) and added to grease and smeared on simple string fences (Hoare, 2001*a*).

The use of chilli has been developed furthest in Zimbabwe by Loki Osborne and colleagues. There, the most comprehensive *in situ* quantitative study revealed that chilli spray was more effective than traditional methods at limiting the amount of time elephants remained within a field, although practical constraints limit this rather high-tech method (Osborn 2002). The simpler use of chilli grease applied to rope fences around fields has been tested effectively in short term trials in both Kenya and Mozambique (Duncan, 2003).

Electric fence along protected area boundary or around farms

With the failure of deterrents and other barriers, the use of electric fencing has become widespread as a means of preventing elephants from gaining access to drops, in both Africa and Asia (Thouless & Sakwa, 1995). Electric fences, when successful, can reduce HEC incidents considerably. One study in Zimbabwe revealed a 65% decline in HEC after fence construction (Taylor, 1993).

Compared to other strategies tested in a study in Namibia, only electric fencing reduced elephant crop damage at the community level (O'Connell-Rodwell *et al*., 2000). However, this was only the case where a village was entirely enclosed by a fence (rather than fencing a protected area boundary). Moreover, whilst HEC incidents in this village fell, those in adjacent villages rose, suggesting that the electric fence only served to displace the problem elsewhere. Equally, it was found that elephants went around the ends of a fence along the boundary of Tsavo East NP in Kenya, resulting in greater conflict at each end of the fence despite reductions in the middle area (Kasiki, 1999).

Displacement aside, electric fences are likely to be most effective if they totally encircle an area (Taylor, 1993; Hoare, 1995). However, this forms a hard edge between land use types and therefore encroaches on elephant range, and may not be practical where small farms are interspersed with uncultivated land (Tchamba, 1995). Equally, electric fences cost a great deal to erect and maintain (US$2500-4000/km construction costs, plus annual maintenance costs of US$150/km, Thouless & Sakwa, 1995), and without a long-term commitment to maintenance and security they soon become ineffective. Moreover, there have been cases of communities themselves destroying fences to gain access to protected areas for cattle grazing (Ngure, 1995). In another example, two fences around Liwonde National Park in Malawi were vandalised by local residents and the wire used for snares (M.Borner, *pers comm*.).

In a comprehensive test of electric fence design in Laikipia, it was found that elephants could break through even the most sophisticated type of fence (Thouless & Sakwa, 1995). This was generally achieved by elephants knocking over the fence posts that were not electrified, or by breaking wires with their tusks. Even with successive modification elephants learnt how to break fences. The difference in effectiveness of different fences was attributed more to the prior experience of the elephants to fencing in each place rather than to fence design. Availability of natural food may be a further factor determining the lengths that elephants will go to in order to break through an electric fence. Furthermore, if fences are combined with shooting of problem animals early on, this may act as more of a deterrent since elephants may attribute greater danger to the fence than a mere electric shock. In this case the fence would serve more as a deterrent than a barrier.

Electric fencing is something of a controversial issue in Tanzania, and in Serengeti in particular. The current national policy resists fencing in protected areas, and this is unlikely to change in the near future. Moreover in the case of Serengeti, there is a worry that fencing would interfere with the wildebeest migration. It is known that the migration does not remain entirely within protected area boundaries (Thirgood *et al*., 2004), and in drought years they may depend more heavily on external areas. Cattle fencing in Botswana had a devastating effect on wildlife during droughts, cutting off traditional migration routes. Thus, there would be a need for very careful research and wide-ranging consultation with stakeholders before a large-scale fencing project was implemented in this area.

Other non-electrified barrier methods

Traditionally a variety of barriers have been used to mitigate HEC, including numerous fences (poles, hedges, and wire), walls and moats. All are fairly labour intensive and have proved costly to construct and repair.

Non-electric fences have proved largely ineffective since elephants are usually able to break them down easily. In Transmara a variety of fencing, from wooden poles to live hedges, have been tried with little effect. Indeed, farms with fencing were found to be more susceptible to HEC incidents, perhaps because people in these farms were relying on fencing as opposed to other more successful measures (Sitati, 2003).

Stone walls have been tried in Laikipia, but alone do not comprise an effective barrier because elephants can push them over (Thouless & Sakwa, 1995). They may be more effective with a concrete top or an electrified wire above, but are only feasible in areas with plentiful supplies of stone.

The use of moats and trenches constructed around cultivated areas to prevent elephant access has also been tried. However, this has a number of side effects, including the interruption of drainage systems, the potential hazard of stagnant water building up inside them, and the high costs of construction and maintenance. A trench was tried in Transmara but soon became abandoned and overgrown as resources for its maintenance dwindled. Moats were also attempted in Laikipia, and were found to be most effective when combined with fences. However, as in Transmara, a lack of maintenance led to all the trenches and

moats in Laikipia falling into disrepair, and none are now functional (Thouless & Sakwa, 1995).

Buffer crops around fields

The planting of buffer crops around the boundary of fields, i.e. unpalatable cash crops that elephants do not like such as tobacco, tea, eucalyptus or chilli, has been contemplated for many years, but as yet there is little evidence that it actually works, as elephants are known to simply pass through these buffers (Bell, 1984). Chilli pepper buffers are currently being planted on a small scale in Malawi and Zimbabwe, and in the latter there has been some monitoring of their effectiveness in reducing elephant incursions (G.Parker, *pers. comm*.). Chillies do however provide an alternative cash crop, if there is a system in place to get them to market.

Planting alternative crops

Elephants have been shown to eat a wide variety of crops, but it is clear from the data presented here that elephants favour certain crops above others, and avoid certain crops almost entirely. Encouraging farmers to plant alternative, less favoured crops may be a useful strategy, but is often difficult in practice. Soils and climate affect the viability and yield of different crops. Equally, where a range of crops are planted, such as in Serengeti District, human tastes may mirror elephant tastes, so that crops favoured by elephants such as maize and sorghum are also favoured local staples that it may be difficult to reduce or replace. Moreover, in an area such as this where many people are subsistence farmers and transport networks are not well developed, it may be difficult to encourage people to replace their subsistence food crops with cash crops such as cotton or tobacco that elephants do not eat.

However, the district has been successful in encouraging people to grow more cassava, which is viewed as a useful crop for food security due to its year-round availability and greater drought resistance. It is also less favoured by elephants. However, there are nutritional and health concerns surrounding over-reliance on cassava which mean that it should not be viewed as a complete replacement for other staples.

Buffer zones, village planning and district land use planning

The use of larger scale buffer zones between protected areas and cultivation may be more effective than buffer crops around individual fields. Again, however, where settlement is increasing right up to protected area boundaries, setting aside further unused areas of land may be impractical and politically difficult.

An intermediate-scale solution between buffer zones and buffer crops around individual fields, given the clear differences in palatability of different crops to elephants, would be to consider strategic planning of the layout of fields, crops and settlements within village boundaries. For example, it may be better to plant unpalatable cash crops along the village boundary closest to the elephant range, followed by less palatable food crops such as cassava, with the most palatable food crops such as maize in the centre of the village territory. With game scout guard posts on the periphery and concentrated human settlement around maize and sorghum fields in the centre, there may be adequate early warning and deterrence, combined with less accessibility for elephants.

HEC exists where agriculture and human populations encroach on elephant range. A clear solution, then, is to move away from agriculture to more compatible forms of land use within elephant ranges. Indeed, in areas of high elephant threat, it may be necessary to consider abandonment of farming or relocation of settlements. This is a very politically sensitive topic, and one that usually results in significant local opposition. However, in some cases it is the most appropriate and lasting solution, especially where alternative options can be made

available. Wildlife-related land use options, such as tourism and hunting, could provide direct benefits for local communities whilst conserving biodiversity.

In Serengeti District, for example, the village of Robanda is situated some distance form other settlements and at the heart of the elephant range in the western Serengeti. Increasing cultivation around this village (possibly partly as a response to declining hunting opportunities) is clearly going to result in increasing HEC, and this village receives a lot of support from TANAPA in combating HEC. However, this village is in a lower-yield area of the district, in an area of lower rainfall that ecologically is more consistent with the surrounding protected areas than the settled areas of the district to the north and west. Ecologically, the best solution for Robanda would be to reduce or cease all cultivation in the large, unprotected farming blocks that are expanding from the village centre. Such an approach, however, would require stronger government policy on land use planning, and viable alternatives for Robanda's farmers. In the shorter term, it may be better to use Robanda as one of a range of testing grounds for selected mitigation methods (see below). If it is ultimately shown that this area is more difficult to defend then there will be greater rationale for considering stronger planning limitations.

Removing elephants: translocation and lethal control

Translocation of elephants has received much publicity in recent years, and is popular amongst animal welfare organisations because it is non-fatal. However, despite considerable development of the technique (Coetsee 1996), it remains a difficult and expensive process, requiring huge financial resources and skilled personnel (Njumbi *et al.* 1996), and may only serve to displace the problem to other areas. In a large and expanding population like that of the Serengeti, the removal of a few elephant groups is unlikely to have any real impact on crop raiding.

Killing elephants has been used alongside non-fatal methods of HEC mitigation for decades (Taylor, 1993). Destruction of problem elephants has been used mainly to appease local communities affected by HEC, and to provide some indirect compensation in the form of meat (Hoare, 1995; Tchamba, 1995; Lahm, 1996). However, shooting persistent problem elephants seems to have little effect on HEC (Bell, 1984; Ekobo, 1997; Hoare, 2001*b*). This is partly because identifying the persistent offender can be very difficult, particularly when centralised decision-making results in huge delays between reporting of HEC incidents and PAC activity (Ngure, 1995; Lahm, 1996). Shooting problem animals seems to have no deterrent effect on other elephants in the area. Furthermore, after the removal of problem animals, other elephants usually take their place as crop raiders (Hoare, 2001*b*). However, a sustained policy of low-offtake shooting each year in Kenya was perceived to control HEC, particularly if implemented at an early stage in the history of HEC in an area and in conjunction with other methods such as fencing (Thouless & Sakwa, 1995). Equally, if controlled shooting is restricted to the peak conflict periods it may be a more effective deterrent since it is more likely to induce association between killing and crop raiding (Hoare, 1995).

Compensation

Tanzania does not offer compensation for crop losses to wildlife. However, across Africa, governments have attempted to mitigate human-elephant conflict by offering financial compensation to farmers for crop damage and other losses. However, these schemes are expensive and cumbersome to administer, whilst claims are difficult to evaluate or verify and funds are rarely sufficient and easily misappropriated (Hoare 1995, 2001a). They have largely failed, in part for the logistical reasons cited and in part because they only address the symptoms and not the problem, so conflict is not actually reduced (Hoare 2000). Equally, the existence of a compensation scheme can increase cultivation and loss of natural habitat near protected areas (Sitati, *pers. obs*.). Throughout the continent, many compensation schemes have been abandoned as unworkable (Bell 1984; Ngure 1995; Tchamba 1995).

Benefit-sharing

By generating benefits from elephants or other wildlife to offset costs of living with them, community attitudes and tolerance can be improved. This is the rationale behind much of CBNRM and community-based conservation and outreach in Africa. However, as noted above, even where significant benefits flow from protected areas, they rarely offset the individual costs borne by the farmers whose crops are destroyed by elephants. It is also the case that such benefits are not always attributed to the existence of wildlife, and so do not influence local attitudes, support and tolerance (Walpole & Thouless, in press.).

Benefits need to be as targeted as possible without becoming a form of compensation. This could be achieved by using some benefits for mitigation activities (such as supporting village game scouts, etc.), assisting the development of village insurance schemes, or providing education, training and awareness for farmers (either *in situ* or through study trips) in how to reduce HEC, improve crop yields, and gain greater access to markets. In association with this, education activities to increase people's understanding of the linkages between wildlife and local benefits, and the trade-offs that this involves regarding farming and HEC, are likely to be very valuable.

Study trips

The DGO mentioned a plan to take some farmers from the district to other locations where HEC mitigation is being practiced, in order for them to learn appropriate techniques from farmers in similar situations, especially before any methods have been tested or implemented locally. This is relatively easy and inexpensive, and can be implemented rapidly. However, its direct effect is limited to a small number of participants unless these participants are chosen carefully and given the appropriate training and support to demonstrate and disseminate their new knowledge and experience locally. As such, study trips may be most effective where they are linked to follow-on implementation activities such as the establishment of demonstration plots.

Demonstration plots

The DED expressed his support for demonstration plots to test mitigation methods and spread local awareness. These serve the dual purpose of actually mitigating conflict as well as providing *in situ* examples for other farmers to observe, learn from and hopefully adopt. They too can be implemented rapidly, and can be used to raise awareness amongst a much greater number of farmers than study tours (see Box 2).

Research as a tool for mitigation

Several district officials recognised the need for further research into HEC locally. Besides basic monitoring of the extent of crop raiding, and patterns of elephant movement, etc. research into the efficacy of different mitigation methods can and should be integrated into a practical mitigation programme. This allows the effectiveness of new methods to be evaluated, and provides the ongoing evidence necessary to develop the most appropriate adaptive mitigation strategy (see Box 2).

Box 2. A research-based approach to mitigating human wildlife conflict in Transmara District. Kenya.

A project to mitigate human-elephant conflict in an area adjacent to the Masai Mara in Kenya illustrates the use a research-based approach to monitoring and evaluation. The project was a partnership between WWF, DICE (an academic institute), Kenya wildlife Service and the local community. Somewhat unusually it began as a research project, providing baseline data on patterns and causes of conflict, and local attitudes towards elephants and the Reserve (Walpole *et al*., 2003).

The research identified some potentially successful mitigation methods (early warning, communal guarding, the use of chilli as a deterrent), and in a subsequent phase worked with the community to implement these methods in selected high conflict zones by constructing watchtowers and training and equipping teams of farmers to act as crop guards (see Appendix II for photographs). By monitoring conflict continuously before and after implementation, in target and non-target zones, and incorporating monitoring of potentially confounding factors including elephant distribution and rainfall, the project was able to demonstrate that:

- Incidences of crop raiding had declined in general due to increased rainfall.
- Incidences of crop raiding declined more dramatically in target zones than in non-target zones.
- This was despite an increase in elephant presence in target zones.
- Chilli rope fencing prevented damage for two years to a farm that had been raided seven times in the previous two years.
- A habitually raided farm in the heart of the elephant zone was only subsequently raided when the farmer's supply of thunder flashes ran out.

Follow-on social surveys are currently being conducted to detect whether reduced conflict has resulted in increased support for conservation, and increased local adoption of novel mitigation methods as a result of demonstration plots.

An added benefit of the project was the training and employment of community scouts to monitor conflict. This has injected valuable wage earnings into the community. Moreover, the goodwill generated by this has led to an increase in voluntary scout activity to monitor illegal activities including snaring and ivory poaching. This has provided a more fundamental measure of conservation success (reduced threat) to be implemented. It has also served to demonstrate a modern value to traditional cultural practices, in this case *Moranism*, or nomadic warriorhood. Morans have proved to be the most enthusiastic an efficient scouts, using their skills and traditions to improve environmental security (Walpole, 2004).

6. Conclusions and Recommendations

6.1 Conclusions

- Crop raiding by elephants is a recent phenomenon in Serengeti District, that has emerged within the past 3-4 years as a result of increasing cultivation on the boundaries of the elephant range, increasing elephant numbers in the ecosystem, and increased security in the Game Reserves bordering SNP that has resulted in greater incursions of elephants into settled and cultivated areas.

- Crop raiding has escalated since November 2003, and has become a significant issue for both village and district authorities. Data on crop raiding have been collected at both levels, which enabled a more detailed assessment of crop damage than hitherto expected. In particular, it was possible to elucidate elephant crop preferences and to make broad estimates of the magnitude of losses. Crop raiding takes place between November and June. Elephants clearly preferred grain crops, such as sorghum, millet and maize, to root crops such as cassava and potatoes, and rejected cotton, a minor cash crop in the district.

- However, limitations in the methods and uniformity of data collection across the district are evident. In particular, relying on farmer's reports of crop raiding may lead to overestimates of loss. Equally, the nature of the records taken by each village differs, and they contain little or no spatial or temporal information. This makes it difficult to obtain more than a basic picture of crop raiding.

- Currently, farmers do little to defend their crops from elephants, and believe that their simple guarding and deterrent methods do not work. This is partly due to a lack of experience of dealing with elephants and partly due to a lack of early warning systems that enable detection of elephants prior to their entry into fields. Instead, farmers rely on TANAPA and Grumeti Reserves to respond to reports of crop raiding by sending vehicles and rangers to chase the elephants away after they have begun to raid crops. However, such post hoc interventions are always going to be secondary to effective front line deterrents.

- Attitudes towards conflict mitigation differ between farmers and district leaders. Whilst the former wish to see more intervention and support from wildlife authorities, those at the district level are keen to explore land use planning, reduced cultivation in elephant-adjacent areas, and research. A Grumeti Reserves proposal to erect an electric fence along the boundary of the protected areas has received some support locally but remains controversial, and may not be appropriate at the present time without further research and consultation.

- Where elephants coincide with cultivation, it is unlikely that HEC will ever be completely eliminated. However, by developing an integrated programme of monitoring, research, participatory mitigation using small-scale and cost effective measures, and education, it is likely that HEC will be significantly reduced to more tolerable levels. The following sections outline a series of recommendations for monitoring and mitigation.

6.2 Recommendations for monitoring HEC

HEC is a relatively new phenomenon in Serengeti District, and as such there is currently little rigorous and comparable data. Whilst findings from elsewhere can be used to infer possible solutions to the problem, there is no substitute for rigorous and comprehensive *in situ* information gathering. Research and monitoring should not be divorced from implementation of HEC mitigation, but should be central and integral to the whole process; without such information it is not possible to design appropriate interventions, evaluate their impact, make

the necessary modifications or respond to changing circumstances. Thus, a research and monitoring programme should encompass the following core elements:

- Continuous baseline monitoring of crop raiding to establish where and when it is happening, its intensity, and how these factors change over time.

- Establishment of comparative mitigation trials that can be monitored for their effectiveness.

In addition, the following secondary elements are likely to be useful as part of a broader monitoring programme:

- Monitoring of elephant movement and distribution patterns to establish the extent to which this dictates patterns of crop raiding, and to provide a potential early warning system.

- Monitoring of local attitudes and activities over time, to discover the extent to which interventions have improved local support and tolerance, or changed the way people approach livelihoods and conflict mitigation.

Monitoring, like mitigation, is often most successful when it is an inclusive process of collaboration between authorities/external stakeholders and residents. Thus, the use of local labour, in the form of community game scouts or similar, to collect baseline information is an increasingly common occurrence, and one that also acts to raise local awareness and provide some benefits back to a community suffering HEC in the form of wages or honorariums (Walpole, 2004). The following recommendations are built around such a process of inclusion

Assessing crop damage

- Identify, train and employ a district co-ordinator for HEC monitoring. The co-ordinator should be educated to at least degree level and capable of compiling and analysing quantitative data, using GIS software for mapping, and writing reports. They should be familiar with the use of GPS and social research methods, and capable of training and overseeing a team of village enumerators who will be responsible for recording timely and accurate information on HEC. Their role will include continuous spot checks of enumerators to verify the accuracy of their reporting. They do not necessarily have to originate from the district, and a research assistant or higher degree candidate from a technical body elsewhere in Tanzania may be appropriate.

- Select one literate individual from each sub-village adjacent to the protected elephant range, and train them to be HEC enumerators. Each individual should be equipped with a GPS, bicycle, and a standardised enumeration form (see below) on which to record details of every HEC incident. These individuals may be existing village game scouts or other enthusiastic and suitably qualified local residents. Each should participate in an initial training course, and should then be paid a monthly honorarium throughout the crop raiding season (Nov – Jun) to act as a local focal point for reporting HEC, and to follow up and verify the details of each incident.

- Each enumerator should visit the location of each crop-raiding incident that occurs within the boundaries of their sub-village along with the complainant, as soon as possible after the incident. Records of the incident should be collected by interviewing the complainant *in situ* and verifying the facts with careful observation and measurement. A standardised reporting form should be used for data collection similar to that developed by the IUCN/SSC African Elephant Specialist Group (Hoare, 1999, available from the AfESG website). A version of this form is reproduced in Appendix IV.

- Accurate measurements of field size and crop damage should be made by pacing out the area of the field and the area of damage. Training will be required to ensure a standardised ‘pace’, unless enumerators can also be supplied with relatively long and durable tape measures. With experience it may be possible for enumerators to accurately

estimate the size of fields and damaged areas by eye, but if such a method is to be used then it will require regular testing and 'recalibration'.

- For the purposes of establishing the relative magnitude of losses, elephant crop preferences, and the spatial dynamics of HEC, an accurate spatial map of the location and size of all cultivated fields in each sub-village should be prepared prior to the onset of crop raiding. This should consist of a database of the GPS location of each field, its size, and the crop planted that can then be utilised in a GIS. Although potentially relatively labour-intensive, this exercise could be conducted by each enumerator in concert with existing village efforts to record the extent of their agricultural activities each year, with support from the district where necessary.

Establishing mitigation trials/evaluating effectiveness

- The various community-based initiatives for mitigating HEC recommended below should be replicated in consistent fashion in several villages along the protected area boundaries. Besides recording incidents of crop raiding village enumerator should be responsible for recording details of each challenge that elephants make to the defences, whether successful or not. Villages or farms where initiatives are not replicated act as comparative 'controls' (for further details, see Appendix V).

Training and capacity-building for community-based HEC monitoring

- In order to achieve the above and initiate it prior to the onset of the next HEC period (November 2004), contract an external consultant, with field experience of training and co-ordinating a team of local HEC enumerators and developing mitigation trials, for a short period to assist with the initiation of the monitoring and trials programme, and to train both the enumerators and the HEC co-ordinator for the district. The consultant should also be familiar with the compilation and analysis of HEC data using GIS.

Monitoring elephant movement and distribution

- In order to understand more about the dynamics of crop raiding within an elephant population, it would be valuable to initiate a research project in the western Serengeti, Grumeti GR and Ikorongo GR. This should focus on identifying individuals and groups and monitoring their movement patterns in relation to crop raiding. This would be best undertaken as a longer-term study initiated by a qualified individual, and as part of a wider study of the way that the expanding elephant population is using the ecosystem.

- Regular patrolling of the boundary areas of the protected areas by rangers should include recording, with GPS, of the location of elephant groups sighted. Group size and composition, and the identification of individuals where possible, should also be recorded. This would assist any ongoing research study.

6.3 Recommendations for mitigating HEC

Observations from here and elsewhere suggest that reducing HEC means making crop raiding as unattractive a prospect as possible for elephants. This can be done by reducing the temptation to crop raid and increasing its difficulty. The latter can be done relatively easily by increasing early warning and local deterrent efforts, whilst the latter involves making changes to agricultural practices and land use planning. In both cases, local residents themselves should be involved rather than relying entirely on external support and decision-making. The current lack of any real form of mitigation activity means that there is ample scope for improvement in the situation with the application of a few simple initiatives. The following recommendations are intended for the district, villagers and external supporting agencies in partnership (TANAPA, Grumeti Reserves, FZS, etc.):

- Improve early warning of elephant approach by establishing a communication system between villages and existing ranger patrols within and along the boundary of SNP, Grumeti and Ikorongo GRs and Sasakwa, so that elephant groups in areas close to, and moving towards, villages can be reported to villages in advance of possible raiding.

- Improve early warning of elephant approach by establishing wooden watchtowers (in trees or freestanding) on the edge of villages near to the front line of farms facing the direction in which elephants usually come. These watchtowers should be manned overnight during the crop raiding season by a team of trained village game scouts (see below) equipped with high power torches, with which to detect elephants, and whistles with which to alert other scouts/farmers to respond to elephants.

- Improve village-based guarding effort by training a team of village game scouts or equivalent in detecting and deterring elephants prior to their entry into crop fields. These scouts should be trained to use a standard suite of methods, including lighting fires, banging tins, etc., and working communally to defend the front line. Where possible, one member of the team should be trained and licensed (possibly as a police or army reservist if necessary) to use thunder flashes or a firearm with blank ammunition to scare elephants should other methods fail.

- Construct simple rope fences, coated with chilli grease, around front line fields or farming blocks. Chilli can be relatively expensive to purchase but can be grown easily with training, providing an additional cash crop as well as a resource for HEC mitigation. The chilli peppers should be ground up and mixed with some form of grease or old engine oil, and coated on to a rope positioned at around head height and supported by wooden posts (see Appendix II for photographs). Nylon rope has been found to be more effective than sisal, which is less durable. Regular re-application of the grease through the conflict season is necessary to effect continuous deterrence.

- Establish, train and equip a mobile rapid response team of six TANAPA rangers with a dedicated vehicle, to be based at Fort Ikoma, with communication links to all boundary villages affected by HEC, and supported where possible with funds from the District, Grumeti Reserves and FZS. This team should be available to follow-up on reports of HEC where village-based deterrents have failed to displace elephants. This should be considered as a last resort rather than the cushion upon which villages currently rely. The team should be equipped with overnight equipment and thunder flashes/ammunition so that they can be temporarily stationed at particular villages to assist village game scouts.

- Villages along protected area boundaries should develop clustered cultivation zones further from protected area boundaries, and discontinue remote and outlying farms that are more susceptible to crop raiding and less easily defended. Such zones should be guarded communally and, where possible, fenced with chilli rope or strong barriers. Sisal should be avoided as a barrier or boundary marker.

- Villages along protected area boundaries should plan the layout of their cultivation so as to ensure that grain crops such as maize, sorghum and millet are located in centrally, well protected areas surrounded by less palatable crops and manned watchtowers. Smaller, clustered zones of grain crops at the centre of villages should also be specially guarded in case the front line early warning systems fail.

- Villages along protected area boundaries should in the longer term consider reducing or discontinuing the cultivation of sorghum, millet and maize, and instead focus on cotton, cassava, potatoes and chilli. If such a reduction is enacted, there will be a need to make grain crops accessible to such villagers by improving market access or food support.

- The village of Robanda should be encouraged to find alternatives to cultivation, or to reduce cultivation to a smaller, more heavily defended enclave. External support for cultivation and HEC mitigation should not focus as heavily as it currently does on

Robanda since this takes resources away from other areas and acts as an incentive to continue cultivation in an areas where it is never likely to be compatible with wildlife.

- Where possible, benefit-sharing schemes by TANAPA, the Wildlife Division and Grumeti Reserves should target HEC mitigation initiatives. Part of the TANAPA SCIP fund, and discretionary community development resources from Grumeti Reserves, could be used to support village projects such as the establishment and training of game scout teams with watchtowers and torches, or the development of chilli growing farming co-operatives.

- Consider taking a selected group of farmers/village leaders (from each affected village) on a study tour to an HEC zone elsewhere in Tanzania/East Africa, to raise awareness of the ways in which other communities are mitigating conflict.

- Use the establishment of some of the mitigation initiatives described above as demonstration plots for other farmers in adjacent farms/villages, so as to encourage the adoption and expansion of novel mitigation methods. Organise regular visits to each demonstration plot by groups of neighbouring farmers, with a presentation by the village enumerators or HEC coordinator.

- A community education and awareness programme should be initiated in the district. Through village meetings and schools programmes, the importance of elephants within the Serengeti, the benefits that wildlife generates for people, and the ways in which communities can mitigate HEC should all be communicated. The HEC coordinator should ensure that regular updates of the performance of mitigation methods in reducing HEC are disseminated locally through this programme.

6.4 Next Steps

Prior to the next raiding season that will begin in November 2004, the following should be done:

- Convene a stakeholder meeting to agree a strategy for HEC mitigation.

- Contract a short-term training consultant with HEC experience, for 2-3 months to:

    - develop village-based mitigation trials
    - recruit and train the HEC coordinator
    - recruit and train village game scouts to be crop guards, and train village conflict enumerators.

A list of potential candidates for such a role can be supplied by the lead author of this report upon request.

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Appendix I: Terms of reference for the lead consultant

1. To lead a small team of consultants including one representative from Tanzania National Parks and one representative from Wildlife Division who will assess Human-Elephant Conflict in the Serengeti Ecosystem.

2. To assess available information on long-term changes in elephant numbers and distribution in the Serengeti Ecosystem.

3. To assess available information on crop damage caused by elephants and other crop raiding vertebrates in the Serengeti Ecosystem.

4. To conduct interviews with local communities and other relevant stakeholders to assess perceptions of elephant crop raiding in the Serengeti Ecosystem.

5. To develop and implement a rigorous system of assessment of crop damage by elephants and other vertebrate pests in the Serengeti Ecosystem.

6. To assess the full range of conflict mitigation techniques currently available to reduce human-elephant conflict in the context of the Serengeti Ecosystem.
7. To make recommendations for further action.

8. To submit a comprehensive written report (electronic copy) on the above tasks.

Appendix II: Photographs from the evaluation

Cultivation bordering protected areas in Serengeti District

More densely settled areas of the District

Members of the evaluation team

Verifying elephant crop damage

A sisal boundary fence destroyed by elephants

Elephant dung in a raided field provides incontrovertible proof of the culprits

Ripe sorghum before raiding

Sorghum after elephant raiding

Cotton, a cash crop, is not eaten by elephants but is sometimes trampled

Cassava, promoted as a food security crop, is not a favourite elephant food compared with sorghum, millet and maize.

Appendix III: Minutes of a district meeting on elephant crop raiding

A BRIEF REPORT ON THE MEETING OF GRUMETI DIVISIONAL LEADERS AND WILDLIFE MANAGEMENT INSTITUTIONS HELD AT NATABIGO ON 5/2/2004

Present:

1 Ag. Grumeti Divisional Secretary – Chairman
2 District Commissioner – Serengeti District
3 Village Chairpersons
4 Village Executive Officers (one was appointed a secretary for the meeting)
5 Councillors
6 District game Officer
7 Officer Commanding District (Police Chief)
8 Director – VIP Club
9 Project Manager – SRCP
10 Projects Officer - SRCP
11 Anti-Poaching Warden – SNP

Absent:

1 Some of the village chairpersons and village executive officers
2 Some of the councillors.

Agenda:
The agenda was only one (1) that was to identify means/ways of preventing elephants from entering into farms and damaging crops (food), the problem that is serious at present.

Report of the Damage already made:
Each village gave a report of crop damage for the period of January this year. It became obvious that the damaged crops include maize, sorghum, cassava, and potatoes. There are villages that received serious damage, some minimal and others did no have elephant problem. In the whole of Grumeti Division, the total of 575 acres (five hundred and seventy five) of the crops mentioned above have been damaged by elephants (see annexed chart).

Recommendations on Steps to be taken:

1 Using a traditional medicine man
2 Putting up an electrical fence around the farms
3 Putting up an electrical fence on the boundaries between the farms and the wildlife areas
4 Shoot and kill the group leaders (matriarch)
5 To build many ranger posts in between the farms and game reserves and patrol be conducted day and night in those areas.
6 To kill the elephants using bows and arrows
7 The radio calls be available in the villages for quick communication when the elephants come to the village and use artificial bullets to chase them away.
8 To burn things that produce obnoxious smell such tobacco, oil, old tires,
9 To patrol regularly on the periphery of the game reserves.

The discussion continued to analyse each of the above recommendations.

A traditional medicine man:
The DC said that this is outdated practice and he did not want the secretary to record in the minutes, as it is only lies. It was further explained that Rubanda once tried this method without success; elephants ate even the crops of the medicine man.

Fencing the farms with electric fence:
It is expensive and difficult because the farms are scattered.

Electrical fence between the farms and game reserves:
It is expensive and takes time. Also it disrupts natural wildlife movements and seasonal migration. But VIP promised to help when the responsible institutions have agreed and permitted, after the impact assessment has been done.

Killing (matriarch) the leaders of the groups:
It is not appropriate, as elephants will decline.

Building many ranger posts:
The project is very expensive

Killing elephants using arrows and bows:
It is a negative measure, as it will cause elephants extinction.

Provision of radio calls in villages:
It is expensive and its management difficult. VIP has issued radio calls to some villages.

Burning things with obnoxious smells:
It is a good exercise but availability of such things maybe difficult.

Patrolling along the boundaries:
This is possible provided that there is a budget for funds and equipment. It was agreed that the District council, SNP, VIP and FZS be requested to collaborate in this issue.

Resolution:
Briefly, the exercises to burn things that produce obnoxious smell, to scare elephants using artificial and real bullets and regular patrols on the boundaries/edges are means that were agreed as interim or short-term solutions. The erection of electric fence on village lands and edges of game reserves from Iharara through Isenye open area to park Nyigoti is a long term solution, although it requires scrutiny and permit from appropriate authorities.

Thanks:
The meeting thanked the DC, SNP, VIP, DGO and the community for the deliberate measures taken to deal with the elephant problem and that this spirit should continue. Also the participants thanked the divisional leaders and Nata ward fro lunch after the meeting.

A point stressed out:
The DC insisted that there is no law in Tanzania for issuing compensations for the victims. He asked them not to despair but should plant their crops again.

Annexed part:

Crops damaged by elephants in Grumeti division January 2004

Ward	Village	Crops damaged	Damaged size (acres)
Isenye	Iharara	Sorghum	9
	Nyaisingisi	Maize, Sorghum	126
	Nyiberekera	Sorghum	0.5
Natta	Mbiso	Maize, sorghum	32
	Motukeri	Maize, sorghum	39.45
	Nyakitono	Sorghum, maize, cassava, potatoes	100
Kyambahi	Nyichoka	Sorghum, maize, cassava, potatoes	200
Ikoma	Robanda	Maize, sorghum	26
	Park Nyigoti	Maize, sorghum	42
Total			**574.95**

Appendix IV: A standard framework for monitoring HEC

(Adapted from Hoare,1999)

Form No…….. Date…….. Location..……
GPS location x……. / y …….
Enumerators Name…….. Complainants Name…….
Date of incident …….. Time of incident ……..
Number of animals ……. Composition …… (1. Male 2. Female 3. Mixed 4. Unknown)
Means of identification ……. (visual, tracks)
Place of detection ……... (before entering field, in field, not detected)

I. Crop damage

Crop type	Farm size (acres, paces, m^2)	Area damaged (acres, paces, m^2, or no. of stems)	Crop maturity level (young, medium, mature, dry)	Crop quality (good, medium, poor)

Action taken: ……

II. Other conflicts

(a) Human attack: ……. (1.Death 2.Injury)
Name of victim ……... Age …….. Sex ……. State …… (1. Drunk 2. Sober)
(b) House damage: ……. (1. Major 2. Minor) …….
(c) Water damage ……. (1. Major 2. Minor) ……..
(d) Food stores …….. (1. Major 2. Minor) ……...
(e) Fence damage……. (1. Major 2. Minor) ……
Type of fence……. (1.Traditional, 2.Wire, 3.Live fence, 4.Other)
(f) Other property damage (specify) ……..…… (1. Major 2. Minor)

Action taken: ……

III Reporting

Was the incident reported to the authorities? (1.Yes 2.No)
When ……. Where ……...To whom? ……
What was the response? ……

Appendix V: Establishing mitigation trials and demonstration plots

The **objective** is to replicate trials in multiple sites, using as comparable a method as possible, in order to assess their effectiveness in a wider range of situations.

Each scout to work with local farmers (with supervision by the HEC co-ordinator) to:

- Select front line group of farms for watchtower and collective guarding, where there has been recorded raiding in the past.
- Select (at least one, but ideally two) additional (more isolated) farm(s) for chilli rope fence, also where there has been repeated raiding in the past.
- Ensure there are comparative farms nearby (< 1km) that will not be included in trials, where there has been recorded raiding in the past.

The following should be recorded at the outset:

- Make a sketch map of the distribution of included and non-included farms in each 'trial zone'. This should include field layouts, location of houses and buildings, location and composition of fences if there are any, location of streams or rivers, location of any forest, and location of watchtower(s). Give each farm a unique identifier (either a number, code name or name of farmer)
- Record the sizes of each farm, their date of establishment, crop type, any previous raids, and past methods of defence (including usual number of guards, and whether they were family children, etc.).
- Record the exact GPS location of watchtowers and farms.

The following should be recorded continuously after establishment of the trials:

- Successful raids using the standard report form, but ensure to record the identifier for the raided farm as well (whether number, code name or farmers name) to be sure which one it is. If it was a farm covered by the communal guarding/watchtower(s), record whether the watchtower(s) were being manned and by how many people.
- Unsuccessful raids where elephants were detected but did not reach farms should also be recorded (date, time, elephant composition of possible, and a description of what happened).
- Any changes to planting regime (including planting and harvesting dates and changes in crops sown), abandonment of farms, and development of new farms.

Demonstration and awareness-raising activities:

- Once trial plots are established, organise a demonstration visit to each trial by a group of nearby farmers from outside the trial site. Record brief minutes, including date, time, names and locations of attendees, what was done, and what was discussed, including their response to the demonstration.

- Each scout should organise to give a brief talk to the students of a nearby school on HEC and their role as scouts, and what the district is trying to do to mitigate the problem. Regular updates and feedback visits would also be useful.