Spatial Interactions of African Elephant *Loxodonta africana* with the Resident Communities Bordering a Semi-arid National Park in Northern Kenya

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Received: 23 Mar., 2013
Accepted: 29 Mar., 2013
Published: 27 Apr., 2013

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Preferred citation for this article:


**Abstract**

Northern Kenya is endowed with rich ecosystems that support populations of African Elephant, *Loxodonta africana*. The changing human demographics accompanied by climate change have exacerbated the incidences of human-wildlife conflicts, especially around the protected areas – the parks and reserves. Recorded incidence of conflict between humans and elephants, in particular crop-raiding, is increasing in rural Africa, undermining efforts to conserve biological diversity. Gaining an understanding of the underlying determinants of human-elephant conflict is important for the development of appropriate management tools. We examined the causal factors of the human-elephant conflicts around Marsabit National Park, and evaluated potential mitigation strategies. Our findings showed that incidences of elephant conflicts affected both agricultural farms and livestock around the park. Seasonality (wet and dry) and distance from the park boundary also influenced the frequency of human elephant conflicts. Our findings further showed that the problem animal control unit presently organized by the wildlife management authority in Kenya – the Kenya Wildlife Service had little impacts in mitigating the existing human-elephant conflicts in the area. We discuss the implications of our findings in the contexts of land use planning and partitioning of resources around the Park, and the need for community engagement as a long-term strategy for winning support for conservation of African elephant in northern Kenya.

**Keywords**

African elephant; Marsabit National Park; Human-elephant conflicts

**Introduction**

Many parks, reserves and sanctuaries, especially in Africa were established based on the U.S Yellowstone conservation model with little regard for the ecological processes that maintained the areas and the species within them (Marekia, 1991). This exclusionary protectionism for wildlife has remained central to many conservation initiatives (Chatty and Colchester, 2002). Though well-intentioned, such practices have had repercussions for the livelihoods of rural communities worldwide, especially those that border the parks and national reserves (Owino et al., 2012). The increasing human population accompanied by poverty has led to increased demand for resources within the parks and reserves, especially in developing countries (Worden et al., 2009).

Crop-raiding by a range of wildlife species is a major cost for people in many parts of the world, in some extreme cases leading to subsistence crisis (Naughton-Treves, 1998). Such direct costs are relatively straightforward to quantify (Graham et al., 2010). African elephant (*Loxodonta africana*) is one of the large terrestrial mammals in the Kenya and occupies diverse habitats (Western, 1989; Omondi, 1994; Cumming et al., 1990). However, their range has contracted markedly over the years (Sitati, 2003). This has been largely as a result of competition with humans for essential resources. It is expected that climate and land use changes in their strongholds would further lead to shifts in the distribution and ranging patterns leading to increased spatial interactions with the communities, especially those who border the parks/reserves. This phenomenon is evident in areas such as Marsabit National Park.
northern Kenya – one of the strongholds of African Elephants, where the level of human and wildlife interactions continue to increase because of the changing human demographics and the accompanying land use practices (Guerbouis et al., 2012; Graham et al., 2010; Sitati, 2003).

The confinement of wildlife within parks/reserves, especially of African elephants within parks and reserves significantly curtail their dispersal and movements – an important aspect in their ecological requirements (Hayward and Zawadzka, 2010; Baxter and Getz, 2005). It also leads to scale dependent impacts to habitat because of browsing impacts (Kerley and Landman, 2006). Overall, elephants expand their ranges when forage and/or water are limited (Western, 1989; Western and Maitumo, 2004). Consequently, more movements occur from their confines of parks/reserves into surrounding areas in search of forage and water (Western, 2006). In the process, they encroach into farmlands, resulting in increased conflicts with people who settle around the parks/reserves. In addition, pests and diseases are transmitted to the livestock, and the increased interactions with humans lead to incidences of human injuries and even deaths caused by elephants. This contributes to cases of increased hostility towards elephants and the protected area by local people in many strongholds of elephants in northern Kenya.

We examined the spatial interactions and the extents of human-elephant conflicts in areas around Marsabit National Park, and evaluated the causal factors and the effectiveness of problem animal control strategy as currently applied by the wildlife management authorities in Kenya, the Kenya Wildlife Service. We hypothesized that human activities and distance from the forest edge did not affect the frequency of human-elephant conflicts and that the problem animal control programmes as presently undertaken by the wildlife management authorities in Kenya do not reduce the incidences of human-elephant conflicts. We discuss the implications of our findings in the context of human-dominated landscapes surrounding the Marsabit National Park, and the mitigation measures required to alleviate the human-elephant conflicts in northern Kenya.

1 Study area

Marsabit National Park is located in Marsabit County, Eastern Province, about 600 km from Nairobi. It lies at longitude 37°20’E and latitude 2°20’N (Litoroh et al., 1994; Figure 1). The Park covers an area of 360 km² including the 110 km² Forest Reserve managed jointly by the Kenya Wildlife Service and the Kenya Forest Service within the Central and Gadamoji divisions of Marsabit County in northern Kenya. The area is designated as an ecologically sensitive site in Africa (IUCN/UNEP, 1987). In 1973, part of the area surrounding the park and reserve was excised for the expansion of Marsabit town and human settlement (Litoroh et al., 1994). The Park and the surrounding areas are characterized by low rainfall with peaks in April-May and October-November (Kirubi et al., 2000).

Figure 1 Marsabit National Reserve, Kenya

The eco-climatic zone of the forest in the area is categorized as sub-humid and the surrounding plains fall within the very arid category (Eiden et al., 1991). The main vegetation types comprise of dwarf shrub-land, woodland, perennial grassland, evergreen to semi-deciduous bush-land, and evergreen forest
with characteristic plant species comprising of *Cordia abyssinica*, *Casearina* spp, *Croton megalocarpus*, *Strombosia scheffleri*, *Diospyros abyssinica*, *Olea africana*, *Olea capensis*, *Cassipourea malosana* and *Apodytes dimidiata* (Schwartz and Walsh, 1991). The lower elevation areas are characterized by progressively drier habitats with belts of Acacia woodlands and grasslands. The Park and the surrounding areas is globally recognized as important bird area with over 350 different bird species (Bennun and Njoroge, 1999).

2 Methods
We focused on areas adjacent to the Park including Songa, Karare, Kituruni, Badassa and Dirib-gombo sub-locations of Central and Gadamoji divisions of Marsabit County. These areas have experienced increased human demographic changes over the years with human population densities of over c. 22 persons/km², with crop farming and livestock keeping as the main economic activities. Secondary data on human population densities and livelihoods were obtained from the Kenya National Bureau of Statistics and departmental annual reports from the relevant ministries in the area.

2.1 Socio-economic surveys sampling procedures
Face-to-face interviews and special structured questionnaires were used in the socio-economic surveys with the questionnaires administered to the communities living around the Park. These were closed-ended questions with 10–15 minutes interviews per respondent in household sample units conducted by trained teams comprising of the local community members. The local administration, provided the total number of households in each village, and based on this, we estimated the sample sizes across the areas as follows: Sample size \( n = N(1+N(e)^2) \), where \( N \) = total number of households per village as supplied by local administration, \( e \) = error margin derived from the selected confidence interval, in our case we used 90% confidence interval (error margin 0.10), and stratified the survey with random selection of respondents procedures to cover two divisions divided into three administrative boundaries, regardless of whether they were located in the reserve or outside the reserve and or some distances from the Park boundary.

2.2 Spatial extents of human – elephant interactions and effectiveness of problem animal control programmes
Our assessments of interactions of elephants and the communities focused on the nature and extent of conflicts in different locations around the Park – sampled using questionnaires and focused discussion groups with the local communities. In addition, we undertook field observations and mapped the hotspots for conflicts, especially waterpoints, farmlands and livestock grazing sites. Our assessment was divided into wet and dry seasons to determine whether there were any differential effects of interactions and conflicts linked to seasons, and scored the nature and extents of elephant impacts across the sites. Information on various elephant control strategies as applied in the area, their effectiveness, and the most preferred options were assessed across sites, again using the questionnaires administered to the local communities and wildlife management authority staff. The respondents were asked about their views regarding the control strategies – scored according the existing and known control procedures as applied by the Kenya Wildlife Service.

2.3 Data analysis
The information obtained from the questionnaire was entered into Microsoft Excel spreadsheet and processed using Statistical Package for the Social Sciences (SPSS, 2010), and the results presented mainly in the form of descriptive tabular summaries. We used Chi-square and paired t-tests (Zar, 1996) to examine differences of quantitative socio-economic characteristics across the sites, and the impacts of elephants. Where applicable, we transformed data and applied multivariate statistical tests, especially on the nature and extents of human-elephant conflicts using principal component analysis (PCA) with varimax (Kaiser Normalization) rotation.

3 Results
3.1 The type and extent of human-elephant interactions
The extents of spatial interactions between humans and
elephants around Marsabit National Park showed fluctuations of different strengths across sites. Out of the 135 respondents, incidences of farm abandonment following elephant impacts pooled across sites was much higher accounting for 69% of respondents. The assessment and comparison of individual sites’ abandonment following elephant impacts showed the level of abandonment of sites, especially at Badassa, Songa and Karare Divisions were significantly differed (Chi-square goodness of fit, $\chi^2=17.297$, df=2, $P=0.027$).

Overlap in both space and time in the use of same water resource led to conflicts. Over 70% of the respondents across the sites reported water use conflicts with elephants ($\chi^2=49.7$, df=1, $P<0.0005$). In particular, the pastoralists were the most affected, and the conflicts showed fluctuations of different strengths during wet and dry seasons, with the levels of conflicts increasing marginally during dry seasons compared with wet seasons, especially at Karare and Songa compared to Badassa ($\chi^2=12.5$, df=2, $P=0.002$).

### 3.2 Transmission of livestock diseases

Predictably, livestock disease transmissions could have an effect on human-elephant conflicts, and among the diseases suffered were: foot and mouth, ephemeral fever, bovine pleuro-pneumonia and rinderpest. Overall, the locals blamed the increased incidences of diseases on elephants and the presence of the Park in the area. Over 80% of the respondents reported different livestock diseases attributed to the presence of elephants, and the presence of the park in their neighbourhood with 55% reporting that presence of the park was the major cause for livestock diseases incidences. The responses with regards to diseases transmissions by elephants differed significantly between Karare, Songa and Badassa ($\chi^2=21.785$, df=2, $P=0.0005$). Most respondents at Songa (75%) reported the park as the source of the disease causing vectors while 69% from Badassa reported organisms outside the park as the cause of livestock diseases (Figure 2).

### 3.3 Encroachment on elephant dispersal and migratory corridors

Most respondents (95%) had knowledge that elephant corridors existed. When further, asked whether the corridors had increased or decreased in width over the year majority, 84%, reported that the corridor widths had decreased while only (10%) reported an increase in the width. The response differed across Badassa, Songa and Karare ($\chi^2=24.841$, df=2, $P<0.0005$). Human settlement was the major reason cited for the decrease in corridor width (93%) with 10% of respondents in Badassa giving settlement as the main reason.

### 3.4 Seasonality and human-elephant interactions

Rainfall determines water availability in Marsabit and surrounding areas, and influenced the spatial distribution and movements of elephants in area. Seasonality influenced the incidences of human-elephant conflicts, with marginally higher incidences being reported during dry seasons compared to wet seasons, especially around the water points. Karare had the highest incidence of water use conflicts. Overall, crop raid frequencies by elephants differed between seasons ($\chi^2=117.029$, df=1, $P<0.0005$). June-August (98.5%, n=132) and December-January-February (98.4%, n=130), with no seasonal differences between the three sited Badassa, Songa and Karare ($\chi^2=3.240$, df=2, $P=0.198$).

### 3.5 Distance from the park boundary and human-elephant conflicts

A significantly larger number of respondents (95%) reported elephant crop raids between the distances of 0.5–2 km from the park boundary (Figure 3a, 3b, 3c), with relatively fewer attacks between the distances of 4.1–5 km from the park boundary. Thus, the raids...
decreased with increase in distance from the park boundary ($\chi^2=23.851$, df=4, $P=0.002$).

3.6 Elephant conflict control strategies
Most respondents (73.8%) disproportionately singled out the use of electric fence as the best option ($\chi^2=432.428$, df=6, $P<0.0005$). 13.8% suggested the establishment of elephant control bases manned by wildlife rangers, and increased rangers patrols, whereas 12.4% suggested other methods (e.g. digging of boreholes outside the park boundaries, degazettement of the park, establishment of permanent elephant corridors, compensation of victims of wildlife related losses, and involvement of the local people in the management of wildlife resources). However, the mitigation proposition did not differ among the respondents ($\chi^2=26.691$, df=2, $P=0.109$). The existing response mechanisms to the human-elephant conflicts by the wildlife authority in the area was reported as inadequate with a significant proportion (90%) of the respondents recommending that this is an area that requires improvement by the wildlife management authority.

4 Discussion
One of the dilemmas associated with wildlife conservation has been how to deal with land use conflicts in a manner that meets both conservation and the human needs (Ngare, 1995). Different land use activities have been introduced to co-exist on the same parcel of land with wildlife. Unfortunately, there has been lack of a coordinating body to ensure that development programmes are in harmony with wildlife conservation. Most farmers have abandoned their land in areas around Marsabit National Park indicating that indeed there is a problem with elephant damage being the main reason for farms abandonments. In such circumstances, therefore, elephant conservation, crop production and agro-pastoralism are incompatible land use strategies. The abandonments of farms lead to vegetation succession around the Park and possible spread of invasive species.

4.1 Crop damage and human encroachment in elephant dispersal areas
Elephants are feared the most because of the difficulty in stopping them and the dangers involved and the great
damage they cause in a single attack (Naughton-Treves, 1998; Kasiki, 1998). Subsistence farmers’ livelihoods are seriously affected by wildlife crop damage. In this study area, incidences of crop raiding by wildlife species were frequent and wide spread.

Human population in areas around Marsabit National Park increased from less than 5000 people in 1969 to well over 35,000 in 1999 (DDP, 2002). Moreover, there is change in lifestyle from nomadic pastoralism to more sedentary agro-pastoralism. Findings of this study revealed that almost all the farmers own land albeit a few acres. Land is either used for crop growing or mixed farming. People have now settled in Badassa, Dirib Gombo, Songa, Elpus, Kituruni and Karare practicing agriculture.

Further, due to the tendencies for expansion of government and NGOs supported agricultural technologies in the Central and Gadamoji divisions of Marsabit district, conservation and management of wildlife, especially elephant is becoming more and more difficult. The areas targeted for livestock rearing are the lowlands where it is hoped that improved services in output-increasing technologies would aim at maximizing agricultural output. Elephants disperse to the lowlands during wet seasons. This has culminated into less area left for the elephants. When their natural habitat dwindles to isolated fragments of forest, due to encroachment by the rapidly increasing human population adjacent to the park, they have no option but to break fences and cause conflicts with the people who settle in their ranges. Elephants isolated in parks at high densities inevitably raid surrounding farms (Mwathe, 1992; Barnes et al., 1995; Gachago and Waithaka, 1995; Naughton-Treves, 1998). Human population density and activities could affect movement of elephants. Forest excisions for settlement create “island farms” in the elephant range and are thus, the cause of conflicts (Kiiru, 1995).

A rapid decline of wildlife has been noted in areas where benefits do not accrue to the local community (Norton-Griffiths, 1978). This is because the community tries to engage in other land use types that are not only detrimental to wildlife population, but also cause increased conflicts. Among the land use that favorably or unfavorably impacts on wildlife includes crop production, livestock production, and settlement (Ngare, 1995). Litoroh et al (1994) in their studies around Marsabit argued that increased formal education and cultural erosion among the pastoralists was forcing them to adopt crop farming and sedentary lifestyle as a form of land use since they no longer have the time and do not see the need to lead nomadic lifestyle. Therefore, policies geared towards encouragement of these activities would jeopardize wildlife conservation, elephants included.

The importance of dispersal areas and migratory corridors for elephant population survival cannot be over-emphasized. The revelation by the respondent that settlement is the major cause of decrease of elephant corridors is worrying. Apparently, change in lifestyle has forced the local people to acquire large chunks of land either for farming or for settlement. The communities are again, moving away from the traditional village (clumped) system to more dispersed settlements. The resultant outcome is the blocking of elephant migratory and dispersal corridors through use of fences and other permanent structures. This is a major problem for the elephant population in the park and especially so in the wet seasons when they disperse to the low lands to take advantage of the new and nutritious growth.

While other studies have shown that there exist no relationship between human density and crop raiding (Kasiki, 1998, Hoare and du Toit, 1999), others have shown that crop raiding increased with increasing human population density (Kiiru, 1995; Ndungu, 1995). To support this she argued that low population density gives room to unoccupied habitats that are suitable for habituation by megaherbivores and that scaring away raiders by human beings is also low at low population densities.

Our findings that the park was the source of livestock diseases as reported by the respondents are expected, especially when the local communities increasingly interaction with wildlife from the Park such as African elephant. A high incidence of foot and mouth disease was reported in almost all the households visited. This is a major bone of contention between the livestock owners and the park authorities, hence
the conflicts.

### 4.2 Causal factors of human-elephant conflicts

The type of crop grown influenced the vulnerability to elephant raids. In the current study, it became apparent that elephants preferred some crops to others. Maize and bananas appeared to be the most preferred crops since other crops were not attacked in their presence and the two were highly attacked even in the presence of other crops. Ngure (1992) and Kiiru (1995) reported that elephants had a tendency to raid some crops more than others. Preference for mature maize can be based on the fact that the maize cob being the storage organ of maize plant is rich in starch and oils and therefore the high nutritive value is worth the risk of harassment (Sitati, 2003). Maize has a higher percentage of moisture and crude protein during the dry season than grass and browse (Osborne, 1998).

Season significantly influenced human-elephant conflicts in areas around the Park. Dry seasons recorded the highest cases of water use conflicts, crop raiding and livestock deaths. Rainfall influences the natural cycle of forage production and determines grass growth and therefore biomass production. Marsabit elephants move out of the forested areas of the Park to the lowlands at the onset of the rain. There was some degree of seasonal variations shown by elephants in crop raiding. Severe crop raids occurred mainly towards the end of the wet months when crops are almost ready. The months of June, July, December, and January recorded the highest raids. These are the months when forage is readily available within the park and therefore, shortage of food in the wild would not have been the incentive. However, in Marsabit, these times (June-July and December-January) coincide with the period of crops (maize, beans and peas) ripening and elephant’s movement into the forest from the lowlands trespassing crop farms. This creates a convergence and therefore, increased conflicts. It is important to note that most of the farms are in the traditional elephant migratory corridors or just a few meters away. The greatest losses would be expected during this time when there is increased foraging outside the park. Sitati (2003), however, argued that most crop raids occurred during the dry season when there was low grass height, low percentage cover, low biomass, and low grass moisture content and that changes in environmental parameters determined diet of elephants. Barnes et al (1995) reported that most raids occurred in the rainy season. However, Ndungu (1995) observed that severe crop raids occurred at the end and during the growing season.

Seasonal and climatic differences have caused different patterns of crop raiding by elephants in Kenya since the 1920’s (Sitati, 2003). Kasiki (1998) in his studies in Tsavo observed that the El nino caused heavy rainfall that resulted in crop failure and hence little conflicts. Little conflict was reported in Trans Mara District too during the El nino (Sitati, 2003). Even though the loss of livestock to elephants is generally low compared to other factors like drought and rustling, the few kills by elephants is intolerable, as the livestock owners do not perceive any gain from elephants. At the same time, the cost to a livestock owner in terms of the deprivation of water and dry season grazing are high. Thus, livestock owners run the risk of either being caught by the park authorities or their animals attacked by the elephants and hence take their animals into the park. However, the need to come into the park is reduced during the wet season when more surface water and grass are available outside the forest park.

### 4.3 Distance from the park boundary and human-elephant

In the present study, it became apparent that the crop raid incidences were higher in farms near the park boundary but decreased with increased distance from the forest edge. Dirib-gombo in Badassa stratum, the furthest location from the park edge recorded the lowest number of incidences compared to Karare and Songa. Probable reasons that one can advance for the lower number of incidences at Dirib-gombo would be the longer detection distance and the early warning signals by the farmers nearer the park edge and hence the preparedness to repulse the raiders. Besides, the settlements, namely Gabra scheme and Badassa, which are situated between Dirib-gombo and the Park, also act as a physical barrier for the elephants. Crop raiding has been reported to occur mostly near the
frontage of Protected Areas (PAs) (Bhima, 1998; Kailas, 2000; Ndungu, 1995) and decrease further away (Kagoro-Rugunda, 2004). Moreover, under the cover of the thickets and bushes in abandoned farms and unkept hedges between farms, elephant encroachment into farms becomes rather easy. The difficulty for the elephants to penetrate into the interior farms undetected could be speculated to be the major reason behind more crop raid incidences in farms near forest boundary than further away. The results were also consistent with those of Kangwana (1995) where he reports a decrease in crop raid incidences with increase in the distance from the park. Lahm (1996) and Naughton-Treves (1998) observed that proximity to the forest was the strongest predictor of damage where farms on the edge absorbed disproportionate amount of damage. However, Osborn (1998) observed that crop-raiding elephants in Zimbabwe moved further away from PAs when confronted with better protection measures. On the contrary, studies by Hoare and du Toit (1999), and Smith and Kasiki (1999) established no association between crop raiding intensity and distance from the PAs.

Livestock disease incidences inversely related to distance from the park. More residents living nearer the park boundary compared to those living further away reported livestock diseases from the park. Similarly, water use conflicts related inversely to distance from park boundary. Those respondents closer to the park reported more water use conflicts than those farther away. This could be due overlap in range use hence easy spread of disease vectors such as ticks from wildlife to the livestock as well as increased water use conflicts and livestock deaths.

4.4 Effectiveness of conflict mitigating strategies
The majority of the respondents indicated that erection of electric fence would be the best solution to solve the conflicts. The highest proportion of the respondents in this group came from Karare. Apparently, what influenced the respondents to prefer this solution was possibly respondents’ knowledge of its effectiveness when the fence was first erected in the area. However, electric fencing of the entire park would be an unsuitable solution towards minimizing human-elephant conflicts in areas around Marsabit National Park if we are to conserve the biodiversity inside and outside the park.

Traditionally, conflicts between local people and wildlife in Africa have been resolved by creating barriers to the movement of wildlife (Newmark et al., 1994; Ngene, 1998). Electric fencing can be a highly effective intervention (Thouless and Sakwa, 1995), but the effectiveness of the method has however been criticized by Kangwana (1995) who argued that the solution was limited because elephants have been seen going through electrified fences. Furthermore, Tchamba (1996); Thouless (1994), and Kasiki (1998) reported that its use was limited by the prohibitive costs of erecting and maintenance. Moreover, this fences, would lead to forced restrictions and will have adverse ecological effects on the availability of foliage within the park, the potential loss of access for certain species to critical food resources located immediately adjacent to the park and competition within the park, and the increased likelihood of local extinction for many species not to mention the resultant disruption of movements and annual migrations of wildlife (Ngene, 1998).

Some respondents advocated for the de-gazettement of the park as another solution to the conflicts. This observation was worrying because majority of the respondents around the park were peasants. This suggestion should be taken with a lot of caution for humans are known to frequently persecute and exterminate animals that are considered problematic.

Involvement of local people in the management of wildlife resources, digging of boreholes outside the park boundaries and compensation for wildlife related losses were other suggestions. Some responses were not surprising given that the majority of the respondents were peasants and expectancy bias may have influenced the observations. That is, respondents expected some rewards. The best approach to reducing conflicts would be to permit wildlife to utilize adjacent areas and the community allowed accruing benefits from non-consumptive utilization of wildlife outside the park for economic gains.
Conclusions

Our study showed that indeed there existed (i) real conflict between humans and elephants, (ii) that the conflict is due to competition for same resources limited in space and time, (iii) conflict may be related to the land use patterns (livestock grazing, crop growing and settlement) which have reduced the wildlife carrying capacity of the area and (iv) that the problem animal control unit of KWS is inefficient and ineffective in the area. Therefore, due to the ever-increasing human-elephant conflicts, the conservation of elephant in the area is heavily threatened.

From the foregoing, a question that looms large is whether Marsabit National Park and the elephants therein have any future. Given the size of the forest park, the ever-increasing demand for services such as fuel wood, water, and pasture for livestock and building materials from the park, the future does not look promising. To avert the predicament there is need to initiate an programmes aimed at addressing the potential sources of conflicts such as water and human encroachment in elephant dispersal area around the Park. Our field observations and discussions with the communities showed that there was element of seasonality aspects of elephant crop raids, livestock deaths, and water use conflict in the study area. This suggests that human elephant conflicts occur throughout the year. Therefore, it is imperative that the problem animal control unit of the wildlife management authority, the Kenya Wildlife Service be on the alert throughout the year to be able to mitigate the conflicts whenever necessary. The unit should also be well facilitated and equipped to deal with problems without gratuitous delay.

Acknowledgements

Kenya Wildlife Service through the Elephant Research Trust Fund (ERTF) funded this study. We are grateful to Mr. Patrick Omondi of Kenya Wildlife Service for their support during the entire field data collection. Special thanks to Mr. Roba Wario who provided the much-needed transport during the fieldwork.

References

http://dx.doi.org/10.1890/02-5382
http://dx.doi.org/10.1080/14772000.2010.533716
http://dx.doi.org/10.1111/j.1365-2664.2012.02192.x
Hayward M.W., and Zawadzka B., 2010, Increasing elephant Loxodonta africana density is a more important driver of change in vegetation condition than rainfall, Acta Theriologica 55(4): 289-298
http://dx.doi.org/10.1007/BF03192333
http://dx.doi.org/10.1046/j.1523-1739.1999.98035.x
http://dx.doi.org/10.1111/j.0968-4817.2004.00444.x
Kailas R., 2000, Patterns and determinants of crop raiding by elephants (Elephas maximus) in the southern India state of Andra Pradesh, Thesis for M.S., Durell Institute of Conservation and Ecology, University of Kent, UK
Kangwana F.K., 1995, Human elephant conflict, the challenge ahead, Pachyderm, 19: 11-19
Kasiki S.M., 1998, Human-elephant conflict in areas adjacent to the Tsavo National Parks, Kenya. Thesis for Ph.D. University of Kent, UK
http://dx.doi.org/10.1046/j.1365-2028.2000.00208.x


http://dx.doi.org/10.1046/j.1523-1739.1998.96346.x
http://dx.doi.org/10.10111/j.1523-1739.1998.96346.x

Ndungu S.K., 1995, Elephant crop raiding around Aberdares National Park, Moi University, Eldoret, Kenya

Newmark W.D., Manyanza D.N., and Gamassa Dec-gratias M., 1994, The conflict wildlife and local people living adjacent to protected areas in Tanzania, Biological Conservation, 8: 249-255
http://dx.doi.org/10.1046/j.1523-1739.1994.08010249.x

Ngare P.M., 1995, Integration of the local community into wildlife conservation: A case study of Lamuria and Central divisions of Laikipia District, Kenya, Thesis for M.Phil, Moi University, Eldoret, Kenya


http://dx.doi.org/10.1016/j.jnc.2012.08.004


Sitati N., 2003, Human-elephant conflict in Trans-Mara district adjacent to Masai Mara national reserve, Thesis for Ph.D, University of Kent, UK

http://www.kent.ac.uk/dice/publications/Smith_%26_Kasiki_HEC_repo rt.pdf

SPSS (2010), SPSS for Windows, Release 17, Chicago: SPSS Inc

http://dx.doi.org/10.1016/0006-3207(95)00040-2

http://dx.doi.org/10.1016/0006-3207(94)00071-W

http://dx.doi.org/10.1017/S0030665500028428

http://dx.doi.org/10.1111/j.1365-2028.2004.00506.x

http://dx.doi.org/10.1111/j.1365-2028.2006.00710.x


Worden J., Western D., and Warungu L., 2009, Exploring potential economic and livelihood impacts of climate change and possible adaptation mechanisms in the Kenyan rangelands, African Conservation Centre, Nairobi,

Zar J.H., 1996, Biostatistical analysis, Department of biological Sciences, Northern Illinois University