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Source: *Conservation & Society*, 2022, Vol. 20, No. 4 (2022), pp. 283-292

Published by: Ashoka Trust for Research in Ecology and the Environment and Wolters Kluwer India Pvt. Ltd.

Stable URL: https://www.jstor.org/stable/10.2307/27206643

Conservation and Society 20(4): 283-292, 2022

Research Article

Complex Ways in Which Landscape Conditions and Risks Affect Human Attitudes Towards Wildlife

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Abstract

Negative interactions between humans and wildlife (i.e. those presenting risks to human security or private property) can trigger retaliation and potential human-wildlife conflict (HWC). The nature and strength of these human responses may depend on previous interactions with wildlife and can be shaped by landscape conditions. However, the ways in which previous experiences and landscape conditions interact to shape peoples' attitudes towards wildlife are not well-understood. We conducted our study in Tsavo Conservation Area, Kenya, which experiences some of the highest rates of HWC documented in East Africa. We explored how previous experiences with wildlife and landscape conditions interact to inform the attitudes of people towards wildlife. We conducted semi-structured surveys among 331 households and fit an ordinal mixed-effects regression model to predict human attitudes to wildlife as a function of landscape conditions and previous interactions. Respondents indicated that baboons, elephants, and lions posed the greatest risks to human security and private property. Households experiencing risks from wildlife wanted wildlife populations to decrease, whereas households depending on grazing lands outside the study area wished to see wildlife increase. Our study demonstrates that human-wildlife interactions have important social and spatial contexts, and are not uniform across households in the same area owing to location of private property. Correspondingly, for interventions to be effective, we recommend considerations of local contexts and landscape conditions of communities.

Keywords: Human-wildlife conflict, Coexistence, Human dimensions of conservation, Tsavo Conservation Area, Wildlife risks

Access this article online	
Quick Response Code:	Website: www.conservationandsociety.org.in
	DOI: 10.4103/cs.cs_112_21

INTRODUCTION

Wildlife is an integral component of the ecosystem structure and central to the cultural heritage of people in coupled human and natural systems around the world (Mainka et al. 1995; Bobo and Ntumwel 2010; Bhatia et al. 2017). In many cultures, for example, wildlife is depicted as spiritual totems, designated as national symbols, or as central figures in storytelling (Mukul et al. 2012; Bortolamiol et al. 2018; Fernández-Llamazares and Cabeza 2018). The role of animals in human culture has led to the development of independent policies for wildlife management as maintained by certain indigenous tribes (Ikanda and Packer 2008; Negi 2010; Jimoh et al. 2012). Thus, the normative behaviours and attitudes of people towards wildlife are important components of local, municipal, domestic, and international conservation and management strategies (Manfredo and Dayer 2004; Teel et al. 2007).

In the cognitive hierarchy model of human behaviour (Fulton et al. 1996), attitudes are influenced by basic belief patterns, which are often slow-changing, and typically classified as being either positive or negative (Vaske and Donnelly 1999). Human attitudes are also informed by memory and considered a directional evaluation of specific events in time (Lischka et al. 2018). Correspondingly, human behaviour, which is informed by these attitudes, is contextual and temporally dynamic (Fulton et al. 1996). As such, a key component of the creation and implementation of viable conservation strategies is to quantify human attitudes towards wildlife (Treves et al. 2009; Baruch-Mordo et al. 2011; Espinosa and Jacobson 2012).

The outcomes of human-wildlife interactions can be benign, positive, or negative (Morzillo et al. 2014). For instance, photographic tourism in protected areas can yield positive interactions, in that observing animals can induce a deep sense of well-being and fulfilment in humans (Setchell et al. 2017; Dou and Day 2020). This fulfilment is intrinsically linked to the recognition that wildlife is an essential part of a healthy ecosystem (Curtin 2009). However, people who share landscapes with wildlife can experience negative interactions which can trigger human-wildlife conflict (Peterson et al. 2010; König et al. 2020). Negative interactions often derive from risks which wildlife poses to human security or private property (Kretser et al. 2009). The severity and/or frequency of these risks inform human conceptualisations of certain wildlife species as problematic (McIvor and Conover 1994; Hoare 2012). Given the frequency of negative human-wildlife interactions globally, conflict presents an important challenge for human well-being and wildlife conservation (Treves et al. 2006; Redpath et al. 2015; Anand and Radhakrishna 2017).

Negative human-wildlife interactions and the resulting conflict can be particularly severe in the Global South where humans living adjacent to protected areas often reside in systems with comparatively high faunal biodiversity (Distefano 2005; Seoraj-Pillai and Pillay 2017; Ontiri et al. 2019). East Africa, for example, has experienced an increase in human-wildlife conflict coinciding with the expansion of human settlements in the periphery of protected areas (Myers et al. 2000; Kaswamila 2009; Ogutu et al. 2014). In this region, smallholder farming accounts for about 75% of agricultural production, and farmers also tend to keep livestock (Njarui et al. 2016). As such, agro-pastoral systems featuring both farming and livestock husbandry provide a primary source of income for a large portion of the rural population (Salami et al. 2010). Wildlife that roams into these agro-pastoral human settlements raids crops, depredates livestock, and threatens the security of local people (Tweheyo et al. 2005; Abade et al. 2014; Chaka et al. 2020). These risks include physical injury, damage to infrastructure, and weakened food security, all of which can disrupt psychosocial wellbeing (Ogra 2008; Barua et al. 2013; Goodale et al. 2015). Correspondingly, people may seek to remove 'problem' animals or convert habitats to minimise risks to human security or private property (Treves et al. 2009; Dunham et al. 2010; Acharya et al. 2016). Additionally, non-problematic wildlife may also be subject to human retaliation, which can scale to deleterious population-level consequences (Treves et al. 2006; Virani et al. 2011; Swanepoel et al. 2014; Jędrzejewski et al. 2017).

Within the East African region, Kenya has experienced high levels of human-wildlife conflict. An estimated 60% of the country's wildlife inhabits lands which are outside government-managed protected areas (Western et al. 2009). Human-wildlife conflict is especially intense in northern (Laikipia, Meru, and Samburu counties) and southern (Kajiado, Narok, and Taita-Taveta counties) Kenya, where areas used by wildlife have a high degree of overlap with human community lands (Ogutu et al. 2016; Long et al. 2020). In these systems, the productivity of the land for keeping livestock and growing crops presents a primary source of income (Gross et al. 2019; Mukeka et al. 2019; Long et al. 2020). Consequently, landscape conditions are particularly important in understanding the mechanisms associated with human-wildlife conflict. For example, water availability and access to grazing lands for livestock are necessary both for wildlife persistence and human well-being. Thus, competition over these increasingly scarce resources may exacerbate human-wildlife conflict (Sangay and Vernes 2008; Karanth and Kudalkar 2017). In these instances, communities experience conflict with wildlife because water quality deteriorates after use by wildlife, or forage is consumed by wildlife at a faster rate compared to livestock, thus affecting human livelihoods (Ocholla et al. 2013). However, it remains unclear how previous interactions with wildlife and underlying landscape conditions inform human attitudes to wildlife. Here, we sought to document whether local people subjected to wildlife risks would prefer to see those wildlife populations decrease, remain at the present levels, or increase after and under what landscape conditions.

We assessed the human attitudes to wildlife posing the greatest risks to human security (e.g. aggression towards people) or private property (e.g. crop raiding, livestock depredation, or damage to human structures) in the Tsavo Conservation

Area (hereafter referred to as Tsavo) in southern Kenya. We positioned this study in Tsavo because it experiences the highest levels of human-wildlife conflict documented in Kenya (Long et al. 2020; Mukeka et al. 2020). We selected species of wildlife which were most associated with human-wildlife conflict or commonly interacted with humans in the village lands of Tsavo. We then administered semi-structured surveys to individuals living in the villages to assess whether human attitudes (as inferred from desired population-level changes) to these species varied according to risks to human security or private property and the landscape conditions of the area (i.e. drought, access to grazing land, access to water, land degradation, and conflicts with local leaders or government officials). Human and wildlife behaviours are predominantly studied as drivers of conflict (Gross et al. 2019; Kissui et al. 2019; Mukeka et al. 2019), but there is a need to incorporate other domains of human-wildlife conflict to identify long-lasting solutions (Montgomery et al. 2018a). Therefore, we place the results of our study within local contexts where sustainability of human-wildlife conflict mitigation efforts must align with the diverse heritage of local communities (*sensu* Montgomery et al. 2020). We demonstrate how incorporating historical knowledge and assessing landscape conditions can inform mitigation efforts.

METHODS

Study area

Covering approximately 60,000 sq. km, the Tsavo landscape is one of Kenya's most important coupled human and natural systems. Annual rainfall in Tsavo varies from ~300 mm to 1,200 mm, giving rise to a number of seasonal rivers (Oremo et al. 2019) which support different habitats and a taxonomic diversity of wildlife. The landscape is characterised by a mix of open savannahs and woodlands with comparatively large populations of carnivores and ungulates (Henschel et al. 2020). Within this matrix of protected areas, including two of Kenya's largest national parks, are human villages (Figure 1). Tsavo covers approximately two-thirds of Taita-Taveta County, and almost a third of the human population is found in Voi town centre, which has ~110,000 inhabitants and ~32,000 households (Kenya National Bureau of Statistics 2019). While the killing of wildlife is illegal in Kenya under the Wildlife Conservation and Management Act of 2013, an offender may not be prosecuted in cases of human-wildlife conflict, provided that: 1) there is sufficient evidence that the risks which the target animal poses warrants lethal retaliation and 2) the killing occurred outside protected areas (Kenya Wildlife Service 2016). Any killing of wildlife, whether they pose risks to human security/private property or not, inside protected areas is punishable by law (Kenya Wildlife Service 2016).

We initially verified wildlife species which threaten human security and private property in the six administrative areas of Kasigau, Mackinon, Marungu, Mwachabo, Mwatate, and Sagalla. We selected these areas because of their involvement in the Kasigau Corridor REDD+ (Reducing Emissions from Deforestation and forest Degradation in developing countries) project. We held two consultative meetings with research assistants affiliated with the Wildlife Works Kasigau Corridor REDD+ project to determine species which frequently posed risks to human security or private property (i.e. crops, livestock, or human structures) in Tsavo. Via this process, we selected 11 common species including large carnivores (cheetahs (*Acinonyx jubatus*), leopards (*Panthera pardus*), lions (*P. leo*), and spotted hyenas (*Crocuta crocuta*)), large herbivores (African savanna elephants (*Loxodonta africana*), buffalo (*Syncerus caffer*), giraffe (*Giraffa camelopardalis tippelskirchi*), hippopotamus (*Hippopotamus amphibius*), and zebra (*Equus quagga*)), as well as yellow baboons (*Papio cynocephalus*) and mongooses (*Herpestes ichneumon*).

Household surveys

Between June and July 2019, we administered semi-structured surveys to residents in six administrative locations within the study area (Figure 1). Semi-structured surveys are used in instances where there is a lack of subjective knowledge of phenomena and participants are free to respond to open-ended questions included in the survey (McIntosh and Morse 2015). Researchers may also probe responses to ensure that participants reflect on their experiences, following a certain order or 'structure' of questions (Leech 2002; Whiting 2008). In our study, we used this technique to determine whether people's attitudes to wildlife varied according to landscape conditions and the types of risks posed by wildlife. We trained 10 research assistants from local communities, who were conversant with the REDD+ project and familiar with the study area to: *i*) improve clarity of our questionnaire, *ii*) translate responses from local languages, and *iii*) assist in conducting the surveys. We selected households via systematic random sampling at the start of each day, where we chose the first house closest to the road and then interviewed the present head of the household. Subsequent households within a day were again selected at random with a minimum distance of two kilometres between residences. To initiate each survey, we explained the context and objective of our research and offered a consent form to respondents. Consent was given verbally by the respondents and recorded in writing by the researchers. We explicitly explained that the survey could be terminated at any time of the respondent's choosing. All research protocols and survey instruments were approved by the Michigan State University Institutional Review Board (study id 00001610) and the National Commission for Science and Technology of Kenya (permit number NACOSTI/P/20/5611).

The first part of our survey evaluated the frequency with which respondents encountered the 11 focal species of wildlife. We then asked respondents to evaluate whether they had experienced risks to human security or private property from these species. Research on human-wildlife conflict globally,

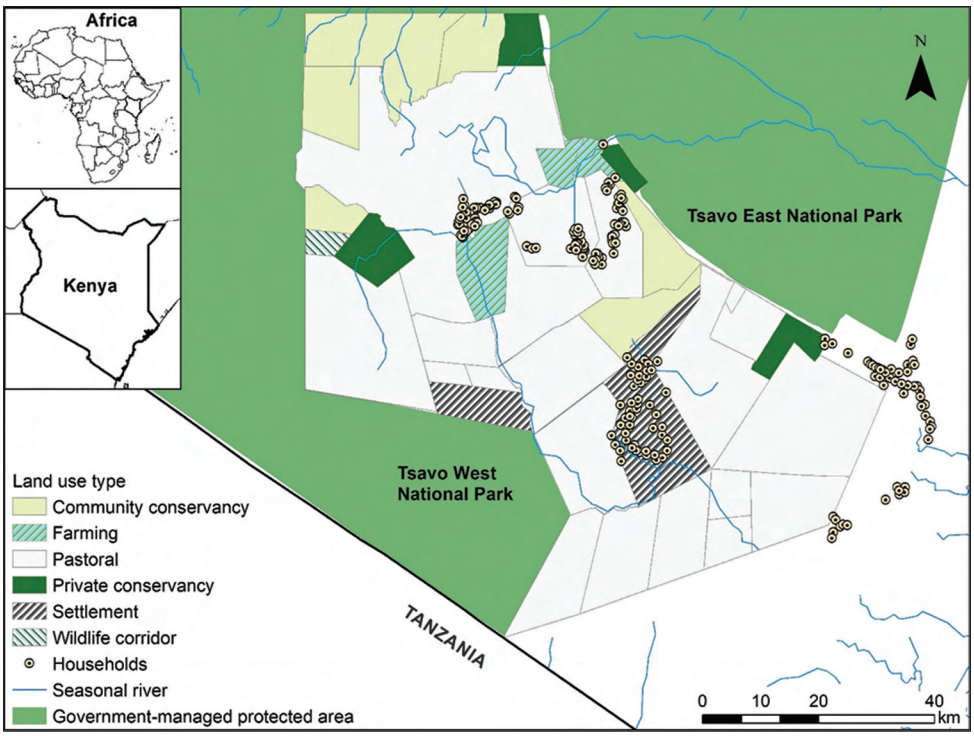

Figure 1

Locations at which household surveys were conducted between June and July 2019 to assess the different human-wildlife interactions in Tsavo, southern Kenya. The Kasigau Corridor of Tsavo has different land use types and is situated between two major protected areas

and indeed in Kenya, demonstrates that local people can experience a variety of risks from wildlife including those affecting human security (i.e. threatened, chased aggressively by wildlife, injured by wildlife, or having knowledge of a person killed by wildlife) and those relating to private property (i.e. crop raiding, livestock depredation, or any other risk which we had not listed; Ocholla et al. 2013, Mukeka et al. 2019, Long et al. 2020). We also documented social factors such as primary means of income, whether a member of the household owned land in Tsavo, and the type of ownership system (family inheritance or community land). Next, we asked respondents about the landscape conditions which could have impacted their villages, such as drought, land degradation, conflicts with local leaders, clashes with government officials, clashes with neighbouring communities, access to grazing land, access to water, or any other condition which we had not listed. Finally, we assessed people's attitudes to the 11 wildlife species based on respondent interests to see their populations decrease (-1), remain the same (0), or increase (1) within the next five years.

Data analysis

We fit an ordinal mixed-effects regression model predicting respondent attitudes towards wildlife (i.e. negative (-1), neutral (0), or positive (1)) as a cumulative link function of wildlife risks and landscape conditions (see Table 1 for predictor variables). We included village ID as a random effect using adaptive Gauss–Hermite quadrature approximation to account for any spatial dependences in our survey design (Pan and Thompson 2003). Among our model diagnostic procedures, we assessed collinearity among predictor variables and sequentially eliminated correlated variables based on variance inflation factors (VIFs) >3.0 (Harrell 2016). VIFs indicate the degree of multicollinearity in a set of multiple regression variables. In our analytical approach, VIF > 3.0 indicated that the specific variable was highly correlated with other variables in the model. After removing collinear covariates, we fit a global five-parameter model and examined significance at an alpha level of $P < 0.05$. We opted for the global model given that our interest was in prediction, and furthermore, regression models provide a means towards interpolative predictive accuracy considering that the additional parameters reduce variation around the estimated regression function and decrease chances of omitted variable bias (Moll et al. 2016). We completed all analyses in R v4.0.3 (R Core Team 2020) using the packages *brant, MASS, ordinal,* and *rms* (Brant 1990; Harrell 2016; Bürkner and Vuorre 2019).

RESULTS

Between June and July 2019, we completed 331 semi-structured surveys from a pool of 350 households (19 households stopped the interviews midway). The average size of a household was 7.1 (range 1–37) people. About half of the respondents (48.3%; $n = 160$ of 331) were crop farmers, 14.5% ($n = 48$)

Table 1

Descriptions and summaries of explanatory variables used in models assessing attitudes to wildlife by households which experienced risks posed by wildlife to human security and private property. Data were collected between June and July 2019 via semi-structured surveys with residents inhabiting Tsavo, southern Kenya

Variable	Description	Variable category	Value type and summary
Wildlife change	Assesses whether respondent would want wildlife numbers to change in next five years		Likert scale (3) Decrease: *n*=54 (17.2%) Remain the same: *n*=235 (74.8%) Increase: *n*=25 (8%)
Threatened	Assesses whether member of household has been aggressively chased by wildlife	Risk to human security	Binary No: *n*=96 (30.6%) Yes: *n*=218 (69.4%)
Crop raiding		Risk to private property	Binary No: *n*=22 (7%) Yes: *n*=292 (93%)
Livestock injured/ killed		Risk to private property	Binary No: *n*=125 (39.8%) Yes: *n*=189 (60.2%)
Person injured/killed		Risk to human security	Binary No: *n*=275 (87.6%) Yes: *n*=39 (12.4%)
Other (house destroyed)		Risk to private property	Binary No: *n*=300 (95.5%) Yes: *n*=14 (4.5%)
Drought	Whether respondents have been directly affected by drought in the study area	Landscape condition	Binary No: *n*=2 (0.6%) Yes: *n*=312 (99.4%)
Animal or crop disease	Whether respondents have been directly impacted by animal or crop disease	Landscape condition	Binary No: *n*=8 (2.6%) Yes: *n*=299 (97.4%)
Access to grazing lands	Whether respondents are affected by access to grazing lands	Landscape condition	Binary No: *n*=54 (17.7%) Yes: *n*=251 (82.3%)
Access to water	Whether respondents are affected by problems relating to access to water	Landscape condition	Binary No: *n*=42 (13.4%) Yes: *n*=272 (86.6%)
Wildlife risk	Whether respondents previously experienced risks posed by wildlife in landscape	Landscape condition	Binary No: *n*=45 (14.7%) Yes: *n*=261 (85.3%)
Conflict with local leaders	Whether respondents are impacted by conflicts with local leaders	Landscape condition	Binary No: *n*=125 (44%) Yes: *n*=159 (56%)
Conflict with government officials	Whether respondents are affected by conflicts with government officials	Landscape condition	Binary No: *n*=123 (43.9%) Yes: *n*=157 (56.1%)
Conflict with neighbouring communities	Whether respondents are affected by conflicts with neighbouring communities	Landscape condition	Binary No: *n*=140 (47.6%) Yes: *n*=154 (52.4%)

listed small business as their primary source of income, 12.7% ($n = 42$) were pastoralists, 2.1% ($n = 7$) were employed in the ecotourism sector, and 22.4% ($n = 74$) listed other sources of income (such as teaching, mining, and motorbike riding). More than two-thirds of the households owned land (68.6%, $n = 227$), and among these individuals, 86.3% ($n = 196$ of 227) inherited that land from family members while 11.1% ($n = 25$ of 227) owned land through community conservancies or ranches. Approximately 2.6% ($n = 6$ of 227) of the landowners elected not to describe the structure of their land ownership system.

Almost 90% ($n = 292$ of 331) of households had previously experienced crop raiding, 57.1% ($n = 189$) suffered from livestock depredation, and 11.8% ($n = 39$) knew of a member of their community who had been injured or killed by wildlife. Furthermore, 70% of respondents ($n = 218$ of 314) experienced being chased aggressively by wildlife. Approximately 4.5% ($n = 14$ of 314) of respondents directly experienced elephant

damage to their homes or other human infrastructure (Table 1). Respondents stated that baboons (76.1%; n = 239 of 331), elephants (69.1%; n = 217), zebras (22.6%; n = 71), and buffaloes (14.6%; n = 46) were the species predominantly associated with crop raiding. Respondents also indicated that baboons (30.9%; n = 97 of 314), lions (30.3%; n = 95), hyenas (11.8%; n = 37), mongooses (7.6%; n = 24), and leopards (3.5%; n = 11) either injured or killed their domestic animals. Respondents had previous experience of elephants (60.2%; n = 189 of 314), baboons (28.7%; n = 90), lions (10.5%; n = 33), and hippopotamuses (2.9%; n = 9) threatening human security. Considering these interactions, baboons, elephants, and lions were the three species described to pose greatest risks to both human security and private property (Figure 2). No species was reported to pose risks only to human security. The majority of households (70.9%; n = 200 of 282) indicated that elephants had increased in number over the previous five years. Similarly, more than half of the households indicated that mongoose, baboon, buffalo, hyena, and zebra numbers had increased in the previous five years.

We found that 9 of the 14 variables had VIFs > 3.0, and we thus eliminated these from our modelling analysis. The results from our ordinal mixed-effects regression model showed that two covariates significantly predicted human attitudes to wildlife (Table 2). Respondents who experienced previous risks from wildlife in their villages wanted wildlife numbers to decrease (Table 2) and thus were more likely to have negative attitudes to wildlife (β = –0.93; n = 261; $P < 0.05$; Table 2). Respondents who had limited or no access to grazing lands for livestock they owned wanted population numbers to increase (β = 0.86; n = 251; $P < 0.01$).

DISCUSSION

The results of our analysis demonstrate that past, risky experiences with wildlife and ownership of grazing lands for livestock significantly affected human attitudes towards wildlife. Human-wildlife conflict is one of the most important challenges facing wildlife conservation and human well-being in southern Kenya (Ogutu et al. 2014; Mukeka et al. 2020) and beyond (Riddle et al. 2010; Jędrzejewski et al. 2017; Margulies and Karanth 2018). A large number of our respondents were crop farmers living in areas heavily used by wildlife (Ngene et al. 2017; Henschel et al. 2020). These conditions (i.e. agro-pastoral systems with high population numbers of wildlife and humans) led to a high number of interactions between humans and wildlife. Human settlements in the study area occur in a wildlife corridor between the government-managed Tsavo East and West National Parks (Figure 1). Additionally, recent infrastructure development, including the construction of a standard gauge railway and the proliferation of fences in Tsavo, has altered movement patterns of wildlife (Mukeka et al. 2018; Nyumba et al. 2021). Elephants in Tsavo for instance exhibit behavioural responses which commonly occur in stressful conditions or risky landscapes near these infrastructural developments, which are adjacent to human settlements (Okita-Ouma et al. 2021). While the use of fences in some areas may temporarily protect private property and enhance human security, fences can alter wildlife movements, thereby resulting in similar problems for unfenced neighbours (Osipova et al. 2018). More than half of our respondents knew of aggressive behaviour by wildlife, and had experienced crop damage and livestock depredation, which suggests that negative interactions with wildlife are common in Tsavo. This is because almost half of the respondents were smallholder farmers, who depended on land and livestock as a primary means of income.

Most respondents felt that species which posed risks to human security and private property had increased in population numbers over the past five years. Recent surveys in Tsavo support these perceptions as elephant and buffalo populations are currently at their highest levels since the 1980s (Ngene et al. 2017). Across this same time period, livestock numbers in Tsavo have also expanded owing to the increase in the number of smallholder farmers and pastoralists who keep large herds to provide for their households (Ogutu et al. 2016). We posit that the growth of both wildlife and livestock populations increased competition for resources, which exacerbates human-wildlife conflict. For instance, while drought and disease can lead to crop loss, crop damage from wildlife is often perceived with more bitterness among local people (Tweheyo et al. 2005).

Table 2

Model parameter estimates, standard errors, and statistical significance from the ordinal mixed-effects regression model predicting attitudes to wildlife as a function of the risks posed by wildlife and landscape conditions which impact households directly in Tsavo, southern Kenya. We fit the model using data from 331 household surveys. Variable descriptions are provided in Table 1

Parameter	Estimate	SE	z	P
$\text{Threatened}_{\text{Yes}}$	-0.18	0.30	-0.58	0.56
$\text{Person\_injured\_or\_killed}_{\text{Yes}}$	0.22	0.43	0.52	0.60
$\text{House\_damage}_{\text{Yes}}$	0.49	0.63	0.77	0.44
$\text{Conflict\_wildlife}_{\text{Yes}}$	-0.93	0.41	-2.27	0.02**
$\text{Access\_grazing\_land}_{\text{Yes}}$	0.86	0.34	2.48	0.01***

P-values: ***<0.01; **<0.05; *<0.1

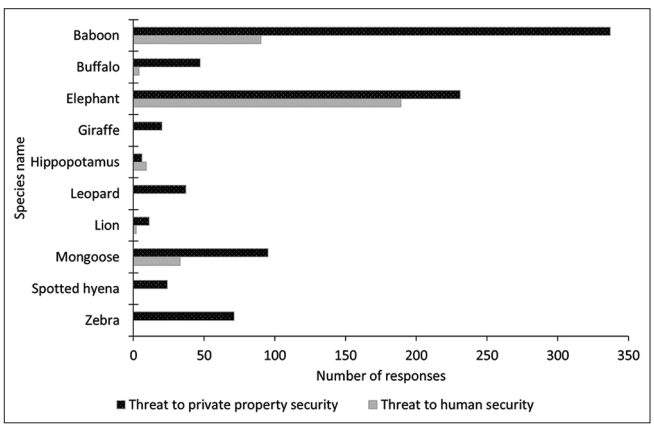

Figure 2

Wildlife species which posed risks to human security and private property relating to households in Tsavo, southern Kenya. Responses were obtained from 331 households in which at least one member had experienced risks posed by wildlife in the local area

Interpretations of our model output showed that people who had previously experienced risks from wildlife in their villages wished to see wildlife populations decrease in the next five years. We hypothesise that this perception could be influenced by household location. For instance, risks of crop raiding and livestock depredation are typically high in and among human settlements adjacent to conservation areas. These risks can also increase in intensity in landscapes where people feel threatened by high numbers of wildlife, which may not typically pose risks when in low numbers (Messmer 2000; Nyhus 2016). Given that human response to risks posed by wildlife can be disproportionate in such instances (Messmer 2000; Hudenko 2012; Margulies and Karanth 2018), it is important to develop management plans which address the resource use of both wildlife and humans (Hockings et al. 2020). For instance, grazing plans which are linked to wildlife management plans and landscape conditions of specific areas can enhance coexistence (Cros et al. 2004; Vavra 2005). As such, wildlife management and grazing strategies should be incorporated into the spatial plans of local governments to nurture both conservation and development practices.

Landscape conditions, especially drought, which was a significant variable in our model, also influenced human attitudes towards wildlife. We found that people with limited or no access to grazing lands for their livestock tended to have positive attitudes towards wildlife (Table 2). Both Tsavo East and West National Parks provide important sources of pasture for livestock during the dry season (Ngene et al. 2017), even though there are many private and community ranches in Tsavo (Figure 1). It is important to note that most of the local communities in Tsavo used to graze their livestock in lands which were eventually gazetted as Tsavo East and West National Parks in 1948, well before Kenya's independence (Seno and Shaw 2002). However, in present times, the practice of grazing livestock in national parks is illegal and perpetrators are subject to considerable financial penalties (Kenya Wildlife Service 2016). As an alternative to grazing livestock in national parks, some of the private and community wildlife ranches in Tsavo charge pastoralists a fee to graze livestock (Heath 2001). This option may not be tenable for individuals with large herds of livestock, considering that fees can be prohibitive (ranging from KES 200 (~USD 2) to KES 500 (~USD 5) per head of livestock; Heath 2001). Wildlife management authorities have expressed difficulties in arresting livestock owners who illegally grazed livestock in national parks (Malemba 2016). In most cases, children accompany livestock, and as such, law enforcement personnel are forced to review infringements on a case basis (Gikunda 2016; Malemba 2016). Thus, we hypothesise that households which had a positive attitude towards wildlife despite having no access to grazing lands recognised the indirect benefit of alternative sources of pasture in protected areas during the dry season (Waweru and Oleleboo 2013; Masiaine et al. 2020). Recognising the history and vulnerability of people who share landscapes with wildlife which potentially pose risks to their livelihoods, especially during dry seasons, can have positive impacts and provide indirect benefits (Lesorogol 2008; Hazzah et al. 2017). For instance, seasonal agreements between land owners and pastoralists can promote positive attitudes toward wildlife and coexistence (Goldman 2003; Mbane et al. 2019).

Human-wildlife conflict is a global and complex problem which will require creative solutions (Hoare 2012; Beck et al. 2019; Montgomery et al. 2020). Future studies examining the severity and cost of various wildlife risks can provide crucial information on these aspects by conducting more robust analysis. While the importance of exploring the interdisciplinary domains which are inherent to conflict has been highlighted (Hockings 2009; Montgomery et al. 2018b), we advocate for the consideration of the ways in which landscape conditions and the spatial context of risk may influence human perceptions of conflict and coexistence. Landscape conditions, for example, have received little attention in human-wildlife conflict studies even though they may also directly or indirectly influence risks which wildlife pose to human security and private property (Abade et al. 2014). Wildlife managers need to incorporate traditional knowledge and practices adapted to the local context to mitigate human-wildlife conflict (Dickman 2010; Karanth and Kudalkar 2017; Parathian et al. 2018). As such, mitigating risks posed by wildlife to human security and private property requires approaches which address both social and environmental factors which vary both temporally and spatially (Mukeka et al. 2018). Our study demonstrates that despite the inherent risks to human security and private property posed by wildlife, people's attitudes to wildlife should be interpreted in consideration of the landscape conditions of the study area.

Author Contribution Statement

A. B. Muneza and R. A. Montgomery were the project leaders for this study and also conducted the statistical analysis. A. B. Muneza, B. Amakobe, S. Kasaine, and M. Githiru collected the data and sorted the data in Tsavo Conservation Area, Kenya. All authors assisted with the methodological development and the write-up of the manuscript.

Acknowledgements

We thank Ahmed, S., Kibwanga, J., Wario, M., Mwangeje, J., Kazungu, C., Kalingu, A., Mwazaule, L., Mwasi, M., Mwakoro, E., and Juma, A. for their assistance in collecting data and improving the clarity of the semi-structured survey in local languages.

Declaration of competing/conflicting interests

The authors declare that they have no known competing financial interests or personal relationships which could have appeared to influence the work reported in this paper. The authors declare no financial interests or personal relationships which may be considered as potential competing interests.

Financial Disclosures

This research was realised through grants from the Giraffe Conservation Foundation, Leiden Conservation Foundation, Wildlife Conservation Network, African Wildlife Foundation, and National Geographic Society.

Research Ethics Approval

All survey techniques were reviewed and approved by the Michigan State University Institutional Review Board (study id 00001610). Our research was also approved by the National Commission for Science and Technology of Kenya (permit number NACOSTI/P/20/5611) and the Kenya Wildlife Service.

Data availability

The data are not accessible due to privacy restrictions.

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Received: 06-Sep-2021**; Revised:** 03-Feb-2022**; Accepted:** 24-Feb-2022**; Published:** 01-Jun-2022