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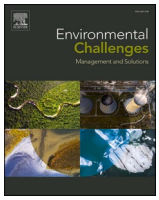

Sharing landscapes with megaherbivores: Human-elephant interactions northeast of Tarangire National Park

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ABSTRACT

The rising elephant population in Tarangire National Park of northern Tanzania has led to increasing human-elephant interactions in dispersal areas to the northeast of the park. While the movement dynamics of elephants across the landscape are well documented, anthropological dimensions of human-elephant coexistence warrant more research. The present study used stratified random sampling to survey 1076 people living across twelve villages surrounding Manyara Ranch and Randilen Wildlife Management Area (WMA) about their lived experiences, perceptions, attitudes, and tolerance towards elephants. Villages between Manyara Ranch and Randilen WMA reported regular conflicts with elephants, while those to the west of the ranch did not consider elephants to be a major concern. Crop raiding was particularly frequent in Makuyuni, Lengoolwa, Mswakini Juu, Mswakini, Lemooti, and Nafco. Economic impacts of elephant crop raiding ranged from as low as $4USD per household per year in Lolkisale to approximately $812 per year in Mswakini, and accounts of property damage were most severe in Makuyuni and Naitolia. The vast majority of respondents (96 %) did not have a household member who had been injured by elephants over the preceding twelve-month period, suggesting that elephant attacks on humans were relatively infrequent on the whole. However, between 10 and 24 % of participants in Lemooti, Nafco, Mswakini, and Mswakini Juu noted injuries incurred in the past year. Different ethnic groups had statistically significant differences in their attitudes towards elephants. People with higher levels of education had more positive attitudes towards elephants, and elders had more negative attitudes than youth. Elephants disturbed the sleep of men more than women highlighting the gendered dimensions of human-wildlife interactions. Despite these visible and hidden costs of elephants, most people (72 %) across the whole study area were somewhat tolerant of elephants, except in Makuyuni, Lengoolwa, and Nafco where seasonal crop raiding was severe and tolerance for elephants was extremely low. People in those villages, as well as Mswakini Juu and Mswakini, were largely in favor of government-sanctioned culling, though 94 % of all respondents viewed elephant poaching as bad. Tolerance towards elephants was negatively correlated with livestock holdings and positively associated with total farm size. Greater attention to community perspectives is necessary for promoting human-elephant coexistence in the Tarangire ecosystem.

Introduction

Human-elephant interactions are a pressing environmental issue with potential negative repercussions for elephant populations and human well-being (Ram et al., 2022). Across Africa and Asia, land use changes driven by political and economic factors at different scales have led to reductions in elephant habitat and decreased ecological connectivity (Shaffer et al., 2019). In many cases, expanding human settlements and conversion of landscapes for crop cultivation in elephant dispersal areas have resulted in direct interactions between people and elephants (Nad et al., 2022; Rathnayake et al., 2022). From a conservation biology point of view, elephants have long evolutionary histories, culminating in specialized habitat requirements that render them vulnerable to anthropogenic pressures (Lim and Campos-Arceiz, 2022). Like humans, elephants are highly intelligent, social animals with their own intrinsic rights to place (Galaty, 2017). Habitat fragmentation, ivory poaching, and persecution from humans threaten the persistence of elephant populations (Somerville, 2017; Hoare, 1999). From a human

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perspective, elephants have an imposing presence on landscapes given their size—the largest of any land animal on Earth, in the case of African savanna elephants (*Loxodonta africana*) (Botey et al., 2022). Interactions with elephants can have visible socioeconomic consequences for human communities in the forms of crop raiding, property destruction, and threats to safety (Hoare, 1999; Raycraft, 2023). They can also engender a range of hidden costs like increased worry, social suffering, altered behavioural patterns, and decreased access to education (Jadhav and Barua, 2012; Mayberry et al., 2017; Barua et al., 2013; Sampson et al., 2021; Ogra, 2008). Considering these multidirectional social-ecological effects of human-elephant conflict, sustainability hinges upon a relational understanding of how people and elephants interact with each other (Othman et al., 2019; Songhurst et al., 2016; van de Water et al., 2022; Thekaekara et al., 2021).

This paper documents patterns of human-elephant interactions in the Tarangire ecosystem of northern Tanzania based on anthropological survey research with Maasai agropastoralists living to the north and northeast of Tarangire National Park. While the demographic and movement dynamics of the local elephant population are well-researched by conservation biologists, human-elephant interaction trends outside the park are less studied.

Based on quantitative data on human perceptions and lived experiences, our analysis focuses on three dimensions of human-elephant interactions derived from review of scholarly literature and knowledge of the local social-ecological context: 1) We assess the spatial and temporal distributions of human-elephant interactions across 12 study villages in the Tarangire ecosystem according to the perspectives of local agropastoralists. 2) We examine the gendered social and economic impacts of elephants on livelihoods and human well-being, and 3) We evaluate associations between socioeconomic and demographic variables and attitudes towards elephants. We then discuss the significance of these findings regionally and in the context of scholarly literature on social-environmental justice and conclude by highlighting the benefits of integrating community perspectives into elephant research.

Research context and study area

The African savanna elephant (*Loxodonta africana*) is the only elephant species found in Tanzania. Savanna elephants are widely distributed across southern, eastern, and central Africa, though they are classified as endangered on the IUCN Red List of Threatened Species (Gobush et al., 2022). Savanna elephants are keystone species that play vital roles in clearing forests and bush and opening up savanna grazing areas for wild ungulates and livestock (Galaty, 2017). Elephants are found throughout Tanzania in major reserves and protected areas, with their largest populations located in southern and central Tanzania (Montero-Botey et al., 2021). In northern Tanzania, the Tarangire ecosystem supports one of the densest populations of savanna elephants in the world, making it a coveted destination for safari tourists (Foley and Foley, 2022; Bond et al., 2022). Tarangire National Park, in the middle of the ecosystem, is known colloquially in the tourism industry as "the home of elephants."

In the 1970s and 1980s, ivory poaching was widespread in the Tarangire ecosystem leading to significant declines in the elephant population (Foley and Faust, 2010). During this period, elephants sought refuge inside Tarangire National Park where ranger patrols offered greater protection from poachers (Foley and Faust, 2010; Foley, 2002; Lamprey, 1963). Following the implementation of an international ban on commercial ivory trade in 1989 by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), demand for ivory in East Asia declined (Foley and Foley, 2022; Prins and de Jong, 2022). State-level crackdowns on ivory poaching in Tanzania further helped reduce poaching in the Tarangire ecosystem, though elephant populations in southern Tanzania continued to decline (Foley and Foley, 2022). Remarkably, elephants in the Tarangire ecosystem experienced rapid population growth beginning in the 1990s, in keeping with maximal growth rates of elephants (Foley and Foley, 2022; Foley and Faust, 2010). Aerial counts of elephants in the ecosystem showed that the overall population rose from roughly 2300 in 1995 to 4200 in 2014 (Foley and Foley, 2022). Most recently, in 2020, Foley and Foley (Foley and Foley, 2022) estimated that the overall population of elephants in Tarangire National Park surpassed 5000.

The significant rise in Tarangire's elephant population over the past thirty years is a marvelous conservation success. However, it has created a major management challenge in the form of frequent human-elephant interactions in areas adjacent to Tarangire National Park (Foley and Foley, 2022; Bond et al., 2022). The park spans only about 2,600km^2 of the wider 25,000km^2 Tarangire ecosystem. Its central feature is the Tarangire River, which provides a permanent water source year-round (Borner, 1985; Kiffner et al., 2022). Rainfall in the Tarangire ecosystem varies considerably, with most falling between November-January and March-May in a bimodal pattern, with a mean annual amount of about 656 mm (Foley and Faust, 2010). Elephants and other ungulates typically disperse outside Tarangire National Park in the wet season and return to the park in the dry season (Lohay et al., 2022; Galanti et al., 2006; Pittiglio et al., 2012). The park hosts three distinct subpopulations of elephants, with each comprising separate families that follow distinct movement patterns outside the park (Foley and Foley, 2022; Galanti et al., 2000). Existing ecological studies on the northern subpopulation reveal that it comprises at least 27 family groups, with a shared home range covering the northern part of Tarangire National Park and extending out to the north via Manyara Ranch and to the northeast via Randilen Wildlife Management Area (WMA) (Fig. 1) (Foley and Foley, 2022; Bond et al., 2022). Notably, no elephants from the northern subpopulation family groups have been killed by poachers over the past 25 years (Foley and Foley, 2022).

Unlike Tarangire National Park, which prohibits all forms of local livelihood activities (crop cultivation, livestock grazing, hunting, harvesting, settlement), Manyara Ranch and Randilen WMA are community-based areas that permit multiple land uses. Manyara Ranch is administered as a wildlife reserve and cattle ranch for the benefit of two neighbouring pastoral Maasai villages (Oltukai and Esilalei) via a conservation trust model administered by the African Wildlife Foundation and the Monduli District Government. Randilen WMA comprises eight member villages (Oldonyo, Lolkisale, Nafco, Lengoolwa, Lemooti, Naitolia, Mswakini, and Mswakini Juu) and is governed through an authorized association of representatives from each village (Raycraft, 2022a). Both areas are managed by village game scouts with support from the Honeyguide Foundation and generate revenue through photographic safari tourism. Randilen WMA shares a portion of tourism revenues with member villages as mandated by state law. Local livestock grazing is permitted in both areas in accordance with a seasonal zoning scheme. Hunting is prohibited in both areas and crop cultivation and settlements are only allowed in designated village areas of Randilen WMA.

Areas to the northeast of Tarangire National Park are inhabited mainly by Kisongo Maasai pastoralists and Arusha (Maasai) agropastoralists (Raycraft, 2022a). Both groups speak the Maa language, uphold an age-set system, exercise gender-based divisions of labour, and participate in shared rites of passage and rituals. The Kisongo are primarily pastoralists who consider cattle to be the foundation of their economy and social life (McCabe and Woodhouse, 2022; Woodhouse and McCabe, 2018). They use customary institutions including rotational grazing practices, ethnic reciprocity, and culturally enforced rules to regulate pasture access (McCabe et al., 2020). In a contemporary context, they have diversified their economies to include crop cultivation, wage labour, and other business ventures (McCabe et al., 2010; McCabe et al., 2014; Homewood et al., 2009; Trench et al., 2009; Sachedina and Trench, 2009). The Kisongo have probably been present in the Tarangire ecosystem for at least 200 years. The Arusha are mainly cultivators who moved into the area in the late 1950s and 1960s during a period of land scarcity on Mount Meru due to increasing settlements and

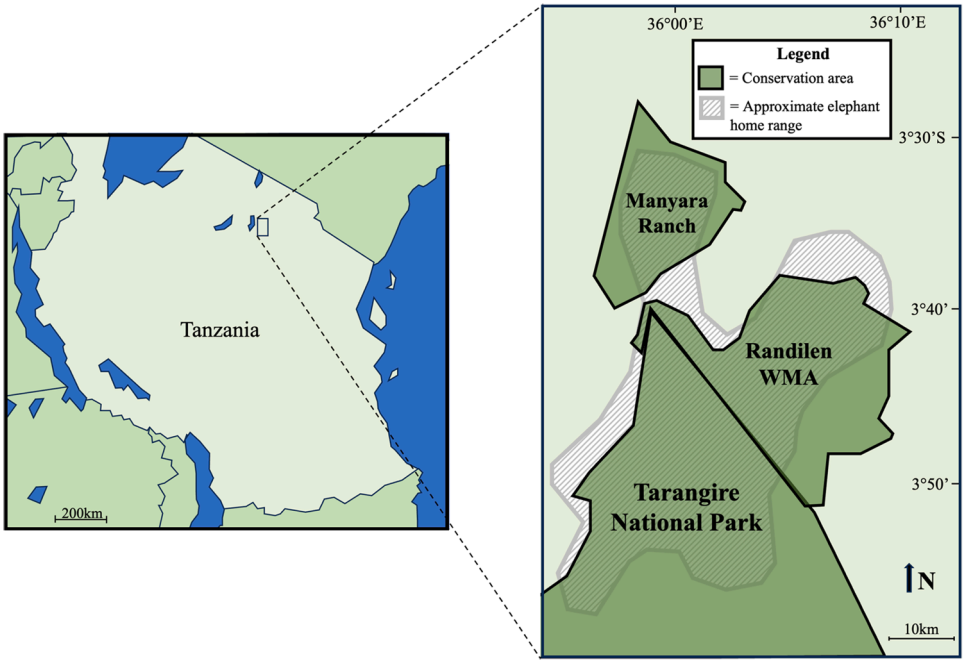

Fig. 1. Approximate home range of the northern subpopulation of elephants in the Tarangire ecosystem. The map was drawn by the author based on elephant range information from Foley and Faust (2010) and protected area shapefiles from district government. The map on the left provides wider geographic context of the study area location.

politically driven land alienation (Spear, 1997; Spear, 1993; Neumann, 1998; Igoe, 2010; Bluwstein, 2017). Arusha began settling the area with government encouragement during this period (Raycraft, 2022b; Igoe, 2010; Hodgson, 2001). Like the Kisongo, the Arusha keep and value livestock a great deal, but to a lesser degree than the Kisongo (Spear, 1993). Both groups keep cattle, goats, sheep and cultivate maize and beans, but the Arusha also grow a variety of other crops including sunflowers, fruit, and vegetables for commercial sale.

The twelve villages surrounding Manyara Ranch and Randilen WMA—Esilalei, Oltukai, Olasiti, Mswakini Juu, Mswakini, Naitolia, Makuyuni, Lemooti, Lengoolwa, Nafco, Lolkisale, and Oldonyo—were selected for this study to examine human-wildlife interactions to the north and northeast of Tarangire National Park. The twelve villages wrap around the approximate home range of the northern subpopulation of elephants documented by Foley and Faust (2010) (Fig. 2).

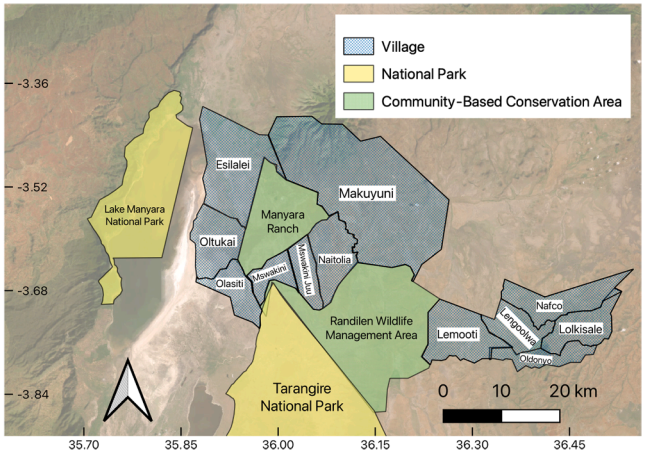

Fig. 2. Location of twelve study villages in the Tarangire ecosystem. Village boundaries were visualized using district government shapefiles. Notably, some village boundaries have not been officially mapped, and boundary conflicts persist. Approximate boundaries were drawn by hand in these cases and may not be exact. The boundaries of Makuyuni village are highly contested, and an overly broad area is included in this depiction of village boundaries in solidarity with community interests. Notably, in 2023 and 2024 a large portion of land that was previously considered part of Makuyuni has been reallocated as the state-run Makuyuni Wildlife Park.

Methods

The primary scope of this study was born of collaborative ethnographic fieldwork with local agropastoral Maasai communities and community-based, participatory research (CBPR) methods. Ethnographic fieldwork was carried out continuously over the course of a year (July 2019–2020) and over two-month intervals during summer months in subsequent years (June – July 2022; April – May 2023; April – May 2024). The primary focus of the ethnography was about trying to understand challenges affecting pastoral and agricultural livelihoods under the umbrella of a COSTECH research project called "the Social Landscapes of Livelihood" (Permit No. 2019-426-NA-2019-299). Ethical reviews for conduct of research with human subjects were provided by McGill University (REB File #: 479–0419) and the University of Lethbridge via the University of Alberta (Pro00130079). Research was initially oriented towards understanding how Maasai communities felt about community-based conservation initiatives on village land and was soon after broadened to encompass human-wildlife interactions (Permit No. CST00000398-2024-2024-00240; Ethics review: Pro 136507), a topic that local community members consistently voiced as one of the most pressing issues affecting their everyday lives. Dispersals of elephants onto village land in the Tarangire ecosystem engender a range of visible economic costs and hidden effects on human well-being. The main economic cost is crop raiding. The staple crop across the study villages is maize, which is a primary source of food and income for households (Raycraft, 2024a).

The research presented in this paper used anthropological survey methods to provide an overview of human-elephant interactions to the north and northeast of Tarangire National Park. A key applied objective was to systematically document the extent of elephant interactions with people on village land, from the perspectives of local agropastoralists.

Foley and Faust (2010) diagram suggests that elephants are mainly dispersed in the reserved areas of Manyara Ranch and Randilen WMA (formerly Lolkisale Game Controlled Area). Participant observation, interviews and informal conversations with people residing in the study villages in 2019, however, revealed that people encountered elephants frequently on village land and that local perspectives were not adequately being addressed by elephant conservation research. A questionnaire survey was designed to document people's perspectives on human-elephant interactions in these villages. Explanations of sampling and participant recruitment procedures are already published (Raycraft, 2022a, 2022b, 2023), but are reiterated here succinctly for reference. Lists of all female and male-headed households across the study villages were prepared by hand and tallied to establish overall sampling frames (Table 1).

Using Cochran (1963) formula for calculating sample sizes, assuming a 95 % confidence interval, 5 % margin of error, representative sample sizes for each frame were determined. Using sub-villages as strata, stratified random sampling was used to select participants from each sampling frame (Table 2).

Lists of household heads in each sub-village were numbered and selected via random number generator. A minimum of 15 % of all households were selected from each sub-village. Samples from each stratum were not exactly proportionately weighted but were reasonably representative of differences in population sizes across the study villages. Recruited numbers of male household heads typically ranged from about 15–20 % of all household heads in each village, and female-headed households ranged from about 50–100 % due to fewer numbers of female household heads overall. Since male-headed households outnumbered female-headed households by approximately 5:1, a third sampling frame was established—females in male-headed households—to reduce gender bias in responses. As part of this frame, the senior wife of every second male household head was also recruited for participation. In total, 1076 people were surveyed including 547 male household heads, 270 female household heads, and 259 females in male-headed households (wives) (Table 3). Kibaoni A sub-village in Olasiti and Makuyuni Mjini in Makuyuni were both excluded from this survey since they are towns.

The survey asked demographic questions and then a range of thematic questions about elephants. These included questions about people's attitudes towards elephants (1–5 Likert scale), their views on the importance of elephant conservation (yes or no), their tolerance for living with elephants (3-point scale), fear of elephants (4-point scale), crop raiding frequency (5-point scale), crop raiding time of day (3-point scale), crop raiding time of year (4-point scale), threats to livestock (3-point scale), effects on sleep (4-point scale), perceived rates of elephant population change over the past five years (5-point scale), crop-raiding trends over the past 5 years (5-point scale), effects of elephants on physical mobility (4-point scale) and school attendance (4-point scale), property damage over the last twelve months (4-point scale), threats to safety (4-point scale), elephant-induced stress (4-point scale), estimated number of bags of maize harvest lost due to elephants over the past twelve months (continuous), and a series of management-related statement agreement questions evaluating associations between elephants and government (yes or no), perceptions that there were too many elephants (yes or no), views on whether elephant poaching was bad (yes or no), and recommendations about government-led culling (yes or no).

Taken together, the survey provides a descriptive overview of the 'human dimension' of human-elephant interactions to the north and northeast of Tarangire National Park that is grounded in the lived experiences and perspectives of local Maasai communities. In keeping with the spirit of CBPR methods, community members were primarily interested in communicating the scope and scale of their concerns about sharing landscapes with elephants. Survey data on the spatial and temporal distributions of human-elephant interactions are thus

Table 1
Household sampling frames by village and sub-village on the Manyara Ranch side of the study area.

Village	Total # of male heads	# of male heads sampled	% of male heads sampled	Total # of female heads	# of female heads sampled	% of female heads sampled	# of wives sampled
Makuyuni							
Lemiyon	127	30	24	10	4	40	12
Saburi	62	13	21	9	5	56	7
Esimangori	4	2	50	1	1	100	0
Makuyuni Juu	103	22	21	23	11	48	10
Esilalei							
Esimiti	40	8	20	2	1	50	4
Kanisani	57	12	21	3	2	67	6
Shuleni	52	11	21	6	4	67	5
Endepesi	29	6	21	0	0	0	3
Makuyuni Masaini	22	5	23	0	0	0	2
Oltukai							
Simbi	22	5	23	8	5	63	1
Engusero	37	8	22	7	5	71	3
Ilera	47	10	21	8	5	63	5
Oltukai	29	7	24	5	3	60	4
Olasiti							
Eluai	120	24	20	2	1	50	12
Oltukai	61	12	20	10	7	70	6
Kibaoni B	71	14	20	9	7	78	6
Mswakini (Chini)							
Shuleni	91	20	22	12	10	83	8
Kanisani	44	9	20	7	7	100	4
Engasiti	51	10	20	15	9	60	5
Mswakini Juu							
Shimamo	68	14	21	18	10	56	10
Randilen	84	17	20	15	13	87	8
Orbukoi	99	21	21	21	13	62	11
Naitolia							
Engusero	127	26	20	10	7	70	11
Ormang'way	107	21	20	9	6	67	10
Total	1554	327		210	136		153

Table 2
Household sampling frames by village and sub-village on the Randilen WMA side of the study area.

Village	Total # of male heads	# of male heads sampled	% of male heads sampled	Total # of female heads	# of female heads sampled	% of female heads sampled	# of wives sampled
Oldonyo							
Nyorit A	54	8	15	5	4	80	3
Lengijape	44	7	16	3	3	100	3
Oldonyo	90	15	17	12	6	50	7
Loosikitok	63	10	16	0	0	0	4
Lolkisale							
Lolkisale B	113	17	15	37	20	54	9
Makao Mapya	87	13	15	21	12	57	7
Lolkisale A	67	12	18	25	11	44	5
Endarpoi	98	15	15	7	4	57	8
Nafco							
Lengoolwa C	197	31	16	45	21	47	16
Lengoolwa B	66	10	15	21	13	62	4
Osilaley	60	9	15	8	6	75	4
Lengoolwa							
Lengoolwa	57	9	16	6	4	67	6
Engosipa	93	15	16	12	4	33	8
Donyon	109	17	16	22	12	55	8
Orkisima	63	10	16	8	5	63	4
Lemooti							
Olorisyo	54	8	15	5	4	80	5
Lesiday	16	3	19	1	1	100	1
Lemooti	35	11	31	7	4	57	4
Total	1366	220		245	134		106

Table 3
Total number of people surveyed in each study village.

Village	Number of people surveyed
Esilalei	69
Oltukai	61
Olasiti	89
Mswakini Juu	117
Mswakini	82
Naitolia	81
Makuyuni	117
Lemooti	41
Lengoolwa	102
Nafco	114
Lolkisale	133
Oldonyo	70
Total	1076

presented descriptively in this paper as part of a place-based analysis of the Tarangire ecosystem. Reported estimates of bags of maize harvest lost due to elephant crop raiding were used to provide a rough measure of the economic impacts of elephants on households. Across the study villages, kernels on the cob are harvested by hand, separated from stalks, and sorted via 20 kg buckets into 120kg-capacity sacs for home storage or sale in markets. The price per bag of unprocessed cobs varies depending on macroeconomic conditions. For the purposes of this analysis, one bag of maize harvest is assumed to be worth 100,000Tsh (~$40USD), which was the current market price in December 2023.

Estimating exact crop yield losses caused by elephants is a challenging endeavour as there are other environmental factors that bear on production like rainfall variability and insect pests. Ideally, crop damage by elephants is assessed and verified immediately as it occurs, but capacity for systematic monitoring of human-elephant conflicts across the study villages is limited. The estimates provided in this paper were reported by farmers themselves, and thus should be interpreted cautiously. People may have felt inclined to exaggerate their losses with the hopes of increasing their chances of receiving 'consolation' money from the government. However, the large sample size ($n = 1076$) ensured that the results are representative of the views of the overall study population.

Average losses per household were calculated for each study village. Surveys were conducted at people's homesteads and GPS locations were collected and used to map perceived differences in severity of crop raiding by elephants in people's farms using QGIS-LTR software. The result is a map of Human-elephant conflict hotspots across the study area. A caveat to this methodological approach that should be mentioned here is that people's farms were often not situated precisely at the location of their homesteads, as some people's farms were positioned further away from their bomas. Most people's farms were within walking distances, but the map should nonetheless be taken as a rough approximation of geographic variation and not as a fine-grained ecological visualization.

Based on our readings of existing literature on gendered dimensions of human-wildlife interactions, we hypothesized that there would be significant differences between the experiences and perspectives of men and women. (Ogra, 2008; Carter and Allendorf, 2016; Banerjee and Sharma, 2022). To effectively parse out the gendered effects of elephants on human well-being, we compared the results of men and women on a number of survey items including fear of elephants (1–4 scale), sleep disturbance (1–4 scale), effects on physical mobility (1–4 scale), elephant-induced stress (1–4 scale), and perceived threats to safety (1–4 scale). Since the data was not normally distributed, we used Wilcoxon Rank Sum Tests (i.e. Mann-Whitney U tests) to compare medians by gender. Statistically significant differences ($p < 0.05$) between men and women are highlighted and discussed in our analysis.

We also assessed whether there were associations between socio-economic and demographic variables (ethnicity, age, gender, education level, livestock and land holdings) and people's general attitudes towards elephants (1–5 scale) and their tolerance for sharing landscapes with them (1–3). Attitudes were measured on a scale ranging from strongly dislike to strongly like and tolerance was measured in terms of degree of willingness to live with elephants ranging from wanting them totally eradicated to being happy living with them as things currently are. Wilcoxon Rank Sum Tests were used to compare differences between men and women, and Kruskall-Wallis Tests were used when the demographic variables had three or more categories. Ethnicity comprised three groups including the two dominant groups of Kisongo Maasai and Arusha, and the remaining minority groups were grouped together as 'other.' The Maasai age-set ordinal categories (Raycraft, 2022a) were used as a measure of age and education was grouped into

none, primary, secondary, and university (Table 10). We hypothesized that elders and those with higher education would have more positive attitudes towards elephants.

Livestock holdings were measured as tropical livestock units (TLU) using standard conversion rates for Tanzania (Cattle = 0.7, sheep and goats = 0.1, donkey =0.5, chicken = 0.01), and land holdings were represented in terms of number of acres (Mkonyi et al., 2017). Spearman's Rank Correlation Tests were performed to check for correlations between material holdings and attitude scores. We hypothesized that wealthier households in terms of livestock would have more positive attitudes towards elephants given the compatibility of pastoralism and herbivore mobility, while those with larger farms would hold more negative sentiments, given their increased susceptibility to crop raiding. Kruskall-Wallis Tests were also used to compare differences in reported harvest loss by ethnic group. We hypothesized that Arusha respondents would report higher harvest losses than Kisongo due to their higher reliance on crop cultivation.

Results

Descriptive statistics on the demographics of the study population are published in greater depth elsewhere (Raycraft, 2022a, b, 2024b). A basic overview is displayed in Table 4 for reference.

Spatial and temporal distributions of human-elephant interactions

People living in villages to the northeast of Tarangire National Park reported frequent encounters with elephants, though patterns of interaction varied by village (Fig. 3). Across the entire study area almost half (48 %) of all respondents reported either daily or weekly crop raiding events from elephants (Table S1).

In terms of general trends, most people (71 %) across all villages felt that elephants raided crops mainly at night, a finding that triangulates an existing ecological study that used GPS telemetry to study elephant movements outside the park (Galanti et al., 2000). The exceptions were Oldonyo and Lengoolwa, where most people (97 % and 84 % respectively) noted no discernable time-of-day differences in crop raiding frequency. Most respondents (79 %) articulated that they only had troubling encounters with elephants during the farming season, which coincides with the wet season dispersal patterns of elephants from Tarangire National Park. Two exceptions were Oltukai where the majority (64 %) said they never have conflicts with elephants, and Nafco, where most people (81 %) noted year-round problematic encounters.

When survey results were disaggregated by village, it became clear that some villages were particularly affected, while some areas reported

Table 4
Descriptive overview of sampled population (n = 1076). SD stands for standard deviation and TLU represents Tropical Livestock Units. TLU were calculated as follows: Cattle = 0.7, sheep and goats = 0.1, donkey =0.5, chicken = 0.01.

Gender	Ethnicity	Age	Education	Mean TLU± SD	Mean Land holdings ± SD
Man (50.8 %) Woman (49.2 %)	Arusha (58.3 %) Kisongo (32 %) Iraqw (2.3 %) Nyaturu (1.5 %) Mrangi (1.3 %) Nyiramba (1.1 %) *12 others* <1 %	Korianga (40.5 %) Landiis (30.8 %) Makaa (12.2 %) Seuri (7.5 %) Nyangusi (7.5 %) Nyangulu (6.5 %)	Primary (54.3 %) None (39.4 %) Secondary (5.4 %) University (0.9 %)	21.07 ± 42.95	6.3 ± 6.93

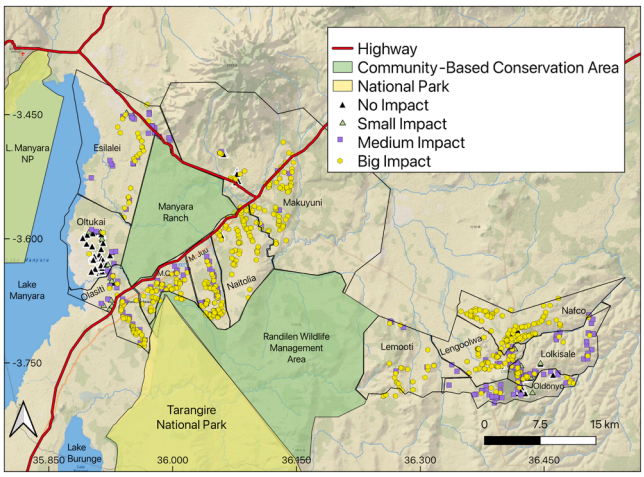

Fig. 3. Map of human-elephant conflict hotspots based on household surveys (n = 1076) administered in 2019–2020. Symbols represent homestead locations and differences in reported severity of elephant impacts on crop production. Basemap powered by Esri and National Geographic. Map produced in QGIS-LTR by authors.

no events at all. The majority of respondents in Oldonyo (73 %), Naitolia (65 %), Olasiti (94 %), and Oltukai (83 %) noted that crop raiding incidents occurred only a few times a year or less, while most respondents in Lolkisale (80 %), and Esilalei (96 %) reported monthly events. Most people in Nafco (59 %), Lemooti (68 %), Mswakini (67 %), and Mswakini Juu (64 %) recorded weekly frequencies, while the majority of people in Lengoolwa (55 %) and Makuyuni (81 %) lamented daily crop raiding incidents. A basic summary of these variations across villages are shown in Table 5.

On the whole, most survey respondents (73 %) said that the elephant population has increased significantly over the past five years. The vast majority of respondents (80–100 %) in each village reported major increases, except villages along the western side of Manyara Ranch—Olasiti (67 %), Oltukai (55 %), Esilalei (57 %)—which mainly reported no change to the elephant population. About a third in Esilalei (33 %), and Olutkai (36 %) reported decreases over this period. These findings seem to point to elephants avoiding the villages west of Manyara Ranch. People's accounts of elephant population increases northeast of Tarangire National Park align with existing ecological studies from Foley and Faust (2010) and others, which documented rapid increases in the northern subpopulation of elephants in the Tarangire ecosystem. Unsurprisingly, the majority of respondents (67 %) across all twelve villages reported that crop raiding by elephants had been increasing significantly over this period, though these trends varied considerably by village. Reports of major increases were particularly striking in Oldonyo (83 %) Nafco (100 %), Lengoolwa (95 %), Lemooti (100 %), Makuyuni (98 %), Naitolia (85 %), Mswakini (90 %), and Mswakini Juu (91 %). These trends should be contextualized relative to overall frequencies of crop raiding events. Major increases in Oldonyo, for instance, have still resulted in relatively infrequent crop raiding (less than yearly) as compared to other villages. Most people in Esilalei (57 %), Oltukai (55 %), and Olasiti (67 %) reported no change in village-level crop-raiding trends over the past five years.

Elephant impacts on livelihoods and well-being

As mentioned in Section 2, elephant dispersals onto village land affect human well-being and produce visible economic costs for local people including crop damage. Breakdowns of harvest losses (Table 6) can be used to estimate approximate economic losses per household per year from crop-raiding elephants. Across the entire study area, people reported an average loss of 9.6 bags of maize harvest last season, which

Table 5
Percentages of responses ($n = 1076$) disaggregated by village on perceptions of human-elephant interaction trends. Responses were consolidated into proportion of respondents by village reporting 'weekly or more' crop raiding incidents, proportion of respondents reporting increases in the local elephant population over the past five years, and proportion of people who perceived increases in elephant crop raiding over the past five years. Complete proportions of survey responses are shown in Table S1. Percentages of 85 % or higher are bolded for emphasis.

	Esil.	Oltuk.	Ola.	M. Juu	M. C.	Nait.	Maku.	Lemo.	Len.	Naf.	Lolki.	Oldon.	Total
Weekly crop raiding or more	4 %	0 %	5 %	**90 %**	**89 %**	21 %	**89 %**	**88 %**	69 %	82 %	10 %	12 %	48 %
Increasing elephant population	34 %	10 %	51 %	**94 %**	**89 %**	**85 %**	**100 %**	**95 %**	**100 %**	**99 %**	83 %	84 %	81 %
Increasing crop raiding	10 %	9 %	30 %	**93 %**	**90 %**	**89 %**	**98 %**	**100 %**	**95 %**	**100 %**	23 %	83 %	77 %

Table 6
Reported maize losses per household last harvest season due to elephants based on surveys ($n = 1076$) administered in 2019–2020 to the north and northeast of Tarangire National Park. Figures above $700 a year are bolded for emphasis.

Village	Mean number of bags (120 kg) lost ± SD	Approximate losses in $USD
Naitolia	15 ± 10.5	$600
Mswakini Juu	14.8 ± 13.9	$592
Mswakini C.	20.3 ± 19.5	**$812**
Olasiti	8.3 ± 10	$332
Oltukai	.2 ± 1.3	$8
Esilalei	17.4 ± 15.7	$576
Makuyuni	18 ± 14.3	**$720**
Oldonyo	1.8 ± 5.2	$72
Lolkisale	.1 ± 0.4	$4
Nafco	6 ± 7.9	$240
Lengoolwa	4.5 ± 9.2	$180
Lemooti	7.7 ± 11.3	$308
Total	9.6 ± 13.2	$384

converts to roughly $384USD. Average costs, however, ranged from as low as $4 in Lolkisale and $8 in Oltukai to $812 in Mswakini.

There was a statistically significant difference in estimated harvest losses across ethnic groups (Kruskal-Wallis Test, X^2=76.5, df=2, p = <0.001) (Fig. 4). Arusha respondents reported the highest harvest losses (mean 11.49 bags), followed by Kisongo Maasai (mean 7.29 bags), and other ethnic groups (mean 5.13 bags).

Aside from crop damage, more than half of all survey respondents (56 %) claimed that elephants caused either moderate or major property damage in the past twelve months (Table 6). The most heavily affected villages were Makuyuni and Naitolia, where the vast majority of people claimed (87 % and 75 % respectively) that elephants had caused major damage during this period. Most people in Oldonyo (74 %), Lolkisale (66 %), Oltukai (91 %), and Esilalei (90 %) by comparison noted no damage during the past year (Table 7).

People's concerns about safety varied across the villages, with highest reported concerns by far in Makuyuni, where almost all respondents (96 %) were significantly worried about elephant attacks. Several other villages also consistently recorded major concerns including Lengoolwa (63 %), Naitolia (52 %), Lemooti (39 %), and Olasiti (33 %). On the other end of the spectrum, most people in Oldonyo (57 %), Lolkisale (71 %), Nafco (70 %), Oltukai (65 %), and Esilalei (87 %) had only minor or moderate worries. No significant differences between the experiences of men and women were found (Wilcoxon Rank Sum: $W_{547,526}$= 152,631,p = 0.068).

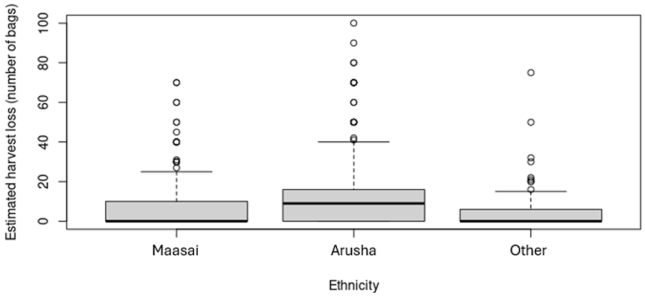

Fig. 4. Boxplot graph showing differences in estimated maize harvest loss to elephants by ethnic group based on surveys administered in 2019-2020 (n = 1076).

Most surveyed individuals did not have a household member who had been attacked by an elephant in the past twelve months (93 %). This finding clearly points to the relative infrequency of elephant attacks on people. However, these results varied considerably from zero reports in Oltukai, Esilalei, and Naitolia, to numerous in Lemooti (10 %), Nafco (11 %), Mswakini (13 %), and Mswakini Juu (24 %). Those villages clearly represent hotspots for dangerous interactions with elephants that affect human safety.

When asked how often they were frightened by elephants in their everyday lives, Makuyuni stood out from other villages as almost everyone (90 %) reported being scared by elephants very often. At the other end of the range, the majority of participants in Oltukai (95 %) and Olasiti (53 %) were either never or occasionally frightened by elephants. Most villages, however, seemed to fall in the middle range. There were no significant differences between men and women in terms of fear of elephants (Wilcoxon Rank Sum: $W_{546,528}$=147,520,p = 0.477).

Just over a quarter (27 %) of all respondents felt that elephants posed a major threat to livestock. Responses varied greatly by village with no one reporting danger to livestock in Esilalei, Oltukai, and Olasiti, and majorities considering elephants a major threat in Lemooti (61 %), Lengoolwa (88 %), Nafco (51 %), and Oldonyo (64 %) (Table S2).

The effects of elephants on people's physical mobility in their home villages were varied, though Makuyuni again stood out from the rest. There, 85 % of surveyed people expressed that elephants majorly constrained their movements. Most participants in Lolkisale (64 %) and Esilalei (67 %) conveyed minor restrictions on movements, while respondents in Oltukai (81 %) and Olasiti (51 %) noted no concerns about mobility. No significant differences between genders were noted (Wilcoxon Rank Sum: $W_{546,527}$=148,932,p = 0.298).

Elephant-related movement constraints sometimes affected the abilities of children to attend schools in the study villages, though the majority of people across the study area (55 %) reported never experiencing these barriers to education. People in Lengoolwa (66 %) and Nafco (35 %) reported daily disturbances and scored notably higher than other villages in this regard. Most people in Esilalei (75 %), Oltukai (98 %), Olasiti (62 %), Mswakini Juu (90 %), Mswakini (80 %), Naitolia (79 %), and Lolkisale (98 %) pointed out that elephant-inducted restrictions on school attendance never occur in their villages.

Reduced sleep quality—another hidden effect of elephants on human well-being—was unevenly reported. Almost a third of all respondents (28 %) said that elephants disturbed their sleep nightly. Reports ranged from almost everyone in Oltukai (93 %) asserting that elephants never disturbed their sleep, to the vast majority of people in Lengoolwa (59 %) and Makuyuni (68 %) conceding that elephants disturbed them nightly. Lemooti (59 %) also had a notably high number of people whose sleep was regularly affected. There was a statistically significant difference between men and women (Wilcoxon Rank Sum: $W_{547,526}$= 164,352, $p \leq$ 0.001), with men (median 3; mean 2.764) reporting more frequent sleep disturbances than women (median 2; mean 2.506) (Table 8).

Relatedly, elephant-induced stress—psychological distress about the

Table 7
Proportions of responses on elephant impacts by village. 'Property damage' reflects the percentage of people reporting major damage from elephants in the past twelve months; 'Danger to livestock' represents the proportion of people who considered elephants a major threat to livestock; 'Preventing school attendance' includes proportions of respondents who reported elephants preventing children from attending school weekly or more; 'household member injured' shows proportions of 'yes' responses when asked if a household member had been injured by elephants in the past twelve months. Percentages above 85 % are bolded for emphasis.

	Esil.	Oltuk.	Ola.	M. Juu	M. C.	Nait.	Maku.	Lemo.	Len.	Naf.	Lolki.	Oldon.	Total
Property damage	0 %	0 %	2 %	33 %	47 %	75 %	**87 %**	34 %	41 %	28 %	5 %	1 %	32 %
Danger to Livestock	0 %	0 %	0 %	26 %	35 %	4 %	3 %	61 %	**88 %**	51 %	3 %	64 %	27 %
Preventing school attendance	0 %	0 %	9 %	4 %	9 %	1 %	19 %	7 %	66 %	35 %	0	6 %	15 %
Household member injured	0 %	0 %	1 %	24 %	13 %	0 %	5 %	10 %	5 %	11 %	1 %	4 %	7 %

Table 8
Gender differences in hidden effects of elephants on human well-being. Left columns represent medians and the right columns display means. Significance ($p < 0.05$) is marked with an asterisk based on Wilcox Rank Sum Tests.

Demographic Variable	Categories	Attitude (1–5)		Tolerance (1–3)		Fear (1–4)		Sleep disturbances (1–4)		Effects on mobility (1–4)		Stress (1–4)		Safety (1–4)	
Gender	Man	3	2.431	2	2.239	2.5	2.74	**3***	**2.764***	3	2.745	3	2.91	3	3.069
	Woman	3	2.414	2	2.256	2	2.723	**2***	**2.506***	3	2.769	3	2.818	3	2.975

threats or costs of living with elephants—was distributed geographically around the Makuyuni elephant dispersal area documented by ecologists. Large proportions of people in Makuyuni (91 %), Naitolia (48 %), Mswakini (28 %), Mswakini Juu (34 %), Lemooti (32 %), Lengoolwa (56 %), and Nafco (26 %) were significantly stressed about elephants, while villages located a little farther away from this key dispersal area where less worried. The majority of people in Esilalei (61 %) and Oltukai (69 %) were not stressed about elephants at all, and most in Olasiti (77 %), Lolkisale (81 %), and Oldonyo (42 %) were either minorly or moderately stressed. There were no significant differences between men and women in the context of elephant-induced stress (Wilcoxon Rank Sum: $W_{546,527}$=152,896,$p = 0.062$).

Attitudes, tolerance, and management preferences

Given the high frequencies of human-elephant interactions in villages to the northeast of Tarangire National Park, coexistence largely depends on the attitudes and tolerance of people living in those areas towards elephants. Most people in Esilalei (78 %), Olasiti (58 %), Lolkisale (51 %), and Oldonyo (77 %) had neutral views on elephants, as did just under half of participants in Mswakini Juu (47 %), Mswakini (45 %), and Naitolia (49 %) (Table 9, Table S3). People in Oltukai had notably higher proportions of people (36 %) who strongly liked elephants, which is unsurprising since that village reported no conflicts with elephants. Somewhat more surprisingly, just under half of all participants in Lemooti (49 %) expressed that they liked elephants, even despite significant socioeconomic impacts from elephants in that village. Several villages, where costs incurred from elephants were particularly pronounced, had majorities with very negative attitudes towards elephants. Most people in Makuyuni (61 %), Lengoolwa (92 %), and Nafco (73 %) strongly disliked elephants.

Statistical analyses showed significant associations between ethnicity and attitudes towards elephants (Kruskal-Wallis Test: X^2=34.049, df=2, $p \leq 0.001$) with Arusha respondents reporting more negative scores (median 2; mean 2.25) than Kisongo Maasai (median 3; mean 2.737) and other ethnic groups (median 3; mean 2.413). Age was also significantly associated with attitude towards elephants (Kruskal-Wallis Test: X^2=25.761, df=6, $p \leq 0.001$), with the eldest age set (Nyangusi) reporting the most negative attitudes (median 1, mean 1.48) and the second youngest age set (Korianga) recording the most positive (median 3, mean 2.498). Furthermore, education level was significantly associated with attitudes (Kruskal-Wallis Test: X^2=9.367, df=3, $p = 0.025$). Those with no education had the most negative attitudes (median 3; mean 2.348) and those who had attended university had the most positive (median 3; mean 3.3). Mean scores increased with education level. There were no significant correlations between land holdings and attitudes (r_s=0.005, $S = 204{,}852{,}082$, $n = 1073$, $p = 0.868$), between TLU and attitudes (r_s=−0.005, $S = 207{,}563{,}880$, $n = 1074$, $p = 0.863$), or gender and attitudes (Wilcoxon Rank Sum: $W_{547,527}$=144,648,$p = 0.916$) (Table 10).

For the most part, people across the study villages (63 %) felt that elephant conservation was important, however, the results were largely divided by village. People in Esilalei (90 %), Oltukai (97 %), Olasiti (83 %), Mswakini Juu (79 %), Mswakini (60 %), Naitolia (77 %), Lemooti (100 %), and Lolkisale (94 %) mostly felt that elephant conservation was important, while those in Nafco (85 %), Lengoolwa (71 %), Makuyuni (67 %), and Oldonyo (61 %) expressed that it was unimportant.

On the whole, most people (72 %) across the study area were somewhat tolerant of elephants and expressed that they were happy to share landscapes with them as long as the animals did not harm people, their crops, or their property. This viewpoint held across Esilalei (94 %), Oltukai (88 %), Olasiti (85 %), Mswakini Juu (97 %), Mswakini (95 %), Naitolia (90 %), Lemooti (98 %), Lolkisale (99 %), and Oldonyo (86 %). However, tolerance levels were notably low in Lengoolwa (76 %) and

Table 9
Consolidated proportions of responses on attitudes by village. "Attitudes" represent proportions of respondents with positive attitudes towards elephants; "conservation importance" reflects the proportion of people who think elephant conservation is important; "tolerance" includes those who are happy sharing landscapes with elephants (very tolerant). Percentages of 85 % or higher are bolded for emphasis.

	Esil.	Oltuk.	Ola.	M. Juu	M. C.	Nait.	Maku.	Lemo.	Len.	Naf.	Lolki.	Oldon.	Total
Attitudes	18 %	72 %	18 %	10 %	3 %	5 %	1 %	64 %	3 %	6 %	39 %	7 %	17 %
Conservation importance	90 %	97 %	83 %	79 %	60 %	77 %	33 %	**100 %**	29 %	15 %	**94 %**	39 %	63 %
Tolerance towards elephants	0 %	10 %	1 %	0 %	2 %	0 %	0 %	0 %	0 %	1 %	1 %	6 %	1 %
Elephants are brought by government	5 %	3 %	6 %	**88 %**	81 %	26 %	31 %	20 %	9 %	18 %	32 %	**96 %**	36 %
There are too many elephants	28 %	52 %	43 %	**94 %**	**90 %**	**100 %**	**100 %**	**100 %**	**99 %**	**98 %**	**100 %**	**100 %**	**86 %**
Government should cull elephants	2 %	2 %	18 %	**92 %**	**87 %**	11 %	91 %	10 %	84 %	63 %	4 %	20 %	46 %
Poaching is bad	**100 %**	**100 %**	**93 %**	**99 %**	**100 %**	**100 %**	**100 %**	**100 %**	**94 %**	59 %	**100 %**	**99 %**	**94 %**

Table 10
Associations between demographic variables and attitudes towards elephants and tolerance for sharing landscapes with elephants. Columns on the left are medians and the ones are the right are means. Statistical significance is signified by an asterisk. In accordance with the survey instrument, tolerance ranges from most tolerant (1) to least tolerant (3) and attitudes range from strongly dislike (1) to strongly like (5).

Demographic Variable	Categories	Attitudes (1–5)		Tolerance (1–3)	
Ethnicity	Maasai	3*	2.737*	2	2.239
	Arusha	2*	2.255*	2	2.252
	Other	3*	2.413*	2	2.250
Age	Nyangulu	3*	2.464*	2*	2.319*
	Korianga	3*	2.498*	2*	2.202*
	Landiis	3*	2.489*	2*	2.245*
	Makaa	3*	2.354*	2*	2.254*
	Seuri	2*	2.111*	2*	2.321*
	Nyangusi	1*	1.480*	3*	2.640*
Gender	Man	3	2.431	2	2.239
	Woman	3	2.414	2	2.256
Education	None	3*	2.348 *	2*	2.329
	Primary	3*	2.438 *	2*	2.204
	Secondary	3*	2.655 *	2*	2.138
	University	3*	3.300*	2*	2.000
TLU	(*continuous*)	−0.005		0.150*	
# acres total farm	(*continuous*)	0.005		−0.084*	

Nafco (56 %), and strikingly low in Makuyuni (87 %), where most people in those villages expressed no tolerance for elephants and a desire for them to be eradicated. There were significant differences in tolerance across age sets (Kruskal-Wallis Test: X^2=26.244, df=6, $p \leq 0.001$), with the eldest age set (Nyangusi) the least tolerant (median 3; mean 2.64). Education was also significantly correlated with tolerance (Kruskal-Wallis Test: X^2=24.980, df=3, $p \leq 0.001$). Those without any education were the least tolerant (median 2; mean 2.329) while those who had attended university were the most tolerant (median 2; mean 2).[d] There was a significant, weak negative correlation between tolerance and TLU (r_s=0.150, S = 175,463,413, n = 1074, $p \leq 0.001$), and a significant, weak positive correlation (0.084) between land holdings and tolerance (r_s=−0.084, S = 223,120,289, n = 1073, p = 0.006). Ethnicity (Kruskal-Wallis Test: X^2=0.124, df=2, p = 0.940) and gender (Wilcoxon Rank Sum: $W_{547,527}$=141,945,p = 0.579) were not significantly correlated with tolerance.

A commonality across most of the villages was agreement that there were too many elephants in the area. Almost all respondents across the entire area (86 %) agreed with this statement, patterns that were reflected in the village-level results from Mswakini Juu (94 %), Mswakini (90 %), Naitolia (100 %), Makuyuni (100 %), Lemooti (100 %), Lengoolwa (99 %), Nafco (98 %), Lolkisale (100 %), and Oldonyo (100 %). Just over half of participants in Oltukai (52 %) also agreed that there were too many elephants. Olasiti (57 %) and Esilalei (72 %) were exceptions with most people disagreeing with the statement.

Elephants were generally associated with government policies in the study villages, but most respondents across the study area (64 %) did not feel that elephants were brought to their villages through concerted efforts by the government. Nine out of the twelve study villages reported similar trends, with the exceptions being Mswakini Juu (92 %), Mswakini (87 %), and Oldonyo (96 %) where most people felt that elephants were indeed brought by the government. These findings provide insights into people's levels of trust in wildlife authorities.

When asked whether the government should cull the elephant population, people across villages provided polarizing responses. The vast majority of participants in Esilalei (99 %), Oltukai (98 %), Olasiti (82 %), Naitolia (89 %), Lemooti (90 %), Lolkisale (96 %), and Oldonyo (80 %) felt that the government should not sanction population reductions, while most people in Mswakini Juu (92 %), Mswakini (87 %), Makuyuni (91 %), Lengoolwa (84 %), and Nafco (63 %) agreed that the government should reduce the number of elephants through culling.

Despite widespread interest in reducing the elephant population, almost all study participants (94 %) viewed elephant poaching as bad. All villages reported between 0 and 1 % disagreement rates with the statement "elephant poaching is bad," except for Nafco (41 %), Lengoolwa (6 %), and Olasiti (7 %). This finding is unsurprising given the strict consequences for ivory poaching, which is illegal and prosecuted aggressively by the state.

Discussion and conclusion

The present study highlights some of the village-level variations in people's experiences of sharing landscapes with elephants to the north and northeast of Tarangire National Park. There, the home range of Tarangire's northern subpopulation of elephants overlaps village land posing a pressing environmental challenge for wildlife authorities. While herders living to the west of Manyara Ranch experienced little to no conflict with elephants—a finding that aligns with a recent study on human-elephant interactions in those villages (Kioko et al., 2022)—villages to the south and southeast of the ranch lamented frequent crop raiding, and in the case of Makuyuni and Naitolia, significant property damage from elephants. In the cases of Mswakini, the economic impacts of crop raiding were roughly $812USD per year, amounting to a significant loss for agropastoralists, the majority of whom do not have formal employment and who live off their livestock and farms for subsistence. While attacks on people were relatively low across the entire area, Lemooti, Nafco, Mswakini Juu, and Mswakini had alarmingly high numbers of households with people who had been injured in the past year (10–24 %). These acute incidents have lasting hidden effects on people's well-being in the forms of fear, stress and insecurity, feelings that were particularly entrenched in Makuyuni (Raycraft, 2023). Worry about defending farms from crop-raiding elephants affects people's quality of sleep and fear of elephant attacks affects people's decisions to move about in the villages, especially at night when elephants feed on crops more regularly. In the mornings, children sometimes encounter herds of elephants on their walks to school and are frightened into remaining home for the day. Most people in Lengoolwa and Nafco considered these incidents to be daily occurrences.

The uneven geographic distributions of elephant impacts on crop production across the study area also intersect with ethnicity in a consequential way. The significant difference between reported harvest losses from Arusha farmers as compared to Kisongo Maasai and other ethnic groups speaks to their higher dependence on crop cultivation, and perhaps their heightened sense of the importance of farming to their cultural identities. Given their geographic locations and economic modes of production, the Arusha are thus more vulnerable to elephant dispersals than Kisongo Maasai villages, which are predominantly herding communities despite increasing economic diversification in recent years.

The finding that those with larger farms were more tolerant of elephants is somewhat surprising, though the correlation was weak. The result may have been due to the fact that those with larger farms are generally wealthier and have more means to protect their farms from elephants through fencing and guard labour. Furthermore, they may be less impacted by elephant encroachments than cultivators who depend on small farms with inadequate fencing.

On the whole, the effects of elephants seem to be fairly evenly distributed across men and women, likely due to the interconnected nature of household economies and the roles that both men and women play through culturally-specific divisions of labour. The finding that men's sleep was significantly more disturbed than women's is most likely due to the fact that men are responsible for waking up in the night to defend farms from crop-raiding elephants. Thus, this particular hidden consequence of human-elephant interactions—disturbed sleep—is

[d] On the tolerance survey item, 3 represented the least tolerant and 1 represented the most tolerant.

gendered.

The fact that Arusha respondents had significantly more negative attitudes towards elephants than other ethnic groups was probably attributable to their higher dependence on smallholder farms. The finding that elders had more negative attitudes and were less tolerant is perhaps related to the fact that they have witnessed the rise of the local elephant population in their lifetimes. The positive relationship between education and attitudes speaks directly to the importance of conservation outreach and education programs.

Taking a community perspective, the cumulative effect of elephant-induced visible economic costs and hidden psychosocial effects is a significant social justice issue that local people feel has been underrepresented by government policy and wildlife conservation efforts. This finding aligns with other studies, including Rubino et al. (2021) who interpret human-elephant conflicts in Borneo through the lens of environmental justice (Rubino et al., 2020). The most promising efforts to support local communities in dealing with dispersing elephants have been spearheaded by grassroots NGO Honeyguide, which has helped member villages of Randilen WMA re-invest some of their tourism revenues into human-elephant conflict reduction toolkits comprising torch flashlights, chilli bombs, and roman candles (Honeyguide, 2023). Local communities greatly appreciate these efforts, both for their efficacy in reducing elephant crop raiding, but perhaps more importantly as gestures that symbolize respect for people's livelihoods and a willingness to listen to their concerns (Raycraft, 2022b). The use of chilli fences (Chang'a et al., 2016) and drones (Hahn et al., 2017) have also been piloted as deterrent methods, but questions remain about the scalability of these measures as Tarangire's elephant population continues to grow in both range and size (Foley and Foley, 2022).

Looking to the future, conservation must continue to expand its gaze to better understand human-elephant interactions on shared landscapes (Sampson et al., 2019). The current situation of elephants moving onto people's farms, and people angrily attempting to scare them away in response, seems perhaps to be an unsustainable solution in the long-run that is likely to continue to build discontent between people and elephants. Elephants, like people, do not appreciate being yelled at and harassed (Kioko et al., 2022), and no farmer likes having their crops raided and trampled. Living with elephants is a relationship that needs work and, in this case, more support through effective governance institutions that ensure that people's livelihood concerns are not neglected in favor of wildlife mobility (Carter and Linnell, 2016). Political barriers affecting the uptake of community perspectives into wildlife policy in Tanzania are perhaps the most significant factor to be addressed from a policy perspective. Excluding local people from conservation discourse and expecting them to willingly bear the social and economic costs of elephant dispersals is a precarious prospect that erodes people's willingness to live peacefully together with wildlife (Mariki et al., 2015). Tolerance towards elephants was strikingly low in Makuyuni, Lengoolwa, and Nafco, unsurprisingly where crop raiding was particularly severe. Low levels of tolerance towards elephants could jeopardize conservation initiatives outside Tarangire National Park and undermine the prospects of human-elephant coexistence (Kioko et al., 2022). Thus, addressing people's concerns about elephants, is crucial both for elephant conservation and human well-being. As evidenced by the fact that most people across the study area (72 %) were willing to share landscapes with elephants (as long as they do not harm people, crops, or property), there is a great deal of hope for fostering human-elephant coexistence to the northeast of Tarangire National Park in the future. But it will take some work to get there.

CRediT authorship contribution statement

Justin Raycraft: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **George Tanner:** Formal analysis, Writing – review & editing, Visualization. **Edwin Maingo Ole:** Writing – review & editing, Data curation.

Declaration of competing interest

None to declare.

Data availability

The data that has been used is confidential.

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Supplementary materials

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