

CONTRIBUTED PAPER

A spatially explicit assessment of factors shaping attitudes toward African elephant conservation

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Abstract

Conservation plans that explicitly account for the social landscape where people and wildlife co-occur can yield more effective and equitable conservation practices and outcomes. Yet, social data remain underutilized, often because social data are treated as aspatial or are analyzed with approaches that do not quantify uncertainty or address bias in self-reported data. We conducted a survey (questionnaires) of 177 households in a multiuse landscape in the Kenya–Tanzania borderlands. In a mixed-methods approach, we used Bayesian hierarchical models to quantify and map local attitudes toward African elephant (*Loxodonta africana*) conservation while accounting for response bias and then combined inference from attitude models with thematic analysis of open-ended responses and cointerpretation of results with local communities to gain deeper understanding of what explains attitudes of people living with wildlife. Model estimates showed that believing elephants have sociocultural value increased the probability of respondents holding positive attitudes toward elephant conservation in general (mean increase = 0.31 [95% credible interval, CrI, 0.02–0.67]), but experiencing negative impacts from any wildlife species lowered the probability of respondents holding a positive attitude toward local elephant conservation (mean decrease = −0.20 [95% CrI −0.42 to 0.03]). Qualitative data revealed that safety and well-being concerns related to the perceived threats that elephants pose to human lives and livelihoods, and limited incentives to support conservation on community and private lands lowered positive local attitude probabilities and contributed to negative perceptions of human–elephant coexistence. Our spatially explicit modeling approach revealed fine-scale variation in drivers of conservation attitudes that can inform targeted conservation planning. Our results suggest that approaches focused on sustaining existing sociocultural values and relationships with wildlife, investing in well-being, and implementing species-agnostic approaches to wildlife impact mitigation could improve conservation outcomes in shared landscapes.

KEYWORDS

African elephants, attitudes, coexistence, community-based conservation, hierarchical modeling, human–wildlife conflict, spatial planning

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INTRODUCTION

Where people and wildlife share space, developing and implementing conservation plans that are both effective and socially supported can improve conservation outcomes (Ban et al., 2013; Bennettt et al., 2017; Niemiec et al., 2021). The implicit goal of conservation in shared landscapes is to achieve human–wildlife coexistence, which occurs when risk and conflict are managed at levels that are acceptable and sustainable for both human communities and wildlife populations (Carter & Linnell, 2016; Pooley et al., 2021). Though coexistence is an implicit goal of conservation, the explicit focus of most research on human–wildlife interactions has been on direct, negative impacts that people and wildlife can have on each other, typically termed human–wildlife conflict (Bhatia et al., 2020; Redpath et al., 2015). The imbalanced research focus on negative interactions has hindered the understanding of complex human–wildlife relationships that underlie coexistence (Bhatia et al., 2020; Pooley et al., 2021; Redpath et al., 2015).

Conservation psychology evaluates how and why people undermine or facilitate coexistence by assessing individual thought and behavior in conservation contexts (Bennett et al., 2017; St. John et al., 2010). Many studies have measured attitudes toward wildlife because attitudes are antecedents of intentions and behaviors (St. John et al., 2010; Vaske & Donnelly, 2002). Attitudes are the tendency to evaluate an entity positively or negatively (Eagly & Chaiken, 1993; Fishbein & Ajzen, 1977), whereas behavioral intention is the likelihood an individual will engage in a behavior based on measurements of preferred actions, and behavior is an observable action (Fishbein & Ajzen, 1977). Though general attitudes may not reliably predict specific behaviors (Ajzen, 2020; Heberlein, 2012), they can predict general behavioral patterns, and specific behaviors can be explained by attitudes toward that behavior (Ajzen et al., 2018; Hazzah et al., 2017; Liu et al., 2011). For example, attitudes toward carnivores and prior behaviors toward them are strongly associated (Bruskotter et al., 2015; Hazzah et al., 2017).

Stakeholder attitudes and behaviors toward wildlife can be considered to interact on scales of negative to positive and passive to active, for example: active intolerance (negative attitudes acted upon), passive tolerance (negative attitudes without action), passive neutral (neutral attitude and no action), appreciation (positive attitudes without action), and active stewardship (positive attitudes and actions) (Bhatia et al., 2020; Brenner & Metcalf, 2020; Bruskotter & Fulton, 2012; Carlson et al., 2023; Glikman et al., 2021). Attitudes are hence linked to behavioral intent and behavior and can be useful indicators of human–wildlife relationships, particularly when behavioral patterns of interest, such as intentionally sharing land with wildlife, cannot be reliably measured (Bruskotter et al., 2015; Glikman et al., 2019; Hazzah et al., 2017).

Yet, social concepts remain broadly underutilized in conservation planning (Manfredo et al., 2019; Niemiec et al., 2021; but see Vogel et al., 2023). One difficulty is that social data, often collected for different research aims, are frequently treated as aspatial, making them difficult to retroactively include in spatial conservation plans (Ban et al., 2013). Spatially explicit assess-

ments of social factors across landscapes with varying land-use and management regimes may be critical for effective conservation plans for wide-ranging species, particularly if assessments examine why attitudes are held. Additionally, social data are typically collected using surveys or interviews but are rarely analyzed with methods that account for biases inherent in self-reported data (St. John et al., 2014; Whitehouse-Tedd et al., 2021; Young et al., 2018). These errors can propagate when social data are integrated with ecological data for spatial planning (Lechner et al., 2014). For example, social desirability bias—respondents consciously or subconsciously answering questions in a manner they believe will be socially acceptable—is a known source of response bias that frequently occurs when questions are administered by interviewers or cover sensitive topics, such as illegal wildlife hunting or endangered species (Kreuter et al., 2008; Nuno & St. John, 2015). Advanced questioning methods like anonymous or randomized response techniques can help address such biases, but are challenging to implement and may not work as intended in all cultural contexts (Ibbett et al., 2022).

We addressed these barriers to integrating social variables in conservation planning by quantifying and spatializing local stakeholder attitudes toward African elephant (*Loxodonta africana*) conservation in the Kenya–Tanzania borderlands of East Africa. We applied hierarchical modeling techniques to account for response bias in self-reported attitudes and estimated the probability that people have a positive attitude at a local scale (i.e., a positive internal evaluation of elephant conservation) (Vasudev & Goswami, 2020). We considered positive local attitudes toward elephant conservation as an indicator of people's willingness to share space with elephants locally (i.e., on community, private, or village lands). We quantified positive attitudes explicitly because positive local attitudes are closer to active stewardship than, for example, passive tolerance (Bhatia et al., 2020; Glikman et al., 2021). Additionally, local attitudes pertain to living with and having contact with wildlife, whereas anyone can have an attitude toward wildlife in a general or abstract sense (hereafter notional attitudes) (Vasudev & Goswami, 2020). For example, a person may generally support elephant conservation inside parks (notional attitude) while also being opposed to elephants using land near their home (local attitude). This distinction is particularly crucial for African elephant conservation because elephant populations rely on habitat outside of formal protected areas across the continent (Wall et al., 2021), and mapping positive local attitudes could identify unprotected locations of high coexistence potential to prioritize for conservation effort (Vogel et al., 2023).

Previous assessments of attitudes toward wildlife and elephants among the Maasai, who are Indigenous to the Kenya–Tanzania borderlands, show variation in attitudes associated with conservation benefits (Broekhuis et al., 2018; Gillingham & Lee, 1999; Hazzah et al., 2013; Homewood et al., 2009), land use and livelihoods (Browne-Nunez et al., 2013; Fernandez-Llamazares et al., 2020; Gadd, 2005), age and gender (Kideghesho et al., 2007; Western et al., 2019), and education level (Broekhuis et al., 2018; Western et al., 2019). However, most studies focused on elephants have exclusively examined conflict and crop loss, precluding holistic understanding of

human–elephant interactions (for exceptions, see de Pinho et al. [2014] and Kioko et al. [2015]). Our objectives were to understand the lived experiences of people who share space with elephants, investigate their attitudes toward elephant conservation and the factors that explain these attitudes, and quantify and map local positive attitudes toward elephant conservation to support conservation planning. We combined inference from attitude models with analysis of qualitative data and coin-terpretation of results with local communities to gain deeper understanding of what explains attitudes of people living with elephants.

METHODS

Ethics statement

Our research protocol was approved by the Colorado State University Institutional Review Board (IRB) under protocol number 20–9752H, and research permission was granted by Kenya's National Commission for Science Technology and Innovation (NACOSTI) under research license number NACOSTI/P/20/4080. All respondents gave free and informed consent to participate (Appendix S1).

Study region

The study region covered 1500 km² of the Greater Mara Ecosystem between the Maasai Mara National Reserve (MMNR) to the west and the Naimina Enkiyo Forest in the east in Narok County, Kenya (Figure 1). The population is dominated by the Purko Maasai ethnic group in the west and Loita (*Iloita*) Maasai in the east, and population density is relatively low (median = 11.8 people/km² [Bondarenko et al., 2020]). Maasai primarily herd livestock and farm, but many also lease land parcels for either commercial agriculture or wildlife conservation and tourism through conservancies as a result of national land privatization policies (Homewood et al., 2009). The sole operating conservancy in the study region is Olderkesi Conservancy bordering the reserve (Figure 1). Narok County supports an estimated 30% of Kenya's wildlife (Ogutu et al., 2016). Wildlife populations in Narok rely on habitat outside the reserve, including the study region, which is a wildlife dispersal area and an elephant movement corridor (Ogutu et al., 2016; Waweru et al., 2021). The Naimina Enkiyo Forest is a vital dry-season grazing resource for livestock and wildlife and supports rare endemic plants and endangered wildlife species including elephants.

Questionnaire

We developed a semistructured questionnaire to examine people's experiences with and attitudes toward elephant conservation (Appendices S1–S4). We included both structured Likert scale questions and free-response questions because we sought

to quantify attitudes and gain a deeper understanding of what drives attitudes. Likert questions were posed in the form of a statement to which respondents rated their level of agreement on a 5-point scale to provide a consistent method of observing attitudes (Vasudev & Goswami, 2020; Willits et al., 2016). Questions pertained to sociodemographics, livelihoods, and land use; attitudes (Likert scale measures); experiences living with elephants and sociocultural values associated with elephants; and perceptions of human–elephant coexistence. For example, to understand sociocultural values associated with elephants, we asked, “Are elephants important in your culture?” and “If so, how, and what roles do elephants have in your culture?” We developed the questionnaire in English, had it translated to Maa (the most commonly used language) by fluent speakers, and then had it back-translated to ensure accuracy. We piloted the questionnaire in a village near the study area and made minor adjustments based on pilot responses.

Sampling design and data collection

Because locations of occupied households were not available, we used QGIS 3.8 to create a uniform grid of 1.6-km² cells across the study region (Figure 1). The region was remote with limited infrastructure, so we constrained sampling to accessible areas for interviewer safety and excluded inaccessible cells. We applied a generalized random stratified tessellation sampling algorithm to randomly select 160 sample cells (minimum desired based on simulations) (Vasudev & Goswami, 2020) in a spatially balanced manner to avoid spatial bias in sampling across the study region (Stevens Jr. & Olsen, 2004). Excluded cells are a potential source of nonresponse bias; however, this is likely minor due to low population densities in these areas. Within sample cells, interviewers opportunistically identified households and first asked to speak with the household head or the closest adult kin if the household head was not present. We targeted long-term residents (residents of ≥1 year). We stratified survey effort by population density, surveying 3 households per cell if population density in the cell exceeded the 75% percentile for the study area, 2 if the estimate exceeded the median, and one in all other cells based on gridded population data (Bondarenko et al., 2020). Interviews were conducted from June to August 2020 by 2 trained enumerators.

Hierarchical modeling of attitudes toward elephant conservation

We implemented a hierarchical Bayesian model developed by Vasudev and Goswami (2020) to estimate the probability that a person holds a positive attitude toward elephant conservation. We used this approach to account for response bias in self-reported attitudes while investigating what drives attitudes and to distinguish locally positive attitudes (i.e., willingness to share space) from notional attitudes (Vasudev & Goswami, 2020). We estimated positive attitude probabilities from answers to Likert questions. Self-reported attitudes can result in 2 possible forms

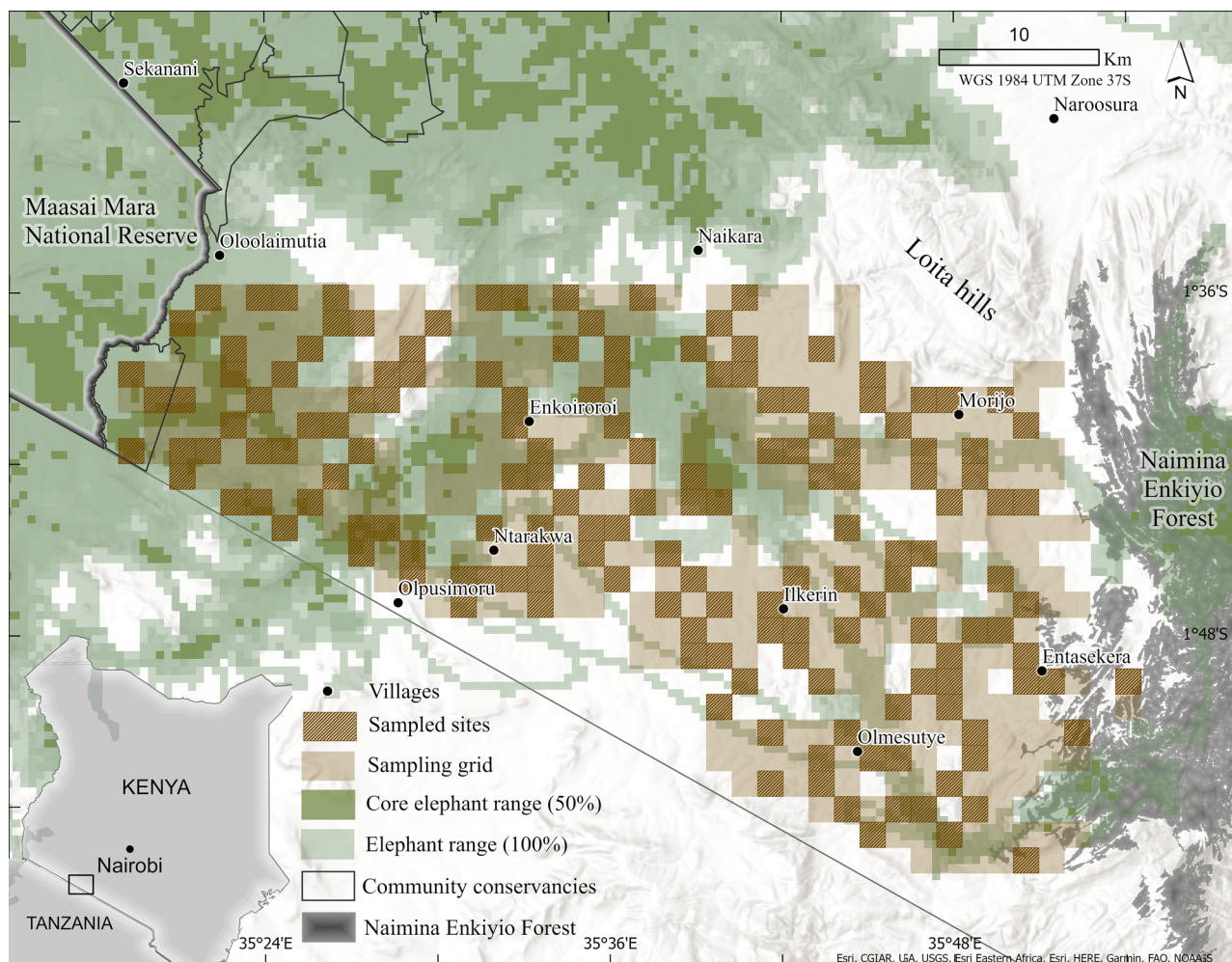


FIGURE 1 Study area in southwestern Kenya detailing the spatial sampling grid and 160 sampled sites (1.6 km^2) where questionnaires were distributed to assess attitudes toward elephant conservation overlaid with known African elephant core range (50%) and overall range (100%) estimated from geographic position system tracking data.

of response bias: false-positive error, where a person who is not positive toward elephants reports a positive attitude, and false-negative error, arising from a person who is truly positive toward elephants but reports a nonpositive attitude. For example, a person may report a falsely positive attitude to a local interviewer because of social desirability bias related to depicting a positive image for the wildlife tourism industry or a falsely negative attitude to conform to a social norm of negativity toward wildlife as a response to the history of displacement and exclusion of Maasai from land in the name of wildlife conservation (Fernandez-Llamazares et al., 2020). To account for such bias, we used a modification of the multiple detection method (here, different types of Likert questions [Appendix S2]) from false-positive occupancy models used in ecological studies to explicitly quantify false-positive and false-negative error rates and reduce bias in the estimates for the true attitude state of interest (Cruickshank et al., 2019; Miller et al., 2011). Details of the method are in Appendices S3 and S14 and Vasudev and Goswami (2020).

To distinguish local from notional attitudes, we estimated each separately for all respondents with a multilevel model in which the probability of a person holding a locally positive attitude toward elephants is conditional on their notional attitude, such that people who are notionally negative or notionally neutral cannot be locally positive. The questionnaire included positive and negative statements, so we converted all responses to a positive scale (e.g., agreeing with a negative statement about elephants became a negative response). We then converted responses to each statement to the binary scale of nonpositive (0) or positive (1), treating neutral as nonpositive. A person's true notional attitude state can thus be considered a Bernoulli random variable, such that $\alpha_i = 1$ if person i is notionally positive toward elephants and $\alpha_i = 0$ when the person is not notionally positive with probability ψ , such that $\alpha_i \sim \text{Bern}(\psi_i)$. Given that person i has a positive notional attitude, they may or may not be positive toward elephants at a local level. Thus, a person's local attitude state is also a Bernoulli random variable where $\lambda_i = 1$ if they are positive toward elephants or $\lambda_i = 0$ if

not, with probability ϕ that their true local attitude state is positive such that $\lambda_i \sim \text{Bern}(\phi; \alpha_i)$ (Vasudev & Goswami, 2020). We modeled the above parameters on sociodemographic factors that we expected to influence notional attitudes toward elephants based on evidence from the literature; specifically, a person's age group, access to formal education, gender, and religious beliefs may influence the likelihood of that person to be notionally positive toward elephants (Browne-Nunez et al., 2013; Kideghesho et al., 2007; Western et al., 2019). We used coded responses to an open-ended question about sociocultural roles of elephants to identify respondents who believe that elephants have sociocultural value because we hypothesized that sociocultural values may influence notional attitudes (Kioko et al., 2015; Manfredo et al., 2021).

At the local level, we hypothesized that attitudes may be most strongly driven by individual or within-household experiences. We expected households that cultivate to be less positive because of the potential for crop loss due to elephants (Browne-Nunez et al., 2013). We expected that households that had experienced problems caused by elephants (Nyumba et al., 2020) or problems with any wildlife including elephants might be less positive (Western et al., 2019). We anticipated that people living near core elephant ranges may have had more interactions with elephants (positive or negative), so we identified respondents from households near known core elephant ranges estimated from elephant tracking data (Wall et al., 2024). We expected that people who identified benefits derived from elephants may be more positive (Dickman et al., 2014; Störmer et al., 2019). Finally, we tested whether formal education influenced local attitudes because education access has been associated with positive wildlife conservation attitudes in Maasailand and may be considered an indirect benefit of wildlife conservation (Western et al., 2019).

To map local positive attitudes toward elephants across the study area, we developed a landscape model for local attitudes. We used the same notional attitude model structure as above but modeled local positive attitude probabilities for subregions that we expected may have different attitudes toward elephants based on land cover and land use, cultural differences, and land privatization status (Appendix S8). This allowed us to evaluate what explained variation in attitudes among people and to make spatially explicit predictions of positive attitude probabilities at a scale that could be useful to communities and conservation practitioners. Finally, we controlled for an effect of interviewer identity on local attitude misreporting probabilities in all models because we expected that individual interviewers may elicit different patterns of response bias from respondents.

We used R 4.0.5 for all data analyses (R Core Team, 2022). We checked the internal consistency and dimensionality of our attitude measures by calculating Cronbach's alpha and performing single-factor confirmatory factor analyses (CFAs) (Whitehouse-Tedd et al., 2021). Cronbach's alpha showed reasonable internal consistency ($\alpha = 0.73$ notional, $\alpha = 0.76$ local), and CFA fit statistics indicated that our groupings of notional and local attitudes were an acceptable fit (Appendix S2). We used the R packages *Lavaan* (Rosseel, 2012) and *psych* (Revelle, 2023) for

this part of the analyses. We estimated all hierarchical model parameters with Markov chain Monte Carlo (MCMC) simulations with a Metropolis–Hastings algorithm. We examined trace plots to ensure mixing, assessed convergence with the Gelman–Rubin statistic, and assessed model specification with graphical posterior predictive checks (Hobbs & Hooten, 2015; Appendices S9–S13). Results from the first model evaluated variation in attitudes among respondents, and we used results from the landscape model to map attitudes across the landscape.

Hypothesis testing

We evaluated differences in positive attitude probabilities between social groups indexed by our individual covariates by calculating the pairwise difference between group mean parameters at each MCMC iteration. We used the posterior mean of this derived quantity for hypothesis testing and measured the strength of the effect by calculating the posterior probability for the mean difference between groups as the proportion of parameter estimates for each group that had a larger absolute value than the reference group across all MCMC iterations (Hobbs & Hooten, 2015). We followed the same procedure to assess spatial variation across subregions.

Qualitative analyses

We conducted a thematic analysis (Braun & Clarke, 2006; Clarke & Braun, 2013) on responses to open-ended questions with MaxQDA 20.4.0. We created analytical categories guided by our research questions (i.e., living with elephants, sociocultural values, and perceptions of human–elephant–livestock coexistence). For example, we asked respondents “Should people and livestock live alongside elephants?” and “Why or why not?” to assess perceptions of human–elephant–livestock coexistence. We conducted an initial round of structural coding, then used in vivo coding to develop detailed subcodes from responses (Clarke & Braun, 2013). We identified final axial and subcodes and tallied the frequency of codes across respondents.

Cointerpretation

We returned to the study area 1 year after data collection and attended public meetings to discuss and share our preliminary findings with community members. We distributed handouts with infographics and gave presentations with live translation to Maa. We then held informal focus group discussions for the purpose of cointerpretation with a subset of 7–10 meeting participants identified with purposive sampling to qualitatively assess how our interpretation of the results aligned with or deviated from local interpretations (Nyumba et al., 2018) (Appendix S5). We identified themes that emerged from cointerpretation that either deviated from or were missed in our initial interpretation.

TABLE 1 Sociocultural values of African elephants identified by questionnaire respondents (free-response questions) in southwestern Kenya who believe elephants have sociocultural value ($n = 108$; 61.1%).

Coded sociocultural values and percentage of respondents who identified each value	Example quotation
Ecological (38.9%) ^a	“Elephants clear the thick bushes and pave the way for new plant growth.” “[Elephants] increase soil fertility through their dung deposition.”
Economic (37.0%)	“Elephants attracts the tourists which bring income to Kenya’s economy and also to [the] community.” “[Elephants] bring income in terms of employment to many [Maasai] and earnings from land leases [through conservancies].”
Resource conservation (18.5%)	“Elephants are important because they protect the forest that is highly destroyed by people by burning charcoal and also [making] fencing posts.” “Elephants are important in providing security and also in protecting forests which are water catchment area[s].”
Oral literature & traditions (18.5%)	“[The elephant’s] size, strength, and wisdom have inspired many tales, sayings, and riddles with these virtues, such as Meek olenkaina ilala lenyanak, which means [in Maa] the elephant never tires of his tusks.” “Elephants represent and name Maasai clans.”
Use of elephant products (10.2%)	“Elephant dung is/was [used] as traditional medicine.” “If the afterbirth of an elephant is found it is seen as a good omen and may be used for ceremonial purposes.”

^aPercentages do not sum to 100 because respondents could identify multiple roles.

RESULTS

Respondent demographics and livelihoods

We analyzed responses from 177 adult residents, 75 (42.3%) of whom were women and 102 (57.6%) men. The mean age of respondents was 37 years (SD 11.63) (range 19–70), and the mean residence time in the study area was 13.7 years (12.2) (range 2–49). When asked to identify livelihood activities and sources of income, 99% of respondents identified livestock husbandry, 71% crop cultivation, 21% small business (e.g., shops, livestock sales), and 7% employment. Livestock husbandry was the most important source of income for 84.7% of respondents, whereas 13.5% reported crop cultivation as most important. About 31% ($n = 55$) reported that they or someone in their household were members of a conservancy; most had membership at Olderkesi ($n = 44$) or Siana Conservancy. Most respondents (112, 63.2%) had no formal education, whereas 42 (23.7%) completed primary school, 12 (6.7%) completed secondary school, and 11 (6.2%) attended a college or university. Most people (140; 79.1%) reported their religious beliefs as Christian, and 37 (20.9%) reported holding traditional Maasai beliefs.

Notional attitudes toward elephant conservation

Overall, respondents were moderately positive toward elephant conservation at a notional level (i.e., expressed support for elephant conservation in general). The mean probability of a respondent holding a positive notional attitude (ψ) ranged from 0.34 (95% credible interval [CrI] 0.25–0.65) to 0.84 (95% CrI 0.56–0.96) across sociodemographic groups (Figure 2a). Those

who believed elephants have sociocultural value (Table 1) had the highest mean positive attitude probabilities, averaging 0.31 (95% CrI 0.02–0.67) higher than those who did not, with a posterior probability of 0.90 (i.e., this difference was seen across 90% of iterations, indicating strong support for this effect) (Figure 2b). The most frequently reported sociocultural values in free-response questions related to elephants’ ecological (38.9%) and economic (37%) roles. Over 18% of respondents reported cultural importance related to environmental conservation and Maasai traditions (Table 1). For example, multiple respondents noted that the presence of elephants in forested areas is a deterrent to illegal logging. We found weak or no support for other differences between sociodemographic groups (Figure 2b). Individuals who had received formal education were slightly more likely to be positive with a mean increase in positive attitude probability of 0.17 (95% CrI –0.16 to 0.57), with a posterior probability of 0.73 (Figure 2b). Older individuals (ages 48–70 and 34–47) were slightly more likely to have positive attitudes than those aged 18–33, and women were on average slightly less likely to be positive than men (Figure 2). We found no evidence that religious beliefs affected positive notional attitude probabilities.

Local attitudes toward elephant conservation

Local positive attitude probabilities were lower than notional estimates, indicating that people with positive notional attitudes were not always willing to share space with elephants at a local level. Mean local positive attitude probabilities (ϕ) ranged from 0.16 (95% CrI 0.04–0.60) to 0.56 (95% CrI 0.25–0.88) (Figure 3a). Human–wildlife conflict experience with any species including elephants had the strongest effect on local

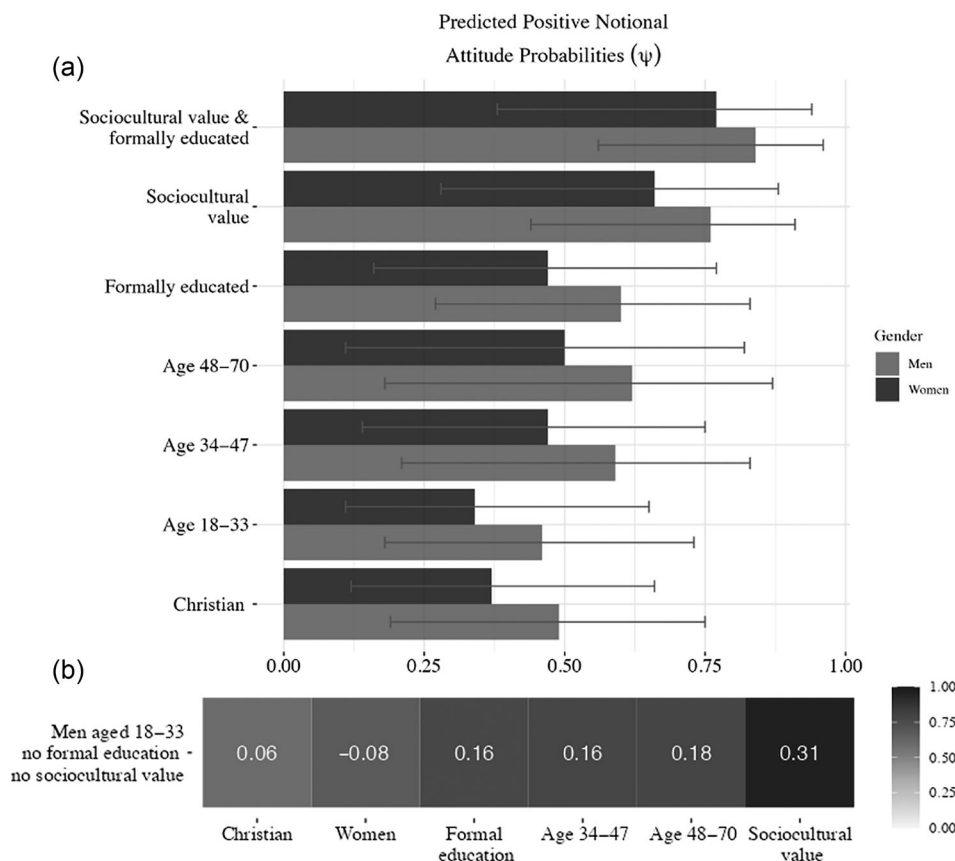


FIGURE 2 (a) Predicted, marginal posterior mean positive notional elephant attitude probabilities and 95% credible intervals across sociodemographic covariates from a Bayesian hierarchical attitude model and (b) derived posterior mean difference in positive notional attitude probability for each group compared with the reference group (men 18–33 years old without formal education; no values associated with elephants) (evidence strength: the darker the shading, the stronger the evidence for the value associated with a covariate).

attitudes. Individuals ($n = 156$) who had experienced conflict with any wildlife had a mean decrease in positive attitude probability of -0.20 (95% CrI -0.42 to 0.03), with a posterior probability of 0.96 indicating strong evidence for this effect (Figure 3b). Hyenas were the most frequently reported conflict species (78%), followed by baboons (46%), buffalo (40%), leopards (35%), and then elephants (22%). We found some evidence that individuals with formal education were more likely to be locally positive (0.16 [95% CrI -0.05 to 0.43] on average, with a posterior probability of 0.90) and weak evidence that people living near core elephant ranges were less positive (Figure 3b). We found no evidence that individuals who felt that they received benefits derived from elephants were more locally positive or evidence that experiencing conflict with elephants alone made people less locally positive (Figure 3b). Finally, we did not find evidence that household cultivation influenced local positive attitude probabilities.

Attitude misreporting

The model estimated a mean false-positive reporting probability for notional attitudes toward elephants of 0.55 (95% CrI 0.47 – 0.62) and a mean false-negative reporting probability

of 0.32 (95% CrI 0.29 – 0.36). At the local level, misreporting varied substantially among interviewers, and false-negative misreporting was higher compared to notional attitudes. The mean false-negative reporting rate of local attitudes was lower for interviewer A ($q_{ucA}^{10} = 0.41$, 95% CrI 0.28 – 0.55) (where uc denotes uncertain questions) than for interviewer B ($q_{ucB}^{10} = 0.55$, 95% CrI 0.37 – 0.68), whereas the false-positive rate was higher for interviewer A ($q_{ucA}^{01} = 0.53$, 95% CrI 0.50 – 0.56) than interviewer B ($q_{ucB}^{01} = 0.30$, 95% CrI 0.26 – 0.34). Inferring attitudes from raw average Likert scores would have overestimated positive notional attitudes for most sociodemographic groups and underestimated positive local attitudes for most groups. For example, the mean notional attitude Likert score for men aged 18–33 was 64% positive, but the model-estimated mean positive attitude probability after accounting for misreporting was 46% (95% CrI 0.18 – 0.73) (Appendix S7).

Mapping local positive attitudes toward elephant conservation

We used the landscape model to estimate true local positive attitude probabilities for the subregions of Olderkesi,

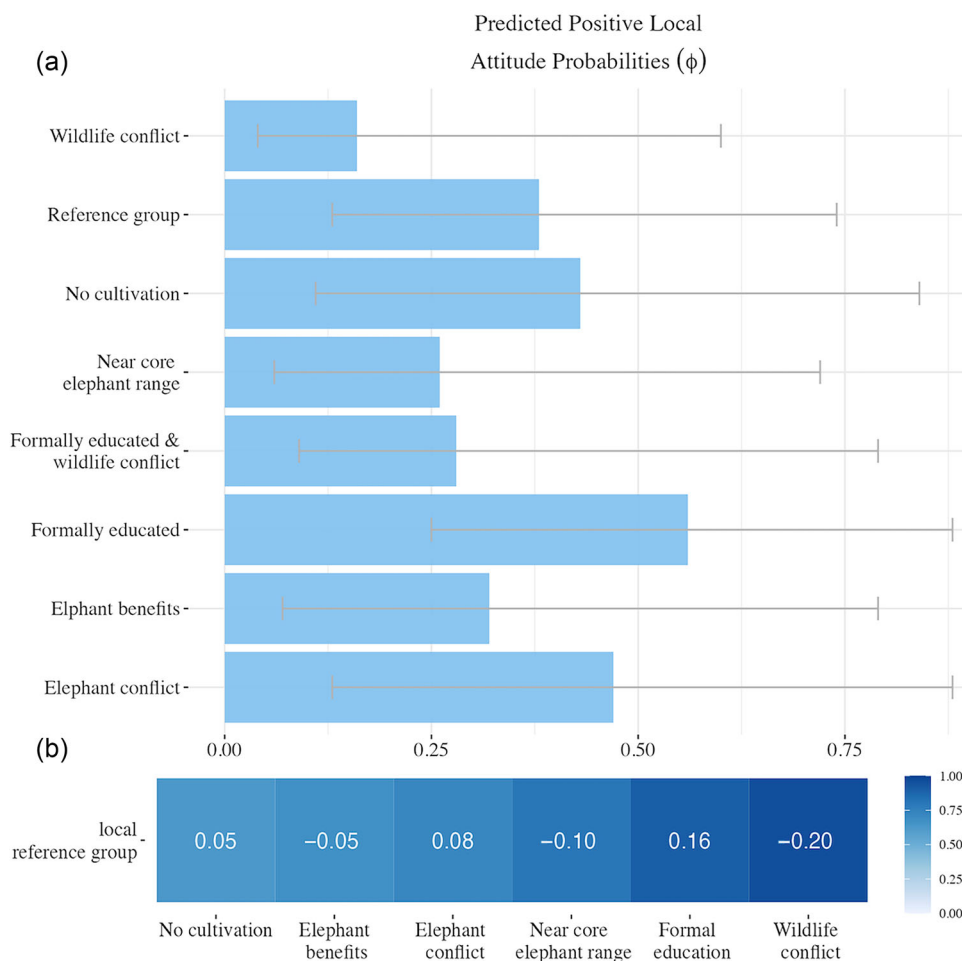


FIGURE 3 (a) Predicted, marginal posterior mean positive local elephant attitude probabilities and 95% credible intervals across covariate groups from a Bayesian hierarchical attitude model and (b) derived posterior mean difference in positive local attitude probability for each group compared with the local reference group (no formal education, no conflict experience, no benefits, etc.) (evidence strength: the darker the shading the stronger the evidence for the value associated with a covariate).

Naikarra, Enkoiroroi, Ilkerin, Loita North, and Olmesutye (Figure 4). Mean positive attitude probabilities ranged from 0.32 to 0.41 across subregions, but differences were weak (Figure 4). Respondents from Loita North and Olmesutye were the most likely to report positive attitudes (mean positive attitude probabilities of 0.41 and 0.40, respectively), and respondents from Naikarra and Ilkerin were the least likely to report positive attitudes (0.22 and 0.23, respectively) (Figure 4). We found no evidence of a difference in the probability to be positive among respondents from Enkoiroroi, Ilkerin, and Naikarra and only weak evidence that respondents from Loita North and Olmesutye were more likely to be positive than those from Enkoiroroi (Figure 4).

Living with elephants

All but 8 respondents (95%) had seen elephants at least once. Respondents frequently described elephants as “destructive” and “dangerous.” Fifty-seven percent preferred fewer elephants

in their area, 43% preferred no change, and 14% favored an increase in elephant numbers. Those that preferred fewer elephants explained that elephants threaten human safety, livestock, and crops. Those preferring no change in numbers rarely saw elephants and worried that an increase would cause conflicts. People favoring more elephants were concerned about the loss of elephants due to poaching and habitat loss or hoped that more elephants would increase tourism revenue. Over 73% of respondents ($n = 130$) believed elephants impact daily life in their communities when they are nearby, explaining elephant presence causes widespread fear. The most frequently described impact of elephant presence was altering activities due to fear of encountering elephants (92%), leading herders to avoid preferred grazing routes, parents keeping children home from school, and everyone avoiding travel to markets and water sources. Other reported impacts included crop and property destruction (e.g., fences) (38%), loss of livestock life (<1%), and loss of human life (<0.5%).

Twenty-two percent of respondents ($n = 39$) had directly experienced negative impacts from elephants. Among people

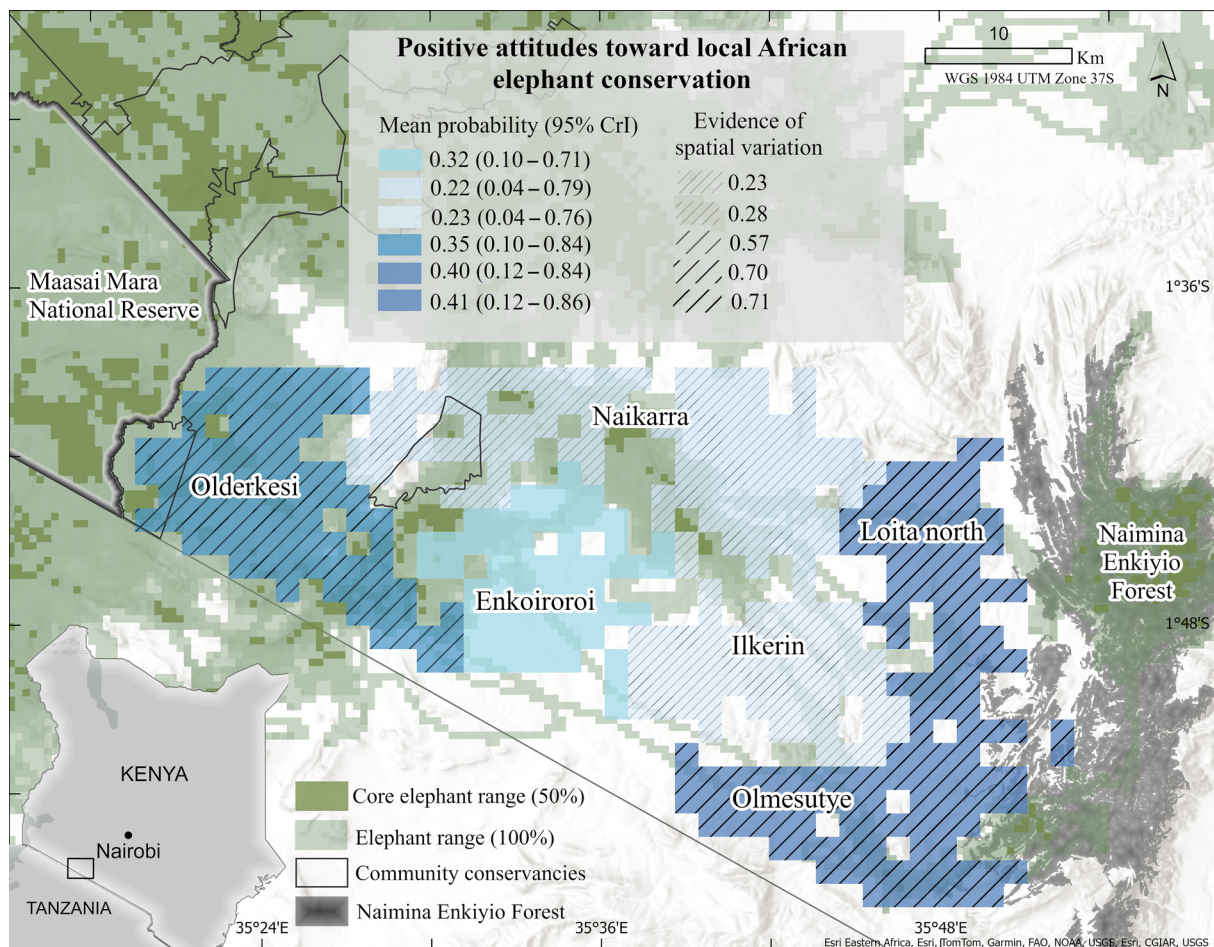


FIGURE 4 Predicted, marginal posterior mean positive local elephant attitude probabilities from Bayesian hierarchical attitude landscape model (the darker the shading, the higher the mean positive attitude probabilities; the bolder the hashing, the stronger the evidence for differences in probabilities between subregions).

who had experienced impacts, crop destruction was most frequently cited as the biggest problem (69%), followed by restricted movements of people and livestock (26%), threatening human safety (15%), killing livestock (1%), and causing injury to or loss of human lives (<1%). Among respondents who cultivated and experienced crop loss during the 2019 and 2020 growing seasons ($n = 89$), all reported some loss caused by wildlife. However, only 31% selected wildlife as the biggest cause compared with weather, pathogens, and insects. The most frequently reported animals causing the most crop damage were zebras (28%), followed by baboons (20%), warthogs (16.5%), and elephants (12.7%).

Benefits derived from elephants were reported by 41% of respondents ($n = 73$), but most people qualified benefits as indirect. The most frequently reported (indirect) benefit was that elephants attract tourists to Narok County and therefore support the local economy (51%). About a quarter (27%) of respondents reported jobs in tourism or conservation, held mostly by relatives but perceived as more direct benefits, and 12% mentioned community development projects funded through tourism or conservation. A minority described non-economic benefits from elephants, for example, that elephants

create easily accessible firewood when pushing down trees to feed on roots.

Perceptions of human, elephant, and livestock coexistence

Perceptions about coexistence among humans, elephants, and livestock among respondents ($n = 177$) were mixed, but only 22% expressed positive perceptions about coexistence in their communities. Most respondents in favor of coexistence said it was a result of tradition and precedent that should be continued to benefit future generations (47%). One respondent described it as follows: “[E]lephants have been staying many years with people and livestock and that is [evidence] that they can still live together for many years to come.” Others mentioned economic benefits of elephants through community conservancies, and a few respondents cited rights of wildlife. For example, one respondent explained, “[W]ildlife have a right to move freely.” However, most who favored coexistence also identified challenges and threats to coexistence. One respondent said, “Wildlife are the backbone of the Kenya economy, especially the

Narok economy, but local people are suffering a lot from losses caused by wildlife.”

Most respondents who were not optimistic about coexistence (83%) said that conflict is a certain outcome of people, elephants, and livestock sharing space because of threats to human safety, livestock safety, and crops (e.g., “[E]lephants can kill both livestock and people and also destroy crops.”). Other challenges to coexistence included concern over competition for water and pasture between livestock and elephants (9%) and a lack of tangible benefits from wildlife (10%). Finally, an emergent theme across responses was a sense of exclusion from power and decision-making. For example, one person described frustrations and concerns: “[T]he government needs to involve local people in decision making regarding wildlife conservation, as they have coexisted together with wildlife for a long time, and we feel we are not included or important.”

DISCUSSION

Understanding local attitudes toward sharing space with wildlife and accurately measuring those attitudes are directly relevant to supporting human–wildlife coexistence in shared landscapes (Carter & Linnell, 2023; Vogel et al., 2023). Our results illustrate that the accuracy of self-reported attitudes is improved by accounting for response bias and that, when interpreted with the context provided by qualitative data, this can provide reliable information about attitudes and their drivers. A majority of agropastoralists in the mixed-use landscape supported elephant conservation in general but were unlikely to support sharing space with elephants locally outside of parks, and our approach allowed for quantification of this difference. Notably, we found that low willingness to share space with elephants was not primarily driven by human–elephant conflict experience but by conflict experience with any wildlife, perceptions that sharing space with elephants would result in frequent conflict and negative outcomes for people, and concerns that the well-being and safety of local people living with wildlife are generally overlooked. Overall, our study demonstrated a repeatable approach to quantifying and mapping conservation attitudes; contributes new understanding of the experiences and complex factors that can shape conservation attitudes of people living with wildlife; and provides insight into conservation planning and practice in shared landscapes.

Attitudes toward elephant conservation and perceptions of human–elephant coexistence

Our results provide evidence that a greater focus among conservation practitioners on sustaining existing sociocultural values that support coexistence while adapting approaches as values change could lead to better conservation outcomes (Dheer et al., 2021; Dickman et al., 2014; Fernandez-Llamazares et al., 2020; Melubo, 2020). We found evidence of diverse sociocultural values associated with elephants, and people who believed elephants have sociocultural value were the most likely to be

notionally positive about elephant conservation, which aligns with research showing that values can be strong predictors of wildlife-related attitudes (Dheer et al., 2021; Manfredo, 2008; Manfredo et al., 2021). Ecological values were the most frequently described, and people who favored coexistence cited the precedent of coexistence with wildlife as a practice that should be continued. This result may be linked to *eramatare*, a Maasai ethos of relationship and reciprocity between people, rain, land, vegetation, cattle, and wildlife (Melubo, 2020). Yet, many respondents also considered the economic value of elephants important, adding some support for the observation made in recent studies that values of wildlife in Maasailand are becoming narrower and more focused on the costs and benefits of wildlife, partially as a result of the monetization of wildlife through tourism and conservation (Fernandez-Llamazares et al., 2020; Western et al., 2019).

However, experiencing negative impacts from any wildlife—not just elephants—significantly reduced the probability of people to be positive about sharing space with elephants locally. It is possible that negative impacts from carnivores, for example, could increase a household's livelihood vulnerability if additional impacts from other species (e.g., crop loss due to elephants) occur, making people less positive about sharing space with elephants (Dickman et al., 2014). Additionally, pastoralist societies living in rural Kenya tend to have collectivist self-identities, where the self is more strongly defined by social group relationships (Homewood et al., 2009; Ma & Schoeneman, 1997). If social group membership is relevant to the context, attitudes and behavior are more likely to conform to shared social expectations (Ma & Schoeneman, 1997; Rabinovich et al., 2020). Relatedly, direct negative impacts from elephants did not affect attitude probabilities in our models (22% of people), but open-ended responses revealed high levels (73% of people) of perceived threats to human life, livestock, and crops associated with elephants that were viewed as barriers to coexistence. It is plausible that other's problems with carnivores and elephants and a common view that wildlife negatively impact well-being and livelihoods of others could reduce positivity toward elephants even without direct impacts (Dickman et al., 2014).

People who do experience direct negative interactions with elephants can suffer severe financial losses and physical and emotional trauma (Cassidy & Salerno, 2020; Nyumba et al., 2020). That elephants were widely perceived as a threat aligns with the findings of Western et al. (2019), who found elephants were thought to pose the greatest threat to human life, along with buffalo and lion, across other Maasai communities, and of Vogel et al. (2023), who found that experiencing elephants as threat to human life reduced willingness to coexist with elephants. Several people felt the safety of their communities was not a priority of wildlife officials. This sentiment was echoed during a cointerpretation discussion in which a participant asked and others then agreed: “Why does the government respond quickly when a person kills an elephant, but not when an elephant kills a person?” These concerns along with our finding that some people feel a sense of disempowerment regarding wildlife management indicate that indirect impacts, including

conflicts among communities and land and wildlife officials, may also contribute to lower local positive attitude probabilities, possibly explaining why direct elephant impacts alone did not appear to influence attitudes in our models (Redpath et al., 2013, 2015).

Our results are consistent with growing evidence that conservation efforts focused on benefits alone, such as payment programs, are unlikely to sustain coexistence between people and wildlife when impacts, well-being, and safety concerns remain unaddressed (Davis & Goldman, 2017; Fernandez-Llamazares et al., 2020; Galvin et al., 2018; Nyhus et al., 2005). Benefits were less salient than concerns about safety and wildlife impacts in explaining attitudes, and an emergent theme was that the costs of living with wildlife outweigh the benefits—a finding that is increasingly common in shared landscapes (Bond & Mkutu, 2018; Ngorima et al., 2020; Salerno et al., 2016). Tourism is limited in the study region compared with other parts of Narok county, and there are no direct payments to Olderkesi conservancy members, possibly explaining why most respondents felt that benefits were too little or indirect to be effective. Others expressed dissatisfaction with conservancy leadership and stated that benefits were not fairly distributed, suggesting that elite capture (Sheely, 2015) and conservancy governance issues may temper perceived benefits (Galvin et al., 2018). Though we found only weak evidence that local attitudes varied spatially among subregions, it is possible that the variation we did observe reflects some spatial variation in the perceived costs and benefits of living with wildlife. For example, positive attitude estimates were lowest in subregions with little to no reported benefits and high wildlife presence, whereas attitudes were more positive near the national reserve, where potential benefits are greatest, and in subregions with low wildlife presence and positive perceptions of the potential for economic benefits from wildlife conservation in the future.

Previous studies focused on spatializing and quantifying social factors have typically mapped variables with predictive approaches at coarse spatial scales (e.g., states, counties; Bowman et al., 2004; Gangaas et al., 2013; Manfredo et al., 2021). Such approaches are useful for consistently representing general patterns across very broad extents. However, most are derived from ancillary demographic data that are not available in all geographic contexts and ignore finer-scale spatial variation, for example, among conservancies, which could result in mean estimates that are sensitive to extreme values or are too generalized to inform locally adapted conservation (Piédallu et al., 2016). Our study offers an approach to mapping social variables when ancillary data are not available, is empirical rather than predictive, is thus linked with qualitative data that provide important context (i.e., explains what the map means), and can account for fine-scale variation. The trade-off is that we could not map attitudes across large areas to support planning at broad extents.

Reducing attitudes to positive or nonpositive is a simplification of the complexity of attitudes toward wildlife. Attitudes can be diverse and shaped by traditional and Indigenous knowledge systems and historical and political dimensions that we could not fully capture (de Pinho et al., 2014; Fernandez-Llamazares et al., 2020; Kioko et al., 2022). It is also possible that other fac-

tors we did not consider could influence attitudes. For example, measuring the experiences of kin and neighbors in addition to the sample household may result in a better representation of perceived wildlife impacts given strong social networks (Baird et al., 2021; Homewood et al., 2009). Additionally, estimates of positive attitude probabilities from our models did not have high precision at the local level. This is likely due in part to high individual variation in attitudes and high rates of false-negative reporting of local attitudes in our study (Cruickshank et al., 2019; Vasudev & Goswami, 2020). Future work could focus on strategies to improve the precision of estimates with survey approaches that result in fewer false-negative responses. Furthermore, future work could develop approaches to measure behaviors while accounting for misreporting because behaviors are likely more directly linked to outcomes for wildlife (Nilsson et al., 2020).

Attitudes can change depending on the context; thus, willingness to share space with elephants in the study region will likely change over time (Fernandez-Llamazares et al., 2020; Western et al., 2019). A benefit of our approach is that positive attitude probabilities are standardized measures that can be repeated and compared across time, contexts, and landscapes. For example, we found that local attitudes toward African elephants in our study were about 14% lower on average than local attitudes toward Asian elephants across tea estates in northeastern India, but our estimates of misreporting rates were similar (0.30–0.63 this study, 0.22–0.68 in Vasudev & Goswami [2020]). We found strong evidence that misreporting varied between interviewers. A possible explanation is variable response bias due to interviewer identity. One interviewer was a well-known local conservation and tourism professional and thus was perhaps more likely to elicit false positives, whereas the other was an outsider from a different region, and respondents may have been more skeptical of his intentions, potentially leading to more false-negative reports. Our findings caution against the sole use of quantitative attitude measures in future studies if no actions are taken to reduce response bias. At a minimum, controlling for interviewer identity in statistical analyses is a straightforward approach to test for and potentially account for some response bias.

Implications for conservation planning and practice

Our approach offers a spatially explicit, rigorous assessment of local attitudes that can directly inform spatial conservation plans that better support the well-being of both people and elephants. For example, our map of willingness to share space with elephants and associated uncertainty measures could be used with ecological data and elephant movement data to prioritize suitable corridors based on both ecological and anthropogenic landscape resistance (Ghoddousi et al., 2021). Our results suggest that conservation initiatives that directly address safety concerns and perceived threats in addition to impact mitigation may lead to better conservation outcomes. For example, agencies or nongovernmental organizations could employ local

community rangers that specifically provide security for communities living near elephant core areas, a potential strategy that was suggested by respondents in the cointerpretation discussions. When engaging in impact mitigation and prevention, adopting a species-agnostic approach guided by community needs may be more effective than focusing on impacts from one species. Overall, our results support appeals for conservation conflict mitigation strategies that are grounded in direct cooperation with affected communities and designed such that those communities have real agency in the entire process (Cassidy & Salerno, 2020; Dickman, 2010; Hoare, 2015). This community-oriented approach to conservation conflict mitigation could ideally be paired with sophisticated land-use planning to address the resource use and needs of both people and wildlife so that coexistence planning can be integrated into policy at relevant scales of governance.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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