



# Evaluating the determinants of wildlife tolerance in the Kavango-Zambezi Transfrontier Conservation Area in Zimbabwe

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## ABSTRACT

Human-wildlife interaction is a complex issue that has positive as well as negative implications for both humans and wildlife that share the same habitat. In this paper, we used the Wildlife Tolerance Model (WTM) as the theoretical framework to determine the factors that affect tolerance towards the African savannah elephant (*Loxodonta africana*), chacma baboon (*Papio ursinus*) and spotted hyena (*Crocuta crocuta*) among the Tonga indigenous people of Zimbabwe. We used structural equation modeling for the identification of causal pathways to see which variables – namely, exposure, positive and negative interactions, costs and benefits – affect tolerance. Our study finds that intangible benefits are the most significant determinants of tolerance across all three species. Contradictory to the expectations, tangible cost had no effect on the tolerance for any of the three species. We find that reducing exposure would also have a strong mediating effect on tangible and intangible costs from the three species. We discuss the roles that socio-economic and cultural factors play to help explain the differences in communities' attitudes towards the three species. We conclude that more emphasis should be given to increasing the awareness of the intangible benefits, such as the ecosystem services provided by the species. Finally, we recommend using the WTM to help establish a mitigation strategy for the targeted communities and then conducting a Before-After-Control-Impact (BACI) study to evaluate the true impact of those mitigation strategies on the communities' wildlife tolerance.

## 1. Introduction

With the rapidly growing human population along the edges of protected areas in most countries in the global south (Geldmann, Manica, Burgess, Coad, & Balmford, 2019), the potential for Human-Wildlife Conflicts (HWCs) is increasing as land is converted and agricultural fields expand into wildlife corridors to feed this population (Schübler, Lee, & Stadtmann, 2018). Examples of such conflicts include crop raiding (Mumby & Plotnik, 2018), livestock predation (Schiess-Meier, Ramsauer, Gabanapelo, & König, 2007), property damage (Gross et al., 2021), and even loss of human life (Löe & Röskaf, 2004). Moreover, enhanced interactions with wildlife also increase the risk of zoonotic disease transmission to livestock and humans (Broad, 2020).

Communities' attitudes and perceptions play a significant role in the fate of wildlife conservation as they are the ones who are living in and around protected areas for generations (Ebua, Agwafo, & Fonkwo,

2011). Various factors affect human attitudes toward wildlife, and acceptance depends on the species and culture (Castillo-Huitrón, Naranjo, Santos-Fita, & Estrada-Lugo, 2020). Communities are often more tolerant towards certain species, while they may be intolerant towards others (Manfredo, Teel, & Henry, 2009; Marzano, Carss, & Cheyne, 2013; Cerri, Mori, Vivarelli, & Zaccaroni, 2017; Zainal Abidin & Jacobs, 2019). Reasons for tolerance variations can be historical (Bluwstein, 2018), religious (Lee & Priston, 2005), and cultural (Saif, Kinsky, Palash, Kidd, & Knight, 2020). Much contemporary conservation planning adheres to the community-based conservation paradigm, arguing that sustainable management and conservation of wildlife resources will be in communities' long-term interest if they share ownership of wildlife and accrue equitable benefits from its management (Gargallo, 2020; Oburah, Lenachuru, & Odadi, 2021; Störmer, Weaver, Stuart-Hill, Diggle, & Naidoo, 2019). There is also an on-going debate on the importance of incorporating the role of compassion in wildlife conservation as

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opposed to the traditional conservation practices currently being carried out (see Callen et al., 2020; Coghlan & Cardilini, 2022; Greving & Kimmerle, 2021). Moreover, the inclusion of communities in conservation efforts, through initiatives such as citizen science, has the potential to improve the relationship between communities and wildlife (Larson, Conway, Hernandez, & Carroll, 2016; Toomey & Domroese, 2013). However, even well-established community-based conservation struggle with the collateral costs of HWC which hinders such improvement in relationships (Oduor, 2020). This study focuses on Zimbabwe, where the law currently does not enable the devolution of management rights and responsibilities to communities, as, for instance, observed in Namibia (Bandyopadhyay, Humavindu, Shyamsundar, & Wang, 2009). This deficiency limits the potential to involve communities in developing context-based comprehensive HWC strategies, which are often planned at the district or regional level instead (Grimaud, Gumbo, & Le Bel, 2022).

Multidisciplinary approaches to studies of HWCs have increased conservationists' and researchers' recognition of the issue's complexity (Frank, 2016). HWC, for instance, affects its victims differently. The perception of farmers towards the animals causing damage varies with their socio-economic status, among other factors (Oliva-Vidal et al., 2022). A farmer with a diverse livelihood portfolio may be less adversely affected than a farmer with a monoculture, even if their harvest loss is more or less equal (Dickman, 2010; Kansky, Kidd, & Knight, 2016; Lischka et al., 2018; Slagle & Bruskotter, 2019).

Community response to these conflicts is also complex and varied. While some resort to retaliatory killing of wildlife (Mariki, Svarstad, & Benjaminsen, 2015), others are more tolerant, often considering such incidents as acts of God or nature (Lee & Priston, 2005; Saif et al., 2020). The complexities of the determinants of human behavior concerning wildlife include the cultural norms, values, and attitudes of the community they belong to, combined with individual differences such as personal preferences and experiences (Nicholson, 1998; Reis, Collins, & Berscheid, 2000). This makes HWC a complex issue and researchers have therefore resorted to using the concept of tolerance as an instrument to understand stakeholder perceptions in wildlife conflict situations (Baynes-Rock, 2013; Frank, 2016; Kansky et al., 2016, 2021; Saif et al., 2020; Slagle & Bruskotter, 2019). However, this complexity and variation between communities mean that a conservation strategy that works in one area might not yield the desired results in another location. Therefore, a thorough site-specific understanding of the determinants of human tolerance in HWC is needed.

This study was conducted in Binga district, Zimbabwe, part of the greater Kavango-Zambezi Transfrontier Conservation Area (KaZa-TFCA), shared between Angola, Botswana, Namibia, Zambia, and Zimbabwe. According to Le Bel et al. (2022), the main household-level HWC impacts in the area are livestock depredation, followed by crop destruction, fear and disturbance, disease transmission to livestock, and human casualties. Species frequently causing problems include mammals, namely the black-beaked jackal (*Canis mesomelas*), spotted hyena (*Crocuta crocuta*), African savannah elephant (*Loxodonta africana*), chacma baboons (*Papio ursinus*), lions (*Panthera leo*), leopards (*Panthera pardus*), and birds like the red-billed quelea (*Quelea quelea*). Aside from negative livelihood implications for the involved communities, such conflicts erode long-term support for conservation and can induce community members to engage in retaliatory actions against wildlife (Madden, 2004). Hence, this study was conducted as part of an attempt to understand the determinants of the local Tonga indigenous people's tolerance towards the wildlife species with which they most often come into conflict.

## 2. Methods

### 2.1. Theoretical framework

We employed the Wildlife Tolerance Model (WTM) proposed by

Kansky et al. (2016) to understand the determinants of human attitudes toward wildlife (Fig. 1). The model was initially developed through a case study of baboons in Cape Town, South Africa, but has subsequently been used in a range of HWC studies, including human-elephant conflicts in Bangladesh (Saif et al., 2020) and for comparative analysis across several species (baboon, elephant, hyena, kudu, and lion) in Namibia and Zambia (Kansky, Kidd, & Fischer, 2021). The model attempts to identify the determinants of tolerance towards wildlife species sharing the same habitat and being responsible for HWC incidents (Fig. 1). The model assumes that exposure to wildlife leads to a certain meaningful experience, which translates into a perception of costs and benefits associated with the problematic species. The perception of costs and benefits, both tangible and intangible, then determines the level of tolerance towards the species in question. Tolerance is perceived in terms of acceptable spatial proximity to the species, damage that an individual can tolerate due to the species before desiring to kill the species, the maximum tolerable population of the species, and the preventive measures that an individual expects the authorities to take to mitigate conflict with the species.

Exposure is divided into nine categories reflecting the number of times the species in question has entered the (1) village, (2) household vicinity, and (3) households property (including crop fields, livestock sheds, and other private infrastructure owned by the household apart from their homestead), in the last: (i) dry season, (ii) rainy season, and (iii) hot season. Experience measures the number of times the household has had a positive or negative experience with the species in question.

The tangible cost associated with the species in question is categorized into three types: (1) monetary damage incurred by the species, (2) monetary cost of mitigation applied to control the conflict with the species, and (3) likely extent of future damage by the species on a rating scale from 1 to 5. The perception of intangible costs associated with the species in question is divided into three categories, i.e. negative emotions, negative feelings, and other intangible costs. Negative emotions include the feeling of being: (1) frightened, (2) annoyed, (3) stressed out, (4) fragile, (5) disgusted, and (6) furious. Negative feelings include: (1) feeling like a prisoner in their own home, (2) worrying about the safety of children, (3) worrying about the safety of cattle and livestock, (4) the need to be vigilant at all times, and (5) taking a lot of time to deal with the animal. Other intangible costs include: (1) being afraid personally when the species occur in human settlements, (2) being afraid personally when the species enters the premises of the home, (3) other members of the HH being afraid when the species enter the premises of the house, (4) how dangerous is the species for humans, (5) how emotionally stressful it is to live in close proximity to the species, and (6) how much of a nuisance it is to live with the species. Positive emotions included feelings of (1) sympathy, (2) safety, (3) gratefulness, (4) happiness, (5) comfort, and (6) trust toward the species in question. Moreover, a simplification was made of the intangible benefit. Other intangible benefits were reduced to include only (1) how beneficial the species is for the interviewee, (2) how beneficial the species is for the interviewee's neighborhood, (3) how beneficial the species is for mankind, (4) how beneficial the species is for nature, and (5) how much the interviewee enjoy living in close proximity to the species.

Focus group discussions and a pilot test of the questionnaire revealed that the communities did not perceive receiving any tangible benefit from any of the three species (elephant, hyena, and baboon). Hence tangible benefits were omitted from the questionnaire survey. Each aspect is evaluated based on a rating scale from 1 to 5, with 1 denoting extremely weak emotion/feeling/cost and 5 denoting extremely strong emotion/feeling/cost.

### 2.2. Study area

This study focuses on Ward 4, Sinansengwe, in the Mucheni Community Conservancy (CC) in the KaZa-TFCA, Binga district, in Zimbabwe. According to a baseline study conducted in 2020, there are

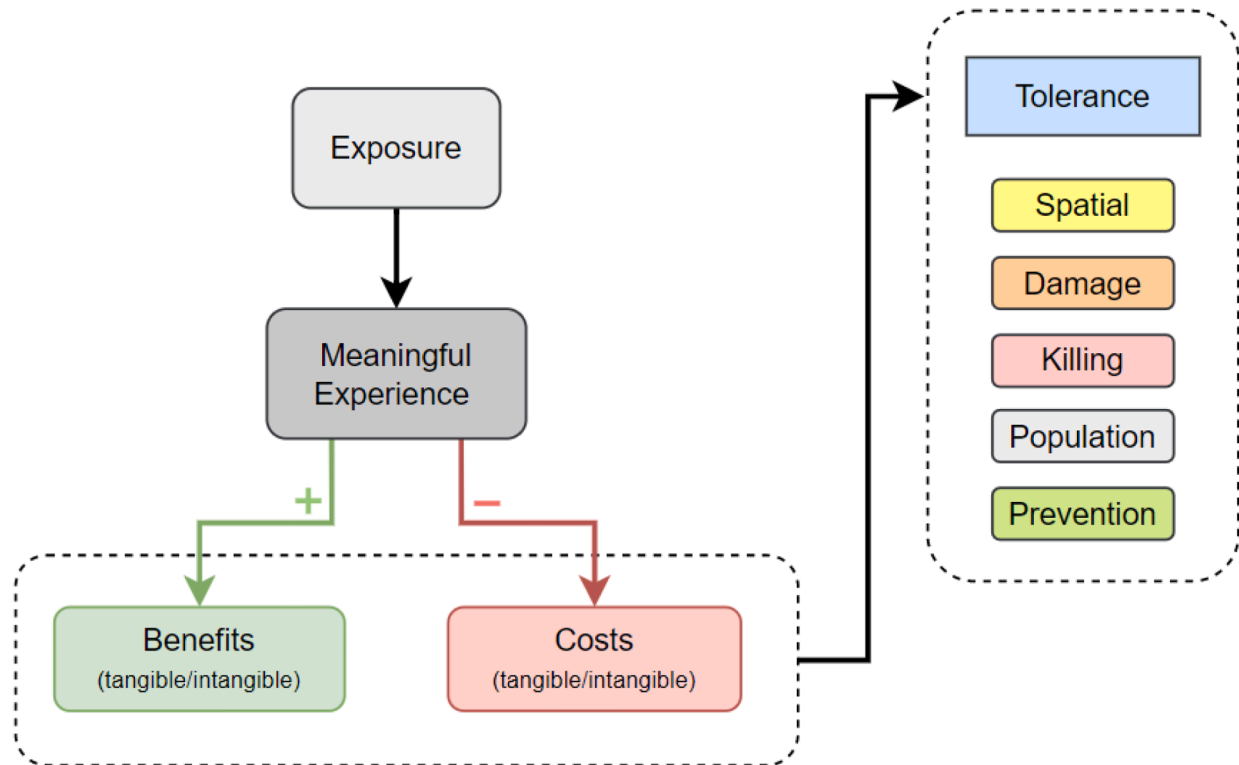


Fig. 1. Wildlife Tolerance Model (Kansky et al., 2016).

820 households in Sinansengwe distributed in six main villages (Usman & Le Bel, 2020). The main livelihood activity is livestock rearing, but other activities such as crop production, trade, and seasonal employment are also practiced. Livestock includes cattle, goats, and poultry, while crops include sorghum, maize, millet, sesame, and cotton.

### 2.3. Sampling

The sample consists of households selected using cluster sampling (Omair, 2014). This method was chosen to ensure the sample's representativeness because a formal list of households in the study area was unavailable. All households in the area were divided into clusters according to their spatial distribution. Using a 95% confidence interval, 5% margin of error, and 50% response distribution, a representative sample of 262 households was selected out of the total 820 households (Israel, 1992), ensuring randomness by instructing the enumerators to interview every third household in each cluster, irrespective of other factors. A map of the study area is shown in Fig. 2.

### 2.4. Data collection

A survey questionnaire suited to the context was drafted to collect demographic and socio-economic information before collecting information on the tolerance towards various species based on the theoretical framework and enabling quantification and measurement of the selected indicators (Table 1).

First households were asked about the exposure to each of the three species as well as the costs and benefits associated with the species (Table 1). Then, a series of questions were asked to quantify tolerance towards the selected species in accordance with the framework. To ensure a common frame of reference and understanding of the context, the following statement was read out to respondents first:

*"In the following questions, you will be asked under what conditions you*

*think it would be justified to kill the [species in question]. Please ignore for now if it is illegal or not, who would make the killing, how it would be killed, or what would be done with its body."* (Kansky et al., 2016).

Subsequently, the respondents were presented with two scenarios for each species in question: the species population is *abundant*, and the species population is *vulnerable*. The concepts of abundant and vulnerable were first explained to the respondents by the enumerators. Then the following seven situations (with increasing intensity of HWC) were presented to the interviewees, asking them whether or not the species should be killed in each scenario:

- If the species is seen in the bush far away from any village, house, livestock, or agricultural crops.
- If the species is seen in the vicinity of where livestock is grazing, vegetable gardens or agricultural crops are growing, or near the neighborhood where they could enter peoples' houses.
- If the species has injured or killed a domestic animal or has raided a house or agricultural crops for the first time
- If the species has repeatedly injured or killed domestic animals or raided houses or agricultural crops but has never harmed a person
- If the species has threatened a child or adult human
- If the species has injured a child or an adult human
- If the species has killed a child or an adult human

The respondent was then given a tolerance score for the species in question based on the option they selected. For instance, a respondent who selected option (i) received a tolerance score of 1, whereas a respondent who selected option (vii) received a tolerance score of 7. Hence, a tolerance score of 1 means very low tolerance, whereas a score of 7 means very high tolerance.

Finally, households were asked about the desired change in species population density that they would like to see in (i) their ward, (ii) their district, (iii) KaZa-TFCA, and (iv) Africa. This information was rated on a



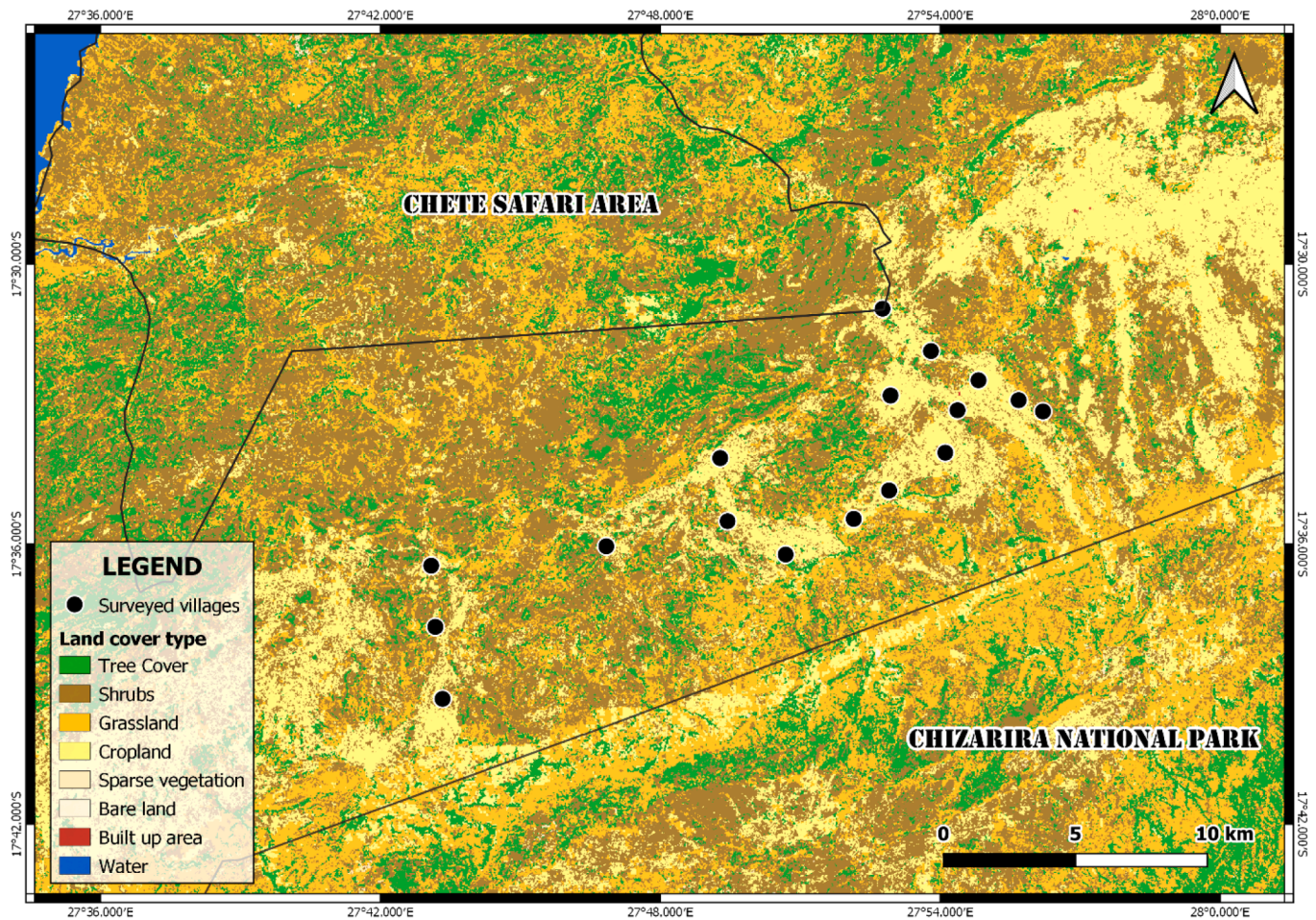


Fig. 2. Map of the study area showing the surveyed villages.

Table 1

Variables used in the wildlife tolerance survey.

Factors affecting wildlife tolerance	Abbreviation	Explanation/example
Exposure	EXPO	Number of times exposed to the animal.
Positive Meaningful Experience	PME	Number of times interaction has been positive, e.g. aesthetic value of seeing an animal.
Negative Meaningful Experience	NME	Number of times interaction has been negative, e.g. attack by the animal, feeling scared and frightened.
Tangible Cost	CT	Tangible cost caused by the animal, e.g. destruction of property, livestock predation.
Intangible Cost	CI	Intangible cost of sharing the habitat with the animal, e.g. feeling insecure for children, negative emotions.
Intangible Benefit	BI	Intangible benefit of sharing the habitat with the animal, e.g. benefit to mankind and nature, positive emotions.

scale from 1 to 5, where 1 reflects a desire for the density to decrease a lot, 3 means that they desire the population to stay the same, and 5 means they want the population to increase a lot. To further quantify the level of tolerance, households were asked about the maximum number of days per year they were willing to tolerate the species in question visiting (i) their village, (ii) the vicinity of their homesteads, and (iii) their property. See the full questionnaire in Appendix A of the [supplementary material](#).

## 2.5. Data analysis

Only species mentioned by more than 100 households were selected for analysis. Out of the total identified species, the three most frequently mentioned were the spotted hyena ( $n = 186$ ), the chacma baboon ( $n = 112$ ), and the African savannah elephant ( $n = 107$ ) (Appendix B – [supplementary material](#), Table S1). This was done to ensure sufficient data to conduct meaningful analysis and to enable a robust comparison among the identified species.

Tests of significant differences between relevant variables among the three species were conducted using the Kruskal-Wallis test combined with Dunn's multiple pairwise comparison test, as all of the observed variables were either non-parametric or not normally distributed (Ostertagova, Ostertag, & Kováč, 2014). Bonferroni's correction was applied to counteract multiple comparison problems. Partial Least Squares Structural Equation Modelling (PLS-SEM) was conducted using the SmartPLS software to predict wildlife tolerance and analyze the relationship between the latent variables. PLS path modeling is a variance-based SEM technique applied noticeably in the field of ecology (e.g. Hodapp, Meier, Muijsers, Badewien, & Hillebrand, 2015; Kansky et al., 2016), as well as in applied social sciences, as it can handle complex models using relatively small sample sizes (Lowry & Gaskin, 2014).

## 2.6. Ethical considerations

This study received ethical approval from the CIFOR Research Ethics Review (RER) Board and followed the ethical guidelines outlined by the

Sustainable Wildlife Management (SWM) Programme. The survey was conducted by obtaining Free, Prior, and Informed Consent (FPIC) from each participant. Before the interview, a thorough explanation of the purpose and objective of the study was given in each household. Participants were assured of anonymity, that the collected data would not be misused, and informed that they could withdraw from the interview at any time.

### 3. Results

#### 3.1. Description of surveyed households

Out of the 262 households surveyed, 98% belonged to the Tonga ethnic group and 2% to the Shona and Ndebele ethnic groups. Most households were Christian (69%), while 9% were Traditional, and 22% of households were composed of members of both Christian and Traditional religions. Household size was, on average, 5.4 ( $\pm 0.26$ , 95% CI) individuals, out of which 3.5 ( $\pm 0.2$ , 95% CI) were working adults and 1.8 ( $\pm 0.2$ , 95% CI) were dependents, including children under the age of 16 years. Many households relied on subsistence agriculture, and 91% of the households mentioned agriculture as their primary, secondary, or tertiary source of income, which highlights the high degree of reliance on agriculture. The average total household cash income was USD 9.0 ( $\pm 3.1$ , 95% CI) per capita per month, which places most households substantially below the poverty line (Fig. S1). Only one household admitted to being involved in hunting. But since hunting is

prohibited by law in the conservation area, this number could be understated due to fear of sanctions from the authorities.

#### 3.2. Results of the tolerance survey

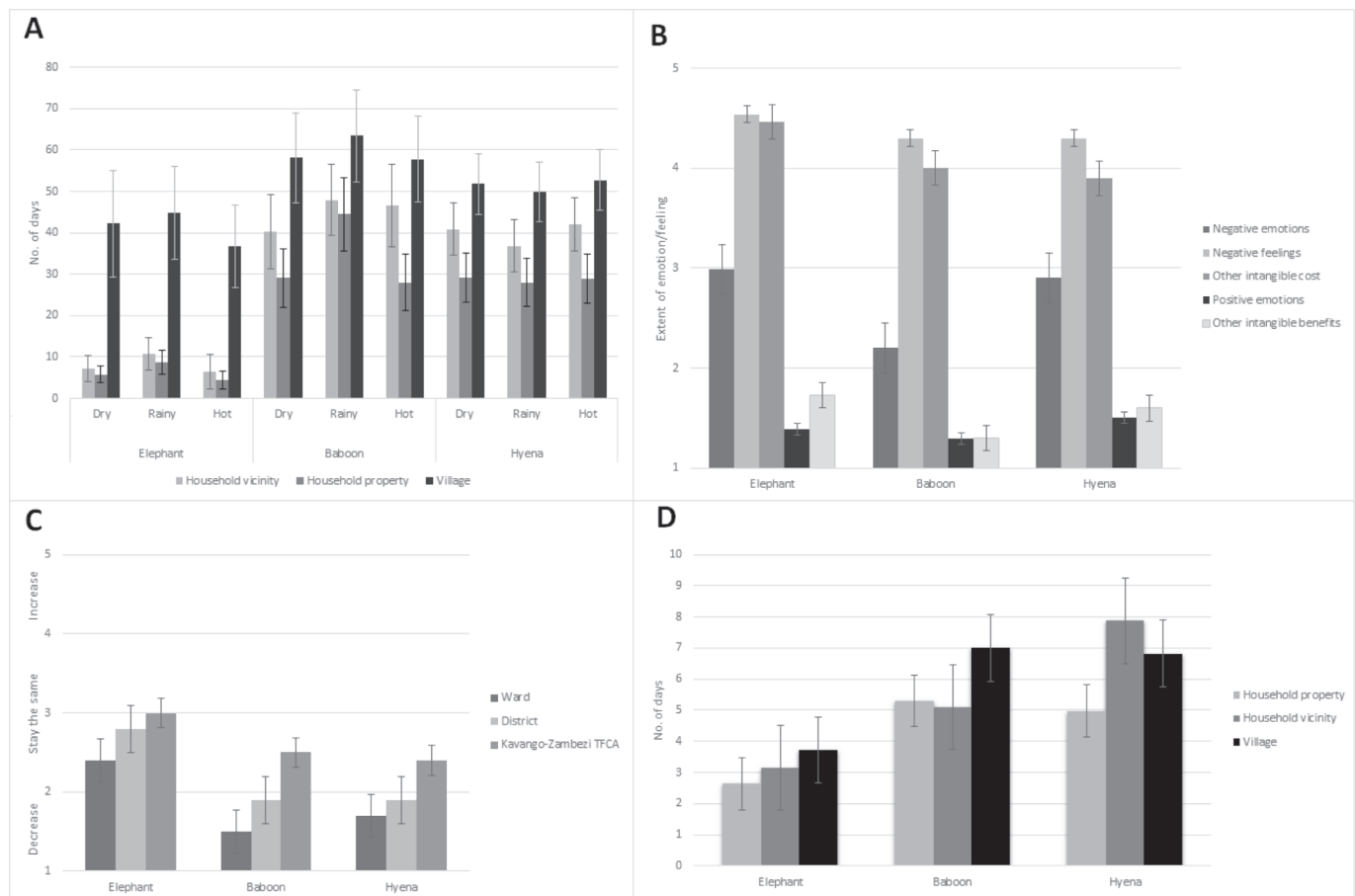
Graphs enabling direct comparison between the three species are presented in this section. Table S2 provides the descriptive statistics for all the variables used in the analysis.

##### 3.2.1. Exposure

Panel A in Fig. 3 compares exposure to the three species across the three seasons and at the household, property, and village levels. Exposure to elephants was significantly lower than exposure to the other two species at all proximity levels and in all seasons, as shown in the summary of results for the Kruskal-Wallis test in Table S3. Exposure to baboons was significantly higher than to other species only in the rainy season at the household [ $H(2) = 46.95$ ,  $p\text{-value} < 0.0001$ ] and household property [ $H(2) = 41.47$ ,  $p\text{-value} < 0.0001$ ] levels. Exposure to elephants was significantly higher at the village level in all seasons (Table S3).

##### 3.2.2. Costs and benefits

The highest amount of damage during the past 12 months was caused by the hyena – USD 330 ( $\pm 78$ , 95% CI) – compared to USD 287 ( $\pm 99$ , 95% CI) and USD 155 ( $\pm 51.5$ , 95% CI) caused by elephants and baboons, respectively. Households spent, on average, USD 243 ( $\pm 89.2$ ,



**Fig. 3.** Figures showing a comparison between the three species considered. Panel A demonstrates the seasonal exposure to the three species. Panel B shows the comparison of emotions and feelings towards the species. Panel C shows how the local communities desire the population of the three species to change [Note: Desired population change in Africa is not shown in the graph as the differences were non-significant for all species]. Panel D demonstrates the comparison of the maximum number of days the local communities are willing to accept the three species visiting their property, household vicinity, and their village. The bars and whiskers represent 95% Confidence Intervals.



95% CI) on mitigation solutions during the past 12 months for the baboon, compared to USD 155 ( $\pm 69$ , 95% CI) for elephants and USD 89 ( $\pm 37$ , 95% CI) for hyenas. However, preventative expenditures were significantly higher for elephants only compared to hyenas [ $H(2) = 7.3$ ,  $p\text{-value} = 0.025$ ].

Panel B in Fig. 3 compares intangible costs and benefits between the three species. Negative emotions [ $H(2) = 12.43$ ,  $p\text{-value} = 0.002$ ], negative feelings [ $H(2) = 7.97$ ,  $p\text{-value} = 0.019$ ], and other intangible costs [ $H(2) = 24.5$ ,  $p\text{-value} < 0.0001$ ] associated with the animals differed significantly between the three species. However, the species-wise comparison reveals that the negative emotions were significantly higher only for hyenas compared to baboons ( $p\text{-value} = 0.0004$ ), and negative feelings were significantly higher only for elephants compared to hyenas ( $p\text{-value} = 0.006$ ). Other intangible costs associated with the elephant were significantly higher than both hyenas ( $p\text{-value} < 0.0001$ ) and baboons ( $p\text{-value} < 0.0001$ ). No significant differences were found in positive emotions. However, other intangible benefits were significantly higher for elephants compared to baboons ( $p\text{-value} = 0.001$ ) and hyenas ( $p\text{-value} = 0.006$ ).

### 3.2.3. Wildlife tolerance

The desired population change for the three species is presented in Panel C in Fig. 3. The elephant is the only species whose population people do not desire to decrease much despite the tangible cost incurred by the species. Hence, the desired population change was significantly lower than for the other two species at all three jurisdictional levels [ $H(2) = 24.9$ ,  $p\text{-value} < 0.0001$ ]. However, the jurisdiction-wise comparison revealed that the respondent's desire for the population of baboons to be reduced was significantly higher only in their ward compared to the district ( $p\text{-value} = 0.002$ ) and the Kavango-Zambezi TFCA ( $p\text{-value} < 0.0001$ ). Meanwhile, the respondent's desire for the population of hyenas to be reduced was significantly higher only in the Kavango-Zambezi TFCA compared to their ward ( $p\text{-value} < 0.0001$ ) and the district ( $p\text{-value} = 0.006$ ).

Panel D in Fig. 3 compares the maximum number of days that communities are willing to tolerate the three species visiting their property, the vicinity of their households, and the village. Respondents' tolerance for elephants to visit their property (crops and other household infrastructure) was significantly lower compared to baboons ( $p\text{-value} = 0.014$ ) and hyenas ( $p\text{-value} = 0.007$ ). Moreover, the tolerance for the elephants visiting the household vicinity was found to be significantly lower compared to the hyena ( $p\text{-value} = 0.005$ ). There was no significant difference found between the three species visiting the village.

### 3.3. Partial least squares structural equation models

Path model diagrams are presented for each species. For validation of the PLS-SEM, four evaluation measurements, (i) Indicator reliability, (ii) Composite reliability, (iii) Convergent validity, and (iv) Discriminant validity, were used to evaluate the relationships between the latent and observed variables. The results of the evaluations are presented in Tables S4–6 of the [supplementary material](#). Values for the evaluation test were within the recommended limits. Bootstrapped confidence intervals and the significance of path coefficients are presented in Tables S7–9 and reported below in parentheses.

#### 3.3.1. The case of African savannah elephants

For the African elephant (Fig. 4), the significant determinants of tolerance were intangible benefits (path coefficient = 0.543) perceived from the species, followed by exposure ( $-0.269$ ), meaningful negative experience (0.132), and meaningful positive experience (0.124). Intangible benefits and costs were significantly mediated by exposure ( $-0.545$  and  $0.604$ , respectively). Intangible costs were significantly mediated by exposure (0.478) and meaningful positive experience (0.232). Meaningful positive experience was significantly negatively

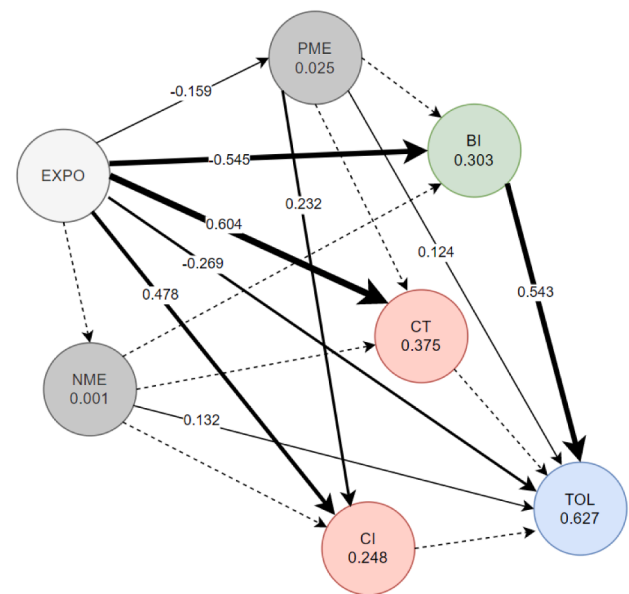


Fig. 4. Path model diagram for African savannah elephant (EXPO = Exposure, PME = Meaningful Positive Experience, NME = Meaningful Negative Experience, BI = Intangible Benefits, CI = Intangible Cost, CT = Tangible Cost and TOL = Tolerance).

affected by exposure ( $-0.159$ ). Looking at the R-squared values, 62.7% of the variation in tolerance was explained by intangible benefits, exposure, meaningful negative experience, and meaningful positive experience.

#### 3.3.2. The case of baboons

In the case of the chacma baboon (Fig. 5), Intangible benefit (0.484) had the strongest significant effect on tolerance towards baboons, followed by exposure ( $-0.252$ ). Exposure ( $-0.478$ ) had a significant mediating effect on intangible benefits, followed by meaningful negative experience (0.104). Tangible and intangible costs and meaningful negative experiences were significantly mediated by exposure (0.639, 0.521, and  $-0.311$ , respectively). Based on the R-squared values, 41.9% of the variation in tolerance was explained by intangible benefit,

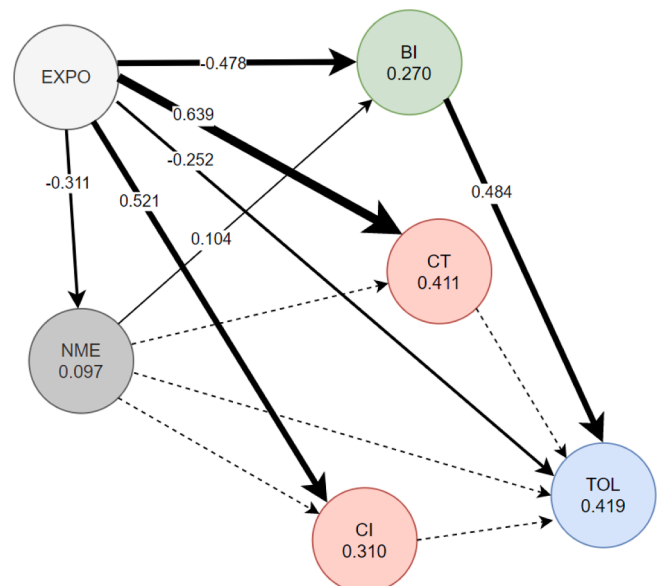


Fig. 5. Path model diagram for chacma baboon.

followed by exposure.

### 3.3.3. The case of spotted hyenas

For the spotted hyena (Fig. 6), the strongest significant effect on tolerance for spotted hyenas was intangible benefits (0.798), followed by a relatively weak but significant effect of intangible costs (−0.150). Intangible benefits, intangible costs, tangible costs, and meaningful negative experiences were all significantly mediated by exposure (−0.324, 0.322, 0.189, and 0.148, respectively). The R-squared values reveal that 67.8% of the variation in tolerance towards spotted hyenas was explained by intangible benefits and intangible costs.

## 4. Discussion

### 4.1. The aesthetic value of elephants

Attitudes toward wildlife depend on many factors, including religion, ethnicity, experience with the species, and intrinsic household characteristics (Kansky et al., 2021; Oliva-Vidal et al., 2022). For instance, Saif et al. (2020) point out how some communities in Bangladesh consider human-elephant conflict as an act of God. Some of their respondents even stated that elephants should not be blamed or persecuted if a person were killed. In contrast, an example of the revenge killing of elephants occurred in West Kilimanjaro, Tanzania, in 2009, where a group of villagers killed six elephants by chasing them over a cliff (Mariki et al., 2015). The event occurred after a herd of elephants raided crops and damaged water pipes during a drought. However, the results of this study show that despite elephants having a high tangible and intangible cost, local communities, despite most households living substantially below the poverty line, have a relatively high tolerance towards the animal, and only wanted the elephant population slightly decreased in their ward. The higher tolerance compared to other species may be attributed to the aesthetic value of elephants as it is the only species that some respondents attributed a positive interaction with, mainly in the form of 'excitement' of seeing the mega-herbivore. Moreover, elephants are charismatic, keystone or flagship species receiving considerable attention in conservation planning and as a basis for ecotourism (Bowen-Jones & Entwistle, 2002; Ochieng, Elizabeth, & Nigel, 2021; Skibins, Powell, & Hallo, 2016). This may make a large elephant population economically valuable to communities in the future despite no one currently mentioning tangible benefits. Furthermore, one of the earliest Community-based Natural Resource Management

(CBNRM) programs in Zimbabwe, called the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE), was preceded by a program called Wildlife Industries New Development for All (WINDFALL). WINDFALL, introduced in the country in 1978, amongst other things aimed to compensate indigenous communities for crop-raiding incidents caused by elephants (Alexander & McGregor, 2000). This may have produced generally positive attitudes towards elephants in Zimbabwe even if the CAMPFIRE program has gradually become unpopular among the local communities due to several factors including the lack of devolution of substantial power to the local communities (Shereni & Saarinen, 2021).

### 4.2. Baboons are perceived as pests

Nonhuman primates are viewed differently depending on the culture, religion, and ethnicity of communities. While the Hindus of India and Buddhists of Nepal, for instance, consider primates sacred and give them a special status in their traditions, farming communities tend to view primates as crop pests (Lee & Priston, 2005). Baboons are often responsible for a high share of lost crops and other livelihood losses in Africa (Warren, Higham, MacLarnon, & Ross, 2011; Walton, Findlay, & Hill, 2021) and are typically viewed negatively by the affected communities (Ndava & Nyika, 2019). A study in Zimbabwe noted that 55% of households considered baboons a threat to their community's development (Ndava & Nyika, 2019). Another study in Gashaka Gumti National Park, Nigeria, reported that 69% of the crop raids carried out by baboon troops were successful and that farmers could only stop them 29% of the time (Warren, 2009). We found that exposure to baboons was higher than for other species and that households spent the most money on mitigation solutions to prevent crop predation and other losses incurred by baboons. The money spent on mitigation was almost equal to the monetary damages caused by the species, but despite trying their best, they seem unsuccessful in preventing problems caused by baboons.

Baboons are often categorized as crop pests due to their frequent involvement in crop raiding (Else, 1991). However, this fails to acknowledge the ecosystem services provided by baboons, including seed dispersal. Tew, Landman, and Kerley (2018) found that chacma baboons are responsible for dispersing at least 24 different seed species in their habitat, hence more than birds or other mammals. They further find that seed dispersal by baboons is almost five times higher than by domestic goats, for instance. Hence, the ecosystem function of baboons cannot easily be substituted by domestic or any other wild species. Despite the ecosystem services provided by baboons, communities' tolerance towards baboons was lower than towards elephants and hyenas. This highlights the frustration local communities experience when dealing with the threat caused by baboons, which includes farmers having to guard their fields against damage, sometimes up to 9 h per day (Ndava & Nyika, 2019). Moreover, baboons not only cause problems in farms and rural areas but also in urban areas, where they are responsible for a wide range of problems, including damage to assets, loss of food, a threat to personal safety, and the stress of dealing with the species (Kansky et al., 2016).

### 4.3. Association of hyenas with witchcraft

Attitudes towards hyenas are relatively complex compared to other animals. Unlike elephants and baboons, who are perceived differently depending on cultures and religions, hyenas are almost universally negatively viewed or feared by local communities in their range due to their unattractive appearance and scavenging behavior (Boneh, 1987; Kruuk, 2019). Dunham (2006) explores the association of hyenas with witchcraft and recounts ancient folklore that has often depicted the hyena as inherently evil. The study explains that even with the advent of monotheistic religions such as Islam and Christianity in Africa, the fear of witchcraft still plays an important role in how communities view the species. Somerville (2021) also elaborates on how mythologies and

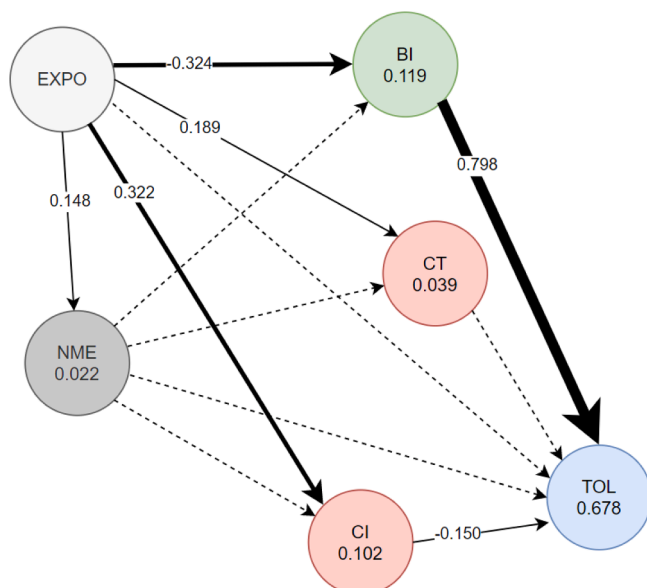


Fig. 6. Path model diagram for spotted hyena.

folktales have significantly influenced people's attitudes toward the species. These myths and folktales often recount how hyenas kill livestock and people and, sometimes, even dig up graves to scavenge the remains of corpses (Kraß, 2018; Somerville, 2021). The following quote, from Kruuk (2019, p. 59) further shines the light on why the communities may perceive hyenas negatively: "...Their loud, staccato 'giggles' are like those of a mad person, and they are mixed with deep growls and howls, all together the cacophony of a very aggressive orgy...for a frightened human in the dark, many such sounds together are hauntingly human, supernatural, a witches Sabbath."

Myths and folktales about hyenas are passed on from generation to generation, promoting a perception of the species as supernatural and generating little or no tolerance for the species. Our results also resonate with these findings as the local communities wanted the hyena population to decrease in their ward, district, and Kavango-Zambezi TFCA. This highlights how generations of negative attitudes towards the species have translated into intolerance. However, like baboons, hyenas play a positive role in the ecosystem. The most critical ecosystem services performed by hyenas are well documented in Ethiopia, where they are known for scavenging on animal carcasses and other waste that would otherwise compromise the hygiene of humans and domestic and wild animals (Moleon et al., 2014; Yirga et al., 2012; Yirga et al., 2015). More importantly, studies have shown that hyenas are relatively immune to deadly diseases, including anthrax and rabies (East et al., 2001; Lembo et al., 2011), which are known to cause animal and human mortality (Cizauskas, Bellan, Turner, Vance, & Getz, 2014; Antonation et al., 2016). Hence, ensuring that hyenas are present to scavenge on the corpses of infected animals eliminates the possibility of further transmission of these deadly diseases to humans and other animals (Mackey & Kribs, 2021; Sonawane, Yirga, & Carter, 2021).

#### 4.4. Intangible benefits and exposure to wildlife

Results from the path models demonstrate the strong effect that the intangible benefits of wildlife have on tolerance towards the three species. One would perhaps assume that tangible costs, such as damage and the amount spent on mitigation efforts would determine the tolerance of local communities as that is the actual physical cost that HWC victims have to bear for living with these species. However, the path model diagrams clearly show that this is not the case. Studies using the wildlife tolerance model in other geographical and cultural contexts have found similar results demonstrating that tangible costs do not significantly affect tolerance (Kansky et al., 2016, 2021; Saif et al., 2020). Despite a need to reduce the tangible costs that communities often bear from HWC, these findings suggest that recognizing intangible benefits may increase the tolerance of local communities more than any other management intervention. Whether these results are an artifact of a lack of recognition or acknowledgment of the tangible costs or perhaps a lack of or skewed distribution of any benefits accrued from wildlife, including through protected area entry fees and tourism income, remains unclear (Naidoo et al., 2016; Abukari & Mwalyosi, 2020). Moreover, as exposure has a strong mediating effect on tangible and intangible costs, efforts should be made to reduce exposure to problematic wildlife species. This could be through interventions such as using chili fences and beehives against elephant intrusions (Chang'a et al., 2016; King, Lala, Nzumu, Mwambingu, & Douglas-Hamilton, 2017), predator-proof livestock enclosures to protect against carnivores (Lichtenfeld, Trout, & Kisimir, 2015), and using guard dogs to protect against primates (Marker, Dickman, & Schumann, 2005).

#### 4.5. Conclusion

The WTM combined with the PLS-SEM has proven useful in describing the determinants of tolerance by local communities towards the three species – elephant, baboon, and hyena. This offers important insights for managing HWC and designing interventions to increase

tolerance. Importantly tangible and intangible costs were not as important determinants as intangible benefits and exposure were. This suggests that efforts to increase tolerance should strive to increase awareness of the intangible benefits, such as perceived aesthetic and cultural values and the ecosystem services provided by the species, while reducing exposure that strongly mediates tangible and intangible costs. This could be achieved through efforts to minimize crop damage, livestock predation, human casualties, and the destruction of infrastructure.

Conducting a baseline study using the Wildlife Tolerance Model in our study area further offers an opportunity to evaluate the effect of interventions to reduce HWC through an impact evaluation. Wildlife tolerance can be used as an indicator of the success of such interventions. I.e. firstly, the WTM can be used to identify the factors affecting the wildlife tolerance of the targeted communities and help create a mitigation strategy. Secondly, by conducting a Before-After-Control-Impact (BACI) study (e.g. Keane et al., 2020), the true impact of project interventions on local communities' wildlife tolerance can be evaluated, paving the way for human-wildlife coexistence and hence conservation.

#### Declaration of Competing Interest

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

#### Data availability

Data will be made available on request.

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#### Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jnc.2023.126466>.

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