

Wildlife institutions highly salient to human attitudes toward wildlife

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Abstract

Efforts to promote human-wildlife coexistence may be overly focused on wildlife-related costs and benefits. We conducted research in Mozambique to gain insights into how governance of wildlife influences potential for human-wildlife coexistence. Mozambique is an under-studied region with a unique history of Portuguese rule, extended civil unrest, substantial wildlife trafficking, and current re-wilding efforts. We conducted surveys, logistic regression, and hotspot analysis to assess which variables are correlated with positive attitudes toward living with wildlife. Most respondents (61%) expressed positive attitudes toward living with wildlife. Attitudes were positively correlated with age, gender, distance from the park, wildlife benefits, restricted access to natural resources, and agreement with wildlife rules. Conflict with wildlife (i.e., livestock predation, human harm, and crop loss) were not significant predictors of attitudes. Respondents who agreed with the rules governing wildlife were 30-times more likely to have positive attitudes. This new and important finding highlights the possibility that institutions that address environmental justice, including the devolution of wildlife to local communities, may be more salient than the conventional measures of costs and benefits for understanding human-wildlife coexistence. Our results suggest that much more attention should be dedicated to the role of local institutions in promoting human-wildlife coexistence.

KEYWORDS

community-based wildlife management, human-wildlife coexistence, human-wildlife conflict, logistic regression, Mozambique, rules, spatial analysis, surveys, trans-frontier conservation area

1 | INTRODUCTION

There is growing recognition of the need for human-wildlife coexistence in shared landscapes outside of

protected areas, and limited consensus on how this can be achieved (Pooley, 2021; Thorn et al., 2012). We consider coexistence to occur when sustainable populations of humans and wildlife develop appropriate adaptations

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(including institutions) that enable them to live together in an integrated human and natural system (Carter & Linnell, 2016). Efforts to promote coexistence between people and wildlife are complex because of the multifaceted and interconnected drivers and impacts of conflict, ranging from direct interactions between people and wildlife to the political ecology of who controls wildlife versus who reaps its benefits or bears its costs. Much of the human-wildlife conflict and coexistence literature focuses on the economic costs (e.g., livestock losses, crop raiding) and benefits (e.g., jobs, income generation) as the primary drivers of human-wildlife coexistence (Aiyadurai, 2016; Madden & McQuinn, 2014; Zimmermann et al., 2020). While the importance of perceived legitimacy of institutions governing natural resources for sustainability of common pool resources is well-documented (Agarwal, 2009; Murphree, 2009; Ostrom, 2009), few studies have addressed the role of perceived institutional legitimacy in human-wildlife coexistence.

Attitudes and perceptions provide valuable insights into people's tolerance for wildlife or willingness to accept the costs of living with wildlife (Kansky & Knight, 2014). As such, understanding the factors that affect people's attitudes toward living with wildlife is necessary to design better policies aimed at promoting human-wildlife coexistence (Kansky & Knight, 2014; Mir et al., 2015). It was previously assumed that attitudes and tolerance levels are predominantly shaped by the costs and benefits of living with wildlife. However, recent research suggests that this assumption is an oversimplification as values, beliefs, personal experiences, and other factors can play equally large roles in shaping attitudes toward wildlife (Bencin et al., 2016; Dickman et al., 2014; Kansky et al., 2016). Many conservationists have designed policies and programs based on the assumption that people's response to human-wildlife conflicts is directly proportional to the amount and frequency of wildlife damages, and that reducing damages increases support for wildlife conservation (Dickman et al., 2014). Accordingly, conservationists have focused on reducing crop destruction, livestock predation, and human injury or death by wildlife. However, these interventions are not always effective (Eklund et al., 2017) and can increase intangible costs such as reduced school attendance by children to guard livestock, time and money spent on conflict mitigation efforts, and loss of sleep worrying about wildlife (Ogra, 2008). In a meta-analysis of attitudes toward conflict species, Kansky et al. (2014) found that intangible costs were the best predictors of attitudes toward wildlife. Additional studies have found that socio-demographics (e.g., gender, age, education, ethnicity, religion, wealth, length of residence in an area), potential

and realized costs of living with wildlife, restricted access to natural resources owing to the creation of protected areas, disagreements over wildlife management decisions, and knowledge of wildlife can influence attitudes toward wildlife and wildlife conservation (Bencin et al., 2016; Dickman et al., 2014; Guerbois et al., 2013; Karlsson & Sjöström, 2007; Mir et al., 2015; Mkonyi et al., 2017; Ntuli et al., 2019; Ogra, 2008; Shibia, 2010).

Institutions and governance play a major role in biodiversity conservation and may be equally critical in human-wildlife coexistence. The importance of socio-political factors and the perceived legitimacy of institutions and policies was highlighted by Ntuli et al. (2019), who found that the perceived legitimacy of park management and rules governing protected areas affect local communities' attitudes toward conservation. Furthermore, Ntuli and Muchapondwa (2018) found that biodiversity outcomes improved in communities with strong institutions and higher levels of cooperation (see related findings by Mavah et al., 2022). The role of institutions is especially relevant in Africa where a legacy of colonialism, exclusionary conservation, and racially based conservation priorities have vilified local people and destroyed local institutions for governing resources, contributing to deep-seated resentment, and conflict that makes human-wildlife coexistence even more challenging (Kashwan et al., 2021; Mavah et al., 2022). Practitioners and communities involved in community based natural resource management (CBNRM) in southern Africa often highlight the importance of strong institutions for biodiversity conservation (Child, 2019; Jones & Murphree, 2001; Murphree, 1994; United Nations Environment Programme African Union, 2019). Yet, the role of institutions in framing the political economy of wildlife (i.e., who benefits and who bears the costs) and strengthening or weakening local control of wildlife is seldom addressed by wildlife coexistence studies. Accordingly, we conducted research in Mozambique to ascertain how institutions governing wildlife influence communities' attitudes toward wildlife and their willingness to coexist with local wildlife.

Previous research efforts in Mozambique have addressed communities' attitudes toward poaching (Sundström et al., 2020), strategies for human-wildlife conflict mitigation (Branco et al., 2020; Virtanen et al., 2021), and communities' attitudes toward specific protected areas (Boer & Baquete, 1998) or conservation policies (Soto et al., 2001). We have found no studies in Mozambique that assess the institutional context in which attitudes toward wildlife are formed, including the devolution of wildlife proprietorship and community mechanisms for governing wildlife. Because the formation of attitudes toward wildlife can vary contextually, it

is important to conduct attitudinal studies in different regions and contexts. Mozambique has a unique history of Portuguese rule, livelihood instability from extended conflict, high levels of wildlife trafficking, and recent rewilding efforts (Hübschle, 2017). As such, findings from surrounding countries may not be generalizable to wildlife conservation efforts in Mozambique. More research on the many facets of human-wildlife coexistence throughout Mozambique is needed, especially on the role institutions play in mediating wildlife tradeoffs, conflicts, and tolerance.

We surveyed community members in the Mozambican portion of the Great Limpopo Transfrontier Conservation Area to assess their attitudes toward living with wildlife. Private wildlife reserves have been established in the borderlands of Mozambique's protected areas to recover wildlife and utilize recovering wildlife populations, mainly through high value trophy hunting. These efforts seek to model the economically successful greater Kruger National Park (Chidakel et al., 2020) across the border in South Africa. One of these privately owned wildlife reserves (Sabie Game Park) initiated a nascent community-based natural resource management program in 2013. The project emphasizes that devolving rights from central governments to local communities facilitates better management of common property resources (Child & Barnes, 2010; Schlager & Ostrom, 1992). The goals of the CBNRM program include reducing historical antagonism between local people and conservation authorities, providing local people with options to complement their livelihoods with wildlife-based income, and providing a positive social framework to address rhino poaching in a community traumatized by recent conflict (Hübschle, 2017). Strong institutions are vital for CBNRM success (Child & Barnes, 2010; Jones & Murphree, 2004; Muchapondwa & Stage, 2015) including benefit-sharing systems (Mosimane & Silva, 2015) in southern Africa.

The objective of this paper is to provide insights on the potential for human-wildlife coexistence on community-owned lands in protected area borderlands in Mozambique. We assess which variables are correlated with positive attitudes toward wildlife and how attitudes vary spatially. Specifically, we tested whether the importance that community members placed on local wildlife (a measure of their attitudes toward wildlife) was correlated with: (1) socio-demographics (gender, household income, education, and livestock ownership), (2) human-wildlife conflicts (livestock loss, crop damage, and human harm), (3) proximity of community members' homes to the protected area, (4) restricted access to resources owing to the creation of Sabie Game Park, (5) the receipt of wildlife-based benefits, and (6) community members'

opinions on the their own institutions and the rules and regulations governing the political economy of wildlife in Mozambique. This research adds to our understanding of standard variables used to analyze human attitudes toward wildlife on working lands and extends this to include the role of institutions governing wildlife. Including all these variables in one model allows us to determine the relative impact of institutions on attitudes. Understanding how perceptions of institutions governing wildlife impact general attitudes toward wildlife can promote both human-wildlife coexistence and environmental justice.

2 | METHODS

2.1 | Study area

We conducted this study in Mangalane community, which occupies approximately 50,000 ha of communal area bordering Sabie Game Park (hereafter referred to as Sabie) in southwestern Mozambique (see Figure 1). Mangalane consists of approximately 480 households and 1800 residents who rely primarily on agriculture and livestock for their subsistence needs (Vundla, 2019). The region is characterized as post-conflict and still recovering from the effects of the extended civil war throughout Mozambique. In 2000, Sabie was granted a 99-year lease on approximately 30,000 hectares bordering Kruger National Park. This lease allowed Sabie to use the land exclusively for wildlife, which resulted in the displacement of some households to outside the newly fenced game park. After investing in wildlife recovery, Sabie commenced hunting operations in 2009 to pay for this investment. An electric fence (40 km) around the park minimizes human-wildlife conflicts by restricting the movement of large mammals but is not impervious. The fence also restricts people's access to the park, although the park staff facilitate some access such as the watering of livestock during droughts and traditional activities, including visits to gravesites.

Sabie Game Park is part of the Great Limpopo Trans-Frontier Conservation Area, a 17,000 km² "peace park" that includes Kruger National Park in South Africa, Limpopo National Park in Mozambique, and Gonarezhou National Park in Zimbabwe, as well as a growing number of private parks and communal lands. One objective of the peace park is to include local people in the management and economic benefits of biodiversity conservation (Spienburg et al., 2008).

In 2013, a CBNRM project was initiated in Mangalane to increase community engagement in wildlife conservation and, ultimately to reduce poverty by integrating

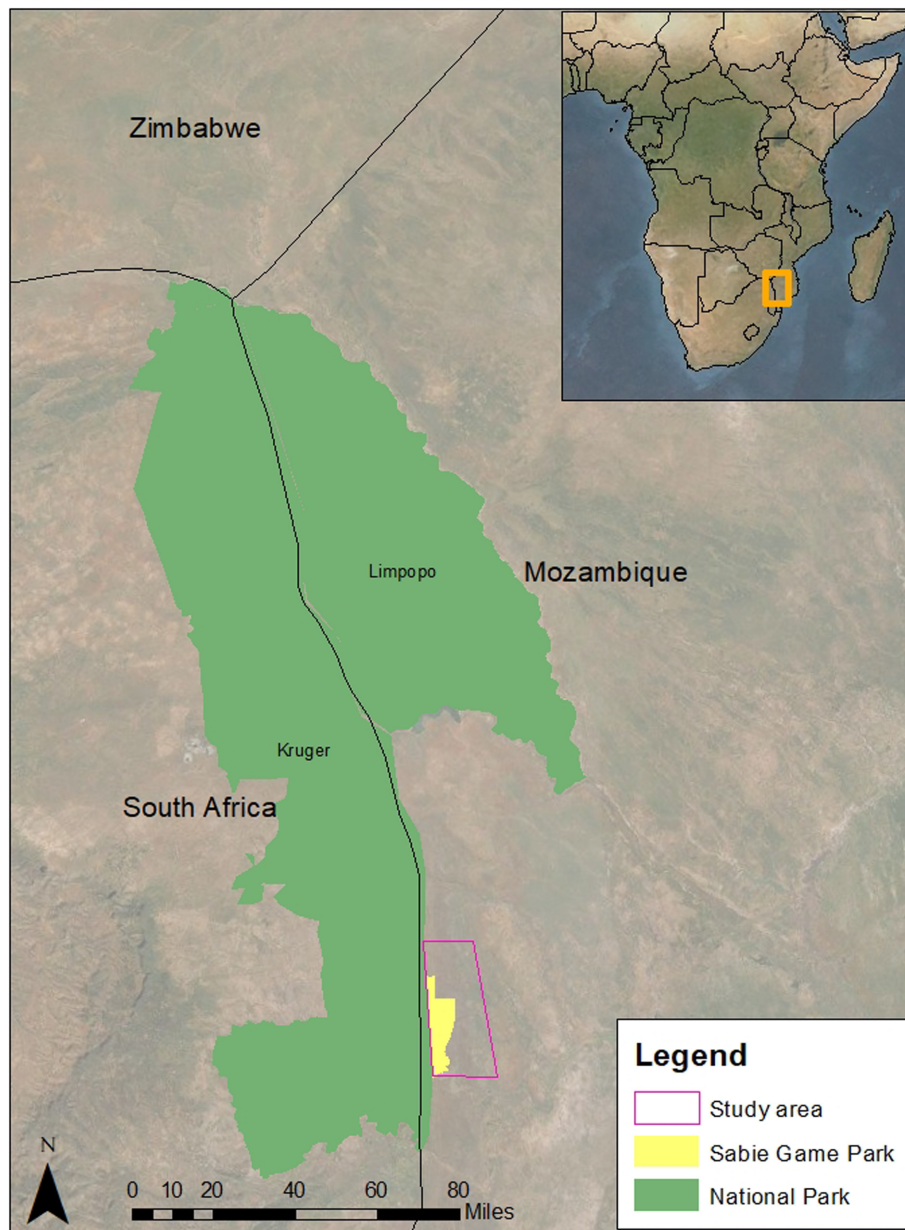


FIGURE 1 Map of study area (outlined in pink) with Sabie Game Park (in yellow) and neighboring national parks (in green)

communities into the wildlife economy. Twenty percent of the trophy hunting fees from Sabie were distributed to the local community, as mandated by Mozambican law, to establish local CBNRM institutions (Merz, 2014; Vundla, 2019). In addition, Sabie employs people from the community and delivers game meat from a small number of hunted animals to the community. These benefits from the government and Sabie were augmented by NGOs that helped with building capacity for local governance, environmental education, provision of wells, human-wildlife conflict mitigation, and the employment of sixteen local “community wildlife police” (Vundla, 2019).

The CBNRM project uses the distribution of a portion of the government’s fees collected for trophy hunting permits in Sabie to organize the community through a set of

rules. Communities created constitutions with specific rules that must be followed before the money from wildlife is distributed. Specifically, communities agreed that (1) wildlife benefits were owned equally by all members of the community, (2) every adult therefore gets an equal share of income, (3) general meetings are held regularly to agree on how income from wildlife is used, (4) committees are elected annually and are accountable to their constituents, (5) a community bank account is required before wildlife benefits are received, and (6) financial reports are due to the community and the government regularly (Merz, 2014). The CBNRM initiative used household cash benefit sharing to entrench these rules (Vundla, 2019), accepting that the initial flow of benefits from recovering wildlife populations would be low. The

community was divided into its five small constituent villages to encourage face-to-face participation in governance and management, while avoiding establishing a single representative body that might lead to elite capture of wildlife-based benefits (Merz, 2014).

2.2 | Survey design and implementation

As part of a much larger socio-economic baseline study of the landscapes around Limpopo National Park, Peace Parks Foundation conducted a household livelihood and attitudinal survey (led by author Shylock Muyengwa) in communities bordering Sabie. The survey included closed-ended and short-answer questions on attitudes, demographics, health, education, natural resource use, and livelihoods. A total of 237 individuals were interviewed and participation was completely voluntary with informed consent obtained. Households were randomly selected from a community membership list and heads of households were asked to complete the survey. The survey was conducted orally in Shangaan by trained interviewers from the community and responses were recorded on tablets and then entered into a spreadsheet. Of the 237 surveys, we removed 12 incomplete surveys and 1 extreme spatial outlier, leaving 224 complete surveys used for analysis (94.5% completion rate).

2.3 | Logistic regression analysis

We used the survey question “Do you think it is important to have wildlife in your area?” (yes = 1, no = 0) as the response variable. This question was intended to gain insights into people’s attitudes toward wildlife, tolerance levels, and potential for human-wildlife coexistence which we refer to as “attitudes toward wildlife” throughout the paper. We then measured how these attitudes were influenced by socio-demographic, spatial, institutional, and wildlife-related factors. The term used for wildlife refers to any wild and non-domesticated animals; we did not differentiate between species or types of wildlife in the survey. We analyzed responses to this question using a generalized logistic regression on all possible combinations of explanatory variables using R (R Core Team, 2018) and the MuMIn package (Barton, 2009; R Core Team, 2018). We included 15 explanatory variables in the logistic regression models: gender; age; education; employment (a proxy for household income); cattle ownership; goat ownership; crop loss owing to wildlife; livestock predation owing to wildlife; human harm by wildlife; restricted access to natural resources owing to the creation of Sabie; agreement with the rules governing

wildlife conservation; receipt of wildlife benefits; the value of wildlife-based benefits received; distances from households to the park fence; and distances from households to the park gate (Table 1). Regarding wildlife-based benefits, participants were asked a yes or no question as to whether they received benefits from wildlife in the previous year, but the term “benefits” was not defined. It was left to individuals to determine what they considered benefits. Respondents may have considered cash payments to households, infrastructure development, employment, game meat, or other forms of benefits when answering this question. While this potentially changes the meaning of the question across participants, it ensured that the individual determined whether they benefited from wildlife. For the amount of benefits, participants listed the type and quantity of benefits and surveyors quantified the monetary value of these benefits in metacais to maintain consistency. For example, if one participant said they received 2.5 kg of meat as a benefit, this was translated into metacais using the local value for 1 kg of beef (the closest substitute for game meat) and the same value was applied across all surveys. We also included interaction variables in the estimated models. We selected the best-fit model based on the lowest Akaike information criteria value.

2.4 | Spatial analyses

The survey team recorded the GPS coordinates for respondents’ houses. We tested for spatial autocorrelation and analyzed the spatial distribution of attitudes toward wildlife. We used a global Moran’s I to assess spatial autocorrelation throughout the study area and conducted a Getis-Ord hot-spot analysis (G_i^*) to identify areas where attitudes toward wildlife were more positive or negative than expected by random selection (Ord & Getis, 1995). We used the optimization method in ArcMap to determine the distance for calculation (ESRI, 2013) because there were no specific boundaries for this area. The optimization used the average distance to a respondent’s 11 nearest neighbors (1.76 km).

3 | RESULTS

3.1 | General survey results

Of the 224 respondents included in this analysis, the majority ($n = 137$, 61.2%) thought having wildlife in their area was important (Table 2). Few respondents reported receiving wildlife benefits (26%), and the average amount of benefits received was 428.35 Metacais or \$7.26

TABLE 1 Survey questions used to derive the dependent variable and 15 predictor variables used in logistic regression analysis with predicted and actual correlations

Variable	Question	Unit	Predicted correlation with attitudes toward wildlife	Actual correlation with attitudes toward wildlife
Dependent variable	Do you think it is important to have wildlife in your area?	Yes/No		
Gender	Are you male?	Yes/No	Positive	Positive
Age	How old are you?	Years	Negative	Positive**
Education	Have you completed primary school?	Yes/No	Positive	Not significant
Employment	Are you employed?	Yes/No	Positive	Not significant
Cattle ownership	Do you own cows?	Yes/No	Negative	Not significant
Goat ownership	Do you own goats?	Yes/No	Negative	Not significant
Crop loss	Wildlife has damaged my crops this year	Yes/No	Negative	Not significant
Predation	Wildlife has killed my livestock this year	Yes/No	Negative	Not significant
Human injury	Wildlife has harmed someone in my immediate family and restricted normal life	Yes/No	Negative	Not significant
Restricted access	The park has restricted my access to natural resources	Yes/No	Negative	Positive
Agreement with rules	Do you agree with the rules and regulations governing wildlife?	Yes/No	Positive	Positive
Wildlife benefits	Does your household get wildlife-based benefits?	Yes/No	Positive	Positive
Value of benefits	How much wildlife-based benefits did you receive in the last year?	0.001 Meticaïs	Positive	Negative*
Distance to fence	Distance from the nearest park fence	Kilometers	Positive	Positive**
Distance to main gate	Distance from the main gate of the park	Kilometers	Positive	Not significant

*Only significant at $p < .1$. **Significant p -value, but odds ratio near 1.0.

($SD = 1520.54$ Meticaïs). Most respondents had lost crops (77%) or livestock (59%) to wildlife in the previous year and had experienced restricted access to natural resources owing to the creation of Sabie (71%). The mean age of respondents was 43.0 years ($SD = 19.7$ years). Most respondents were female (58%), unemployed (78%), and had some education (57%). Respondents lived an average of 5.88 km ($SD = 3.85$ km) from the park fence and 20.85 km ($SD = 11.47$ km) from the main gate to the park. Most respondents (82%) agreed with the rules governing wildlife and the disbursement of wildlife-based benefits. Of those who agreed with the rules governing

wildlife, 67% expressed positive attitudes toward wildlife (Table 2 and Figure 2). Surprisingly, most respondents who experienced restricted access to natural resources, crop loss from wildlife, and livestock predation had positive attitudes toward wildlife. Respondents who had received wildlife benefits tended toward positive attitudes, although only 59 respondents reported receiving wildlife benefits. A higher proportion of men (64%) had positive attitudes toward wildlife than women (58%). The mean age of respondents with positive attitudes toward wildlife was 44.1 years ($SD = 20.6$ years), slightly higher than the mean age of 41.3 years ($SD = 17.9$ years) for

TABLE 2 Aggregate data for binary variables separated by attitudes toward living with wildlife (yes and no categories refer to the response to the binary predictor variable question)

Binary variables	Aggregate data				Respondents with positive attitudes toward wildlife				Respondents with negative attitudes toward wildlife			
	Yes		No		Yes		No		Yes		No	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Agreement with rules	183	82	41	18	123	90	14	10	60	69	27	31
Crop loss	173	77	51	23	116	85	21	15	57	66	30	34
Restricted access	160	71	64	29	114	83	23	17	46	53	41	47
Predation	132	59	92	41	93	68	44	32	39	45	48	55
Education	128	57	96	43	74	54	63	46	54	62	33	38
Goat ownership	104	46	120	54	64	47	73	53	40	46	47	54
Human injury	99	44	125	56	67	49	70	51	32	37	55	63
Cattle ownership	98	44	126	56	60	44	77	56	38	44	49	56
Male	94	42	130	58	61	45	76	55	33	38	54	62
Wildlife benefits	59	26	165	74	46	34	91	66	13	15	74	85
Employment	49	22	175	78	27	20	110	80	22	25	65	75

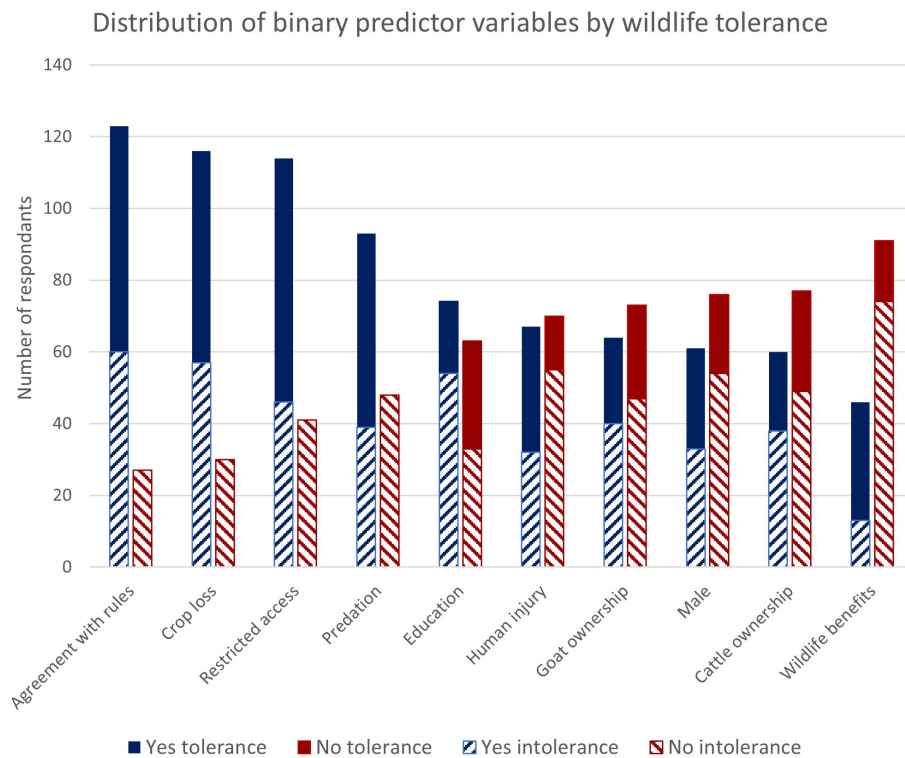


FIGURE 2 Distribution of binary predictor variables (agreement with rules governing wildlife, wildlife-related crop loss, restricted access to natural resources, livestock predation, education level, wildlife-related injury to humans, goat ownership, gender, cattle ownership, receipt of wildlife-based benefits, and employment) by attitudes toward living with wildlife. Individuals with positive attitudes are displayed in blue ($n = 137$) and individuals with negative attitudes are displayed in red ($n = 87$). Attitudes bars are sub-divided by response to the predictor variable with yes displayed with a solid color and no with a hatched pattern. This does not indicate statistically significant relationships, only the proportions of individuals within each category

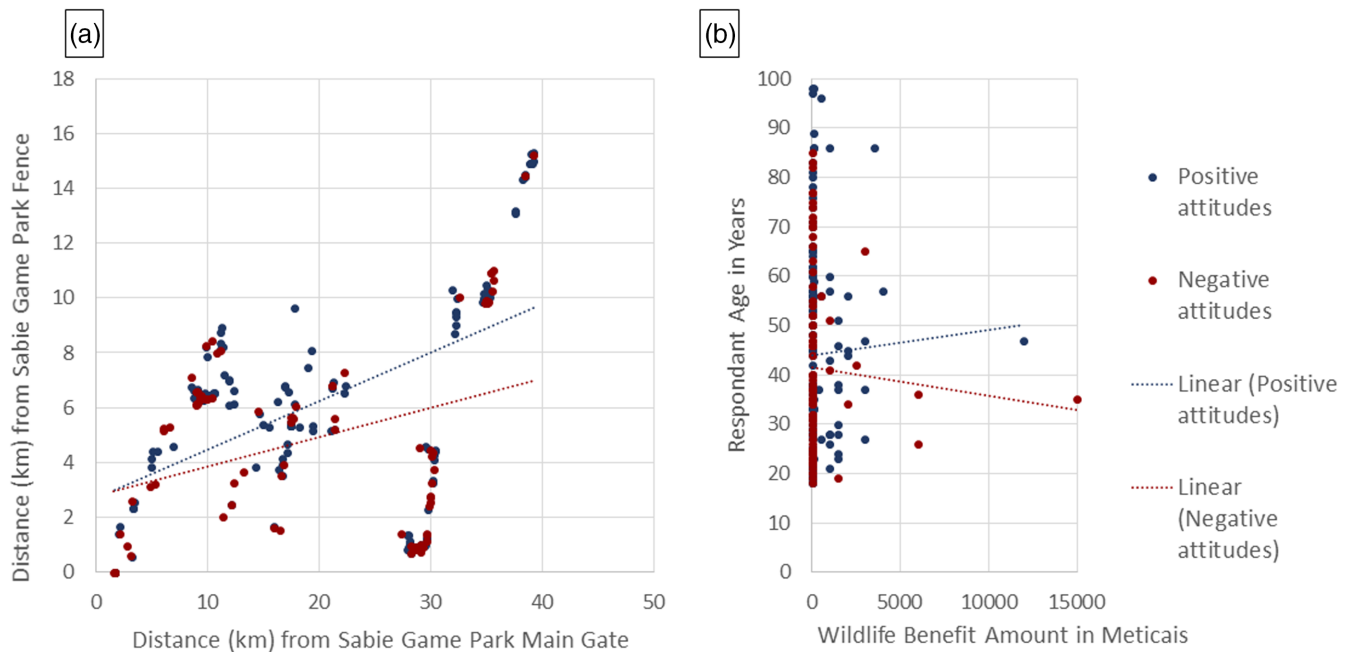


FIGURE 3 Scatterplot comparison of continuous predictor variables. Panel a shows household distance from the Sabie Game Park main gate by household distance from Sabie Game Park fence on the left and panel b shows age by amount of benefits received on the right. Wildlife tolerance is displayed in blue and intolerance in red. Linear trend lines for tolerance and intolerance are included as dotted blue lines for tolerance and dotted red lines for intolerance.

respondents with negative attitudes. Respondents with positive attitudes toward wildlife lived an average of 21.5 km ($SD = 11.4$ km) from the park gate and 6.5 km ($SD = 3.9$ km) from the park fence while respondents with negative attitudes lived an average of 19.9 km

($SD = 11.5$ km) and 4.9 km ($SD = 3.5$ km) from the gate and fence respectively. On average, respondents with positive attitudes toward wildlife received 419.07 Meticais or \$7.10 ($SD = 1250.36$ Meticais) per year in wildlife benefits, compared to an average of 442.99 Meticais or \$7.51

TABLE 3 Results of the best-fit logistic regression model for attitudes toward living with wildlife according to the lowest Akaike information criteria (AIC) value of all possible models run including relevant interaction terms

	Coefficient	Standard error	Z (Wald)	p Value	Odds ratio
Intercept	-4.649	1.028	-4.521	<.001	0.010
Male	0.694	0.339	2.043	.041	2.001
Age	0.040	0.018	2.151	.032	1.040
Agreement with rules	3.409	0.984	3.465	<.001	30.240
Wildlife benefits	1.418	0.490	2.896	.004	4.129
Value of benefits	-0.205	0.121	-1.702	.089	0.814
Distance to fence	0.0002	<0.0001	3.288	.001	1.000
Restricted access	1.528	0.350	4.372	<.001	4.611
Age × agreement with rules	-0.051	0.021	-2.457	.014	0.950
N	224				
Log-likelihood	-118.04				
AIC	254.09				
χ^2 (8 df)	63.19			<.01	
Cox and Snell's pseudo- R^2	.24				

($SD = 1868.30$ Meticais) per year in benefits received by respondents with negative attitudes. The comparative trends in continuous variables are shown in Figure 3.

3.2 | Logistic regression results

Because attitudes toward wildlife are multi-faceted and interconnected, simple relationships as described above do not highlight statistically significant correlations between variables. Logistic regression analysis helps illuminate which factors were correlated with attitudes toward wildlife, taking all other respondent characteristics into account. We found that gender, age, agreement with wildlife rules, receipt of wildlife benefits, distance to the park fence, and restricted access to natural resources best predicted whether respondents thought it was important to have wildlife in their area (Table 3). All other variables that we predicted would be correlated with attitudes (employment, livestock ownership, human harm, crop loss, predation, distance to park gate, and education) were not statistically significant and were omitted from the best-fit model, as were most interaction terms. Men, older respondents, respondents who lived farther from the Sabie fence, and respondents whose access to natural resources had been restricted by the creation of Sabie were likely to express positive attitudes toward wildlife. Respondents who reported receiving wildlife-based benefits were approximately four times more likely to have positive attitudes toward wildlife (odds ratio = 4.129). Controlling for factors predicted to impact attitudes toward wildlife

allowed us to assess the relative impact of institutions on attitudes. We found that respondents' agreement with wildlife rules had the greatest impact on attitudes, with individuals who agreed with these rules being approximately 30 times more likely to have positive attitudes toward wildlife (odds ratio = 30.240). This effect diminished in elderly respondents as indicated by the negative coefficient on the interaction between agreement with wildlife rules and the age of the respondent. Table 1 shows how our results compare to our predictions based on previous research and observations.

3.3 | Spatial analysis

Because distance to Sabie was included in the best-fit model, we tested for global and local spatial autocorrelation to determine if there was a spatial pattern of clustering in attitudes toward wildlife. Figure 4 shows the distribution of respondents by attitudes. The spatial analyses showed no global autocorrelation with a Moran's I of 0.065 ($p = .637$). The G_i^* hotspot analysis at an optimized 1.76 km also revealed no statistically significant ($p < .05$) hot or cold spots in attitudes. Therefore, we did not pursue additional spatial analyses.

4 | DISCUSSION

Successful biodiversity conservation relies on coexistence of humans and wildlife in protected area borderlands.

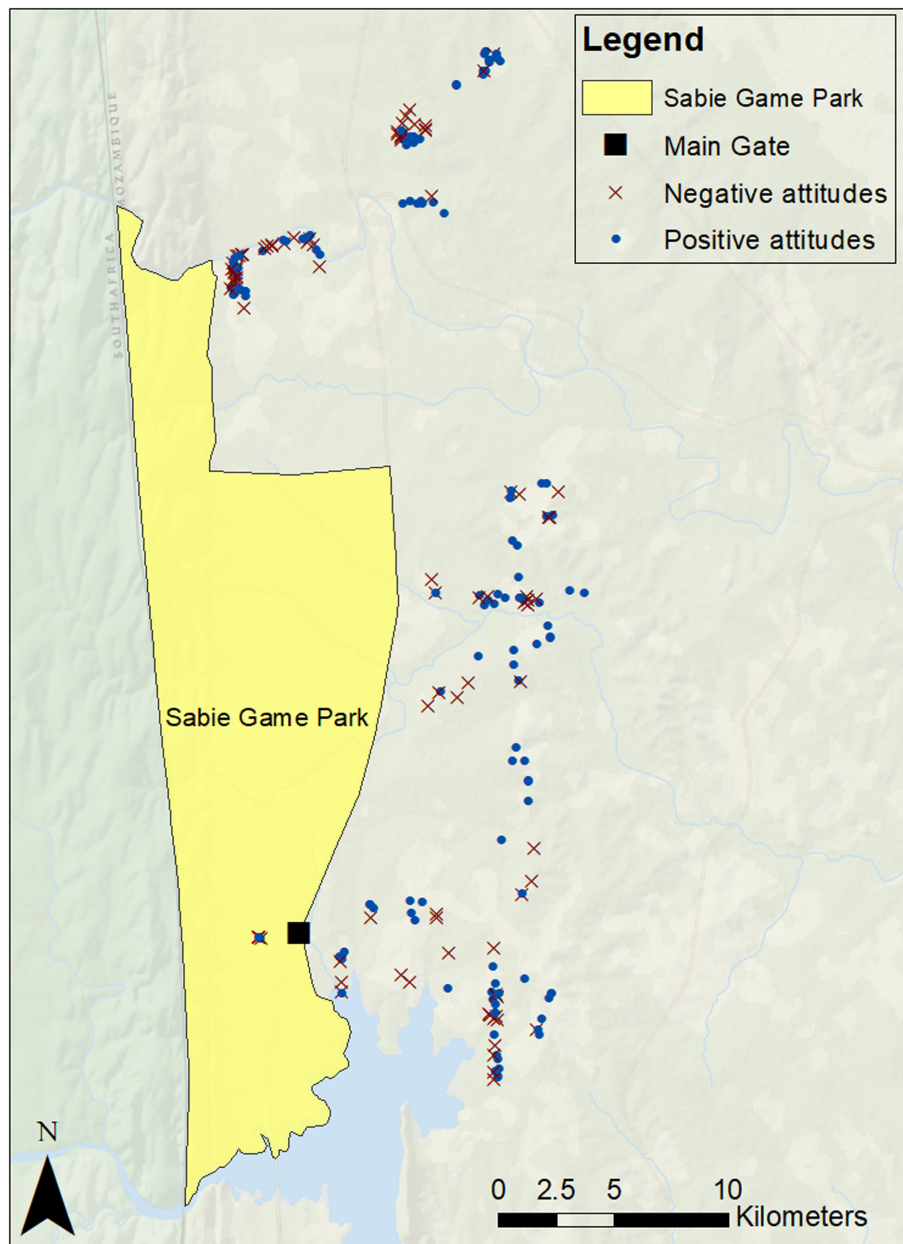


FIGURE 4 Spatial distribution of households surveyed by attitudes toward living with wildlife where respondents with positive attitudes are shown with a blue dot and respondents with negative attitudes are shown with a red x.

Understanding the drivers of attitudes toward living with wildlife is vital for ensuring coexistence in these shared spaces. Our study analyses the factors influencing people's attitudes toward living with wildlife outside Sabie Game Park in Mozambique. We found that attitudes toward wildlife were correlated with economic variables (e.g., households' receipt of wildlife-based benefits), and demographic variables (e.g., gender and age), as expected. Unexpectedly, we found that the game fence that restricts access to natural resources and culturally important sites was also positively correlated with attitudes toward wildlife, likely owing to the fence protecting people from wildlife conflicts. Our spatial analyses revealed heterogeneity in respondents' attitudes toward wildlife with no clear spatial patterns present. Most importantly, our

study revealed that governance and institutions had the greatest impact on attitudes toward wildlife.

Most respondents (61%) in our study thought it was important to have wildlife in their area, despite many experiencing wildlife-related costs and few receiving benefits. A baseline survey conducted in 2013 prior to the CBNRM intervention showed that only 20% of respondents saw wildlife as "important to our future," and that only 1 out of 50 respondents thought that "in our area we should combine cattle with wildlife" (Merz, 2014). Our findings suggest that through community engagement in wildlife rules and some access to wildlife-based benefits, local people have increasingly recognized the importance of maintaining wildlife on the landscape. This is in contrast to much of the human-wildlife conflict literature

which portrays local people as generally intolerant of wildlife and focuses on negative interactions and efforts to improve attitudes and tolerance (Hill, 2021). There may be an opportunity to build on relatively positive attitudes toward wildlife to ensure communities who are willing to live with wildlife are able to develop and maintain institutions necessary to facilitate coexistence.

Prior studies in Zimbabwe (Guerbois et al., 2013) and Kenya (Shibia, 2010) showed that restrictions on access to natural resources in protected areas led to negative attitudes toward parks and wildlife. By contrast, we found that restricted access to natural resources associated with the creation of Sabie was correlated with positive attitudes toward wildlife. Our interpretation is that although the fence restricts access to resources, its effectiveness in reducing negative interactions with wildlife is perceived as a substantial net benefit (see similar findings for the Makuleke community outside Kruger National Park by Eguren & Sprague, 2014). It is noteworthy that perceptions of the fence have improved since baseline studies of communities at the start of the CBNRM program in 2013 revealed animosity toward the park for erecting a fence that separated communities from important natural resources and ancestral graves (Merz, 2014). The progress of the project in returning benefits to the communities, promoting inclusive governance, allowing communities to manage their own resources, and respectful negotiation over conflicts and resource access, may have also contributed to the changing perceptions of the fence by reducing general resentments toward Sabie.

Our findings corroborate more recent literature that attitudes toward wildlife are not solely and proportionally related to costs and benefits of living with wildlife (Broekhuis et al., 2020; Kansky et al., 2014, 2016; Mkonyi et al., 2017). Wildlife-based benefits were an important component of attitudes, with respondents who received benefits being four times more likely to have positive attitudes toward wildlife regardless of the amount of benefits they received, although only 26% of respondents had received benefits in the previous year and benefits were small (\$7.26 [428.4 MT] per year) maximum of \$254 or 15,000 MT. If relatively small amounts of benefits can significantly improve attitudes toward living with wildlife, as indicated by our results, this may be a cost-effective means of attaining desirable wildlife conservation outcomes—especially if benefits are distributed equitably. However, focusing on benefits alone may be misleading because the process of benefit sharing in places like Mangalane is symbolic of a shift in the control of wildlife from the government to the community. This suggests that research that addresses wildlife tolerance needs to be

highly cognizant of the political economic environment in which attitudes are embedded, in this case a shift from exclusionary to inclusive conservation policy.

Although the survey used to provide data for this study was not specifically designed to measure or differentiate between concepts of wildlife-related attitudes, tolerance, and coexistence, it reveals valuable insights into the potential for human-wildlife coexistence, notably the importance of institutions and rules governing wildlife. By far the strongest predictor of positive attitudes toward wildlife was the agreement with rules governing wildlife, which was far more important than we anticipated. Individuals who agreed with the rules were over 30 times more likely to report positive attitudes. However, “the rules” is a very broad term encompassing partial devolution of wildlife rights and benefits from the state to the community, and the development of participatory collective action at local level. The “rules” include several theoretically important concepts that will need to be examined in greater detail (beyond a single binary question) to determine their relative impacts on human-wildlife coexistence. Nonetheless, our findings suggest that although the level of material benefits from wildlife are low, they are appreciated, not least because they are symbolic of the partial devolution of wildlife benefits and the right to personally choose how to allocate these benefits (Child & Peterson, 1991). The transition toward equitable distribution of benefits through face-to-face participation in five villages (as opposed to single representational organizations, often associated with elite capture) reflects a switch from marginalization to participatory self-governance. Moreover, it appears that community members are beginning to see the importance of wildlife as a land use option through the receipt of direct benefits and by watching the development of Sabie. Thus the “rules” includes a fundamental shift from exclusionary to inclusive conservation through the devolution of some aspects of wildlife proprietorship (Schlager & Ostrom, 1992), the establishment of community organization in the form of participatory governance (Child, 2019), and much more frequent and respectful relationships between the game park and the community (Durant et al., 2022). Our findings are consistent with recent literature demonstrating that the legitimacy of, agreement with, or respect for, local conservation regulations improves compliance with conservation rules (Kahler & Gore, 2012; Kandel et al., 2020) and reinforces positive perceptions of conservation (Ntuli et al., 2019). Together, this emphasizes the importance of including institutions in the definition and discussion of coexistence. Further research into the relative impacts of different local institutions on attitudes toward wildlife and the link between attitudes and willingness to coexist with

wildlife could improve our understanding of the importance of local institutions for coexistence.

The spatial analysis revealed high levels of heterogeneity in the variables of interest with no clear spatial patterns present. Ntuli et al. (2019) also found high levels of heterogeneity within and between South African and Zimbabwean communities of the Great Limpopo Trans-Frontier Conservation Area. This confirms there is no single solution that will yield improved attitudes or tolerance toward wildlife globally (Zimmermann et al., 2021). The unique history of Portuguese colonization, extended civil war, and exclusionary conservation practices have all contributed to the local context in Mangalane, but each of these components can have varying impacts on individuals' attitudes toward wildlife. Conducting case studies in under-represented regions and intentionally incorporating community members' preferences for wildlife governance into conservation program design is vital for developing human-wildlife coexistence strategies that are suited to the local context.

Our analysis suggests that developing inclusive wildlife policy and community institutions will have a greater, but complementary, impact on promoting human-wildlife coexistence than decreasing costs of living with wildlife. Building inclusive institutions that empower communities to use, sustain, and protect themselves from local wildlife may be central to wildlife conservation outside protected areas. By strengthening and re-establishing local institutions, communities can develop stronger adaptations for coexisting with wildlife. CBNRM projects that devolve wildlife ownership and management rights, promote strong governance practices, and ensure equitable benefit sharing are likely to be consistent with improving attitudes toward living with wildlife and ultimately human-wildlife coexistence. Our study suggests that an alignment between private wildlife reserves and effective CBNRM provides a social and economic foundation to build an inclusive wildlife-based economy in the trans-frontier conservation area of Mozambique. We hope our findings will encourage researchers to broaden their conceptualization of human-wildlife coexistence and highlight to policy makers and conservationists that rural communities, given the chance, can be willing custodians of the world's biodiversity.

AUTHOR CONTRIBUTIONS

Study design: Leandra Merz, Brian Child, and Timothy Fik; *fieldwork:* Shylock Muyengwa; *data analysis:* Leandra Merz; *writing the article:* Leandra Merz and Elizabeth F. Pienaar; *editing the article:* Leandra Merz, Elizabeth F. Pienaar, Timothy Fik, Shylock Muyengwa, and Brian Child.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Survey data used for this study contains personally identifiable information (household GPS points) that cannot be made publicly available. Requests for access to the dataset should be addressed to Leandra Merz (leandra6@ufl.edu).

ETHICS STATEMENT

The survey data used in this study came from a household livelihood survey conducted in 2017 by author Shylock Muyengwa for Peace Parks Foundation as part of the international Great Limpopo Trans-Frontier Conservation Area. Peace Parks Foundation is a registered non-profit organization operating in Mozambique. They work with government agencies to manage the Great Limpopo Trans-frontier conservation area and other protected areas throughout Southern Africa and are authorized to conduct research with human subjects. While Mozambique does not have a formal IRB process for non-medical research with human subjects, this research complied with all local and national standards for human-subjects research. Prior to conducting any research, Peace Parks Foundation engaged in multiple meetings with key stakeholders (Chief Mangalane, Chef de Poste, private landholders, Inkhomati, Tongaat Hulett) to ensure that research was approved by the communities and was conducted in a socially and culturally appropriate manner, that is, our research was designed and implemented in a manner that respected local beliefs, economic and cultural interests, and rights. Participation was voluntary and oral informed consent was obtained. We maintain privacy and confidentiality of all participants' responses.

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