Exploring the impact of climate change on the future of community-based wildlife conservation

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Abstract
Community-based conservation (CBC) is a wildlife governance approach popular in areas projected to experience a decline in precipitation due to climate change. A survey of residents in four Namibian CBC areas found that the overwhelming majority of respondents felt that (a) a prolonged drought coincided with an increased rate of human-wildlife conflict (HWC), and (b) costs from HWC outweighed any CBC benefits they received. Perceptions of increased HWC frequency were negatively associated with the likelihood of respondents feeling that wildlife benefits exceeded costs. These findings raise questions about the impact of predicted climate change effects on CBC programs across much of the global south.

KEYWORDS
CBC, CBNRM, climate change, community-based natural resource governance, conservancy drought human-wildlife conflict Namibia

1 INTRODUCTION

Community-based conservation (CBC) is a popular wildlife governance approach that has been adopted across southern and eastern Africa (Roe et al., 2009). The approach posits that communities will govern their wildlife resources in a sustainable manner if they receive an enduring interest in and are able control and profit from those resources (Silva & Mosimane, 2012; Songorwa et al., 2000; Störmer et al., 2019). But, before people will sustainably manage wildlife, they must perceive that the overall benefits of doing so outweigh costs associated with living with wildlife (Gosling et al., 2017; Lyons, 2013; Magome & Fabricius, 2004; Murphree, 2009).

CBC programs are often implemented in marginalized areas that tend to experience low annual levels of rainfall and/or monsoon precipitation patterns that limit agricultural productivity (Neumann, 2005). Local economies are frequently based around small-scale and/or subsistence crop or livestock agriculture, with limited alternate employment opportunities (Songorwa et al., 2000). Rural populations must also frequently contend with human-wildlife conflict (HWC), such as the predation of crops or livestock, destruction of infrastructure, and human injuries or fatalities. The lack of economic development, presence of HWC, and pre-existing climatic conditions mean that social-ecological systems in CBC areas may be particularly vulnerable to significant climate perturbation (Bandara & Cai, 2014; Kusangaya et al., 2014).

Rising global temperatures are predicted to have profound impacts on worldwide precipitation patterns, with much of the global south experiencing significantly less precipitation over the course of the 21st century (IPCC, 2014). A burgeoning body of literature acknowledges the severe impacts that this predicted drop in precipitation will have on both human and wildlife...
populations in these regions (Bandara & Cai, 2014; Chu et al., 2015; Pecl et al., 2017; Sivakumar & Stefanski, 2011), and increased HWC frequency is often attributed to decreased precipitation (Acosta-Jamett et al., 2016; Lee & Graham, 2006; Mariki et al., 2015; Modise et al., 2018; Mukeka et al., 2019; Pozo et al., 2020). Increases in HWC could cause CBC participants to feel that wildlife costs outweigh benefits and that change might be expected to undermine the efficacy of the CBC approach. Yet, to date, this author has not identified any discussion that specifically addresses the impact of predicted climate change on CBC approaches to wildlife conservation.

This article addresses that lacuna by examining the impact of a multiyear drought1 on residents’ perceptions in four Namibian CBC areas. Specifically, I examine here the relationship between community residents’ perception of drought-related changes in HWC and their assessment of costs and benefits associated with their CBC involvement.

2 METHODS AND RESULTS

I used survey data collected in 2017 across four Namibian conservancies (formal CBC areas): Puros, Anabeb, Sesfontein, and Omatendeka. Information about Namibia’s conservancy program and this study’s site selection, survey questions, design, administration, and respondents is contained in the Supporting Information. Respondents were asked:

- Whether there had been an increase in HWC problems in the last 5 years (the explanatory “conflict” variable; coded as 1/0 [yes/no]). This question assessed whether the frequency of HWC increased during the approximate time of the drought.
- Whether the conservancy benefits they had received outweighed the cost of living with wildlife (the outcome “benefits” variable: coded as −1/0/1 [no/same/yes]). This question assessed whether the conservancies provide economic incentives for residents to sustainably manage their wildlife resources.
- Whether their conservancy caused their household to experience a different number of HWC problems than they would have otherwise experienced (the alternate outcome “problems” variable: coded as −1/0/1 [more/no difference/less]). This question explored whether residents blamed their conservancies for any perceived increase in HWC frequency.
- Whether their conservancy made their lives better, worse, or about the same (the alternate outcome “improvement” variable: coded as −1/0/1 [worse/same/better]). Whereas the benefits variable emphasized economic gains versus losses, this variable more broadly assessed the overall impacts of conservancies on respondents’ lives, including both economic and noneconomic considerations.

I used Fisher’s exact tests to determine whether a significant relationship existed between the explanatory and the three outcome variables. I then analyzed the nature of those relationships using a two-stage exact logistic regression (ELR). The first stage examined the probability that a respondent would select a response coded higher than “−1” for the particular outcome variable (e.g., whether a respondent would feel that the benefits received either equaled or outweighed the costs of living with wildlife). The second stage investigated the probability that a respondent would choose a response coded as “1” for that variable (e.g., whether the respondent would feel that the benefits received outweighed wildlife costs).

The ELR approach was appropriate given both the size of my sample and the fact that response distributions for two of the four variables (benefits and conflict) are highly skewed (Table 1). Standard logistic regressions rely on a maximum likelihood approach, the assumptions of which are inappropriate for the following conditions that occur within my data: (1) smaller data sets, (2) dependent variables with highly skewed distributions, and (3) some variable combinations (i.e., cell counts) having few or no observations (Faghih et al., 2020; Gao & Shen, 2007; King & Ryan, 2002; Mehta & Patel, 1995; Quintero et al., 2007). Exact logistic regression produces more accurate inferences under these conditions, because the estimate of each variable is separately calculated while conditioning out all of

| TABLE 1 Breakdown of responses to variables of interest |
|--------------------------------------------------------|
| Has there been an increase in HWC? (conflict)          |
| 253                                                    |
| Yes (1): 228 (90.12%)                                  |
| No (0): 25 (9.88%)                                     |
| Has the benefits you have experienced from your conservancy outweighed the cost of living with wildlife? (benefits) |
| 194                                                    |
| Yes (1): 18 (9.28%)                                    |
| Same (0): 25 (12.89%)                                 |
| No (−1): 151 (77.84%)                                 |
| Do you feel that your conservancy has made your life better, worse, or about the same? (improvement) |
| 188                                                    |
| Better (1): 99 (52.66%)                               |
| Same (0): 43 (22.87%)                                 |
| Worse (−1): 46 (24.47%)                               |
| Has your conservancy caused your household to experience a different number of problems with wild animals? (problems) |
| 185                                                    |
| Less (1): 84 (45.16%)                                  |
| Same (0): 25 (13.44%)                                 |
| More (−1): 77 (41.4%)                                 |

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1 The author notes that a multiyear drought is referenced in the text, but the specific duration of the drought is not specified. This could be clarified in the next draft.
the other explanatory variables (Giannakis & Bruggeman, 2015). The drawback to this approach, however, is that it is computationally intensive, making it infeasible to include multiple explanatory variables or to even conduct multivariate analyses for anything other than the smallest datasets (Quintero et al., 2007).

The two-stage approach used here parallels that employed by a generalized ordered logit model (a.k.a., proportional odds model) in that both utilize a series of cumulative logistic regressions while avoiding the “parallel lines” assumption (found in regular ordinal logit models) that all coefficients except for intercepts should be the same across multiple regressions (Williams, 2016). The parallel lines assumption is often problematic when respondents assess their own economic well-being (Cracolici et al., 2013; Harzing, 2016), because, for example, respondents may be disinclined to select more extreme responses.

Brant tests (Lopez-Cevallos et al., 2014) indicate that the parallel lines assumption is violated for the relationships between the explanatory conflict variable and the outcome benefits and problems variables here ($p \leq .1$ and $p \leq .05$, respectively). The parallel lines assumption does not appear to be violated for the relationship between the conflict and improvement variables, but, for the sake of consistency, I also used the two-stage approach to analyze that relationship.

Unfortunately, the computational requirements of the ELR approach prevented the inclusion of more than one additional explanatory variable at a time. Toward against spurious findings, I used multiple variants of each model, each time including a different one of the following explanatory variables (gathered from the same survey data): livestock ownership, gender, age, ethnicity, conservancy of residency, livestock wealth, respondents’ education, time respondent lived in the conservancy, whether the respondent had applied for compensation from their conservancy for lost livestock, and whether the respondent felt that some residents benefit from the conservancy more than others. A description of each of these

| Explanatory variables | Obs. | Level | O.R. | St. Err. | Prob. | $\chi^2$ |
|----------------------|------|-------|------|---------|-------|---------|
| Conflict             | 188  | –1    | .495 | .247    | .254  | 2.04 |
|                      | 0    |       | .251 | .148    | .054* | 6.23 |
| Conflict + livestock ownership | 188 | –1    | .571 | .297    | .412  | 8.76 |
|                      | 0    |       | .289 | .174    | .094* | 9.47 |
| Conflict + gender    | 186  | –1    | .455 | .23     | .201  | 2.65 |
|                      | 0    |       | .236 | .14     | .045**| 6.8   |
| Conflict + age       | 182  | –1    | .482 | .244    | .241  | 2.22 |
|                      | 0    |       | .258 | .153    | .061* | 7.08 |
| Conflict + ethnicity | 187  | –1    | .513 | .258    | .287  | 2.05 |
|                      | 0    |       | .227 | .139    | .045**| 9.02 |
| Conflict + conservancy | 188 | –1    | .604 | .317    | .481  | 7.57 |
|                      | 0    |       | .317 | .203    | .161  | 16.44 |
| Conflict + livestock wealth | 188 | –1    | .498 | .25     | .261  | 2.05 |
|                      | 0    |       | .266 | .158    | .067* | 6.78 |
| Conflict + applied for comp. | 185 | –1    | .509 | .262    | .295  | 2.219 |
|                      | 0    |       | .237 | .148    | .056* | 6.855 |
| Conflict + education | 185  | –1    | .495 | .248    | .256  | 2.15 |
|                      | 0    |       | .263 | .155    | .064* | 6.25 |
| Conflict + residency length | 188 | –1    | .499 | .252    | .267  | 2.04 |
|                      | 0    |       | .3   | .181    | .106  | 8.85 |
| Conflict + some benefit more | 172 | –1    | .535 | .307    | .422  | 2.26 |
|                      | 0    |       | .303 | .223    | .232  | 8.78 |

*Full results, including results for additional explanatory variables, can be found in the Supplemental Information.

$p \leq .1, **p \leq .05.$
additional explanatory variables, together with the rationale for their inclusion, is contained in the Supporting Information.

3 | RESULTS

Over 90% of respondents stated that there had been an increase in HWC over the previous 5 years, and over 75% stated that wildlife benefits were less than costs (Table 1). Just over half (52.66%) of participants responded that their conservancy made their life better, while the remainder were roughly split regarding whether it made their life worse or about the same. Finally, a plurality of respondents felt that their conservancies caused them to experience either less (45.16%) or about the same number (13.44%) of wildlife problems while a large minority felt that their conservancies caused their household to experience more wildlife problems.

Fisher’s exact tests found a significant negative relationship between the explanatory conflict variable and the outcome benefits variable ($p \leq .1$), but this relationship may not be uniform (Table 2 and Figure 1). Across all models, perceptions of increased conflict were associated with a mean 73.2% decrease in the likelihood of a response that wildlife benefits outweigh costs (bottom line of each model regression in Table 2 and the orange columns in Figure 1).2 This relationship was statistically significant in eight of the 11 models.

Fisher’s exact tests did not indicate a significant relationship between the explanatory conflict variable and either of the improvement or problems variables. Furthermore, my analyses did not find any significant relationship between those variables across any of the ELR model variants. While that lack of statistical significance is itself potentially noteworthy, my data do not provide any definitive reasons for it, so the results of those analyses are not further addressed here; additional discussion can be found in the Supporting Information.

4 | DISCUSSION

As an initial matter, the raw numbers presented in this study are noteworthy. The overwhelming majority of respondents felt both that (a) HWC had increased during the period of the drought3 and (b) HWC costs outweighed the conservancy benefits they received. CBC programs are often premised on wildlife conferring economic gains on its participants. The latter of these findings suggests a potential threat to the long-term success of the CBC...
approach, if those sentiments are shared elsewhere. The question, then, is whether perceptions of increased HWC contribute to the predominant view of residents that the benefits they receive do not equal or outweigh the costs of wildlife? My findings suggest that they might.

My core finding—that perceptions of increased HWC are associated with a lower likelihood of residents feeling that conservancy benefits outweigh wildlife-associated costs—is novel, but is, nevertheless, consistent with prior research. Studies of CBC areas have found that non-wage, direct economic benefits to residents are infrequent and relatively small in value (Salerno et al., 2020; Scanlon & Kull, 2009; Snyman, 2014), so any notable increase in HWC losses is likely to outweigh CBC-generated gains. Furthermore, it is widely observed that people tend to be loss averse (i.e., they place greater importance on potential losses than on gains) (Köbberling & Wakker, 2005), and thus, CBC participants may have an innate tendency to discount benefits received when they are faced with the prospect of increased HWC losses.

Questions remain, however, regarding what impact the predicted drying of much of the global south will have on the overall CBC approach. Most participants in my study already felt that losses from wildlife outweighed conservancy benefits, and a large minority (41.4%) believed that their conservancies contributed to HWC. In addition to these raw numbers, in pre-survey interviews, traditional authorities observed that, prior to the conservancies, residents could address HWC by killing problem animals. But now they are prevented from doing so:

- “Before the conservancy, wildlife incidents were few ... problem animals were killed on site.”
- “In the past, if lions killed livestock, we could kill them. Now, if you shoot a lion, you will be punished.”
- “Those days, you could kill a lion that kills your cattle. Now you cannot. The lion population is increasing and also the number of problems.”

If drying in the region becomes the norm, rather than a climatic aberration, it is conceivable that more people will increasingly blame their conservancies for the HWC they experience. If my sample is representative of the population within the study area, it would not take too many additional individuals blaming their conservancies for that view to become the majority opinion in the region. A slim majority (52.66%) of surveyed residents felt that the total package of benefits (both economic and non-economic) conferred by their conservancies outweigh any perceived drawbacks, but it is unclear from my data whether these feelings would persist if drier conditions continue.

Much remains to be learned about whether my findings are representative of CBC communities elsewhere and whether other factors—such as socio-political variables or the role of benefits generated from mechanisms other than wildlife—might have contributed to residents’ perceptions in my study. But, the Namibian Conservancy program is often regarded as a flagship CBC program (Boudreaux, 2008; Koot, 2020), and, because the conservancies included in this study consistently report a positive aggregate income/HWC-damage ratio (NACSO, 2017), they would appear to be successful examples of the approach. Yet, the residents I surveyed held overwhelmingly negative perceptions about both changes in HWC frequency in recent years and whether the economic benefits they derived from CBC outweighed HWC-associated costs. The prevalence of those views raises questions about the potential long-term future of CBC programs within the region and elsewhere if the frequency of HWC increases significantly.

Many, if not most, of CBC programs have so far been unable to consistently provide their residents with significant individual benefits (Blaikie, 2006; Kiwango et al., 2017; Salerno et al., 2020), and any climate-induced increases in HWC will only increase the difficulty of doing so. The poorest and most marginalized members of a community often experience the greatest frequency of HWC (Hartter et al., 2011; Kanapaux & Child, 2011) and benefit distribution can be subjected to favoritism and elite capture (Schnegg & Kiaka, 2018). Thus, climate-related increases in HWC are likely to exacerbate pre-existing socio-economic disparities within CBC communities.

As such, this article highlights the need for additional studies into the impact of climatic changes, both long and short term, on the success of CBC programs across much of the global south. Specifically, the findings presented here suggest that CBC programs may need greater, ongoing financial and administrative support as they contend with climate change and its associated logistical and societal challenges. It will be important to (a) understand and predict the potential socioeconomic impacts that may result from HWC as anticipated climate change impacts develop, and (b) identify additional potential sources of revenue that participants can clearly link to CBC efforts, such as direct payments designed to foster wildlife tolerance (Treves & Bruskotter, 2014) or community-oriented wage employment (Pienaar et al., 2013).

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CONFLICT OF INTEREST
The author declares no conflicts of interest.

AUTHOR CONTRIBUTIONS
Stefan Carpenter was solely responsible for research design, data collection and analysis, and preparation of this manuscript.

DATA AVAILABILITY STATEMENT
Low population levels in the study area means that survey and interview responses could potentially be attributed to individuals through the process of elimination. For this reason, the data used in this paper are not being made publicly available. Individuals wishing to access the data are invited to contact the author.

ETHICS STATEMENT
All research associated with this article was conducted in accordance with all applicable institutional and statutory requirements and received both Institutional Review Board approval and permission from Namibia’s Ministry of Environment and Tourism. Participants included in this study provided informed consent, were assured of anonymity, and their names were not recorded by the survey administrators.

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ENDNOTES
1 The lack of consistent rainfall reporting for the conservancies makes it impossible to accurately report the magnitude and duration of the drought in those areas. Rainfall is highly variable across the Kunene region, including within the borders of individual conservancies. However, pre-survey interviewees in 2017 stated that a severe drought had lasted for over 3 years, and this severity and time period are generally consistent with both national news reports (Grobler, 2016) and academic literature (Inman et al., 2020; van Rensburg & Tortajada, 2021).

2 Full results showing the relative significance of additional explanatory variables are included in the Supporting Information. Table 2 presents findings using odds ratios (O.R.). O.R. represents the odds of a particular outcome (e.g., feeling that wildlife benefits outweigh costs) given a particular treatment (e.g., perceiving an increase in HWC) versus the odds of that outcome absent the treatment (e.g., perceiving no increase in HWC). An O.R. of less than 1 reflects a decreased likelihood of that outcome, while an O.R. of greater than 1 reflects an increased likelihood, with the size of that change measured relative to 1. So, for the baseline regression shown in Table 2, the O.R. of 0.495 shows that individuals perceiving an increase in HWC were 50.5% less likely (1–0.495) to feel that the benefits received from their conservancy outweighed wildlife costs than were those not perceiving an increase in HWC.

3 This study utilizes perceptions of HWC rather than reported HWC counts. The conservancies’ event books reflect that average monthly HWC incidents for 2012–2017 were higher than for 2003–2011 for Anabeb (+8%), Omatake (-11%), and Puros (+81%), but were lower for Sesfontein (-12%). However, the official counts may not adequately reflect predation changes over time. First, data are missing for months or years for some conservancies, hampering comparisons over time. Second, compensation for predated livestock is limited to losses of certain species of livestock that are reported within a few days of the loss, some respondents reported that they had never applied for compensation, and compensation payments appear to have entirely ceased for approximately the preceding 4 years (2013–2017) in Sesfontein. Therefore, there may be many incidents of HWC that go unreported, because residents are unable or unwilling to apply for compensation for those losses. It is also possible that the percentage of incidents that were reported may have fluctuated over time due to a range of other conditions. As such, respondents’ perceptions of HWC levels may more accurately reflect changes in HWC than the formal numbers provided in the event books.

4 Individuals who perceived increased HWC were also less likely to feel that benefits equaled HWC costs, but this finding was not statistically significant. However, the skewness of responses for both the conflict and benefits means that certain answer combinations (for example, respondents perceiving both no increase in HWC and that benefits outweighed costs) were rare. Therefore, it is possible that this lack of significance results from insufficient observations and thus the relationship between these two variables may warrant additional research.

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