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The dietary impacts of drought in a traditional pastoralist economy

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Abstract

Objectives: Arid pastoralism is often understood as an adaptive strategy to marginal environments. As pastoralists become increasingly market integrated, novel dietary preferences and access to low quality market foods can erode traditional diets. These market-based dietary shifts are particularly problematic during sustained drought, where reductions in traditional foods make pastoralists increasingly reliant on a cash economy. Among the Himba of the Kunene region in Namibia, colonial policies prohibiting access to livestock markets inhibit access to a cash-based economy, leaving them vulnerable to food insecurity when nontraditional foods are needed to supplement traditional lifeways during drought. To understand the impacts of long-term drought on diet and food insecurity, we collected longitudinal survey data on diet breadth and food insecurity across 4 years during a multi-year drought.

Methods: Participants completed a five-item food insecurity survey and recalled diet breadth survey over the course of 4 years ($N = 191–234$). Additionally, women completed a short survey of recent stressors, including health and resource stressors ($N = 127$). We used a set of multilevel models to estimate changes in food insecurity items and diet breadth changes over the course of the study period.

Results: Multilevel models predicted score outcomes, as well as individual item responses, by year of data collection. Results indicate a 43% increase in average food insecurity and a 15% decline in average diet breadth over the study period. Dietary recall indicates that drought caused a reduction in sour milk intake, and an increase in nontraditional foods, but no change in meat or maize consumption.

Conclusions: Sustained drought in the Kunene region is having long-term impacts on food insecurity, which could result in dietary shifts that outlast the current period of drought. We consider the implications of this change, especially as it relates to increasing market integration and reliance on a cash-based over a subsistence-based economy.

1 | INTRODUCTION

Pastoralism often occurs in arid environments where sedentary horticulture and agriculture are suboptimal. By exploiting strategic mobility, they are able to utilize animal husbandry to yield productive returns out of these otherwise unhospitable regions. Despite this specialized ability to adaptively respond to an arid environment, sustained droughts can have effects on pastoralist communities that far outlast the drought itself. When droughts erode herd size, the resulting food insecurity can trigger shifts in management strategies that emphasize short-term returns including selling off or slaughtering animals (Krätli et al., 2013). The downstream effects of these changes can trigger reductions in mobility, and increased reliance on market and other nontraditional foods (Fratkin, 2019; McCabe, 1987). This may be particularly true for populations where ecological stochasticity is concurrent with historical processes of marginalization, which restrict their ability to integrate other modes of subsistence or utilize markets. Within populations there is also variation in vulnerability to climatic stressors like drought, with factors like distance to markets, having a female-headed household and number of dependents placing households at greater risk (Hazel et al., 2021, Opiyo et al., 2014).

Multiple lines of evidence indicate that southern Africa is experiencing multiplex climate hazards (Ramirez-Villegas et al., 2021). In Namibia over the last 50 years, the country has experienced reductions in annual rainfall, increased rainfall variability, and increased mean temperatures (Hoerling et al., 2006; Hulme et al., 2001; Intergovernmental Panel on Climate Change, 2007; New et al., 2006; Spear et al., 2018). Future climatic projections suggest these warming and drying trends will continue (Davis & Vincent, 2017; Department of Environmental Affairs, 2013; Dirkx et al., 2008). In the last decade, severe drought has resulted in national emergencies in 2013, 2016, and 2019, the last of which was one of the worst droughts in a century (Liu & Zhou, 2021; Shikangalah, 2020; Figure 1). By the end of 2019, rainfall in northwest Namibia (Opuwo, near the study area) was 51% below normal (Meteorological Services Division, 2019), and the country recorded losses of nearly 100 k livestock (Hartman, 2020). In a survey of Namibians, drought was listed as the second most important problem after unemployment (Afrobarometer, 2019).

As Namibia continues to endure devastating droughts, several factors make small-scale pastoralists, such as Himba, particularly vulnerable. Himba have experienced a long history of social and economic marginalization. Described by Bollig as a policy of "colonial encapsulation," former colonial powers restricted movement, land tenure, and sales of livestock for more than 100 years (Bollig, 1998). Even today, Himba are limited in their ability to engage in sales of livestock outside of the local marketplaces in nearby towns (Bollig, 2006). In response to these restrictions, many Himba began cultivating small gardens to supplement pastoral production with maize, sorghum and other subsistence crops. While these gardens do not produce enough to fully subsist on, their production helps to buffer families against the sale of too many livestock to purchase store-bought maize (Bollig, 2006). Of course garden production is also a high-risk activity in arid environments, where not only the amount of rainfall but the timing of onset, its variability, and the extent of rainfall affects yields (Bollig, 1997). Other drought income diversification strategies that other pastoralists are known to take up, such as the production of charcoal, distribution of liquor or beer, ironwork or menial labor like construction or fence-building is also rare among Himba, in part due to policies by the South African administration that restricted them to a subsistence niche (Bollig, 1997).

The confluence of these historical forces and an already marginal ecological landscape mean that Himba diet breadth is currently very limited. Shifts in the availability of any one food type can have major health consequences, as substitutes are hard to come by. For Himba, as for many pastoralists, this is particularly true of milk, which is a crucial source of daily nutrition. In

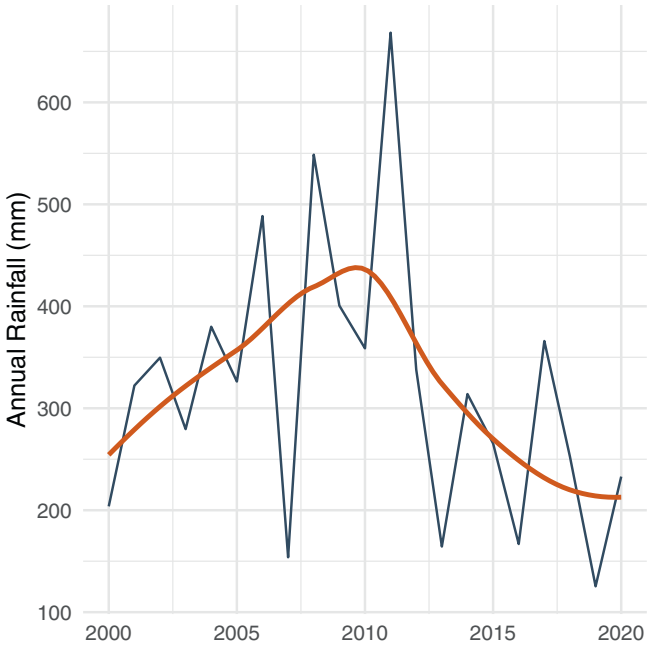

FIGURE 1 Annual rainfall the Kunene between 2000 and 2020. The blue line denotes raw data, while the red line represents a loess smooth. Rainfall data from the World Bank Climate Change Portal (World Bank Group, 2022)

comparison to meat, milk provides double the energetic returns, while retaining crucial livestock numbers to grow the herd (Western, 1982). As a result, milk consumption accounts for more than half of daily calories in some populations (Galvin, 1992; Galvin et al., 1994; Sellen, 1996). Cultural practices in processing milk into cheese, yogurt, butter, and other products extend the shelf life of milk derivatives and opens the potential for participation in local markets. These practices can also beneficially alter the micro and macronutrient densities of milk products (Sadler et al., 2009). Use of fermented milk products in particular is associated with a reduction in diarrheal disease, promoting immune responses, and improving gut health (Heyman, 2000; Shah, 2000). Animal milk is a particularly important food source for children, providing crucial micronutrients and protein (Sadler et al., 2009). In Samburu pastoralists, where maize accounted for half of total calorie intake, milk consumption provided the majority of vitamins and micronutrients, and predicted higher anthropometric scores in children (Iannotti & Lesorogol, 2014). Animal milk also constitutes an important complementary food to breastmilk, and is introduced to weanlings at an early age (Sellen, 1998, 2001). It is also particularly useful as an additive to cereal-based diets. The addition of milk to cereals can make up for a deficiency in essential amino acids crucial to growth when energy requirements are met (Sadler et al., 2009).

One way to understand the effects of drought in communities with limited diet breadth is through the measurement of food insecurity. Food insecurity assesses inadequate access to food at the household level, but also measures stressors and worries about food, and perceptions about access to sufficient quality and quantity of food (Coates et al., 2007). Methods for assessing food insecurity for use cross-culturally and in small-scale populations have been validated and widely used (Deitcher et al., 2010), and have been successfully deployed to study the impacts of drought in several populations in sub-Saharan Africa (Akwango et al., 2017; Bahru et al., 2019; Belayneh et al., 2021). As these cross-culturally validated measures of food security provide multiple avenues to understand the impacts of changes in food availability and access, they can be useful methods to measure how drought shapes access to food.

To better understand the dietary impacts of drought on Namibian pastoralists, we collected longitudinal food insecurity and diet breadth surveys, as well as a survey of perceived resource, health, and social stressors. Our aims are to understand the impacts of long-term drought on food security and diet breadth among Himba. In particular, we are interested in understanding which aspects of food insecurity are most responsive to drought, and how diet composition changes as drought conditions worsen. Finally, we contextualize these results with women's responses to a stress survey, in order to examine how resource related stress compares to other social stressors.

2 | METHODS

This study was conducted with Himba pastoralists in the Kunene region of northwest Namibia, near the village of Okongwati and surrounding areas. Himba live in residential units of 5–25 people, centered around a senior resident man and his wives, children, and various extended kin. Most of the population rely on a subsistence-based diet consisting primarily of maize, sour milk (milk stored in a calabash and left to naturally ferment), and meat. There is limited involvement with the cash economy, except for local sales of livestock and government pension payments, which allow for the purchase of additional foods like rice, pasta, and sugar. Maize is grown in small matrilineally inherited gardens, alongside additional crops like gourds and melons.

Himba families traditionally eat only two meals a day, in the morning and evening. These meals generally consist of maize meal porridge, made by boiling ground maize in water, and adding sour milk. Porridge is also often poured into a basket and left to dry into a cake-like product for later consumption. Meat is variably available, when animals are slaughtered due to old age, or for ritual and ceremonial purposes (Bollig, 2006). During periods of drought, Himba may increase the slaughter of small stock like goats or sheep. Since these animals are kept in larger numbers, and reproduce more quickly, increased slaughter is not as harmful to the overall herd size, in comparison with cattle. As Bollig (2006) recounts, during intense drought goats are slaughtered frequently and "eaten like porridge." Palm nuts are also reportedly used as a substitute food during lean times, although we did not systematically record consumption as these are often eaten opportunistically while out herding or collecting water.

As part of a larger longitudinal study on health and reproduction, we opportunistically surveyed participants from 2016 to 2019 (see Table 1). All research was conducted in the dry season (July–August). We primarily focus on women, who make up the bulk of our food insecurity and diet breadth survey sample. As part of their role in the domestic sphere, women are primarily responsible for food processing, cooking, and the feeding of household members. As such, women may be more in tune to the needs of the household and be more aware of food shortfalls. In contrast, men are often away from the compound, traveling for both subsistence and ceremonial

TABLE 1 Descriptives of food insecurity surveys by year

	2016	2017	2018	2019
N surveys	41	115	43	38
Avg. age (*SD*)	36 (15.2)	45.6 (19.8)	33.7 (13.8)	37.1 (12.9)
% Women	100%	74.8%	100%	78.9%

FIGURE 2 Estimates of the effect of year on food insecurity and diet breadth survey items (posterior median and 95% credible interval): (A) More positive coefficients indicate that the food insecurity item was increasing across the study period. (B) Changes in consumption of various foods across the study period. Coefficients that hover around 0 indicate no change in frequency of consumption of that item. Negative coefficients indicate a food was eaten less frequently as the drought went on, while positive coefficients indicate a food was eaten more often across time

purposes. Men also own the majority of livestock wealth, putting women, and particularly women of female-headed households, in a more precarious position. Each participant completed a five item three frequency food insecurity scale (household hunger scale, HHS-5I-3F), which assesses food insecurity across a 30 day period (Deitcher et al., 2010). To evaluate changes in food insecurity over time, when possible, participants completed surveys across multiple years, with some participants completing as many as four surveys across the study period. Starting in 2017, participants also completed a diet breadth questionnaire, asking if they had consumed any of the six most commonly eaten foods in the past 7 days (see Figure 2). In addition to the questions about food, we developed a short survey of stressors in women. In 2017 and 2018, women were asked a set of questions about their worries over the last 30 days, including topics such as food and water insecurity, livestock numbers, and child health (see Figure 5). Participants responded with a Likert-scale response (never/sometimes/often), and completed this survey only once during the study period. For all participants, age was calculated using the local year name system (Scelza, 2011). Oral consent was granted by all participants in accordance with study procedures approved by the Institutional Review Board at the University of California, Los Angeles (IRB-10-000238), and by local community leaders.

2.1 | Analysis

Food insecurity and diet breadth scores were calculated by summarizing item responses. Both scores were fit using a truncated Poisson regression, with varying intercepts by participant to correct for repeated measures. Age was fit using a spline with default priors (using the *s*() function, defined as $\sum W_k A_k$ below), and year was centered and added as a fixed effect predictor.

$$y \sim \text{Poisson}(\lambda)$$

$$\log(\lambda) = \alpha + \alpha_{ID} + \beta_{\text{year}} * \text{year} + \sum W_k A_k$$

Individual food insecurity responses were modeled similarly, but using a cumulative ordered logit regression, and all items estimated in the same model assuming correlation between responses by individual respondent.

$$\begin{matrix}\text{Item1}\\ \text{Item2}\ \sim \text{Ordered Logit}\,(\theta,\kappa)\\ \text{Item...}\end{matrix}$$

$$\theta = \alpha + \alpha_{ID} + \beta_{\text{year}} * \text{year} + \beta_{\text{age}} * \text{age}$$

Likewise individual food recall items were modeled using a Bernoulli regression, again assuming covariance between individual items.

$$\begin{matrix}\text{Item1}\\ \text{Item2}\ \sim \text{Bernoulli}\,(p)\\ \text{Item...}\end{matrix}$$

$$\text{logit}(p) = \alpha + \alpha_{ID} + \beta_{\text{year}} * \text{year} + \beta_{\text{age}} * \text{age}$$

Finally, to estimate responses to the stress survey, individual responses to all questions from all participants was estimated simultaneously, with varying intercepts by participant and question type. The impacts of age, marriage, and the interaction were estimated by individual question type (denoted as x below) as varying slopes.

$$\text{Item} \sim \text{Ordered Logit}\,(\theta,\kappa)$$

$$\theta = \alpha + \alpha_{ID} + \alpha_{\text{type}} + \left(\beta_x + \beta_{x[\text{type}]}\right) * x...$$

For relevant predictors, the effect was evaluated by calculating the posterior probability of a negative or positive effect on the outcome (Pr[b>/<0]). All analyses were run in R (R Core Team, 2020) using the brms() package (Bürkner, 2017) with regularizing priors, using three chains of 8000 iterations per chain (half warmup). Convergence was assessed using the Gelman-Rubin convergence diagnostic ($\widehat{R} = 1$ in all model parameters). Additional packages used for data cleaning and visualization include tidyverse, janitor, tidybayes, modelr, and cowplot (Firke, 2021; Kay, 2020; Wickham, 2017, 2020; Wilke, 2017).

3 | RESULTS

Food insecurity surveys ($N = 235$ from 180 participants) indicate rising insecurity scores, and elevated household hunger across the sampling period. Between 2016 and 2019, food insecurity scores showed a 43% increase, and the percentage of respondents categorized as experiencing severe food insecurity went from 5% to 18%, while the percentage of respondents experiencing moderate food insecurity climbed from 41% to 63%. Likewise, model results indicate an increase in food insecurity by year (pr[b > 0] = 99.9%). When broken down by individual household hunger scale item, year predicted increased frequency of all individual items (pr[b > 0] >95%), except for "fewer meals" (Figures 2 and 3). The items "hunger at night" and "having no food in the house" showed the strongest responses to the effect of year of sampling.

Results from the diet breadth questionnaires ($N = 192$ from 162 participants) indicate a 15% decline in average diet breadth scores across the study period. Likewise, model results indicate significant changes in types of food consumed. Maize, meat, and melon showed little change in reported consumption (pr[b>/<0] <95%). In contrast, there was a significant drop in reported consumption of sour milk (pr[b < 0] >95%), while sugar and store-bought food showed modest increases (pr[b > 0] = 93% & 89.3%, Figures 2 and 4).

Results from the stress survey ($N = 127$) indicate that women are highly stressed about a number of concerns, with "often" being the modal response in seven of eight categories (Figure 5). Resource stressors were particularly salient, with 75% of women reporting that they worried often about having enough livestock. Model results illustrate differences between types of stressors. Correcting for age, marital status and individual respondent, we find that worries about livestock, children's health, and having enough food are the most likely domains to receive high stress responses (posterior medians of varying intercepts coefficients are 1.1, 0.6, and 0.2, respectively).

4 | DISCUSSION

As human-induced climate change continues to increase the likelihood of acute and chronic droughts, pastoralism is becoming an increasingly vulnerable subsistence strategy. For those like Himba, whose diet breadth has historically been restricted by a history of marginalization and limited access to the cash economy, drought can have particularly pernicious effects on food security, health, and well-being. Our data indicate that across one 3-year drought period, food insecurity and diet breadth progressively worsened. Stress scores further indicate that most Himba maintain a high level of concern about resource security and health issues.

Food insecurity covaries with other relevant health-related indices, suggesting multiplex pathways through which food insecurity both impacts and responds to inequalities and health outcomes. Food security has been linked to other stressors such as water insecurity, anxiety and depression, risk of HIV transmission and decreased access to HIV-related healthcare, and various markers of

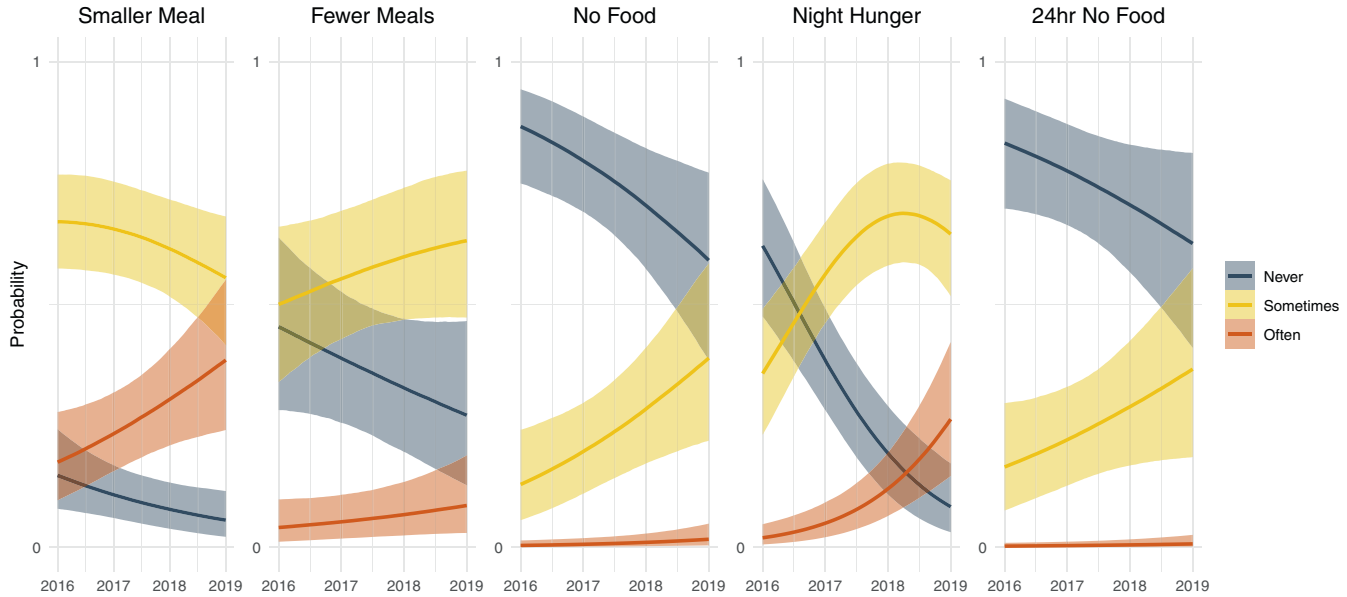

FIGURE 3 Posterior predictions of year on individual items in the household hunger scale (HHS). Each colored line (posterior median with 95% credible interval) shows the change in frequency of a particular response (never, sometimes, often) on the HHS across the study period

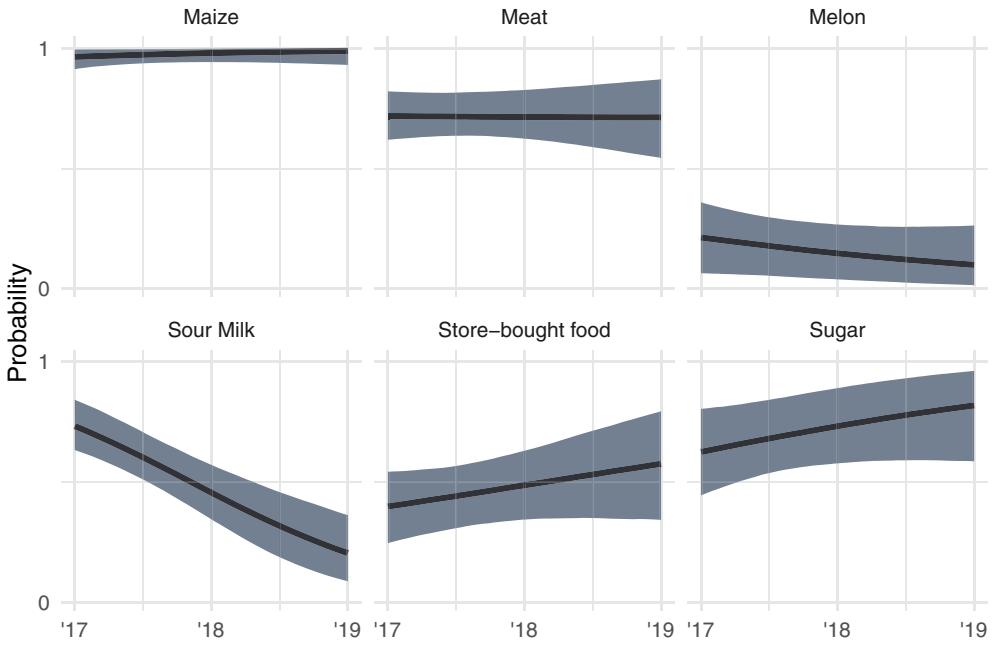

FIGURE 4 Posterior predictions of year on food recall by item type. Each colored line (posterior median with 95% credible interval) shows the change in probability of the food being reported across the study period

acute and chronic child health (Anema et al., 2009; Brewis et al., 2020; Hadley & Patil, 2008; Thomas et al., 2019). Our data indicate a meaningful decline in food security across the study period, in line with anecdotal reports about cattle loss, inadequate household food, loss of milking livestock, and increasing levels of hunger. However, individual food insecurity questionnaire item analysis indicates that some individual questions were less responsive to food insecurity shifts than others. The item "fewer meals" in particular showed the weakest response to year of data collection. It is possible that our respondents (mostly women) thought about the number of meals they cooked over the last 24 h, rather than how many meals they themselves ate. Several women noted that they would cook mainly for the children and the elderly when food was limited. This highlights that, even in well-validated survey instruments, cultural idiosyncrasies can impact outcomes.

Beyond food insecurity measures, shifts in diet breadth may be more illustrative of meaningful change

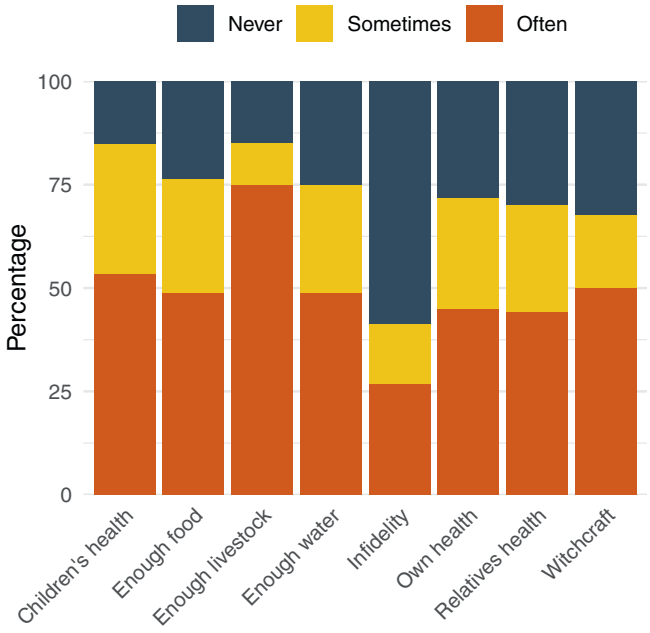

FIGURE 5 Frequency of responses to the stress survey by question type. Notably resource stressors, such as worries about children's health, food, and livestock are among the most common source of stress

in subsistence strategies. Our data show a steady elevation in the consumption of market-based foods, likely to make up for shortfalls in other areas. Many of these foods, which are typically purchased in local markets, are low nutrient starches, like rice and pasta, or sweetened beverages and other products with refined sugars (e.g., chips, biscuits). We also note an uptick in the consumption of sugar, a popular additive for tea and other foods. As food supplies decline, tea consumption may be rising, to keep hunger at bay. Likewise, maize showed no change in consumption over the study period. This may not reflect steady maize production in matrilineal gardens, as records of previous droughts and anecdotal reports during the current drought indicate a decline in garden production (Hazel et al., 2021). Rather, households are likely purchasing maize to supplement garden shortfalls. Meat consumption also shows no change across time in our data, though as with maize, this too may reflect shifts in the ways in which this item is consumed. Small stock, particularly goats, are more likely to be slaughtered during droughts (Bollig, 2006), while consumption of larger stock is likely declining, particularly as slaughters for ceremonial events may be less robust when times are tough. Therefore, while our data show little change in meat consumption across the study period, the increasing loss of livestock (particularly cattle) through die-offs, and slaughter can have major long-term ramifications for household wealth and well-being. Notably, in the stress survey, worries about having enough cattle were of greatest concern, suggesting that even though there were no meaningful shifts in the consumption of meat, current and future herd size was a particularly salient stressor.

In contrast to meat and maize, our data indicate a steep decline in the consumption of sour milk during the drought. As a food with high cultural salience, sour milk is the food most frequently referenced when Himba discuss drought or resource scarcity. It is highly valued for consumption, as an additive to maize meal porridge, and to produce butterfat for consumption and cosmetic use. Unlike maize, there is no adequate substitute when milk is unavailable, meaning that the loss of protein, amino acids, and micronutrients are unlikely to be made up elsewhere. This is particularly detrimental for children, who may require the amino acids (lysine in particular) present in milk but absent from maize-based foods (Sadler et al., 2009). Worries about children's health ranked as the second-most important response in the stressor survey, which may reflect inadequate access to important foods, including sour milk. Milk can also act as an important source of hydration for children and may be particularly important in an arid environment where access to clean and safe water is difficult. Water security is well known to have implications for infant feeding and child health (Schuster et al., 2020), and infants and children without access to milk may need to increase consumption of water. However, analysis of local wells in our study region indicate the presence of bacterial contamination and high levels of inorganic contaminants, making available drinking water "unsuitable for human consumption" (Wanke et al., 2014). As a result, reductions in livestock, and decreased livestock milk production can have wide-ranging effects on health, particularly child health, outside of loss of calories.

While we find changes in food security and diet associated with drought, our data do not highlight individual and household level variation in individual responses. Using a convenience sample allowed us to assess many individuals, some over multiple points in time, but an ideal study would analyze the same individuals year after year in response to local drought conditions and experiences. Individuals and households are not equitability impacted by drought, and level of wealth, access to cash markets, distance to markets and water wells, household size and demographic makeup, and placement within local social networks will all mediate experiences with drought (Hazel et al., 2021). Additionally, while we primarily focus on women, men may additionally experience drought related livestock differently. Future work should consider these effects when interpreting food insecurity scores.

Our focus here has been food insecurity and diet breadth; however, frequent severe droughts fueled by climate change can have repercussions in a number of other areas, including child health, gender disparities in household labor and education, migration to water-stressed urban centers, and political stability (World Food Programme, 2021). Unfortunately, climate predictions suggest continuing warming and drying trends in Namibia, indicating that these problems are likely to worsen in the future. The ways in which Himba respond to climate change are likely to reflect both their history, the ecology of their homelands and their access to other opportunities. Unlike other pastoralist groups, who have been able to shift to other sources of income, sell cattle on open markets, or migrate to less drought-ridden environments, Himba have fewer avenues available to them (Bollig, 2006; Inman et al., 2020). Over the last several decades, while Himba remained largely disconnected from market economies, they have nonetheless experienced increased access to the cash economy and exposure to majority-outgroup norms. These exposures are reflected in many aspects of Himba life (Scelza et al., 2019; Scelza et al., 2021), and will likely continue to affect how they respond to severe drought. Increasing sedentism, reliance on government assistance, and the use of store-bought grains and other goods in lieu of traditional foods are all likely to increase in the face of extreme drought conditions.

AUTHOR CONTRIBUTIONS

Sean Prall: Conceptualization; investigation; data curation; formal analysis; writing (lead); visualization. **Brooke Scelza:** Conceptualization; investigation; writing (supporting); funding acquisition.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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