Assessment of Drought Coping Strategies Practiced by the Households in the Oshipya District of Etayi Constituency in Northern Namibia:
An Item Response Theory Approach

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Abstract

The study objective was to estimate the level of vulnerability and resilience to drought for households in Oshipya District in the Etayi Constituency in nothern Namibia. Levels of household resilience and vulnerability to drought shocks were estimated from ex-ante and ex-post coping strategies respectively, using the Rasch item response theory model. The study showed that risk reduction coping strategies are poorly implemented, thus, making the communal households vulnerable to drought consequences. Instead, households resorted to impact management strategies like disposal of assets. It is encouraged that households prepare for drought by stocking crop residues, planting early maturing drought resistant crops, irrigation and diversification of livelihood activities and sending livestock to cattle posts. After the development of several policies and programmes on disaster risk management, thorough assessments of utilization and impact should be done regularly to reduce the expenditure on drought relief programmes as households will be more drought resilient.

Abstrak

Die doel van die studie was om die vlak van kwesbaarheid en weerstand teen droogte vir huishoudings, in die Oshipya-distrik in die Etayi kiesafdeling in Noord-Namibië, te skat. Die vlakke van huishoudelike veerkragtigheid en kwesbaarheid vir droogteskokke is onderskeidelik geskat aan die hand van strategieë vooraf en agter poste, met behulp van die Rasch-reaksie-teorie-model. Die studie het getoon dat strategieë vir die vermindering van risikovermindering swak geïmplementeer word, wat die gemeenskaplike huishoudings kwesbaar maak vir droogtegevolge. Huishoudings gebruik eerder impakbestuurstrategieë, soos om bates te verkoop. Dit word aangemoedig om huishoudings voor te berei op droogte deur oesreste op te hou, droogtebestande gewasse met vroegryp groei, besproeiing en diversifisering van lewensondernemings te plant en vee na veeposte te stuur. Na die ontwikkeling van verskeie beleide en programme rakende ramprisikobestuur, moet deeglike assessering van die benutting en impak gedoen word om die uitgawes aan droogtehulpprogramme te verminder, aangesien huishoudings bestand is teen droogte.

Introduction

Drought has been categorized as the most frequent climatological tragedy ahead of other natural disasters such as floods and earthquakes (Masendeke & Shoko 2013 Mdungela *et al.* 2017), affecting more people than other natural catastrophes (Agazzi, 2013) and more distressing effects for rural people especially those practicing rain-fed agriculture (African Adaptation Project 2010, Ndlovu, 2009). Agazzi goes on to say that half of the world's population will live in areas of high water scarcity by the year 2020. According to UNISDR (2013), economic losses by drought add up to hundreds of billions of dollars and are estimated to double by 2030. Drought directly affects production, livelihoods, assets and infrastructure as lives may be lost and social networks and capital investments may be destroyed while government funds may be diverted to emergencies. These may contribute to food insecurity and poverty. Namibia is the most arid country south of the Sahara and is vulnerable to undependable and erratic rainfall patterns, persistent droughts and high temperatures (Kaundjua, Angula & Entombed, 2012). A study conducted in Kunene Region found that poor rainfall continues to negatively impact on pastures, resulting in diminishing perennial water in most villages (Deon, 2016). Despite the country being susceptible to drought and other natural hazards, agriculture is still one of the main income sources, with 57% of its rural population relying heavily on agriculture as the main livelihood source (Namibia Statistical Agency (NSA) 2011).

Drought losses have long been attributed to poor vegetation, soil and water management and the absence of effective management strategies (Seymour & Desmet, 2009). Namibia is exposed to recurrent droughts (Amadhila, Rooy & Siyambambo 2013), making subsistence agriculture highly susceptible as it is mainly rain-fed, resulting in devastating impacts

on both livestock and crop production. As a result, there is need for communal farmers to have risk reduction mechanisms to guard against the shocking effects of drought. Such measures should include risk reduction measures in preparation for, and crisis control measures to mitigate shocks after the drought has already occurred. Drought and other risks management have constituted integral part of policy formulation in Namibia through the designing of The National Drought and Policy Strategy (NDPS) (1997), the National Disaster Risk Management Policy and the Hyogo Framework for Action (HFA), which seek to develop the resilience of communities and to move from the emergency response approach to integrated disaster risk management strategies (Amadhila *et al.* 2013). One of the objectives of the NDPS is to encourage farmers to adopt self-reliant approaches to drought risks, shifting the responsibility of handling drought effects from the government to the farmers with financial assistance and food interventions only to be considered in the event of an extreme or disaster drought being declared. The African Adaption Project (2010), Kuvare, Maharero and Kamupingene (2008) identified conservation and organic agriculture, crop diversification, early warning signals, crop irrigation, reduction of stock numbers, increase in extension services and rainwater harvesting to be some of the strategies that can be utilized by the Namibian farmers to mitigate drought effects. The government also called for the implementation of improved information gathering, analysis and dissemination techniques in order to convince farmers to prepare for up-coming droughts and other climate change disasters. However, after the development of such policy interventions, very few studies have been done to assess their utilization and impact.

Ex-ante and *ex-post* drought coping mechanisms

Coping strategies can be defined as short-term responses to an immediate and irregular decline in access to food (FAO, 1997), adopted to attempt to meet physiological, social, economic and political needs of everyday life during periods of drought and other natural disasters (Wisner, *et al,* 2004). According to Pandey and Bhandari (2007), risk-coping strategies can be classified into *ex-ante* and *ex-post* depending on whether they help to reduce risk *a priori* or reduce the impact of risk *posterior* to the disaster. *Ex-ante* mechanisms include awareness and production responses prior to the occurrence of the drought. These include the awareness of the upcoming drought, diversification of crop varieties, planting of drought resistant crops and soil and water conservation techniques in preparation for the impending drought. Crop diversification spreads the risks of total crop failure because if one crop fails, the other might survive. Cultivation of short-, medium- and long-term varieties reduce the risk of complete crop failure because early and late maturing usually react differently to drought (Manzungu, 1999). Incorporation of ethno-science coping mechanisms, such as conservation agriculture, which is a sustainable agricultural production system aimed at minimising soil disturbances and preserving water and soil through zero to minimal tillage and permanent soil cover through intercropping and mulching and crop rotations as well as fallowing to improve water holding capacity can mitigate

consequences of drought. Although there are some legal and legitimacy issues, small-scale farmers sometimes fence their grazing land to not only provide protection from predators but also improve grazing land and herd management (Werner). Other ex-ante coping practices include diversification of income generation which include non-farming activities like having a small shop and growing fruit trees.

On the other hand, risk reduction after the drought has already occurred and entails consumption response, migration and asset response. When people's ability is stretched by drought and the available resources no longer sustain the people, households often adjust their consumption patterns and reduce the number of meals per day or the quantity consumed per meal. In addition, household members often move to other areas in search for food and other means of accessing food such as temporary and permanent employment, resulting in increased seasonal out-migration. In addition, households may resort to less preferred wild fruits and vegetables as alternative sources of food. According to Chenje (1994), rural households in Botswana utilized over 250 wild species and animals during drought. In extreme cases, when farms are deprived of food by drought, they are forced to sell and liquidate their livestock and other productive assets in order to buy food (Carr 1997); where small assets such as chicken are sold first and then bigger assets such as livestock; ploughs and land are sold as a last resort (UNEP, 2002, FAO, 1997). In addition, Namibian households often practice pastoral nomadism in response to drought, where younger members of the community move animals to specific dry-season grazing areas known as "cattle posts" where grazing resources last throughout the dry season (Kunene River Awareness Kit, 2020). Furthermore, households are often forced to borrow and take quick loans at exorbitantly high interest rates in order to buy food.

Several studies have been done on drought coping strategies in the region. Masendeke and Shoko (2013) studied the coping strategies employed by households in Mberengwa District of Zimbabwe while Ndlovu (2009) conducted a similar study to determine the coping mechanisms utilized by communal households in Bulilima and Mangwe Districts of Matebeleland Province in Zimbabwe both under semi-arid to arid climatic conditions. Uddin *et al.* (2014) rated the importance of the coping strategies employed by households in Bangladesh using the Likert Scale continuum and computed coping strategy indices according to farmer perceptions on the importance of the coping strategy to their enterprises. However, most of these studies were on collection of qualitative research methods. Few studies have utilised quantitative statistical models to estimate the magnitude of the effects of coping strategies on household resilience and vulnerability to drought effects on a continuous continuum. The Namibia Vulnerability Assessment Committee (NAMVAC) has been established to conduct vulnerability assessments for early warning purposes and to identify vulnerable groups based on laid down indicators and assessment tools. However, they do not estimate vulnerability at household level.

Crisis control measures usually have negative effects on the socio-economic status of households as they may resort to disposal of productive assets or dispersing of family members. Risk reduction mechanisms, (ex-ante), give a measure of drought resilience

while crisis control coping strategies, (ex-post), give a measure of vulnerability to consequences of drought after the drought has already occurred. In this study, resilience is defined as the ability to adapt to drought risks by employing risk reduction coping strategies while vulnerability refers to exposure or susceptibility to drought shocks. The current researchers saw it necessary to carry out a study to rank the intensities of household resilience and vulnerability to drought risks and identify the strategies that are easy or severe for the households to employ in mitigation of the devastating consequences of drought using the item response theory (IRT) models. The study addresses the recommendations from Angula and Kaundjua's (2015) study that recommends the needs for estimation of vulnerability indices at household level.

Materials and Methods

Study area

The research was conducted in Oshipya District of Etayi Constituency in northern parts of Namibia. The district has approximately 257 households. The mopane bush *(Colophospermum mopane)* grows throughout the district and is primarily limited to 1.0–2.5m in height because of felling, making the district suitable for small scale livestock production. The soil type is mostly sandy and therefore, considered unsuitable for crop cultivation. The dry season lasts from May to October, while the rainy season extends from November to April. The population is mainly reliant on mixed farming agriculture through growing of pearl millet *(pennisetum glaucum),* locally known as *mahangu* and livestock husbandry through cattle and goats husbandry.

Sampling design and data collection

The target population for this study was small scale farmers in Oshipya Distict operating on less than ten hectares of land. The region, constituency and district was purposively selected, based on the fact that the area is susceptible to drought and other natural hazards. There are approximately 257 households in the district consisting of nine villages. Five of the nine villages were randomly chosen to represent the whole district. A sample of 80 households was selected randomly from an approximate total of 180 households in the 5 villages selected for the study. Households were selected using the Systematic Random Sampling method where in each village, a household was randomly chosen at the beginning of the sector and thereafter, every second household was sampled. A questionnaire was used to collect socio-econo-demographic data and data on binary responses (*yes*/*no*) to drought risk reduction and impact reduction coping strategies employed by the sampled households.

Ex-ante coping stragegies for drought preparedness considered include: the planting of drought resistance crops, diversification of livelihood activites, changing of croping systems where some households are now practicing conservation agriculture and intercropping, fencing of grazing areas and water sources, irrigation farming, fish farming, use of forestry conservation strategies, employment of soil conservation techniques as well as movement of livestock to *"cattle posts"* during drier times. The ex-post mitigation strategies utilised by households and considered in the structured questionnaire include asset disposal to buy food, displacement of household members due to food shortages, seeking formal and non-formal employment and seeking and consuming wild food due to food shortages.

Data analysis

The data was cleaned and checked for consistency and completeness before being subjected to descriptive statistical analysis for respondents and item attributes in IBM SPSS version 23 (2015) and item response theory (IRT) analysis using the R version 3.4.0 **eRm** and **ltm** packages. The household drought resilience and vulnerability levels were estimated from responses to ex-post and ex-ante coping strategies respectively, using the 2 parameter logistic (2PL) model for binary/dichotomous responses. The IRT modeling technique was used for analysis as it enables the estimation of latent levels of resilience and vulnerability to consequences of drought by taking cognisance of the item difficulty and person ability (vulnerability and resilience) levels. Such a scale is superior to an index computed by counting the number of coping strategies employed by a household or scores that gives equal weight to all coping strategies (Hargety & Land 2007) as one's ability cannot be judged by the number of correct items, but rather the item attributes/difficulty should be taken into account. In addition, the IRT techniques were selected ahead of methods like the multinomial logit or probit models because they provide estimates of a single scale for all coping strategies while the multinomial logit and probit models either handle coping mechanisms one at a time or restrict coping strategies to be category responses of a multiple responses item, thereby limiting the number of strategies a household can endorse.

The analytical framework

IRT models were developed for the purpose of measuring the unobservable ability (latent trait) of individuals based on their answers to a set of binary multinomial response questions. The models imply the existence of a "scale" on which the respondents can be placed based on their ability/proficiency levels. In the present study, the latent traits being measured are the levels of household adaptation/resilience and vulnerability to drought. The 2PL IRT model examines the fit of the questionnaire items measuring identical underlying constructs along a logit continuum, (Kilanowski & Lin 2012, Nord 2014), by combining information from multiple dichotomous (*yes*/*no*) items to rank the respondents on a

continuum of latent attribute being measured. The main objective is to estimate where the individuals fall on the scale. The model is based on the fact that the observed data consists of p manifest variables (X_1, X_2, ... X_p) that codes the responses as "1= *affirm*" and "0 = *not affirm*". The 2PL model is determined by the probability of affirming the binary response question, given the household's ability (θ_j) to give a correct response to item i, $P[X=1/\theta_j]$, and is given in equation 1:

$$P[X=1/\theta_j] = \frac{\exp\{a_i[\theta_j - b_i]\}}{1+\exp\{a_i(\theta_j - b_i)\}} \quad (1)$$

where b_i is the item severity/difficulty/location parameter and a_i is the discrimination parameter for item i which is greater than 0, captures the ability of each item to categorise the respondents according to the trait being measured.

The theory is that the probability of endorsing an individual item is decided by the difference between item severity (difficulty), and a person's location (ability) on the latent continuum. In this study, the item's difficulty is the level of vulnerability/resilience they capture, and the scale on which households are measured is the severity of the household's vulnerability to effects of drought or preparedness to deal with the effects of drought. The difficulty of an item is the severity level of households that are just at the point of affirming or denying that item. If an item severity is lower than the person's ability, it has more chance of being endorsed. The odds ratio that a household affirms an item right at its severity level is 1, corresponding to a probability of 0.5. As b increases, the probability of affirming the question decreases for a household with a specific value of θ. The households' resilience levels determine the probability of them affirming a given ex-ante coping strategy that defines their preparedness to deal with consequences of drought while the vulnerability level determines the chance of affirming an ex-post coping strategy denoting their exposure to drought shocks. The 2PL assumes that the questions are interpreted in the same way by all households in order to avoid bias in estimation of vulnerability and resilience. The model also assumes a monotonic increasing relationship between the latent variable and the probability of affirming the item and it assumes that items measure a single latent attribute (unidimensional).

Results

Items such as *use of forestry reservation strategies, use of community dam, fish farming* and *employment of soil conservation techniques* were removed from the analysis because their difficulty parameters could not be estimated as they were either affirmed or negated by all respondents.

Diagnostic checks for the assumptions of the Rasch model

Table 1a and Table 1b give the model diagnostic statistics for ex-ante and ex-post coping strategies respectively. The assumption of unidimensionality was assessed using the Cronbach's alpha that gives a measure of interval consistency.

From the findings in Table 1a, the item infit and item outfit statistics for all the ex-ante coping strategies are within the range 0.8–1.2, a range considered to be "very good" by Linacre and Wright (1994). Nord (2014) also agrees as he argues that it is a great indication that there is no wide discrepancy between the observed deviations of responses and the deviations of expected responses, leading to a conclusion that the 2PL model fits the data well. However, the overall Cronbach's alpha (0.4486) and all the other Cronbach's alpha were less than 0.7; an indication that there might be other latent variables being measured by the items other than the level of adaptation/resilience to drought.

The results shown in Table 1b indicate that except for "Sell assets" and "Disperse family members", outfit and infit mean squared statistics for the ex-ante coping strategies are

Table 1a: Diagnostic checks for Ex-ante coping strategies

Item No.	Item	Cronbach's alpha for Item excluded	Outfit MSQ	Infit MSQ
		0.4486		
1	Fence water source	0.4130	0.858	0.934
2	Fence grazing area	0.4165	0.931	0.974
3	Moved livestock to cattle post	0.3845	0.478	0.625
4	Changing cropping system	0.4453	1.017	1.047
5	Plant drought resistant crops	0.4040	0.957	0.949
6	Irrigate crops	0.3795	0.529	0.819
7	Prepared for drought	0.4378	0.930	1.004

Table 1b: Diagnostic checks for the Ex-post coping strategies

Item No.	Item	Cronbach's alpha for Item excluded	Outfit MSQ	Infit MSQ
	None	0.4763		
1	Sell Assets	0.5237	1.931	0.938
2	Seek Wild Food	0.3561	0.769	0.856
3	Disperse Family Members	0.3237	0.723	0.685
4	Work for food	0.3272	0.854	0.794
5	Seek Employment	0.5106	1.108	1.168

0.7–1.3 deemed to be usable by Linacre and Wright (1994) and Nord (2014). This implies that these items fit the Rasch model well. The outfit mean square statistics for the "Sell assets" item is greater than 1.5, which indicates that the item is less strongly or consistently related with vulnerability and hence, does not fit the data very well. On the other hand, the infit statistic for "Disperse family members" is less than 0.7, which implies that the item is strongly associated with household vulnerability and the information it provides might be undervalued. Contrary to the other goodness of fit statistics, all the Cronbach's alpha statistics are less than 0.7. This implies that the items might not be unidimensional, thereby measuring more than one latent attribute. This means that the ex-ante and ex-post items are usable in measuring the drought resilience and vulnerability respectively for households in Oshipya constituency, using IRT modelling.

Item characteristic curves for ex-ante and ex-post coping strategies

The item characteristic curves (ICC) in Figure 1a show that the easiest (most implemented) coping strategies for the communal farmers in Oshipya were the changing of the farming system and planting of drought resistant crops as farmers with low resilience. This shows that the farmers employed these coping strategies as signified by the ICC on the extreme left. Furthermoore, respondents with a 0.5 probability of using the strategies have a resilience level less than 0. However, fencing water sources, fencing of grazing areas, irrigation of crops and movement of livestock to cattle post were employed by more resilient households. Most of the households in Oshipya District have to some extent or another prepare for the drought as the ICC of item 7, inquiring about preparedness, is to the left of all the other items.

The ICCs for ex-post strategies (Figure 1b) show that the most difficult (less employed) risk mitigation coping strategy is the selling of assets to buy food as it requires a household

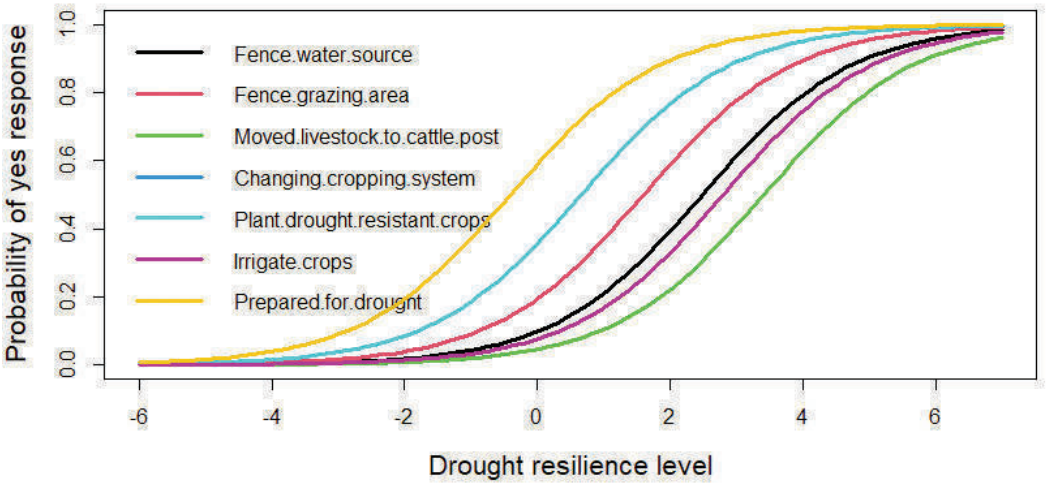

Figure 1a: Comparison of item difficulties for ex-post copying strategies.

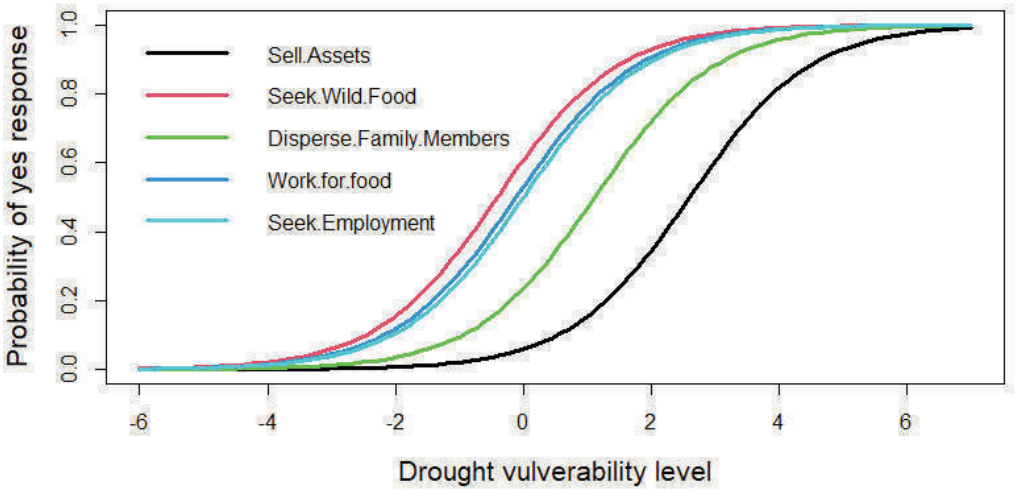

Figure 1b: Comparison of item difficulties for ex-post copying strategies

of vulnerability status of about 2.0 to give an affirmative answer with a probability of 0.5. This shows that it required households with very high levels of vulnerability to dispose assets due to food insecurity. Disposal of household members was fairly difficult and required households of vulnerability status more than 0 to have a 0.5 probability of implementing it. The easiest coping strategy employed by households in the event of drought was searching for wild fruits as it has the flattest ICC to the extreme left of all the other ICCs, followed by working for food. In addition, some households seek employment in the event of drought, although few work for food.

Item parameters for ex-ante and ex-post coping strategies

Table 2a gives the item attributes for the ex-ante strategies while Table 2b gives the item attributes for ex-post coping mechanisms. From the results in Table 2a, the most poorly utilized risk reduction coping strategy was the movement of livestock to cattle post with an item difficulty parameter of 1.656 and only affirmed by 6.25% of the sampled respondents, followed by the irrigation of crops which was endorsed by 10% with a difficulty parameter of 1.084. The easiest coping strategies were the changing of cropping system and planting of drought resistant crops with a difficulty parameter of -0.862, utilized by 37.5% of the households. The item that was most influential in disaggregating respondents, according to their levels of resilience, is the "irrigation of crops" with a discriminant parameter of 2.079 followed by "fencing of water sources" with a discriminant parameter of 1.19. The least discriminating item was the "changing of cropping systems with a discrimination parameter of 0.438. Only households high on the resilience scale fenced water sources (12.5%), fenced grazing areas (22.5%) irrigate crops. Only 6.25% of the sample households moved their cattle to cattle posts in times of drought.

According to the item parameter findings in Table 2b, the most difficult (poorly utlised) coping strategies were the selling of household productive assets to buy food (difficuty parameter = 2.117) only affirmed by 8.75% of the respondents, followed by the dispersal of family members due to high levels of food insecurity, affirmed by 27.5% of the respondentsand an IRT difficulty parameter = 0.490. However, the most commonly employed coping strategies were the seeking of wild food, practiced by 58.75% of the households (difficulty parameter = -1.119), followed by working for food and seeking of employment (difficulty parameter = -0.682), endorsed by 50% of the sampled households.

Person parameters (household resilience and vulnerability levels)

The person parameters (resilience and vulnerability) were estimated on a continuous scale ranging from -4 (poor) to 4 (high) with an expected average of 0. The sample estimates of the household levels of vulnerability to effects of drought ranged from -2.93 (the least vulnerable) to 3.21 (the most vulnerable), relative to other members in the sample with -0.64 being the average with a standard error of 0.169. The household resilience level ranged from 3.32 (least resilient) to 2.22 (most resilient) relative to other group members. The

Table 2a: Item information for ex-ante coping strategies (Resilience)

Item No	Item	Proportion *no*	Proportion *yes*	Difficulty parameter	Discriminant Parameter
1	Fence water source	0.8750	0.1250	0.792	1.190
2	Fence grazing area	0.7750	0.2250	-0.034	0.575
3	Moved livestock to cattle post	0.9375	0.0625	1.656	2.217
4	Changing cropping system	0.6250	0.3750	-0.862	0.438
5	Plant drought resistant crops	0.6250	0.3750	-0.862	1.126
6	Irrigate crops	0.9000	0.1000	1.084	2.079
7	Prepared for drought	0.4250	0.5750	-1.773	0.566

Table 2b: Item information for ex-post coping strategies

Item No	Item	Proportion *no*	Proportion *yes*	Difficulty parameter	Discriminant Parameter
1	Sell Assets	0.9125	0.0875	2.117	0.170
2	Seek Wild Food	0.4125	0.5875	-1.119	-1.782
3	Disperse Family Members	0.7250	0.2750	0.490	-1.368
4	Work for food	0.4750	0.5250	-0.805	-2.954
5	Seek Employment	0.5000	0.5000	-0.682	-0.358

mean of household level of resilience/preparedness to deal with consequences of drought is -1.46 (which is below the expected average of 0) with a standard error of 0.142. About 90% of the respondents have been ranked below 0 on the resilience/preparedness continuum, an indication that they are not very prepared according to the resilience items in the survey. On the other hand, about 35% of the households have been ranked to be above 0 on the vulnerability scale, that is, some of them have affirmed the most difficult/rare coping strategies like disposal of assets to buy food for the household at some point.

Diversification of livelihood activities

One of the ways of dealing with drought suggested in literature is diversification of sources of livelihood so that maybe some of the livelihood sources may subsist drought consequences. Figure 2 gives some of the livelihood strategies used by the Oshipya households to mitigate the effects of drought on food security and livestock husbandry. The planting of fruits and storage of pearl millet stalks were the most common strategies utilized for food security and animal feeds respectively. However, a sizeable fraction of the households did not use any of the extra coping measures highlighted.

One-way analysis of variance (ANOVA) was performed to check if there is a difference between the coping strategies and resilience levels for households that implement the livelihood activities in Table 3. There was a significant difference in the resilience levels for different livelihoods activities ($p < 0.05$) although the difference between the vulnerability levels was not statistically significant ($p > 0.05$). Table 4 gives the mean comparisons for the resilience and vulnerability levels. The results show that it is the least resilient households (mean = -3.32) and less vulnerable households (mean = -1.77) that resort to borrowing in the occurrence of drought. Preparation strategies like shop ownership, preservation of pearl millet stalks and planting of trees improves household level of drought adaptation. There is no significant difference in the resilience levels for households with no diversification

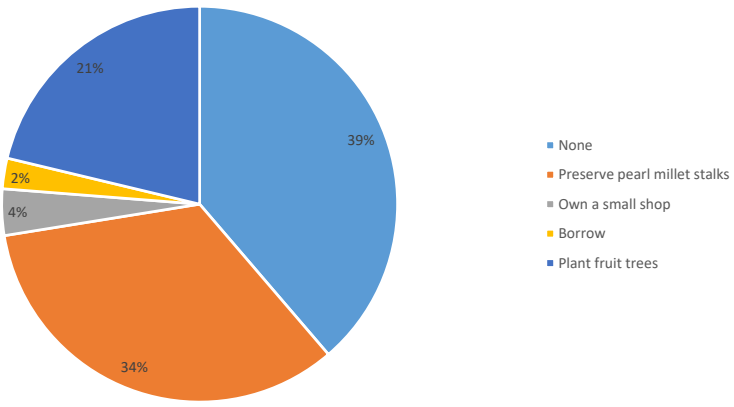

Figure 2: Other ways of preparing for drought

Table 3a: Person parameters for resilience levels

Resilience level	Frequency	Percent
-4 ≤ x < -3	12	15.0
-3 ≤ x < -2	24	30.0
-2 ≤ x < -1	23	28.8
-1 ≤ x < 0	13	16.3
0 ≤ x < 1	4	5.0
1 ≤ x < 2	2	2.5
2 ≤ x < 3	2	2.5
Total	80	100.0

Table 3b: Person parameters for vulnerability levels

Resilience level	Frequency	Percent
-3 ≤ x < -2	12	15.0
-2 ≤ x < -1	17	21.3
-1 ≤ x < 0	24	30.0
0 ≤ x < 1	17	21.3
1 ≤ x < 2	8	10.0
2 ≤ x < 3	0	0
3 ≤ x < 4	2	2.5
Total	80	100.0

Table 4: Mean comparison for types of coping strategies

Copying strategy	Resilience		Vulnerability	
Livelihood strategy	Mean	s.e.	Mean	s.e.
Borrow	-3.32a	0.18	-1.77a	0.26
None	-2.13a	0.20	-0.99a	0.31
Own a small shop to earn money	-1.26ab	0.54	-0.69a	0.38
Preserve pearl millet stalks for animals	-0.93b	0.00	-0.61a	1.16
Plant fruit trees to eat	-0.90b	0.36	-0.52a	0.41

mechanism in place and those that borrow and no significant difference between the resilience levels for households that preserve pearl millet stalk and households that planted fruit trees.

Discussion

The results have depicted low levels of drought resilience and high levels of vulnerability to drought. Only households high on the resilience scale fenced water sources and grazing areas, irrigate crops and moved their cattle to cattle posts in times of drought. This is probably because some of the copying strategies, such as fencing of water sources and grazing areas, are difficult to implement due to legal and legitimacy issues as highlighted by Werner (2012). Similar results were observed by Angula and Kaundjua (2015), who reported low adaption capacity for households in Ohangwena, Oshana and Omusati regions due to climate risk, social, political and cultural factors. The most common risk reduction coping strategies utilized by the Oshipya households are changing of cropping systems and planting of drought resistant crops varieties.

The current findings concur with other findings in literature. Iliffe (1980), in a study in Zimbabwe, reported the chief defence against food scarcity due to drought to be the production of drought resistant crops such as rapoko and pearl millet. Mdungela *et al.* (2017) discovered the planting of drought resistant crops to be relatively utilized by 44% of the sampled households in the drought prone Eastern Province of South Africa. Ndlovu (2009) advocated for the planting of drought resilient small grains which should be accompanied by promotional policies. Swearingen *et al.* (2000) and Mortimore and Adams (2001) observed the use of heat and drought resistant varieties to be beneficial strategies in Morocco and the Sahel region respectively. Furthermore, planting of drought resistant crop varieties like mahangu Okashana 1 and 2 varieties which are early maturing and resistant to drought has also been advocated for by the African Adaptation Project (2010) and Angula and Kaundjua (2015) as a way to combat the effects of drought and climate change in Namibia.

No one affirmed the item on soil conservation and conservation agriculture (CA), making it a very difficult coping strategy; hence, it was removed from the analysis. This is probably because soil and water conservation techniques are practiced in selected communities with the help of non-governmental organisations that are in partnership with the agricultural ministry. Henceforth, CA might not be implemented in the study community yet. However, soil and water conservation techniques were identified by Asfaw and Lipper (2011) to be important ways of climate change adaptation. CA calls for soil and moisture conservation through zero to minimum tillage, crop rotation and soil cover using crop residues. The African Adaptation Project (2010) and Kuvare *et al.* (2008) identified it to be one of the potential adaptation measures the Namibia households should employ to mitigate the effects of climate change and drought. However, the sustainability of such a farming principle is at stake as it may be incompatible with the strategy of saving crop residues for use as animal feeds in the event of drought.

Water management strategies are poorly utilized by households in the survey as very few households fenced water sources. However, water management strategies have been observed as a major factor influencing the household vulnerability to drought risks (Muhammad & Jayan 2013; Mdungela *et al.* 2017; Asfaw & Lipper 2011). Rainwater harvesting and water resource management are among the mitigation strategies encouraged for Namibia (African Adaptation Project 2010, Kuvare *et al.* 2008). In addition, irrigation agriculture was only employed by households higher on the resilience continuum. These findings are in agreement with Mdungela *et al.* (2017) who discovered irrigation to be a coping strategy employed by only 29% of the households in Eastern Province of South Africa. However, Uddin *et al.* (2014) observed an increased use of irrigation to be a common drought coping strategy in Bangladesh, highly rated by 75% of the households in their study. This is probably because water for irrigation is scarce in northern Namibia. Howden *et al.* (2007), and Eakin (2005), also identified the use of irrigation to be an effective way of mitigating the effects of climate change and environmental degradation. A study by Kuvare *et al.* (2008) concluded that irrigation agriculture is a possible means for agricultural populations to adopt to drought.

Households that diversified income sources were more resilient than households that rely on agriculture alone. However, the strategies were collected as categories of a single item on the questionnaire, without giving allowance for multiple responses and hence, information on households using more than activity might have been missed. Crop diversification and non-farm income generation activities were observed to be adaptation strategies that are practiced at household level in response to climate change (Ajao & Ogunniyi 2011, Martimore & Adams 2001; Tazeze *et al.* 2012) and significantly improved households' ability to cope with climate change effects. The government is encouraging the cultivation of high valued crops such as paprika, mushrooms and oriental tobacco as a way to mitigate the effects of climate change (Kuvare *et al.* 2008).

The study findings depict that movement of cattle to a cattle post was a rare coping strategy employed by very few highly resilient households. These findings are in agreement with the findings of Ndlovu (2009) who discovered that the households in Bulilima and Mangwe did not significantly employ this coping measure. However, the movement of livestock is not uncommon among pastoral nomads as they move their livestock in search of pastures. Campbell (1999) observed the Kenyan households to move their livestock to places where there is water and pastures. Livestock mobility and herd accumulation are the most important livestock management strategies (Kuvare *et al.* 2008) with movement to cattle posts as fall-back grazing areas as they are usually unused in normal times because of distance, land tenure constraints and water availability problems.

Crisis management coping strategies

The most commonly employed crisis management coping strategies in the event of drought are the seeking of wild fruits, working for food, migrating to seek employment. Dispersal of family members and disposal of assets were not very common but practiced by most vulnerable households according to the estimated vulnerability scale. The collection of wild foods and fruits was also noted in Zimbabwe in the 1982–84 drought where many rural households resorted to shelling marula *(sclerocarya birrea)* nuts for consumption and for sale (Chenje 1994). Ndlovu (2009) also noted that households resorted to consumption of unfavourable food stuff such as the drinking of wild okra and consumption of wild fruits.

Dispersal of family was deemed a rare coping strategy in this study. However, most households have members seeking employment or working for food within the locality, although a few had to migrate to other areas. These findings are in agreement with the argument of FAO (1997) who argued that labour migration and the selling of big assets such as livestock and fields are the last resort coping strategies. Masendeke and Shoko (2013), in their study in Ward 12, Mberengwa, Zimbabwe reported that male members of the households are sent out of the home to seek temporary and permanent employment and in acute situations, even females. Similar crisis management techniques were noted by Neetjes (2000) in a study in southern Niassa, Mozambique where many individual farmers

depended on piece work and some households dispersed young men to work in occupations such as the construction industry so as to fend for their families.

Productive assets such as cattle and ploughs play a significant economic role in rural households. However, the study showed that in extreme cases of vulnerability, households had to dispose their productive assets in order to buy food for the households. Most studies in literature agree that asset disposal is an extreme coping strategy employed only when there are no other alternatives and smaller assets are that sold first, then bigger assets like livestock, ploughs and fields are sold for food when conditions continue to worsen, (Carr1997, FAO 1997, Iliffe 1990, UNEP 2002). However, it is also vital to note that such extreme coping strategies were rarely employed, probably because households were receiving relief aid from the government and its stakeholders as the drought was declared disastrous. Contrary to these views, Ndlovu (2009) found the selling of livestock to be a very easy coping strategy as most of the households in the study disposed of their livestock to buy food. This is probably because the Bulilima and Mangwe districts in which her study was conducted are heavily reliant on livestock production as a source of livelihood. However, reduction of livestock numbers has been called for by the African Adaptation Project (2010), Ndlovu (2009), Sledger (2008) and Campbell (1999) as a way to handle the effects of drought by reducing the hard to manageable size as well as decreasing the loss of livestock dying because of drought. The farmers can likewise access funds to buy supplementary feeds for the other livestock during drought periods. The qualitative study by Angula and Kandjua (2015) noted that households in the northern parts of Namibia reduce the impact of drought by destocking and selling livestock to buy food. However, the selling of assets, if relied upon too much, can in the long run increase drought risk, as communities will depreciate productive assets to prepare for future droughts unless otherwise if the proceeds from such sales are saved and reinvested for rebuilding lost assets.

Conclusion

The objective of the study was to apply the IRT modelling technique to estimate the levels of household adaptation and vulnerability to drought using their responses to risk and impact management coping mechanisms. The results show low adaptation level is low and high vulnerability, implying that household resort on disaster risk response strategies than preparedness strategies. This is in agreement with Angula and Kaundjua's (2015) study that concluded that there were no long-term adaption options identified in their study areas and farmers orated that the existed strategies are not adequate to cope with more frequent and extreme incidents of drought with no local adaptation institutions in the villages they studied. Amadhila *et al.* (2013) and Kuvare *et al.* (2008) opined that subsistence agriculture remains vulnerable to extreme climate change effects as farmers resort to short term adaptation strategies. This might mean that the farmers are not capacitated enough to deal with extreme drought cases.

It is encouraged that the government and other stakeholders conduct a thorough assessment of the effects of drought on the community as well as the coping mechanisms that are utilised so as to identify gaps and the need for assistance. The government and its stakeholders should encourage effective drought management through risk identification, risk mitigation and emergency preparedness at both community and national level. It is recommended that households be encouraged to utilize farming techniques that reduce effects of drought and other climate change related hazards, such as planting drought resistant and short season varieties. Households should store crop residues and other supplementary feeds for their livestock in the drier seasons, diversify livelihood activities to include non-farming activities and move their livestock to cattle posts where they will get enough feeds. It is suggested that such viable strategies be incorporated into policies and mechanisms to encourage farmers to adopt and cope with drought at household level so as to reduce dependency from relief food supplements which have been noted to cause dependency syndrome among the beneficiary households if over utilized (Ndlovu 2009, National Drought Task Force 1997).

Conservation agriculture is not yet employed in Oshipya District, although it has been identified to be one of the potential adaptation measures for drought prone Namibia. However, the farming technique calls for permanent soil cover using crop residues in order to conserve soil moisture. Research should be done to assess the sustainability of the farming mechanism since it appears incongruent to the concept of keeping crop residues for feeding livestock in the event of drought. In summary, adaptation practices require extensive research and high-quality information on the effects of climate change on agriculture, environment and social systems so that the strategies to be implemented can aim to address all these issues. The need for drought adaptation may not be over emphasized as lives may be lost while social networks and capital investments may be disrupted and government funds rechannelled to emergencies.

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