Risk preferences under multiple risk conditions – survey evidence from semi-arid rangelands

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Summary

We elicited risk preferences and their determinants through a mail survey for commercial cattle farmers in semi-arid rangelands of Namibia, a system that features environmental risks on various space and time scales. We analyzed (i) the occurrence of specific risk preferences, (ii) their relationship with personal and farm business characteristics, and (iii) their relationship with local environmental risk. We found that farmers were generally risk averse, and that risk aversion varied significantly with personal and farm business characteristics. Furthermore, there is tentative evidence that risk aversion was negatively related to environmental risk and does partly depend on regional location of the farm. These results have implications for the design of institutional frameworks for risk management and the application of ex-ante concepts of sustainability under uncertainty.

JEL-Classification: Q15, Q24, Q57

Keywords: environmental risk, risk preferences, survey elicitation, semi-arid rangelands, sustainability

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I. Introduction

Ecosystem users depend upon the spatio-temporal provision of ecosystem services. However, many ecosystem services are influenced by risks acting on various space and time scales. The user's attitude towards risk will therefore influence his management decisions, and this holds in particular for grazing management in semi-arid rangelands.

Risk preferences have been extensively studied in arid and semi-arid regions using the expected utility framework. One approach is the econometric estimation of preferences from production data. This approach has for example been applied in studies on farming in India (Antle 1987), Israel (Bar-Shira et al. 1997) or Cyprus (Groom et al. 2008). A different approach is the direct measurement of risk preference through experiments involving real or hypothetical payout. This approach was performed in studies on farming in India (Binswanger 1980), Madagascar (Nielsen 2001), Zambia (Wik et al. 2004), Ethiopia, Uganda and India (Harrison et al. 2005, Mosley and Verschoor 2005) and Ethiopia (Benzabih 2009, Yesuf and Bluffstone 2009).

These studies found that farmers were generally risk-averse. Furthermore, risk preferences are thought to vary systematically with personal and farm business characteristics. However, evidence from studies in semi-arid regions is scant and often ambiguous. Risk aversion has been found to be higher for females (Wik et al. 2004) and less educated farmers (Binswanger 1980). Age had a positive (Yesuf and Bluffstone 2009) or negative (Harrison et al. 2005) effect on risk aversion, and risk aversion increased (Yesuf and Bluffstone 2009) or decreased with household size (Wik et al. 2004). Farm characteristics such as area of land or number of livestock were negatively related to risk aversion (Yesuf and Bluffstone 2009), and investment into risk management strategies either related (Bezabih 2009) or unrelated (Wik et al. 2004). However, none of these studies on farming in semi-arid regions explored the relationship between risk preferences and environmental risk.

This study examines risk preferences, elicited in experiments with hypothetical payouts, and their determinants in a semi-arid system with multiple risk conditions. As a case study we have chosen commercial cattle farming in semi-arid rangelands of Namibia, because it constitutes a tightly coupled ecological-economic system of high economic importance (Quaas et al. 2007) and is a prime object of study for ecological economics (e.g. Perrings and Walker 2004, Baumgärtner and Quaas 2009). Approximately 2,500 commercial farmers conduct cattle farming in Namibia which is subject to a variety of environmental, economic, political and social risks. Predominant among these is uncertain precipitation and the resulting uncertain forage. Namibia has a mean annual rainfall of approximately 270 mm, but precipitation is highly variable across the country with the coefficient of variation of annual precipitation ranging from below 30% in the Oshikoto region to over 100% in the Erongo region (Sweet 1998, Mendelsohn et al. 2003).

In August 2008 we have conducted a survey with 2,119 commercial cattle farmers in Namibia. Therein, we collected information on ambient risk conditions, the farmers' risk preferences and personal, farm business and environmental characteristics. In this context we explore the following questions: What risk preferences occur among cattle farmers? Do risk preferences vary systematically with personal and farm business characteristics? And finally, are risk preferences related to local environmental risk?

We proceed as follows: Section II elaborates on the methods used to collect and analyze the data. We present results in section III. Finally, we discuss results in Section IV and conclude.

II. Data collection and statistical specification

II.1 Data collection

Description of the survey

Risk preferences, personal, farm business and environmental characteristics of commercial cattle farmers in Namibia were elicited in a mail survey. Prior to the design of the survey we undertook two research journeys to Namibia in March and October 2007 to acquire a sound understanding of system dynamics, decision making and management strategies in commercial cattle farming. During these journeys we conducted a series of qualitative interviews with farmers, experts and decision makers of the agricultural, political and financial sector. Based on the information gained therein we designed the questionnaire and revised it with feedback gained in two pre-testing rounds in October 2007 and June 2008.

We sent out questionnaires to all cattle farming members of the Namibia Agricultural Union (NAU), the main interest group of commercial farmers, and to all farmers that deliver cattle to MeatCo, Namibia's largest slaughterhouse. We mailed out a first batch of questionnaires in the period 19th – 21st of August 2008, and a second batch as a follow up on the 15th of September 2008. Additionally, we randomly selected 39 NAU members for further economic experiments (not discussed here) where questionnaires were completed in the presence of a researcher. Altogether, we reached 1,916 of the estimated 2,500 commercial cattle farmers (76.6%). 399 questionnaires were returned, equaling a return rate of 20.8%.

Elicitation of risk preferences

Within the questionnaire, we measured risk preferences by an adapted multiple price list format involving hypothetical payouts. The method was pioneered in the elicitation of risk preferences by Binswanger (1980) and has since been regularly employed (e.g. Holt and Laundry 2002, Harrison et al. 2005, Anderson et al. 2008). Subjects choose for a number of scenarios between participating in a lottery or receiving a certain payment instead. Scenarios differ in regard to the certain amount, which increases from the first to the last scenario. Subjects in these experiments typically prefer the lottery when the certain amount is low, and switch once the certain amount is deemed high enough.

We presented farmers with six scenarios, where we framed the lottery in the context of selling cattle at an auction. The auction had two possible outcomes for revenues, N$90,000 and N$130,000, each occurring with equal probability. The expected value of the auction (N$110,000) reflected about 1/3 of the annual net income of the average farmer. Instead of taking part in the uncertain auction, farmers could chose to sell to a trader for a certain amount which started at N$100,000 in the first scenario and increased in steps of N$2,500 to N$112,500 in the sixth scenario.

Based on the choices observed in each scenario parameters of an expected utility function can be estimated. Expected utility functions that exhibit constant relative risk aversion (CRRA) are a parametric family of functions that is often used in empirical studies on risk preferences (e.g. Holt and Laury 2002, Harrison et al. 2005, Anderson et al. 2008) and have been shown to adequately explain individual's choices over local income domains (Holt and Laury 2002). We assumed in this paper that CRRA holds for our study population and used the specific function $U(y) = y^{(1-r)} / (1-r)$ where *y* was income and *r* the coefficient of relative risk aversion. Based on this function, indifference between the auction and the amount offered by the trader in scenarios 1 to 6 corresponded to CRRA values of 6.32, 4.38, 2.79, 1.37, 0.00 and –1.40, respectively.

II.2 Statistical specification

Personal, farm business, environmental characteristics and environmental risk

Based on the information gained from our qualitative interviews we selected those personal, farm business, and environmental characteristics that we deemed relevant for our analysis of risk preferences. Table 1 lists the respective variables, their sample mean and standard deviation. The meaning of most variables becomes apparent from their description in this table. Data was predominantly recorded in the form of ordinal measurements, except for the variables age, household size, area of rangeland and size of cattle herd which were recorded as cardinal measurements.

Data on environmental risk in the form of rainy season variability was recorded by a six-item Likert-scale where farmers were asked to rate each of the previous five rainy season. Whether Likert-scale data has to be viewed as ordinal measurements or whether it may also be viewed as cardinal measurements is controverse. When the data is considered to be ordinal, variability in rainy seasons can at most be inferred as the range between the lowest and highest rating of the five rainy seasons. This obviously yields only a crude measurement of risk as further information on the distribution of ratings is omitted. A more refined measurement of risk can be achieved when considering Likert-scale data to be interval measurements. In this case, rainy season variability can be calculated as the coefficient of variation (CV) of ratings, i.e. the ratio of standard deviation to mean.

We took the conservative view by considering Likert-scales to yield ordinal measurements and performed our analysis accordingly by coding rainy season variability as the range between lowest and highest rating. We did, however, repeat the analysis with rainy season variability coded as the cardinal CV, and note the results in the respective sections.

Maximum likelihood specification

We followed in our econometric specification of the expected utility function the approach proposed by Holt and Laundry (2002), which was subsequently applied to studies in semi-arid areas by Harrison et al. (2005). For the risk experiments, the expected utility of the auction was defined as

$$EU_i^A = p_1 U(y_1) + p_2 U(y_2)$$

with p_1 and y_1 being probability and income for outcome 1, p_2 and y_2 probability and income for outcome 2. Since probabilities and incomes from the auction were the same for all scenarios, it followed that

$$EU_i^A = 0.5\ U(N\$90{,}000) + 0.5\ U(N\$130{,}000)$$

The expected utility for income from the trader was defined accordingly. Since this income was certain, the expected utility function reduced to $EU^T_i = U(y_c)$ where y_c was the certain income from the trader.

We estimated the coefficient *r* for the observed choices in each scenario with a maximum likelihood estimation. This estimation assumed a logistic cumulative probability distribution defined over EU difference for the observed choices in each scenario, that is $\nabla EU = EU^A - EU^T$. Thus, the log-likelihood function, conditional on the expected utility model and our CRRA specification being true, was

$$\ln L^{EUT}(r; z, X) = \sum_i \left((\ln(\nabla EU) \mid z_i = 1) + (\ln(1 - \nabla EU) \mid z_i = 0) \right)$$

where $z_i = 1$ (0) denoted whether the subject chose the auction (trader) in the scenario *i*, and *X* was a vector of personal, farm business, environmental characteristics and environmental risk as described in the previous section. We assumed that the parameter *r* was a linear function of these characteristics.

We further assumed that responses of a single farmer were correlated (i.e. that the choice in one scenario was not independent from the choices in the other scenarios). We thus corrected the standard errors by clustering all the responses for a single farmer. By doing so we effectively created a panel which was stratified by farmers.

When analyzing raw responses for the risk experiments it became apparent that farmers who mailed in questionnaires frequently made choices that would have characterize them as extremely risk averse or extremely risk attracted (Figure 1a). Such a pattern was not apparent for those 39 farmer that completed the questionnaire in the presence of a researcher (during our experimental sessions). A two sample Kolmogorov-Smirnov test for equality of distributions revealed significant differences between both groups (p=0.032). In the sessions where a researcher was present we observed that it frequently took farmers a long time to complete the hypothetical risk experiment in the questionnaire. Furthermore, after having filled in the questionnaire some farmers remarked that they had to put aside a personal aversion to selling at auctions or to a trader, respectively, in order to do the experiment as intended.

Based on these observations, we considered the extreme responses of those farmers who mailed-in questionnaires likely to be experimental artifacts that do not reflect true risk preferences. As a robustness check we therefore excluded these farmers in our analysis. A subsequent two sample Kolmogorov-Smirnov test was no longer significant (p=0.626) (Figure 1b). The above described maximum likelihood-estimation is thus at the tails defined only over responses from the 39 experimental participants for which we were certain that they indicated true risk preferences.

III. Results

We found Namibian commercial cattle farmers to be risk averse, with a CRRA coefficient of 0.69 when performing the analysis without any covariates (Table 2a). This value was essentially unchanged at 0.70 when including covariates (Table 2b). Either way, the CRRA coefficient was significantly different from risk neutrality at the 1%-significance level ($p<0.001$).

When we controlled for covariates we found that few variables had a significant effect on risk aversion. Among the personal characteristics we found that gender was significantly related to risk aversion ($p=0.024$) with male farmers being more risk averse than female farmers. Likewise education had a significant effect, with farmers of medium and high education being less risk averse than farmers of low education ($p=0.001$ and $p=0.017$, respectively). None of the other personal characteristics – i.e. age, ethnicity or household size – had a significant effect.

In regards to farm business characteristics we found that residence on the farm was significantly related to risk aversion ($p=0.024$) with farmers who lived on the farm during the week being more risk averse than farmers who lived on the farm only part-time. We found no further significant effect of the farm business characteristics cooperative ownership, area of rangeland, number of cattle herd, net income or proportion of income from cattle farming.

Finally, environmental risk as indicated by the farmer had a significant effect on risk aversion, with farmer that experienced medium or high interannual variability in rainy seasons being less risk averse than those who experienced low variability ($p=0.040$ and $p=0.003$). The decrease in risk aversion was stronger for farmers who experiencing high variability than for those who experienced medium variability. We also found a significant effect of regional location of farmland. Farmers from Oshikoto – a region with high annual precipitation and low variability – were less risk averse than farmers from Erongo, the region with the lowest precipitation and highest variability ($p=0.014$). No other regional location was related to risk aversion.

When we repeated the analysis with the parametric CV of interannual rainy season variability instead of the non-parametric range measure we likewise found a significant negative effect of variability on risk aversion ($p=0.038$). The size of the effect was similar as in the previous analysis (coefficient = -0.08). Significance, sign and magnitude of the coefficients of other covariates were unchanged in the second analysis in comparison with the first.

IV. Discussion and Conclusion

We analyzed risk preferences of ecosystem users under multiple risk conditions. We found that commercial cattle farmers are risk avers and that risk aversion differs systematically with different population segments as well as certain farm business and environmental characteristics. Furthermore, risk aversion also differs in relation to local environmental risk. In this concluding section we discuss these results.

Personal and farm business characteristics

Risk aversion was significantly related to gender of the farmer where men were more risk averse than women. These findings were contrary to those usually found in a non-farming context were men are less risk averse than women (e.g. Eckel and Grossmann 2008) and which were also found in studies of semi-arid areas of Zambia (Wik et. al 2004). We cannot conclusively explain our findings but note that the proportion of women was low (only 3.72%) and that these results may not hold for a larger sample.

Higher education was negatively related to risk aversion in our study, i.e. more educated farmers were more willing to take risks. This result corresponds to what was found for Indian farmer (Binswanger 1980) and which has also frequently been observed in a non-farming context (e.g. Shaw 1996, Guiso and Paiella 2008). The relationship between education and risk aversion is not well understood. One explanation is that education constitutes an investment into human capital whose returns are risky – due to uncertainty in the precise nature of skills that would be acquired and in the future payoff for these acquired skills – and that thus more risk attracted individuals rather pursue such an investment (Shaw 1996). The same reasoning may be applied to the farming context. Farmers in Namibia frequently grown up on farms and thus already acquire essential skills which enables them to lead a farm business. Pursue of higher education may be viewed as risky as farmers may be uncertain if and to what extend the farm business might benefit from additional skills.

We found farmer who resided on the farm – a proxy for full-time farming – to be more risk averse that farmers who only visited the farm on the weekend. The latter group of farmers usually derive their primary income from non-farming sources and often practice farming as a minor income source or even hobby. Thus, these results suggest that farmers who were fully dependent on income form the high-risk farming source rather avoided taking risks than part-time farmers since wrong management decisions would have had a more detrimental impact on their well-being.

We found no other significant effect of personal or farm business characteristics on risk aversion. In regards to those farm business characteristics that reflect risk management strategies this was somewhat surprising, since risk aversion has been found to be related to the pursue of such strategies (e.g. Bezabih 2009). This may indicate that farmers do not consider the analyzed strategies purely under the aspect of risk management. For example, it became apparent from our qualitative interviews that many farmers refrained from entering into shared ownership relationships due to an aversion of having to share authority and due to a perceived loss of status, even though they were fully aware of the risk-sharing benefits of such agreements. The missing relation of risk aversion and pursued risk management strategies may also be due to constraints in the application of certain strategies. For example, diversification into other on-farm income sources such as hunting or crop farming may be impossible for some farmers when environmental conditions does not allow such a diversification (e.g. not sufficient wild in the area or climatic conditions being too dry for crop farming).

Environmental characteristics and risk

We found a significant negative effect between environmental risk of rainy seasons variability on risk aversion when using range of season ratings as a measurement of variability. Rainy season ratings do not merely value the precipitation patterns of a given season, but rather pasture conditions – thus integrating effect from precipitation pattern with other determinants of pasture condition. A link between environmental variability and risk aversion may indicate that farmers self-select themselves into local risk conditions according to their preferences, i.e. that risk averse farmers selectively settle in less risky environments. Alternatively, such a link may indicate that risk preferences itself are shaped by environmental risk conditions. Our survey was not designed to explore these mechanism, and we thus cannot provide any conclusive explanation.

Furthermore, range measurements are only crude approximations to risk as they does not take into account underlying distributions. Our second analysis was conducted with the cardinal CV, a measure which considers the distribution and which has been previously used to measure environmental risk (e.g. Tanaka et al. 2009). This analysis likewise showed a positive relationship between environmental risk and risk preferences, but we are skeptic towards this result due to the methodological issues discussed in Section II.2. We thus take our findings as an indication that risk preferences may indeed be related to local environmental risk but note such a relationship needs to be confirmed though further analyses.

We also found that farmers living in Oshikoto, a region with high annual precipitation and low interannual precipitation risk were less risk averse than those living in Erongo, the region with lowest precipitation and highest precipitation risk. These results seem to contradict those discussed above. However, only 2.13% of the sampled farmers lived in Oshikoto, making these results unreliable due to the low number of observations. Furthermore, many more aspects than amount of precipitation and precipitation risk are associated with regional location, but we could not separate these aspects in our analysis. Thus, we simply note a partial effect of regional location on risk preferences without explaining the precise mechanism.

Conclusion

Our study provides a deeper insight into risk preferences of ecosystem users in an ecological-economic system that exhibits multiple risk conditions. The results are of importance for the design of institutional frameworks that provide risk management to ecosystem users. Results become especially relevant when considering which actions lead to a sustainable use of ecosystem services in such a system under uncertainty since ex-ante concepts of sustainability under uncertainty like viability (see Baumgärtner and Quaas 2009) require knowledge of risk preferences for the design of adequate actions. The erroneous assumption of risk-neutrality may lead to an inadequate design of actions that are not suited to reach sustainability targets. Actions may also have to be tailored to specific population segments. Finally, our results give a tentative indication that ambient risk conditions may also have to be considered in a design of such actions, due to a possible relationship with risk preferences.

Our results present an incentive to continue the exploration of the relationship between risk preferences and environmental risk. We will do so by combining and calibrating data from this survey with small-scale measurement of rainfall attained from other databases. Results on these analyses are forthcoming and we hope to underpin our present results in the near future.

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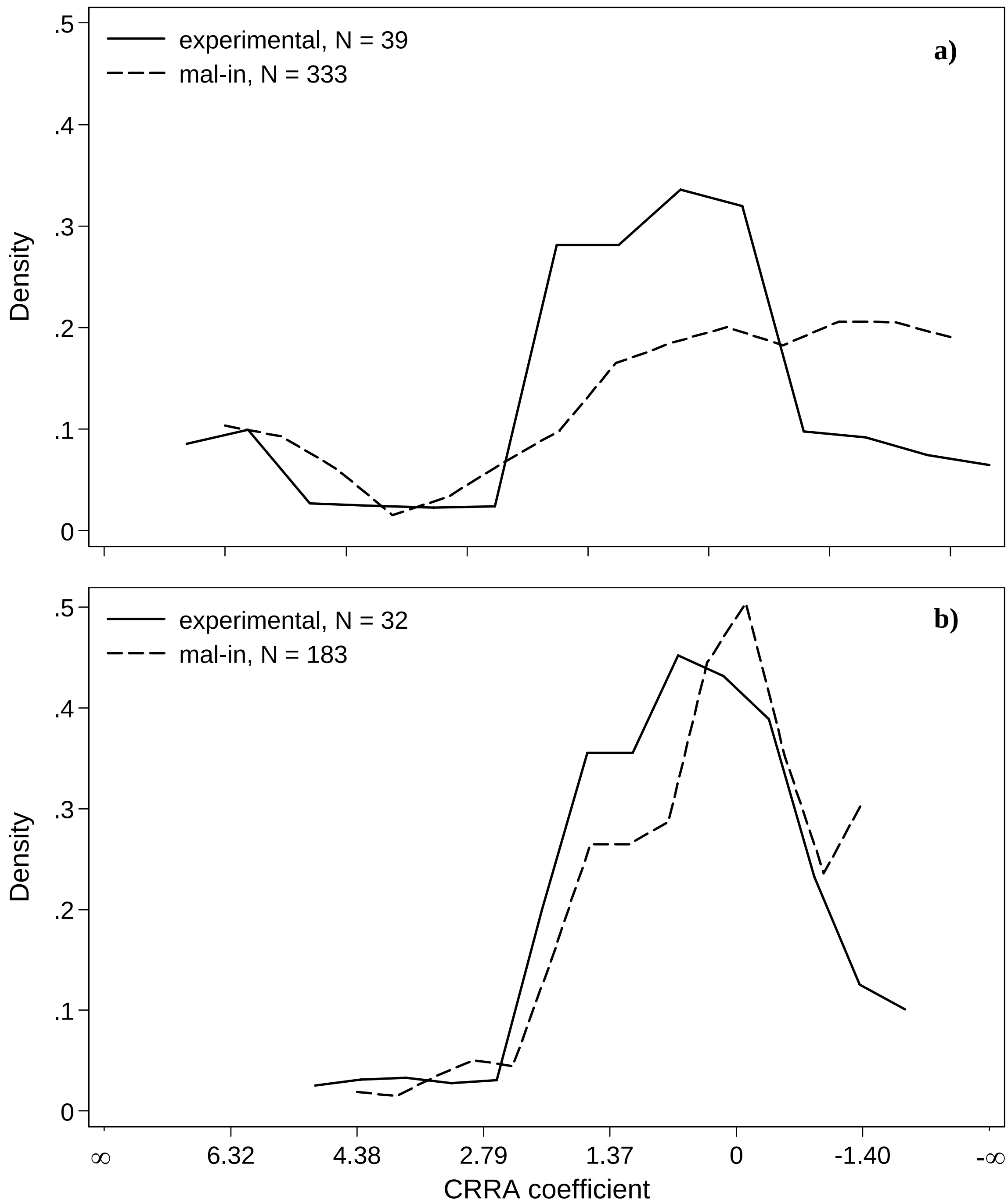

Figure 1: Distribution of responses in risk experiments, shown as the CRRA coefficient of the scenario where farmers switched from the choice for the lottery to the choice for the certain amount. a) with extreme responses, b) without extreme responses.

Table 1: Variable list and descriptive statistics.

Variables	Definition	Sample mean (stand. deviation)
Personal characteristics		
male	Male	96.28%
german	German	45.21%
afrikaans	Afrikaans	51.60%
other ethnicity	Other ethnic groups	3.19%
low education	High school graduation or lower	18.62%
medium education	Trade certificate or bachelor	63.83%
high education	Master or PhD	17.55%
age	Age	53.18 y (11.54 y)
household size	Number of persons in household	3.31 (1.56)
Farm business characteristics		
residence on farm	Residence on farm	79.26%
single ownership	Single ownership of farm	70.27%
cooperative ownership	Cooperative ownership of farm	29.73%
area of rangeland	Area of rangeland	8208 ha (5183 ha)
number of cattle	Number of cattle in November 2007	441 (328)
low income	Annual net income ≤ N$150,000	26.06%
medium income	Annual net income N$150,001 - N$350,000	37.24%
high income	Annual net income >N$350,000	21.28%
low proportion of cattle farming	Proportion of net income from cattle farming ≤ 20%	13.83%
medium proportion of cattle farming	Proportion of net income from cattle farming 21% - 60%	31.38%
high proportion of cattle farming	Proportion of net income from cattle farming > 60%	49.46%
Environmental characteristics and risk		
low range of rainy season variability	Range in variability of rainy seasons 2003-2008 zero or one point	7.98%
medium range of rainy season variability	Range in variability of rainy seasons 2003-2008 two or three points	48.41%
high range of rainy season variability	Range in variability of rainy seasons 2003-2008 four or five points	43.62%
Erongo	Erongo region	5.85%
Hardap	Hardap region	3.19%
Karas	Karas region	0.53%
Khomas	Khomas region	22.87%
Kunene	Kunene region	7.45%
Omaheke	Omaheke region	20.21%
Oshikoto	Oshikoto region	2.13%
Otjozondjupa	Otjozondjupa region	37.77%

Table 2: Maximum likelihood estimation of expected utility model of choice. a) Estimation without covariates, N = 222. b) Estimation with covariates for personal, farm business, environmental characteristics and environmental risk. N = 188.

Variables	Estimate	Standard error	p-Value	95% confidence interval	
a) Without covariates					
Constant	0.68719	0.00803	0.000**	0.6714	0.7029
b) With covariates					
Constant	0.70122	0.05522	0.000**	0.5930	0.8095
Personal characteristics					
male	0.05953	0.02632	0.024*	0.0079	0.1111
afrikaans	-0.01533	0.01321	0.246	-0.0412	0.0105
other ethnicity	0.03055	0.04657	0.512	-0.0607	0.1218
medium education	-0.05962	0.01772	0.001**	-0.0943	-0.0249
high education	-0.04809	0.02009	0.017*	-0.0875	-0.0087
age	0.00046	0.00057	0.417	-0.0006	0.0016
household size	0.00285	0.00436	0.514	-0.0057	0.0114
Farm business characteristics					
residence on farm	0.03728	0.01524	0.014*	0.0074	0.0671
cooperative ownership	-0.02188	0.01339	0.102	-0.0481	0.0044
area of rangeland	0.0000004	0.0000014	0.794	-0.000002	0.000003
number of cattle	-0.00003	0.00003	0.295	-0.000078	0.000024
medium income	-0.01168	0.01501	0.436	-0.0411	0.0177
high income	-0.01030	0.01659	0.535	-0.0428	0.0222
medium proportion of cattle farming	-0.00701	0.01804	0.698	-0.0424	0.0284
high proportion of cattle farming	-0.00683	0.01847	0.712	-0.0430	0.0294
Environmental characteristics and risk					
medium range of rainy season variability	-0.05962	0.02901	0.040*	-0.1165	-0.0028
high range of rainy season variability	-0.08465	0.02816	0.003**	-0.1398	-0.0295
Hardap	-0.05129	0.03487	0.141	-0.1196	0.0171
Karas	0.03252	0.03033	0.284	-0.0269	0.0920
Khomas	0.00897	0.02268	0.692	-0.0355	0.0534
Kunene	-0.02688	0.03058	0.380	-0.0868	0.0331
Omaheke	0.01070	0.02682	0.690	-0.0419	0.0633
Oshikoto	-0.07595	0.03080	0.014*	-0.1363	-0.0156
Otjozondjupa	-0.00400	0.02132	0.851	-0.0458	0.0378