Farmer's Choice of Drought Coping Strategies to Sustain Productivity in the Eastern Cape Province of South Africa

Nomalanga Mary Mdungela, Yonas Tesfamariam Bahta and Andries Johannes Jordaan

Abstract: This paper determines the factors that influence communal farmers' choice of coping strategies to sustain productivity during drought and to determine current adaptation and coping capacities for drought risk in the Eastern Cape province of South Africa using field surveys, structured and semi-structured interviews and a multinomial probit model. The results identified three main coping strategies used by farmers, namely: irrigation, diversification and drought resistant crops/breeds. On average, most farmers used drought resistant crops/breeds (44%), 32% practiced farm diversification, while 29% used irrigation. Farmers who receive relevant information, have experience and receive sufficient income from their work are more likely to adopt resistant crop varieties and choose suitable animal breeds in case of drought. Access to water has, of course, a significant impact and is positively related to the probability of farmers not adopting any coping strategies. The variable risk level was significant and negatively related to the probability of adopting irrigation as a strategy to address drought. Record keeping was also highly significant and positively associated with the probability of using farm diversification to address drought issues. Education and extension services were not significant. Such viable strategies to reduce the farmer's vulnerability to drought and to improve and sustain productivity should be incorporated into the farmer's existing strategy to adapt and cope with environmental uncertainty. Measures such as rain water harvesting and till practice, keeping reserves, would help them survive through bad years, and increase their agricultural productivity and sustainability.

1. Introduction

Drought is considered as a normal recurring event that affects people around the world and is one of the most important natural disasters in economic, social and environmental terms [1]. Dry periods and drought remain the major meteorological factors that have devastating impacts on the livelihood of the most rural people in South Africa. Ngaka [2] estimated that about 65% of South Africa receives an average annual rainfall of less than 500 mm; this implies that most of the farming in South Africa takes place under arid and semi-arid conditions. In South Africa, drought is a major disaster when considering economic losses and the number of people affected.

Akapalu [3] argues that people living in rural areas and resource poor farmers are most vulnerable.

Drought has major implications for the agricultural industry by diminishing production. Every time drought occurs in South Africa, farmers are the most vulnerable as they are the first to be exposed to the devastating effects of drought. According to the Disaster Management Act-57 [4] disaster is declared only when affected people lack the resource capacity to deal with drought.

Vetter [5] found that droughts will pose an increasing challenge to farmers in the future, and finding ways to reduce their ecological and economic impacts should be a major research endeavor. The Red Cross [6] and Mniki [7] focussed on hazard risk and socio-economic factors, which influenced the potential effects of the disaster. Before 1992, the focus was primarily on mitigating the impact of drought on the industrial and commercial agricultural sectors. Jordaan [8] studied drought vulnerability and coping indicators in the Northern Cape Province. Studies on factors that influence communal farmers' choice of coping strategies in the Eastern Cape Province (South Africa) are, however, lacking.

The Eastern Cape Province is the second largest province following the Northern Cape in South Africa and is close to 169,000 square kilometres [9]. The province makes up 13.5% of South Africa's total population. The Eastern Cape Province is made up of 45 municipalities which are grouped as follows: one metropolitan, six district municipalities, and thirty-eight local municipalities. A map of the Eastern Cape Province showing different regions is shown in Figure 1.

The Eastern Cape is one of the six provinces that were declared disaster areas by the previous South African president Thabo Mbeki [10]. The Eastern Cape Province is highly vulnerable to disaster due to a high level of poverty, low standards of living, environmental degradation, poor household economies and a lack of access to resources. The Eastern Cape Province not only has the biggest cattle and sheep herds in South Africa, but is also the place where communal farming is practiced on the largest scale [11].

The following problems were identified among farmers in the Eastern Cape Province of South Africa: insufficient water, animals being injured in accidents, searching for food, receiving early warning information about droughts too late, lack of resources (tractors, land, capital), drought relief does not reach farmers in time and they have to wait for officials from a national department for a disaster declaration. Similar results were found amongst small-holder communal farmers in the Northern Cape [8].

Figure 1. Study areas in the Eastern Cape Province [12].

Hassan and Nhemachena [13] analysed determinants of farm-level climate adaptation measures in Africa using a multinomial choice model fitted to data from a cross-sectional survey of over 8000 farms from 11 African countries. Most studies focus on climate variability and change, adaptive capacity of small scale farmers, farmers' perceptions of drought, cost and risk of coping with drought [14–19]. Less studies deal with factors that influence communal farmers' choice of coping strategies and capacities to drought risk. In view of the importance of the subject and the lack of knowledge with regard to the factors that influence communal farmers' choice of coping strategies, it appears useful to undertake a study.

Thus, the main objective of this study is to determine the factors that influence communal farmers' choices of coping strategies during drought and to determine current adaptation and coping capacities regarding drought risk in the Eastern Cape province of South Africa. To this end, a field survey and multinomial probit model were used. Conclusions drawn could help develop policies and institutional interventions regarding coping strategy and capacities. Moreover, an understanding of factors that influence the choice of communal farmers' coping strategies is critical in designing technological and policy interventions for more effective drought mitigation. This study could not only be applied to South Africa, but to other arid and semi- arid regions as well.

2. Methodology

The study was conducted in three municipalities in the Eastern Cape Province of South Africa, namely Cacadu district municipality, Joe Gqabi district municipality and Oliver Reginald (OR) Tambo district municipality. The focus of this study lay on the communal farmers, where large scale communal farming is practiced and the land is still managed by chiefs or local municipalities. One hundred and twenty-one communal farmers were interviewed from the following districts: Joe Gqabi district municipality (n = 19), Cacadu district municipality (n = 15) and OR Tambo district municipality (n = 87). Primary data was collected by using a structured questionnaire survey and focus group discussion from April–September 2014.

A multinomial probit model was used to investigate the factors that influence the choice of a farmer's specific coping method. According to Munizaga; Daziano and Ziergler [20,21], multinomial probit model applications include constrained and unconstrained versions of the covariance matrix of the multivariate normal distribute of error term. Assumption of a particular covariance structure is unnecessary as the data reveals the substation patterns.

A multinomial probit statistical model is used when there are several possible categories that the dependent variable can fall into. The coping strategies choice model concerns the decision made by farmer "i", $i = 1, 2, \ldots, I$ of the alternative j in the set $w_i = (1, \ldots, j)$, which produces the highest utility level (V_{ij}). Thus, $V_{i1} < V_{ij}, \forall j \in w_i$ in this notation indicates the choice set is allowed to vary across individuals to account for their own specific coping strategy. The drought coping strategies choices denote to 1 for (none of the strategy), 2 (irrigation), 3 (farm diversification), 4 (resistant crops/breeds) and 5 denote to (more than two coping strategies). Resistant crops/breeds are chosen as base category (option 4). The utilities of other choices (1, 2, 3 and 5) are compared to that of the base category. The individual decision is based on the differences between utility derived from the other drought coping mechanisms and the base category (resistant crops/breeds). This can be represented as:

$$Y^*{}_{ij} = V_{ij} - V_{ij} \tag{1}$$

where $Y^*{}_{ij}$ denotes an unobservable choice made, when individual i chooses option j. If $Y^*{}_{ij} < 0$ for $j = 1, ..., J$, then Y_i farmer I chooses the base category option (drought resistant crops/breeds) and $Y_i = 0$. Otherwise, farmer i's choice yields the a higher value for $Y^*{}_{ij}$ and $Y_{ij} = j$. Assuming that each farmer i faces the same j alternatives, a multinomial probit model formulation based on linear-in-parameters utilities may be written as follows:

$$V_{ij} = Z_{ij}\beta + \varepsilon_{ij}, \varepsilon_{ij} \quad N(0, \textstyle\sum) \tag{2}$$

$$y_{ij} = \begin{cases} 1 | if\ V_{ij} \leq V_{ij}\ for\ i = 1, \ldots, I;\ j = 1, \ldots, J \\ 0 | otherwise \end{cases} \tag{3}$$

The variable Y_{ij} denotes the choice made by farmer i, V_{ij} is the unobservable utility of alternative j as perceived by individual i, Z_{ij} is a ($1 \times K$) vector explanatory variables characterizing both alternative j and the individual i. β is a ($K \times 1$) vector of fixed parameters, and, finally, ε_{ij} is a normally distributed random error term of mean zero assumed to be correlated with the errors associated with the other alternatives j, j = 1,..., J, $j \neq i$; and covariance matrix of:

$$\sum = Cov(\varepsilon_i = \begin{pmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} \end{pmatrix}) \quad (4)$$

with $\sigma_{ij} > 0, \forall_j$(positive definiteness). The predicated probability of choosing any of the coping strategies choices represented with the following Equations (5)–(9):

$$P(y_i = 1)P(V_{i1} + \varepsilon_{i1} > V_{i2} + \varepsilon_{i2} \text{ and } V_{i1} + \varepsilon_{i1} > V_{i3} + \varepsilon_{i3}) \quad (5)$$

$$P(y_i = 2)P(V_{i2} + \varepsilon_{i2} > V_{i1} + \varepsilon_{i1} \text{ and } V_{i2} + \varepsilon_{i2} > V_{i3} + \varepsilon_{i3}) \quad (6)$$

$$P(y_i = 3)P(V_{i3} + \varepsilon_{i3} > V_{i1} + \varepsilon_{i1} \text{ and } V_{i3} + \varepsilon_{i3} > V_{i2} + \varepsilon_{i2}) \quad (7)$$

$$P(y_i = 4)P(V_{i4} + \varepsilon_{i4} > V_{i1} + \varepsilon_{i1} \text{ and } V_{i4} + \varepsilon_{i4} > V_{i5} + \varepsilon_{i5}) \quad (8)$$

$$P(y_i = 5)P(V_{i5} + \varepsilon_{i5} > V_{i1} + \varepsilon_{i1} \text{ and } V_{i5} + \varepsilon_{i5} > V_{i4} + \varepsilon_{i4}) \quad (9)$$

Assuming that the response categories are mutually exclusive and exhaustive, then $\sum_{j=1}^{J} P_{ij} = 1$. For each i, the probabilities add up to one for each individual and we have only $J-1$ parameters. This implies that Equation (5) + (6) + (7) + (8) + (9) = 1, which is rewritten as:

$$P(y_i = 1) + P(y_i = 2) + P(y_i = 3) + P(y_i = 4) + P(y_i = 5) = 1 \quad (10)$$

Multinomial probit was adopted to avoid the limitations of the simpler multinomial logit, i.e., nonsensical predictions, since the dependent variable is not continuous, recoding the dependent variable can give different results [22]. Multinomial probit estimates correlation, depending upon choice size and if correlation is high. Therefore, multinomial probit is designed to be used only if the options are relatively small [23]. Empirically, the multinomial probit regression can be written as follows:

$$\begin{gathered} L_{ij} = \alpha_{0ij} + \alpha_{ij}D_{ij} + \alpha_{2ij}K_{ij} + \alpha_{3ij}Fs_{ij} + \\ \alpha_{4ij}Aw_{ij} + \alpha_{5ij}Al_{ij} + \alpha_{6ij}Es_{ij} + \alpha_{7ij}Rk_{ij} + \alpha_{8ij}Ed_{ij} + \alpha_{9ij}I_{ij} + e_{ij} \end{gathered} \quad (11)$$

where ij denotes coping strategies (j = 1 denotes no coping strategies, j = 2 denotes irrigation, j = 3 denotes farm diversification, j = 4 denotes drought resistant crops/breeds and j = 5 more than one coping strategy). Dij = 1 if farmer i received information from the Department of Agriculture and Rural Development; K denotes knowledge of a farmer and Fs represents farming experience. Aw = 1 if farmer has access to water and Al = 1 denotes access to land. Es = 1 if farmer received extension services. *Ed* denotes educational level (primary, high school or degree). *Rk* = 1 if farmer keeps records. *I* denotes income from farming activities. α_{oij} denotes the constant term and $\alpha_{1ij}, \alpha_{2ij}, \ldots, \alpha_{10ij}$ represent the coefficients of the explanatory variables in the model, while e_{ij} denotes the disturbance term.

3. Results and Discussion

3.1. Demographic and Socio Economic Characteristics of the Respondents

Some of the respondents' socioeconomic characteristics are provided in Table 1. More males (73%) than females (27%) took part in the study. A possible reason for the male dominated farming activities in the study area might be that they have access to land. Quisumbing [24] reported that there is a great disparity in the size of landholdings between men and women, and that the mode of women participation in agricultural production varies with the land-owning status of households.

Table 1. Socio-economic characteristics of the respondents.

Characteristics	Sub-Characteristics	OR Tambo (n = 87)		Joe Gqabi (n = 19)		Cacadu (n = 15)		% (N = 121)			Total
		n	%	n	%	n	%	ORT	JG	CD	%
Age (yrs)	25–34	7	8	3	16	2	13	6	2	2	10
	35–44	20	23	3	16	2	13	17	2	2	21
	45–54	25	29	4	21	4	27	21	3	3	27
	>55	35	40	9	47	7	47	29	7	6	42
Gender	Male	62	71	16	84	11	73	51	13	9	73
	Female	25	29	3	16	4	27	21	2	3	27
Education	None	23	26	1	5	3	28	19	1	2	22
	Primary	44	51	13	68	12	80	36	11	10	57
	Secondary	18	21	2	11	—	—	15	2	—	17
	Graduate	2	2	3	16	—	—	2	2	—	4
Household size	0–4	29	33	5	26	8	54	24	4	7	35
	5–8	32	37	11	58	5	33	26	9	4	39
	9–12	14	16	3	16	2	13	12	2	2	16
	>13	12	14	—	—	—	—	10	—	—	10
Access to resources	Land	69	79	17	89	14	93	57	14	12	83
	Water	35	40	10	53	6	40	29	8	5	42
Experience (yrs)	0–4	10	12	4	21	7	47	8	3	6	17
	5–9	20	23	6	32	4	27	17	5	3	25
	10–14	28	32	4	21	2	13	23	3	2	28
	>15	29	33	5	26	2	13	24	4	2	30

ORT = OR Tambo; JG = Joe Gqabi; CD = Cacadu district municipality.

Many respondents (22%) did not have a formal education, 17% had a secondary level education and few (4%) had a tertiary education. The demographic and socio-economic characteristics are important, because they influence households' economic behaviour [25].

Most (83%) of the communal farmers had access to resources (land) and of these, 57% were in OR Tambo district municipality, 14% in Joe Gqabi district municipality and the rest 12% in Cacadu district municipality. Forty-two (42%) communal farmers had access to water area, the majority (29%) were in OR Tambo district municipality. Forty-two (42%) of the respondent were 55 years or older, 39% had household sizes of between 5 and 8 people, and 58% of the respondents had more than 10 years' experience in farming.

3.2. Determinants of the Choice of Drought Coping Strategies

The multinomial probit regression model was used to examine the factors that influence the choice of communal farmers' coping strategies during drought in the Eastern Cape Province. Table 2 represents maximum likelihood estimates of the multinomial probit regression model (The detailed results of the multinomial probit regression model are available in Appendix A, Table A1). Drought resistant crops/breeds were used as reference category for the multinomial probit analysis, because most farmers opted for it. Income, experience, access to land and water, and information from the Department of Agriculture and Rural Development (DARD) were variables fitted in the model, because of significant influence the choice of coping mechanisms.

The coefficient for DARD information is negatively related to the probability of farmers not adopting any coping strategies and was highly significant at the 1% level. This implies that farmers who received information from the DARD are more likely to adopt resistant crop varieties and animal breeds rather than adopting no drought coping strategies. Information on earlier drought impact is very important for planning future drought responses. By comparing most severe impacts of drought, policymakers can plan to minimise the most severe impacts [26,27].

The coefficient for access to water is significant at the 5% level and is positively related to the probability of farmers not adopting any coping strategies. This result is plausible, because the farmers who have access to water already have mitigation strategies to address drought, therefore there might be no need for them to adopt any other strategies. Communal farmers have access to water, but there was insufficient and this limits their ability to expand their farming businesses.

The coefficient for access to land had a positive association with the likelihood of choosing irrigation in favour of resistant crops/breeds with a significance of 1%. This indicates that farmers are more likely to engage in irrigation especially in the Cacadu municipality, because 47% of respondents indicated irrigation use. Most of these farmers produce crops and vegetables, which requires more water compared to other districts. Contrarily, access to land was significant at the 10% level and negatively related to not adopting any of the drought coping strategies. This suggests that farmers are more likely to adopt drought resistant crop varieties or animal breeds, which will curtail the effects of climate change on their production. Previous studies found that farmers having secure land tenure were likely to take up adaptation strategies [28,29].

Table 2. Multinomial probit regression analysis.

	No Coping Strategy		Irrigation		Farm Diversification		More Than Two Coping Strategy	
Variables	**Coef.**	$p > \|z\|$	**Coef.**	$p > \|z\|$	**Coef.**	$p > \|z\|$	**Coef.**	$p > \|z\|$
DARD	−1.954	0.002 ***	−0.753	0.247	0.357	0.59	0.299	0.597
Knowledge	0.942	0.159	−0.449	0.529	0.367	0.571	0.657	0.235
Agricultural training	−0.214	0.734	−1.219	0.121	−0.705	0.296	−0.346	0.559
Experience	−0.042	0.046 **	−0.094	0.043 **	−0.011	0.654	−0.003	0.952
Access to land	1.309	0.065 *	3.602	0.000 ***	0.7	0.331	0.6	0.227
Access to water	1.421	0.024 **	−0.333	0.586	0.674	0.203	0.389	0.424
Risk level	−0.499	0.296	−0.019	0.014 *	0.902	0.365	−0.085	0.667
Extension services	0.907	0.165	−0.734	0.364	−0.859	0.222	−0.654	0.286
Farmers associations	−1.362	0.0018 **	−42.73	—	−1.882	0.007 ***	−1.084	0.044 **
Record keeping	0.392	0.497	2.533	0.000 ***	1.889	0.001 ***	0.484	0.351
Education2	−0.983	0.274	0.285	0.758	0.959	0.293	−1.086	0.201
Education 3	0.41	0.524	0.781	0.392	−0.318	0.613	0.799	0.172
Education 4	42.78	—	1.109	0.345	0.242	0.738	−0.438	0.53
Income 2	−1.288	0.149	1.272	0.081 *	2.601	0.000 ***	2.03	0.006 *
Income 3	−1.621	0.093*	3.823	—	4.082	—	5.3	0.000 ***
Base category			Drought resistant crop or animal breed					
Number of observations	—	—	—	—	—	—		121
Wald chi2(76)	—	—	—	—	—	—		0.000
Log pseudolikelihood	—	—	—	—	—	—		−108.56
Prob> chi2	—	—	—	—	—	—		0.000

***, **, * = significant at 1%, 5%, and 10% probability level, respectively.

The coefficient of experience correlated with the probability of not adopting drought coping strategies in favour of adopting drought resistant crops or animal breeds with a 5% significance. The negative sign of experience implies that farmers who have been in agricultural production are more likely to adopt drought resistant crops or animal breeds to mitigate climate change. Experienced farmers have gathered enough information on weather patterns over a period of time and will therefore be able to choose the appropriate means to address changing weather patterns. Similarly, experience negatively correlated with the probability of adopting irrigation as a mitigating drought strategy in favour of drought resistant crops or animal breeds. The result implies that experienced farmers are more likely to adopt irrigation as a drought coping strategy. Developing irrigation facilities may be costly compared to using drought resistant crops or animal breeds. This implies that communal farmers are more vulnerable as they do not receive enough income due to drought impacts. Studies show that the greater the experiences in agricultural farming, the more likely farmers are to have good knowledge about the weather and climatic conditions and thus adapt. Hisali et al. [28] pointed to the importance of farming experience in adaptation decision making.

The coefficient of income 3 (South African Rand ZAR 50,000–ZAR 100,000) was significant at the 10% level and had negative effects on the likelihood of not adopting any drought coping strategies in favour of drought resistant crops or animal breeds. The results suggests that farmers with income ranges between ZAR 10,000 and ZAR 50,000 per annum are more likely to adopt drought resistant crop or animal breeds as mitigating strategy against drought. The reason is that these farmers have less income and are more vulnerable to drought and thus more food insecure. Farmers with income 4 (ZAR 100,000–ZAR 200,000) can afford to purchase drought resistant crops or animal breeds. Moreover, farmers with income level 5 (> ZAR 200,000) are more likely to adopt more than one drought coping strategy than only drought resistant crops or animal breeds. For example, money can be used to buy additional feed for livestock to survive until the dry period is over.

The variable risk level was significant at 10% and negatively related to the probability of adopting irrigation as a strategy to address drought. This implies that farmers with higher risk levels are less likely to adopt irrigation as a coping strategy. However, risk levels were positively related to the probability of using farm diversification as a drought mitigating strategy in favour of drought resistant crops or animal breeds. Farm diversification may help farmers to cope better during drought as they have additional crops or livestock to support their main farming enterprises. The level of perceived risk associated with the capacity to adapt to climate change determines the likelihood of adopting adaptation measures [28].

Farmers associations are significant at 1%, meaning a probability that those farmers who receive information from associations have the higher probability of adopting farm diversification. However, this is not happening as associations do not operate at grass root level.

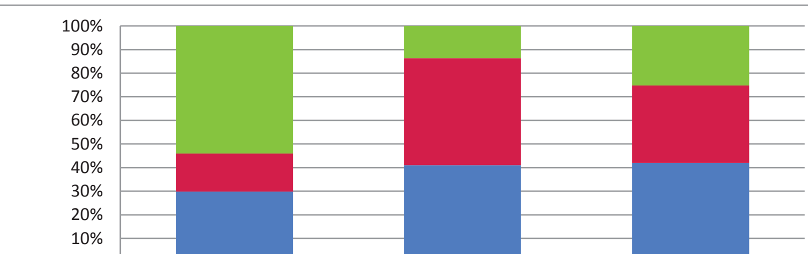
Record keeping was highly significant at 1% and positively associated with the probability of using farm diversification to address drought issues. Record keeping helps the farmer track climate patterns and the performance of the farming operation and enables the farmer to explore alternative risk reduction methods associated with drought.

Even though education and extension services were not significant, they negatively influenced the farmers' probability to use one of the coping strategies. This suggests that farmers can use their education with extension services/support to make informed decisions about their farming. Furthermore, it reduces their level of vulnerability to drought when using coping mechanisms. Education is one of the key determinants in adopting adaptation strategies. Higher education level increases the individual awareness of different alternatives [30].

3.3. Determine Current Adaptation, Coping Capacities and Strategies Opted by Communal Farmers

Coping strategies are remedial actions undertaken by those whose livelihoods are threatened. This involves managing resources both during drought and in normal times in order to withstand the effects of drought risk. Irrigation, farm diversification and drought resisting coping capacities and strategies were selected based on literature, expert opinion, observations, level of ease of measurement and their importance. It was found that 44% of the farmers used drought resistant crops or animal breeds, 32% practiced farm diversification and 29% used irrigation on their farms. Farmers found it easier to farm with drought resistant crops or animal breeds due to the nature of drought tolerance than with irrigation coping strategies. Eriksen et al. [31] describe coping mechanisms as the actions and activities that take place within existing structures and systems; e.g., the introduction of on-farm diversification. Diversification can include alternative feed and fodder sources or livestock types [32].

Figure 2 displays that more OR Tambo farmers employ cultivars or breeds that are less sensitive to drought compared to other two districts. Cacadu district farmers use more irrigation; therefore, they are less vulnerable during drought as they are likely to diversify because of high level of water availability. Figure 2 also indicates that only few farmers employ diversification in their farming activities, which leaves most of the farmers vulnerable. Nevertheless, farmers who practice diversification on their farms are more resilient during drought. Farmers can farm with ostrich and goat since these are recognised to have a potential in the Eastern Cape Province.



	irrigation	farm diversification	Drought resistant breeds/crops
Cacadu	47%	13%	33%
Joe Gcabi	14%	43%	43%
OR tambo	26%	39%	55%

Figure 2. Coping mechanisms used by farmers in the Study area.

To manage drought effectively, diversifying livelihood strategies and income generating options within and outside agriculture is required, especially through non-farm enterprises and employment opportunities. Off-farm income in the three districts should be explored during drought. Farmers also plant food gardens to support their families, others keep chickens.

Communal farmers sell their excess animals and non-farming assets to buy feed for their livestock. Other farmers plant oats to make silage and lucerne for grazing which can be used in dry periods. The farmers were willing to change the type of livestock, crops and reduce herd sizes. It was argued by extension officers that lucerne can be used for fodder banks, but farmers found it too expensive to produce.

The study found that these coping mechanisms assist farmers to cope during drought. Drought insurance and/or tax free savings schemes can be used as tools to increase coping capacity and requires further research.

4. Conclusions

This study investigated the factors that influence the choice of communal farmers' coping strategies in OR Tambo, Joe Gqabi and Cacadu districts of the Eastern Cape Province of South Africa. Firstly, the results indicate that the choice of communal farmers' coping strategies should take into consideration farmers' access to land, income, experience, and education. Non-consideration of factors can lead to the choice of inappropriate coping strategies.

Secondly, the vulnerability and limited coping capacities of farmers is highly correlated with the inability to access land, water, finance, market and timely information. In South Africa, drought has significant negative impacts and continues to pose long lasting effects on the agricultural sector. It was noted that the majority of farmers had limited abilities to deal with drought issues due to a lack of access to resources and information.

Thirdly, any viable strategy to reduce the farmers' vulnerability to drought and to improve productivity should be incorporated into existing adaptation strategies regarding environment uncertainty. Measures such as rain water harvesting, tilling practices, and keeping reserves help farmers to survive and increase their agricultural productivity. Moreover, disaster risk management committees from different stakeholders at municipality level could be established and, together with extension services, improve early warning and information systems. This must be effectively communicated to the communities before disaster strikes. A holistic approach between different stakeholders should be practiced.

Generally, the findings highlight the need for policy adjustments with regard to drought impact, vulnerabilities and lack of coping capacities that take into consideration communal farmers' existing coping strategies as well as the factors that influence the choice of coping strategy.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A.

Table A1. Multinomial probit regression analysis.

Multinomial Probit Regression Log Pseudolikehood = −108.5604				N = Wald chi2(76) Probability > chi2	121 0.0000 0.0000	
Variables	Coefficient	Robust Standard Error	z	$p > \|z\|$	(95% CI)	
1 (no strategy)						
DARD	−1.9542	0.6353	−3.08	0.002	−3.1994	−0.7090
Private sector	0.9709	0.5756	1.69	0.092	−0.1574	2.0991
Knowledge	0.9423	0.6695	1.41	0.159	−0.3699	2.2545
Agricultural training	−0.2148	0.6329	−0.34	0.734	−1.4552	1.0257
Indigenous knowledge	−0.6139	0.5859	−1.05	0.295	−1.7622	0.5345
Experience	−0.0429	0.0216	−1.95	0.046	−0.0852	−0.0007
Access to land	1.3092	0.7097	1.84	0.065	−0.0817	2.7001
Access to water	−1.4209	0.6304	2.25	0.024	0.1853	2.6566
Level of debt	−1.0506	0.7255	−1.45	0.148	−2.4728	0.3714
Risk level	0.2647	0.1937	1.37	0.172	−0.1149	0.6443
Extension services	−0.9069	0.6526	−1.39	0.165	−2.1860	0.3723
Farm associations	−1.3618	0.5743	−2.37	0.018	−2.4875	−0.2361
Record keeping	0.3915	0.5758	0.68	0.497	−0.7370	1.5200
Education 2	−0.9826	0.8988	−1.09	0.274	−2.7442	0.7790
Education 3	0.4103	0.6439	0.64	0.524	−0.8517	1.6723
Education 4	0.6261	0.7762	0.81	0.420	−0.8953	2.1474
Education 5	−42.7807	—	—	—	—	—
Income 2	−1.2883	0.8924	−1.44	0.149	−3.0373	0.4608
Income 3	−1.6212	0.9663	−1.68	0.093	−3.5152	0.2727
Income 4	−32.33932	—	—	—	—	—
2 (irrigation)						
DARD	−0.7533	0.6505	−1.16	0.247	−2.0283	0.5218
Private sector	−0.0098	0.6611	−0.01	0.988	−1.3055	1.2859
Knowledge	−0.4498	0.7147	−0.63	0.529	−1.8507	0.9511
Agricultural training	−1.2185	0.7865	−1.53	0.121	−2.7599	0.3230
Indigenous knowledge	−0.6964	0.5818	−1.20	0.231	−1.8367	0.4439
Experience	−0.0938	0.0463	−2.03	0.043	−0.1845	−0.0031
Access to land	3.6015	0.9826	3.67	0.000	1.6756	5.5274
Access to water	−0.3335	0.6117	−0.55	0.586	−1.5325	0.8654
Level of debt	0.1356	0.6973	0.19	0.846	−1.2311	1.5023
Risk level	−0.4986	0.2961	−1.68	0.092	−1.0789	0.0817
Extension services	0.7340	0.8083	0.91	0.364	−0.8502	2.3182
Farm associations	−42.7349	—	—	—	—	—
Record keeping	2.5334	0.6671	3.80	0.000	1.2258	3.8409
Education 2	0.2847	0.9238	0.31	0.758	−1.5260	2.0954
Education 3	0.7810	0.9132	0.86	0.0392	−1.0089	2.5710

Table A1. *Cont.*

Multinomial Probit Regression						
Log Pseudolikehood = −108.5604			*N* =		121	
			Wald chi2(76)		0.0000	
			Probability > chi2		0.0000	
Variables	Coefficient	Robust Standard Error	*z*	*p* > |*z*|	(95% CI)	
Education 4	1.1093	1.1738	0.95	0.345	−1.1913	3.4098
Education 5	−0.6677	0.9370	−0.71	0.476	−2.5042	1.1688
Income 2	1.2716	0.7297	1.74	0.081	−0.1586	2.7019
Income 3	3.8234	—	—	—	—	—
Income 4	−22.9572	—	—	—	—	—
3 (farm diversification)						
DARD	−0.3569	0.6615	−0.54	0.590	−1.6535	0.9397
Private sector	1.1449	0.6413	1.79	0.074	−0.1121	2.4018
Knowledge	0.3674	0.6449	0.57	0.571	−0.9049	1.6396
Agricultural training	−0.7046	0.6737	−1.05	0.296	−2.0249	0.6158
Indigenous knowledge	−1.1342	0.5459	−2.08	0.038	−2.2041	−0.0644
Experience	−0.0108	0.0241	−0.45	0.654	−0.0579	.0364
Access to land	0.7003	0.7200	0.97	0.331	−0.7108	2.1115
Access to water	0.6735	0.2167	1.27	0.203	−0.3636	1.7105
Level of debt	1.3780	0.7037	2.06	0.039	0.0690	2.6870
Risk level	−0.0193	0.2167	−0.09	0.929	−0.4441	0.4055
Extension services	−0.8596	0.7037	−1.22	0.222	−2.2388	0.5196
Farm associations	−1.8816	0.6920	−2.72	0.007	−3.2378	−0.5253
Record keeping	1.8894	0.5761	3.28	0.001	0.7601	3.0186
Education 2	−0.9587	0.9110	−1.05	0.293	−2.7443	0.8269
Education 3	−0.3175	0.6278	−0.51	0.613	−1.5480	0.9130
Education 4	0.2418	0.7826	0.33	0.738	−1.1775	1.6611
Education 5	0.3997	0.8626	0.46	0.643	−1.2911	2.0904
Income 2	2.6012	0.5964	4.36	0.000	1.4324	3.770
Income 3	4.0823	—	—	—	—	—
Income 4	21.66639	—	—	—	—	—
5 (more than two coping strategies)						
DARD	0.2989	0.5653	0.53	0.597	−0.8091	1.4070
Private sector	0.4729	0.5290	0.09	0.929	−0.9894	1.0840
Knowledge	0.6571	0.5528	1.19	0.235	−0.4263	1.7405
Agricultural training	−0.3456	0.5915	−0.58	0.559	−1.5050	0.8138
Indigenous knowledge	−0.5770	0.4865	−1.19	0.236	−1.5305	0.3765
Experience	−0.0026	0.0278	−0.09	0.925	−0.0571	0.0518
Access to land	0.6000	0.5515	1.09	0.277	−0.4809	1.6809
Access to water	0.3899	0.4875	0.80	0.424	−0.5656	1.3454
Level of debt	0.3453	0.5640	0.61	0.540	−0.7601	1.4507
Risk level	0.1654	0.1781	0.93	0.353	−0.1837	0.5144
Extension services	−0.6538	0.6123	−1.07	0.286	−1.8539	0.5463
Farm associations	−1.0839	0.5389	−2.01	0.044	−2.1401	−0.0276
Record keeping	0.4837	0.5185	0.93	0.351	−0.5326	1.5001
Education 2	−1.0856	0.8497	−1.28	0.201	−2.7510	0.5797
Education 3	0.7997	0.5857	1.37	0.172	−0.3482	1.9477
Education 4	−0.4378	0.6976	−0.63	0.530	−1.8051	0.9296
Education 5	−0.7915	0.8666	−0.91	0.361	−2.4900	0.9071
Income 2	−2.0301	0.7457	2.72	0.006	0.5685	3.4917
Income 3	5.300	0.9555	5.55	0.000	3.4270	7.1724
Income 4	21.7229	—	—	—	—	—

CI = confidence intervals; DARD = Department of Agriculture and Rural Development

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