Climate risk coping strategies of maize low-income farmers: A South African Perspective

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10 May 2021

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Abstract

The aim of this paper is to evaluate the effectiveness of climate risk coping strategies of smallholders in a South African perspective. A quantitative research approach was followed using surveys to collect primary data from participants in key maize producing provinces of South Africa. The results analysed employing multinomial regression, show that reduction of crop production in times of uncertainly is the most preferred coping mechanism. The study further revealed that farmers who use crop insurance have the highest level of preparedness to manage weather risk. The findings contribute to advancing knowledge, guiding policymakers and increasing efficiencies of risk mitigation efforts especially climate risk solutions in the context of climate change and persistent drought affecting South African farmers.

Keywords: *Risk management, risk coping, risk mitigation, smallholder farmers.*

1. Introduction

Farmers are exposed to weather-related production risk on a daily basis; for as long as crops are on the field an element of risk exists that manifests itself in potential loss of yield. In response farmers adopt a combination of ex-ante and ex-post risk management strategies. Risk management in agriculture is concerned with reducing the likelihood of unfavourable outcomes to an acceptable level and has historically formed a large part of agricultural industrialization (Hohl, 2019). The nature of agricultural production makes risk management through adoption of coping strategies a vital tool for the sustainability of farming enterprises. More especially in South Africa, a semi-arid country where crop production mostly takes place under rainfed conditions and exposure to drought risk is significant. Authors such as Hohl (2019), Chakoma and Chummun (2019) put forward that drought adversely impacts crop production in a variety of ways, including, direct effects from reduction in soil moisture which restricts the ability of crops to absorb water in the root zone, and indirect effects where the crop becomes more susceptible to pests and disease. The monetary effects of drought resulted in an estimated ZAR12 billion loss of revenue for maize farmers in the 2015/16 crop season alone (AgriSA, 2016).

Drought has repeatedly been proven to cause a series of behavioural responses that suggests that the welfare burden of drought is much higher than what might have been traditionally observed. Smallholders are typically the most affected by drought because they lack access to funding and insurance to cover their crops and livestock, or to build water infrastructure or even drill boreholes, furthermore, they do not necessarily receive priority in emergency response programs (Partridge & Wagner, 2016) When dry conditions prevail, South African farmers respond with various production reducing techniques to cope with weather shocks, in addition existing production is adversely affected by crop failure (DAFF, 2019). This has serious implication on food security and livelihoods. Classified as the most important grain crop in Africa, maize is multi-disciplinary in nature and is a staple food for human and animal consumption, fodder and bioenergy production.

The subject of risk management in agricultural production, especially crop production has not been fully resolved, and there is always a constant need to develop new models (Chummun & Ojah, 2016). Very few studies have reported about the effectiveness of different coping strategies. Increased agricultural risk fuelled by climate change implies that farmers face new realities that cannot be comprehensively addressed by their indigenous knowledge and informal risk mitigating techniques .

Farmers have been observed to exhibit "cognitive failure," that is, underestimate the severity of catastrophic events in the face of competing priorities as a psychological coping strategy (Romero & Molina, 2015). Psychologically this approach makes it easier to recover from any losses and also makes a compelling case for continuing production. However, affects participation and uptake of adaptive mechanisms. For example, evidence from Limpopo province of South Africa points to the fact that prior to the 2015 wide-scale drought most smallholders were aware of the looming extreme conditions but chose to underestimate the impact of drought on their farm operations (Manderson et al., 2016). This study investigates the most preferred risk mitigating strategy and assesses its effectiveness, by evaluating the strategy against the level of crop losses experienced at farm level and farmers perceptions of readiness to manage weather risk.

2. Literature review

2.1 Ex-ante and ex-post risk mitigating strategies

Risk and the management of risk should to be based on active considerations around trade-offs and opportunities for efficiencies to improve effectiveness (Jarzabkowski et al., 2019). Agricultural risk management entails a basket of ex-ante (planned) and ex-post (reactive) strategies employed by farmers, which involve risk reduction, risk avoidance, risk transfer and risk retention, all in efforts to smooth income effects of weather-related shocks. Resource-constrained smallholder farmers primarily employ informal ex-ante risk management techniques which involve changes in the production strategy, such as low risk, low return approach, shifting production patterns by adopting early planting dates, staggering planting, planting on different plots of land to spread the risk (land defragmentation), generating off-farm income, diversifying crops and following a mixed farming methodology incorporating livestock (Adiku et al., 2017).

2.2 Effectiveness of risk mitigating strategies

A farmer's risk perception, that is, their attitude towards risk will determine the level and extent of risk mitigating tools. These impact-mitigating responses are often complex due to the need for rapid action during the planting season to address weather risk and usually incorporate uncertain trade-offs between expected crop yield recovery and additional costs (Shah et al., 2020). Therefore, the combination of tools applied may not be the most effective in responding to the particular risk. Asravor (2018) found that farm diversification and off-farm employment are perceived by farmers as the most effective risk management strategies for production risk in the semi-arid region of Ghana. In general, the majority of farmers adopted off-farm strategies in Indonesia, but where farmers focused on on-farm activities to reduce risk crop diversification was also the most preferred (Mutaqin, 2019).

2.3 Theoretical framework

The study employs the Protection Motivation Theory (PMT) to explain the choice of risk mitigation strategy at farm level. PMT is commonly applied in agricultural risk mitigating literature (Asravor, 2018). Under this theory individuals are highly likely to consider protective responses to address any form of risk when anticipating adverse outcomes. In essence, risk perception and the management of risk increases when there is a perceived threat. According to the PMT theory (Rogers, 1983) there are two key determinant of protection motivation which are threat appraisal and coping appraisal. Threat appraisal captures risk perception, which involves two assessments: risk impact in term s of severity and a self-assessment of risk probability. Coping appraisal refers to the cognitive process by which an individual evaluates possible adaptation responses that may reduce the perceived threat. It involves three evaluations: response efficacy, response costs and self-efficacy. Response efficacy addresses available and attainable adaptive options and their effectiveness in reducing the severity and extent of loss from a specific threat. Response cost capture the expense with respect to financial resources, time, and effort required to implement the protective action. The coping appraisal process will result in higher protection motivation if the individual perceives that the suggested coping method is practical and simple to use. In this study, the researchers assume that anticipated adverse weather risk influences the management strategies adopted at farm level, hence the PMT theory is adopted by this study.

3. Methodology

3.1 Study area and sampling

The study was conducted using a structured questionnaire to collect primary data in the central to eastern regions of South Africa, in Free State, North West, and Mpumalanga province where most of the maize cropping activities take place.

Only market-orientated smallholder farmers with a farm size of between 20 – 500 hectares were interviewed for purposes of this paper. Average land size for smallholder farmers South Africa is particularly large compared to the rest of Africa where farm sizes are typically less than 2 hectares (FAO, 2015). In South Africa, 2 hectares is typically considered backyard or subsistence farming. The sampling frame statistics were obtained from the Land and Agricultural Bank of South Africa, a development finance institute responsible for agrarian financing in South Africa. Farm level data on sources of weather-related risk, the extent of crop loss, the level of preparedness to respond to risk as well as the most preferred risk coping strategy were collected. All questions were closed-ended questions formulated on the basis of the literature review and the underlying theoretical framework. A total of 224 complete responses was obtained following the application of stratified random sampling.

3.2 Method of analysis

The study employed descriptive statistics to identify the most important sources of risk from 4 prevalent weather events in South Africa and logistic regression.

The logistic regression can be extending to models with multiple explanatory variables. If k denotes number of predictors for a binary response Y by $x_1, x_2, \ldots, x_k$, the model for log odds is (El-Habil, 2012):

$$Logit\ [P(Y = 1)] = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k$$

The parameter βi refers to the effect of x_i on the log odds that Y =1, controlling other x_j, for instance, exp(βi) is the multiplicative effect on the odds of a one unit increase in x_i, at fixed levels of other x_j.

If we have n independent observations with p-explanatory variables, and the qualitative response variable has k categories, to construct the logits in the multinomial case, one of the categories must be considered the base level and all the logits are constructed relative to it. Any category can be taken as the base level, so we will take category k as the base level. Since there is no ordering, it is apparent that any category may be labelled k. Table 1 explains the variable included in the analysis of the effectiveness of risk coping strategies at farm level.

Table 1: Variables in the multinomial regression model

Variable	Description of variable	Measure
Preparedness	Farmers level of preparedness to manage weather risk	Categorical variable
Risk coping strategy	Various risk coping strategies typically adopted to respond to climate risk	Categorical variable
Crop loss	Percentage of crop loss per season attributable to climate risk	Continuous variable

4. Results and discussion

4.1 Summary of responses

Table 2 provides a summary of the 224 responses received and indicates the following: The most significant source of risk is drought (70%). A majority of the respondents are not prepared (49%) to manage weather risk, experiencing losses of between 26 – 50% of the potential crop harvest. The most preferred risk mitigating option is reducing production capacity in times of uncertainty, followed by shifting planting dates to the next optimal planting window. The study finds that all farmers adopted at least one risk response strategy to weather-related shocks, consistent with the Protection Motivation Theory (PMT) response to threat.

Table 2: Summary of responses

Variable	Description	Frequency	Percentage
Sources of weather risk	Drought	157	70%
	Low rainfall	51	23%
	High rainfall	4	2%
	Hail	12	5%
Level of preparedness	Prepared	75	34%
	Neutral	39	17%
	Not prepared	110	49%
Risk coping strategy	Planting less	72	32%
	Shifting planting dates	45	20%
	Crop diversification	28	13%
	Government support	23	10%
	Crop insurance	19	9%
	Off-farm income	12	5%
	Savings	12	5%
	Credit	7	3%
	Irrigation	6	3%
Crop loss per season	Less than 25%	37	16%
	26 – 50%	103	46%
	51 – 75%	58	26%
	More than 75%	26	12%

Source: Primary data

4.2 Multinomial regression

The multinomial regression presented in Table 3 was statistically significant and the model satisfactorily fits the data as evidence by the likelihood ratio test results (chi-square = 68.219, 22 degrees of freedom, *p*=0.000). The model explained 30.2% (Nagelkerke R^2) or 26.3% (Cox and Snell) of the variance in the level of preparedness to contend with and manage weather risk.

Based on the results of the regression model, crop insurance (p=0.027) is positive and significantly related to preparedness at 5% confidence level, indicating that farmers that purchase crop insurance are 13 times more likely to be prepared to manage weather risk than those that do not have the insurance. While planting less in times of uncertainly (p=0.024) is negative and statistically significant, indicating that farmers that reduce crop production are less prepared for managing weather risk, yet this approach remains the most preferred coping strategy. Additional insight suggests that better prepared farmers demonstrate the lowest level of crop losses (p=0.04) estimated as less than 25%. This is largely in part to the effect of insurance indemnifying losses.

Table 3: Multinomial logistic regression

Variables	Beta	S.E	Wald Test	P (Significant)	Exp(B)
Prepared	-0.590	0.627	0.886	0.346	
Planting less	-1.378	0.610	5.104	0.24	0.252
Shifting planting dates	-0.361	0.683	0.280	0.597	0.697
Crop diversification	-1.164	0.661	3.101	0.78	0.312
Crop insurance	2.275	1.167	4.864	0.027	13.126
Off-farm income	-1.769	0.988	3.206	0.73	0.171
Savings	0.666	1.012	0.433	0.511	1.946
Credit	0.353	1.080	0.107	0.744	1.423
Irrigation	0.15	1.114	0.000	0.989	1.015
Government support	b				
Crop loss	-0.642	0.659	0.444	0.505	1.744
Less than 25%	0.556	0.835	1.169	0.280	2.065
26 – 50%	0.725	0.670	1.594	0.207	0.373
51 – 75%	-0.985	0.780			
More than 75%	b				
Neutral	-0.642	0.659	0.948	0.330	
Planting less	-1.788	0.762	5.501	0.19	0.167
Shifting planting dates	-0.552	0.742	0.554	0.457	0.576
Crop diversification	-0.769	0.857	0.805	0.370	0.463
Crop insurance	2.196	1.271	2.984	0.84	8.993
Off-farm income	-0.959	0.995	0.928	0.335	0.383
Savings	1.477	1.060	1.943	0.163	4.379
Credit	0.157	1.430	0.12	0.913	1.169
Irrigation	-0.128	1.425	0.008	0.929	0.880
Government support	b				

a – The reference category is: not prepared
b – This parameter is set to zero because it is redundant

4.3 Discussion of results

A systematic literature review on risk management strategies covering 197 studies shows crop diversification as the main mitigating strategy employed by farmers. It is a stylized fact that smallholder farmers especially in rural areas are risk averse, and will opt for the most effective approach to reduce risk (Haile et al., 2019). In this study, diversification (13%) is the third most considered strategy, with the reduction in crop production the leading approach (32%), this is suggestive of higher than normal risk aversion on the part of South African smallholder farmers. Diversification requires a significant level of investment in crop production both in terms of time taken to learn new skills and financial resources, while crop reduction is the most conservative form of risk coping. Shifting planting dates (20%) was the second most preferred coping strategy. Maize is a drought sensitive crop affected by the level of water and moisture content in different ways at every stage of development and growth. In general, the water requirement of maize crops are very minimal at early growth phases, then reach a peak at plant reproductive growth phase, thereafter water requirements are significantly lower during terminal growth phases. Therefore, a physiologically mature crop with a well-established root system will likely cope better with a period of drought than would a developing seedling (Shah *et al*., 2020). As such, knowledge and timing of weather hazards becomes important, therefore shifting of planting dates and switching to the right cultivar to find the most optimum window becomes an important expert strategy.

When analysing the effectiveness of risk response strategies, results suggest that farmers that use insurance are the most prepared and expectantly show the lowest level of crop loss. This indicates that insurance is the most effective mechanism to increase the utility of farmers. The findings are consistent with Mutaqin (2019) on adaptation-related research, and confirm findings that insurance increases utility, specifically that of risk-averse farmers (Haile et al., 2019). However, unlike the other strategies insurance comes at an increased upfront cost, whereas, crop reduction, the main preferred strategy offers immediate relief in terms of reduced costs of inputs, as well as machinery and labour hours. Over the long-term though, insurance increases the prospects of crop yield and therefore income. According to Carter et al. (2016) insurance almost completely eliminates risk rationing, leading more risk averse agents to borrow capital and adopt higher yield returning technology. It appears though that the upfront expenditure associated with insurance and traditional prohibitively expensive hail and multi-peril crop insurance products may explain low uptake. The current crop insurance market in South Africa is wholly unsuited for the risk transfer needs of smallholder farmers and insurance penetration is estimated at less than 1%. For the smallholder farmers that use insurance, the benefits are evident, reflected in their level of preparedness and confidence regarding navigating turbulent weather variations. Shah et al. (2020) finds that effective coping strategies result in 40 -95% recovery of yield which would have otherwise been lost, at an additional operating costs of between 4 – 34% of the value of the recovered crop yield.

Interestingly, reduction of crop production in times of uncertainty which is the most preferred risk coping strategy is reported to be ineffective when referenced to farmer's self-assessment on their level of preparedness. This highlights the lack of risk transfer options available to farmers. As such, around 10% of farmers identify reliance on government support as an effective risk coping strategy. This situation might very well perpetuate the on-going market failure of insurance, which is a more effective way of responding to adverse weather risk. Disbursement of government emergency funds during times of crisis have been found to be untimely, poorly coordinated and lacking transparency, thus reducing the effectiveness of this approach as a viable coping mechanism. Farmers tend to have more flexibility and capability to cope with risk during the early stages of crop production because a wide range of coping strategies are still available before the risk fully materialises (Shah et al., 2020). However, strategies such as shifting planting dates and relying on irrigation have also been found in this study to be ineffective in a state of relentless drought that continues to expose vulnerable farmers. The vulnerability and limited coping capabilities of farmers is further highly correlated with the inability to access land for geographical diversification, limited water and restrictive water rights, lack of formal markets and timely weather-related information.

5. Conclusion

This paper has evaluated the effectiveness of risk coping strategies of smallholder maize farmers in key production areas of South Africa. It analysed the prevalent risk management practices and considered their viability in relation to the level of seasonal crop losses and based on farmers self-assessment of their level of preparedness in responding to and managing weather-related risk. Despite adopting various ex-ante strategies, a majority of farmer report losses in excess of 25% of crop harvest, with the exception of those using crop insurance showing lower levels of loss. Revenue growth in the agricultural sector continues to be limited by precautionary risk management approaches, in the main, the reduction of crop production to avoid crippling losses which often has long-term effects on farm sustainability. The findings generally confirm the PMT on risk, which show that coping strategies vary according to the sources of risk and at the highest level of threat farmers take the most conservative approach and curtail production as a protection response. The findings of this study add to the existing body of literature on agricultural risk management and the role of insurance in improving farm productivity and income.

Three important policy implications can be draw from these findings. First, addressing insurance market failure for smallholder farmers could improve farmer confidence, promote higher levels of productivity, reduce losses through risk transfer and improve food security at national and household level. Furthermore, the availability of insurance is likely to improve farmer's resilience and reduce vulnerability to weather shocks. Specific products such as index insurance have been championed as solutions for the uninsured and a response to systemic drought risk effects of climate change that affect smallholder farmers disproportionately because of their low financial resilience. Second, policymakers need to respond to farmers' systematic understatement of risk or inability to evaluate the impact of risk by introducing risk identification and mitigation programmes as part of extension support services. This advice and support will allow farmers to better anticipate problems and reduce the potential magnitude thereof. Third, in following the risk layering approach, crop diversification should be promoted as the initial layer of informal risk prevention and reduction measure because of its ability to maintain optimal production of land resources. Farmer's should be adequately supported to learn new production and management techniques of different crops to diversify across crop type and commodity price.

6. Limitations and study forward

The research is only limited to maize producing farmers in select provinces of South Africa, namely, Free State, North West and Mpumalanga. A larger study employing an increased sample size, featuring a wide range of different crop producing farmers in different provinces of South Africa is recommended. Further, Future research and development may want to explore and encourage appropriate insurance schemes and products, as well as investigate appropriate and cost-effective distribution channels. Insurance appears to be a promising avenue to enhance maize intensity and productivity in small scale farming, thereby offering an outlet in South Africa's response to the triple challenge of poverty, unemployment and inequality.

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