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Climate Threat and Alternatives for Farming in Driekoppies, Mpumalanga, South Africa.

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ABSTRACT

The rise and harshness of extreme weather events demands active protection of the environment for sustainable agricultural development. Farmers take cognizance of risk and uncertainty while making choice of appropriate farm management practices. The study examined climate risk mitigation options for sustainable agricultural development in selected areas of Mpumalanga province. Stratified random sampling was adopted to interview 490 smallholder sugar cane farmers in Driekoppies, Nkomazi Local Municipality Mpumalanga, South Africa. The study used the multivariate model to determine possible correlation between the application and use of information communication technology, system flexibility and contingency planning as climate risk management strategies. Findings extrapolated the relevance of climate risk management and adoption decision. The effect of dependent variables on covariate variables used in the analysis were noted. Nevertheless, age of respondents, level of education, flood risk perception, farm size, risk aversion and off-farm activities were the independent variables that influenced the adoption of risk management approach in context. To improve adoption of risk management in the planning of farming practices, the valuation of seasonal climate information should be enhanced.

Keywords: climate, management, agriculture, information, communication technology, system flexibility, contingency plan, decision making.

INTRODUCTION

The land surface of South Africa is 69% and is suitable for livestock farming which is considered the largest sector in agriculture. Even though 80% of the country's land is used for agricultural activities, only 12% is arable. The greatest challenge is inadequate water supply, with erratic and unreliable rainfall. About 1.3-million hectares of land are under irrigation, and partly used for sugar cane farming. The rest is used for grazing. The main agricultural ventures comprise of mixed farming, crop production, sheep farming, cattle ranching, dairy farming, game ranching, aquaculture, apiculture, and viticulture (Statistics South Africa (STAT, 2016). The changes in climate and extreme weather events are impacting on agriculture and will continue to present additional severe challenges to sugar cane farmers. Climate risk in agriculture includes the likelihood of a definite atmospheric and environmental hazard occasioned by climate vagaries, with effects on farming. Risk denotes the likelihood which can be predicted from prior information, while uncertainty connotes a situation in which probability cannot be estimated (ADF, 2010). Decision-making in agriculture takes into cognizance risk and uncertainty while making choice of appropriate management practices. Smallholder farmers are risk averse, with vague understanding of the risk of climate change (Selvaraju, 2012). Climate risk management (CRM) refers to different facets of risk administration processes which includes: the valuation of risk for up-to-date decision-making; risk abating; risk planning and risk sharing and transfer with respect to adaptation (UN, 2011). The CRM approach is relevant for smallholder farmers' decision making. It focuses on a coordinated response for addressing climate risks with committed engagement of farmers in building resilience and sustainable livelihood. Climate risk aversion options have over the years emerged as having the potential to enhance resistance of smallholder farmers in mitigating climate stress. However, there are increases in the benefits of information communication technology (ICT), system flexibility and contingency planning in achieving sustainable agriculture amidst extreme weather events. Smallholder farmers have numerous adaptation strategies to cushion the effect of environmental changes by modulating their agricultural practices and

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sometimes selecting resistance cultivars, drawing from their indigenous knowledge and farm experiences (Lasco RD, Habito MS, Delfino RJP, Pulhin FB, 2011).

For over three decades, South Africa has been witnessing extreme general warming associated with climate change and this phenomenon is almost double the average global temperature trend (Kruger, AC and Sekele, 2012),(Kruger, A.C., McBride , C, and Thiaw, W.M, 2012). Changes in temperature and rainfall pattern have a number of direct or indirect impacts on the biophysical environment which include decreasing availability of water resources, water stress, increased plants evapotranspiration, heat stress on plants and animals, changing ecosystem leading to extinction of animals and plant species. There is severe impact of climate change on food security, human health and livelihoods. Additionally, climate change may have unswerving impact on the community and rural economy and trade. While some communities have been experiencing the impact of climate change at different intensity, many communities have very low resilience and are unable to absorb shocks (Pelser, A. and Redelinghuys, 2009).

Water resources in South Africa are limited. Therefore, there is need to revitalize and increase water availability for sustainable agriculture. However, revitalising water resources is just one part of a broader sustainable agricultural practice. Loss of soil nutrients and uncertainty of water resources brought about by climate change have affected the livelihood of majority of people with opposing consequences on sustainable agriculture (Agholor, 2013). Water is undoubtedly the main avenue through which climate impacts are felt by both smallholder farmers and commercial farmers. South Africa agricultural sector is already enmeshed in risk of rainfall variability (Schulze, 2011). Climate change in terms of erratic and uncontrolled heat waves, rising temperatures, changes in rainfall patterns, droughts and flooding are likely to pose a threat to crops and livestock production. The damage-related costs linked with weather events have far reaching socio-economic consequences to most communities. However, a sense of the degree of these cost,(Environmental, 2011) found that direct cost of weather-related problems between 2000 to 2009 were estimate to be R8 billion. This suggest that the global economic competitiveness of South Africa is at risk because with increased frequency of these weather events, the associated cost is likely to increase.

Climate threat and risk aversion decisions, management, and planning are some of the priorities of farmers in the study area to achieve sustainable production. Sustainable agriculture aims to maintain a functioning agricultural land space, increase soil fertility and mitigate adverse weather events (Cândido, G., Nóbrega, M., De Figueiredo, M., and Maior, 2015); (Altieri, 2002).The approach to climate risk assessment and management encompasses using up-to-date tools for climate data sourcing and analysis. Also, the approach includes automatic meteorological measurements for rainfall, temperatures, and wind; analysis of climate risk assessments, integration of economic models, linear and non-linear method (Selvaraju, 2012). These approaches assist in the provision of full knowledge on the types of livestock and crops to be planted and practices to be adopted in the management of crops and animals. The operative modalities of climate risk management include the collection of real-time local weather and crop information, the analysis of climate risk, vulnerabilities and impact and management choices, and communication of management options to decision makers. Recent development in climate analysis and building of climate knowledge have helped in improving climate risk management with the possibility of enhancing livelihood of rural farming communities in South Africa (Selvaraju, R, Gommes, R. & Bernardi, 2011).

In this study, the authors aligned the synergies of alternative adaptations to climate risk mitigation for sustainable agriculture in South Africa and made a case for information communication technology, system flexibility and contingency planning. Contemporary literature points to an increasing need of risk mitigation alternatives which includes multiple alternatives towards mitigating the hazards associated with climate change. In South Africa, such literature arose from global perceptions, viewpoints and theoretical underpinnings with restrictions on practical field survey. Much therefore, remains to be surveyed and investigated, mainly with respect to climate risk mitigation alternatives for sustainable agriculture in South Africa. Therefore, the study attempts to assess the impact of socio-economic independent variables on the adoption of information communication technology, system flexibility and contingency planning using multivariate probit regression model for analysis.

METHODOLOGY

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Selection and description of the study area

The study was conducted in Driekoppies, Ehlanzeni district situated on the East of Mpumalanga Province, South Africa. The area covers approximately 76,495km^2 comprising of Nkangala, Gert Sibande and Ehlanzeni. The vegetation of the area is mainly grassland in the highveld, bushveld and lowveld regions. The annual average rainfall of 767mm with minimum and maximum tempearure of 19^{0}c and 29^0 c is experienced in the area. Driekoppies community was selected because there are a lot of farming activities, particularly sugarcane farming by smallholder farmers. Sugarcane farming and banana production are the major crops in the area. The available economics of scale that justify the thriving of sugarcane farming in the area is the presence of sugarcane processing mill factory,(the Transvaal Suiker Beperk [TSB]), where sugar cane is processed locally for livelihood. The small holder farmers in the area have been experiencing changes in their weather condition to the extent of receiving precipitation that is significantly below optimal level. This study focused on the adoption of information communication technology, system flexibility and contingency planning as risk ameliorating alternative approach for selected sugar cane farmers in Driekoppies, Nkomazi Local Municipality, Mpumalanga, South Africa. Sugarcane is an important crop in these regions where drought is persistent, and the cultivation is mostly dependent on rainfall. Driekoppies usually has lower rainfall than other parts of the country thus, sugarcane is at high risk of drought-related problems. Nevertheless, drought associated risks have been recorded as the main factor influencing agricultural production in the area (Kahn, E.A., Pei Li and Zhao, 2015).

Figure1: Map showing position of Driekoppies, Nkomazi municipality
Source: (Municipality, 2019)

The data for this study was collected from 490 farmers involved in sugar cane farming. Prior to the start of the study, 10 enumerators who understand the local language(SiSwati) were trained on how to administer the questionnaire. The prepared questionnaire items were pre-tested with 25 households and necessary screening made before the finalization of the interview. The multi-stage stratified random techniques were used and 490 smallholder farmers were sampled. The questionnaire items were divided into two sections. The first section comprised of the socio-demographic attributes of the respondents. The second section covers the adoption behaviour of sugar cane farmers regarding the use of ICT, system flexibility and contingency plan as risk minimizing approach in sugar cane farming.

Approach and Model selection

Most often, the purpose of model choice is to select the type that incorporates future predictions, and it is natural to measure the accuracy of such estimation by squared error loss. Applying the Bayesian method, it is usually perceived that the ideal estimated model is the one with highest posterior probability. This is obvious when two models are being entertained (Berger, A. N., 1997) and is accepted in the variable selection for linear models with orthogonal design matrices (Clyde, M. A. and George, 1999); (Clyde, M. A. and George, 2000). Indeed, even when only three models are being entertained, essentially nothing can be said about which model is best if one knows only the posterior probabilities of the models. In other words, one just itemizes the sequence of posterior model probabilities and add up until the total exceeds 1/2. The model at which the exceedance occurs is referred to as the median probability model (MPM). Nevertheless, MPM (JO, 2004a) was used for this study. The MPM explains that any model comprising of variables whose marginal posterior probability of inclusion is at least 0.5 is considered fit. The MPM rule, however, has become so distinct amongst researchers that it is currently being used for different priors and under correlated designs, even when the properties of MPM are not entirely known. Furthermore, since the covariates in this study are interrelated, the MPM rule of (JO, 2004b) was the best fit to use for model selection. In this paper, the conditions for which the MPM were used, provide real data samples for this study. The numerous dependent and independent variables were employed and used under MPM guidelines for this study.

Dependent variables

Information Communication Technology

Generally, risk management decisions are hinged on correct information which requires consistent data. For a farmer, good information assists in making rational and informed decision on risk management. However, the sources of information vary from repository data, farm activity records, market price data, weather data to extension practitioner. Information communication technology (ICT) assists in facilitating access to a broader set of durable assets, such as mobile tools and information that bring small entrepreneurs and farmers into regional and global supply chains. Information communication technology allows swift access to and mobilization of financial assets through mobile banking and payment systems such as the recent use of Bitcoin wallets. Mobile-based disaster warning and response using ICT, allow relief systems to support recovery efforts and emergency management which has offered innovative adaptations for vulnerable smallholder farmers. The knowledge obtained from the use of information communication technology has offered numerous avenues for adaptation to the effects of climate change. Weather observations and monitoring through ICT opens new ways of assimilating information on weather changes, and providing wider networks to bring about combined action to avert weather shocks (Heeks, R., and Ospina, 2010);(Hilty, L., Lohmann, W., and Haung, 2011);(Melville, 2010). Study conducted by (Higón, D. A., Gholami, R., & Shirazi, 2017) found that information communication technology contributes to the reduction of greenhouse gasses and is able to reduce carbon dioxide emission on a large scale. However, ICT is highly relevant in many sectors of the society, but little research has been done in agriculture to recognize its usage.

System flexibility

Farming system flexibility is imperative for risk management at farm level. Adopting a flexible farming system makes it possible for a farmer to make changes and adjust quickly in production in times of adverse weather events. While adhering to the initiated production plan, it is important for a farmer to allow alternatives as open as possible, so as to respond adequately to climate risk. System flexibility involving the growing of crops and the raising of livestock at the same time is widely practiced across South Africa. A farmer who practises system flexibility is only expanding his portfolio to avert failure. In their study (Tibesigwa, B., Visser, M, 2016), they found that mono crop farmers and mixed crop farmers were likely to be affected by a simultaneous change in temperature and precipitation, but the effects will be felt the most by mono crop farmers and least by those practicing mixed farming methods. The result further identified mixed farming to be a more profitable alternative mitigation approach to climate change than other farming practice. Other studies (Nhemachena, C., Hassan, R., & Chikwizira, 2010) (Tibesigwa, B., Visser, M., Collinson, M and Twine, 2015) found that farmers practicing monocropping experienced severe effects of crop failure from climate change. (Nhemachena, C., 2007) found that with increase in temperature, farmers will shift to different farming practices in diverse agro-ecological zones. Other system flexibility approaches include diversification of crops, planting different crop cultivars, engaging in non-farm activities, modulation of planting and harvesting dates, increasing the use of irrigation, and adoption of soil conservation techniques (Nhemachena, C., 2007). However, system flexibility disallows a farmer from using optimium linkage of resources that gives the maximum possible yield because employing multiple production practices may demand different farm equipment. Therefore, system flexibility minimizes risk while at the same time reduces potential farm income (Fleisher, 1990). Nevertheless, it should be acknowledged that adopting flexible system may not be possible with all farm businesses especially the orchard farms.

Contingency planning

There are uncertainties about weather, incidence of pest and diseases, and fluctuation in prices of farm products, Also, the exigency plans put in place to manage events are, at best, a mere assumptions about how to adapt and manage a range of climate-related risk. Contingency risk management approaches are multi-dimensional and they include a deliberate overvaluing or overestimation of farm inputs and capital items used in the farm by farmer to cover future production cost increases arising from weather events (Hardaker, JB., Huire, 1997). Contingency plans are in most cases incorporated in farm business decision-making. The inclusion of contingency item in a farm budget is paramount and essential not only for planning but also to alleviate the impact of an adverse occurence such as product price decreases, yield failure and cost increases on farm input. Personal savings may also be done by a farmer to secure the future and to remain in proper financial state should his earnings becomes low in future. Contingency plans are put in place at any point in time in response to unexpected eventualities. Contingency planning of household against weather-related shocks differs from selling of assets, saving money, reliance on social networks, petty trading and temporary migration to areas less affected (Osbahr, H., Twyman, C., Adger, W., and Thomas, 2010). Adaptation to weather induced shocks are two-fold processes, which require the awareness that drought exist and then responding to the impact through mitigation strategies such as making contingency plans. Farmers, however, used multiple drought preparedness and mitigation measures which include contingency savings. The study by (Udmale, P., Ichikawa, Manandkar, H., Kim, 2014), found that about 78.8% of farmers preferred to store their crop produce to dealing with anticipated drought impact while 51% of farmers reduced their expenses and saved money for unforeseen contingencies. Social networks increase awareness and use of adaptation options. Social capital as a public good can reduce transaction costs and enhances the exchange of resources and exigency savings. (Adger, 2010) also clearly demonstrated that social capital is a fundamental asset to savings and building adaptive capacity to climate change. Networks of community groups, local savings schemes based on regular membership fees are useful savings strategies in preparation for times of stress and are also very important adaptation for CRM (Ellis, 2003).

Independent variables

Socio-demography and farm characteristics

Age (AGE), level of education (LOE), farm experience (FAME), farm size (FRMS), off-farm activities (OFAMI), flood risk (FLDRK), drought risk (RKDT), pest and diseases risk (PDRK), theft risk (THFRK) and risk aversion (RKSA) are the independent variables used in the study. In similar studies, these variables were found to be relevant factors determining adoption decision for risk aversion options ((Rehima, M.; Belay, K.; Dawit, A.; Rashid, n.d.), (Jianjun, J.; Yiwei, G.; Xiaomin, W.; Nam, 2015). The age, education and farm experience are continuous variable, and were indicated in years. Level of education is the extent of educational attainment while farm experience sums up the total number of years a farmer has spent making farm choice in the production process. The farm sizes represent the magnitude of farm plot cultivated or used for farming and is usually measured in acres. Additionally, off-farm activities were considered as extra engagement outside the farm to earn additional income. The respondents were required to ascertain the impact of flood and drought associated risk. However, the variables, flood risk, drought risk, risk associated with pest and diseases, theft, and risk aversion were considered as dummy variables. Simultaneously, a farmer indicates 1 if he is impacted by any of the dummy variables and 0 otherwise.

RESULTS

Descriptive statistics of the variables used in the study

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Table 1 shows the descriptive statistics of the variables used in the study. Farmers who adopted the use of information communication technology (ICT) as risk management alternative were □X = 48. As expected, many farmers were abreast of the use of mobile phones, radios and internet services. This result is corroborated by (Heeks, R., and Ospina, 2010) who found that ICTs increase the adaptive capacity of human beings to climate change. As shown in Table 1, the□X = 85 indicates the sugar cane farmers who adopted system flexibility as management alternative to ameliorate the risk of climate change. This result is consistent with the studies of (Kingwell, R., Anderston , L., Feldman, D., Speijers, J., Wardell-Johnson, A., Islam, N., 2013) who found that farmers who practiced system flexibility is less exposed to climate risk. It further stated that farmers considered system flexibility as viable lower risk under erratic and unfavourable climatic conditions. The sugar cane farmers with contingency plan for risk management approach had a mean of 55. However, age, level of education, and farm experience were □X = 2.93, □X = 2.36, and □X = 1.70 respectively. Farm size of respondents shows□X = 2.25 while famers who undertook off-farm activities recorded □X = 4.18. The farmers who identified flood, drought, pest and diseases, theft and risk aversiveness with values of 1, if the rate of risk is more than 5 and 0, otherwise as indicated in the options, recorded □X = 4.18, □X = 0.78, □X = 0.83, □X = 0.77, □X = 0.73, and □X = 0.55 respectively.

Table 1. Descriptive statistics of the variables used in the study

Study variables	Description	Mean (□X)	Std. Dev (SD)
ICT	1, if farmer uses ICT for risk aversion and 0, otherwise	0.48	0.502
System flexibility	1, if farmer practices system flexibility and 0, otherwise	0.85	0.361
Contingency plan	1, if farmer has contingency planning and 0, otherwise	0.55	0.500
Age	Age of farmer in years	2.93	1.663
Level of education	Level of schooling	2.36	0.944
Farm experience	Number of years in farming activities	1.70	0.911
Farm size	Total farm area under cultivation measured in acres	2.25	1.263
Off-farm income	Income from other sources apart from farming	4.18	1.904
Flood risk	1 if risk value is more than 5 and 0, otherwise	0.78	0.415
Drought risk	1 if risk value is more than 5 and 0, otherwise	0.83	0.379
Pest & diseases associated risk	1 if risk value is more than 5 and 0, otherwise	0.77	0.422
Theft risk	1 if risk value is more than 5 and 0, otherwise	0.73	0.447
Risk aversion	1 if farmer has risk perception aversion and 0, otherwise	0.55	0.500

Source: Own survey, 2019.

Also, farmers who adopted contingency planning as risk management approach were 55%. Contingency plan undertaken by farmersincludes the building up of buffer stocks and income diversification. However, majority of farmers interviewed were risk averse.

Results for parameter estimates for multivariate model

Table 2 shows the parameter estimates for multivariate analysis. The Bartlett's Test of Sphericity indicates: Likelihood ratio 0.000, Chi-Square 5473.475, df 5, and significance (*p-value*) 0.000. Since the Bartlett's Test of Sphericity has a *P=value* 0.000 less than 0.05, it implies significance, and the variables used are correlated enough to provide a realistic and rational basis for adopting multivariate model. Results from the analysis indicate that the correlation coefficient of information communication technology, contingency planning and system flexibility are positive. The implication is that farmers are inclined to adopt the use of information communication technology, contingency plan and system flexibility as risk management strategies in response to climate change.

Discussions of Parameters Estimates for the multivariate result

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The results and discussions of the multivate analysis are as follows:

Factors influencing adoption of information communication technology

The result indicated in Table 2 shows that flood risk (FLDRK) correlated and positively influenced the adoption of information communication technology as alternative risk mitigation strategy. The implication of the result is that is that holding other variables constant, for every unit increase in flood risk occasioned by adverse weather event, there is an increase in the odds of adoption of information communication technology as a risk management alternative. Though, there is significant relationship, information communication technology-enhanced meteorological data are seldom used by farmers in the area to support the monitoring of rainfall pattern. ICTs such as internet and radio have been used to raise awareness about the risk associated with climate change. However, the application of information communication technology in disaster risk management as a result of climate variation is determined by government commitment (Finlay, A., and Adera, 2012). Also, risk aversion (RKSA) was found to negatively influence farmers' likelihood of adopting ICT as a way of reducing climate risk while other factors remain constant. Some farmers are risk-averse while others are risk takers. Generally, appropriate sources of information will definitely assist farmers to make reasonable risk management decisions relevant to climate risk. The result further indicated that the age (AGE) of farmers negatively influenced the choice of ICT as an attempt to mitigating climate risk. This result suggest that holding other variables stable, for every increase in age there is -.041 decrease in the odds of adoption of ICT as risk management strategy. The more a farmer responds and assesses risk, the better his disposition in making risk management decisions.

Table 2. Parameter estimates for multivariate probit model

Explanatory variables	Information Communication Technology		System Flexibility		Contingency Plan	
	B(Coef.)	p-level	B(Coef.)	p-level	B(Coef.)	p-level
FLDRK	.110**	.048	-.047**	.648	-8.744	.153
PDRK	.029	.834	-.055	.575	1.042	.986
THFRK	-.042	.751	-.098	.303	-3.312	.551
RKSA	-.121***	.304	.104**	.217	1.000**	.000
AGE	-.041**	.437	-8.691	.998	2.965**	.000
LOE	.057	.355	.063**	.158	-3.554	.174
FRMS	.029	.554	.025*	.473	1.388	.492
OFAMI	-.002	.955	.024**	.359	8.731**	.000
FAME	.012	.891	.038	.539	-2.763**	.000
RKDT	-.154	.321	-.034**	.755	-1.335**	.042
Bartlett's Test of Sphericity: Likelihood Ratio: Approx. Chi-Square df Sig.	 .000 5473.475 5 .000					

The significance levels at less than 10%, 5% and 1%, likelihood level respectively.

This finding contradicts the study of (Bucci, G., Bentivoglio., D., Finco, 2019), who found that younger farmers were more inclined to adopt the use of information communication technology than older farmers. In addition, their finding is considered as a consequence of ageing, as older farmers have limited planning prospects, weakened incentives and less exposure to information communication technology (Roberts, R.K., English, B.C., Larson, J.A., Cochran, R.L., Goodman, W.R., Larkin, 2004). Farmers affected by drought are likely to take steps to lessen their vulnerability by adopting the use of information communication technology as risk management alternative irrespective of age. Also, similar study (*Accelerating adoption of drip irrigation in Madhya pradesh, India*, 2012) reported the adoption of information communication technology as a management practice to ameliorate climate risk.

Factors influencing adoption of system flexibility

As indicated in Table 2, risk associated with flood (FLDRK) was found to negatively influence the adoption of system flexibility. This is so because flood risks seldom occur in the area as opposed to other climate events. The paper also detailed a relationship between farmers level of education (LOE) and their choice of system flexibility, and found that the level of education significantly and positively influences the choice of system flexibility as risk management alternative. Educated farmers are more disposed to practice system flexibility in order to increase their farm income, guard against total crop failure and mitigate risk of climate change. The inference here is that when other variables are held constant, an increase in the level of education cascades into adoption of the use of system flexibility by farmers with the aim of averting climate risk. Additionally, the variable farm size (FRMS) was also found to significantly and positively influence the adoption of system flexibility with β = .025. This result suggests that for any unit increase in farm size, there is the likelihood of increase in the adoption of system flexibility as risk management approach.

Also, the study investigated whether risk aversion (RKSA) induces the adoption of system flexibility. Result found a positive correlation (β = 0.104) between risk averse farmers and system flexibility. The implication, therefore, is that risk-averse farmers are inclined to diversify their farming practice to insure against crop failure. In contrast, (Nhemachena, C., Hassan, R., & Chikwizira, 2010); (Gbetibouo, G.A. and Hassan, 2005) in their study found that adverse temperature had no serious impact on specialised livestock farming and horticulture farms but rather showed negative impact to farms practicing system flexibility. (Tibesigwa, B., Visser, M, 2016) also evaluated climate change on commercial farms in South Africa and found that commercial farmers were more affected by climatic shocks than those engaged in system flexibility. However, result from this study found that system flexibility is a more robust alternative to climate risk management strategy. The studies of (Maddison, 2006); (Nhemachena, C., 2007) found that as vulnerability increases, farmers will change farming practices in different farming regions. Consistent with other results, holding other factors constant, RKDT with β =-.034 was also found to be signicantly and negatively influencing adoption of system flexibility as an alternative to mitigating climate risk. Moreover, risk management practices covered in related study (Nhemachena, C., 2007) consist of system flexibility: crops diversification, cultivation of different crop varieties, replacing farm activities with non-farm activities, adjustment of planting and harvesting dates, increasing the use of irrigation, water use efficiency and soil conservation.

Factors influencing adoption of contingency plan

The result as presented in Table 2, found that pest and diseases (PDRK); risk aversion (RKSA), age (AGE); farm size (FRMS) and off-farm (OFAMI) activities were found to positively and significantly influence the adoption of contingency planning. As a standard practice in the area, most farmers engage in off-farm activities as a means of making extra income to prepare for unforeseen contingencies that may arise from weather events. In this study, risk perception in farming coupled with the severity of extreme weather events and increasing incidence of pest and diseases enhanced contingency planning by risk averse farmers. Farm size (FRMS)) was found to significantly influence farmers' adoption behaviour but negatively related to contingency planning as risk management alternative. By implication, for every unit increase in acres of land cultivated, there is 1.388 decrease in the adoption of contingency planning as a climate risk mitigating strategy. Result reveals that farmers with large farm size preferred to adopt contingency planning by changing their crop calendar and used low water consuming crops as opposed to farmers with marginal and small land size. Risk-averse farmers are determined to save in order to mitigate extreme weather events. Also, pest, diseases and intensity of drought are other factors influencing adoption of contingency planning as risk management strategy. In this study, age also has correlation to adoption of contingency plan as risk management strategy. Consistent with this result, (Udmale, P., Ichikawa, Manandkar, H., Kim, 2014) asserted that older farmers are more experienced and are firmly disposed to contingency planning for unforeseen events. (Boulahya, M., Cerda, M. S., Pratt, M. and Sponberg, 2005) found that older farmers used multiple strategies including storage of harvested crops, stored crop leftovers for livestock, saved money, migration for jobs, and distress sales of livestock for income. Contrary to this findings, (Jensen., F.E., Pope, 2004) found that age has no influence on the adoption contingency planning as climate risk mitigating approach. It is argued that personal savings is mainly driven by income and foreseen risk. The variable off-farm activities (OFAMI) with β = 8.731 was found to be significant but negatively related to adoption of contingency planning. This result suggests that for every unit increase in period engaged in off-farm activities, there is -.002 decrease in the odds of contingency planning. Off-farm activities may pose a constraint to adoption of ICT because it competes for labour and time required for on-farm activities (McNamara, n.d.). Farmers who engage in off-farm activities may not be sufficiently informed of technology in the farm.

CONCLUSIONS AND RECOMMENDATION

Sustainable agricultural practices aim to optimise land and water resource management for long term agricultural productivity. Farmers adopt variety of strategies to renounce adverse weather events occasioned by climate vagaries. Contemporary literature points to an increasing need for risk-aversion options which include multiple alternatives towards mitigating the hazards associated with climate change. In South Africa, such literature arose from perceptions, viewpoints and theoretical underpinnings with marginal restrictions from practical field survey. Therefore, this study surveyed and investigated mainly the risk mitigation alternatives for sustainable agriculture in South Africa. Consequently, the study also assessed the impact of socio-economic independent variables on the adoption of information communication technology, system flexibility and contingency planning using multivariate probit regression model for analysis.

Findings of this study uncovered the correlation between climate risk adoption decisions by farmers to mitigate climate event. Results further reveal that the effects of dependent variables on independent variables were not homogenous. However, age, level of education, flood risk, farm size, risk aversion, and off-farm activities influence adoption decisions. Furthermore, risk and uncertainties are prevalent. However, farmers may not be able to put under control variables such as farm product price fluctuation, labour availability, pest and diseases infestation and unexpected weather vagaries.

Although the study is confined to only 490 selected sugar cane farmers in Driekoppies, Nkomazi Local Municipality, Mpumalanga, South Africa, the results could also be applied to other developing regions of the world, especially areas without formal risk disaster management and emergency adversity relief. The risk valuation strategies on seasonal climate information by farmers is important to enhance farm planning. The upsurge in frequency and severity of extreme weather events demands proactive conservation of the environment.

Climate information is critical to advance risk management and it enhances sustainable agriculture. The need to improve risk management approach is dependent on farm systems optimization practices that maybe considered suitable to manage risks associated with climate variability. However, to abate the risks associated with climate change, proper adaptation practices must be implemented by farmers, assisted with empirical data and amalgamated information from South African government.

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Authors have read and consented to the published version of the manuscript.

Conflict of Interest

The authors asserted that there are no conflict of interest.

Research with Human Participants and Informed consent

The study is part of the master's research work of the first author, supervised by the second author (Dr Agholor AI). Informed consent was sought and obtained from all respondents and other stakeholders that took part in this study.

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