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Exploring the Link between Livelihood Capital Assets as Index of Climate Change Adaptive Capacity and Socio-economic Issues: A Case of Small Scale Maize Farmers in South Africa

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ABSTRACT The economies of many African countries are largely agrarian driven and there are increasing revelations that climate extreme events present a negative influence on biophysical, social and livelihood system of human sustenance. This research therefore investigated farmers' adaptive capacity in the North West Province of South Africa. Cross-sectional data obtained from the randomly drawn 346 maize farmers were analysed using descriptive statistics, composite technique and finite mixture semi-parametric model. From the result, majority (60.69%) have a moderate adaptive capacity, while farmers' adaptive capacities are distinguishable in terms of farmers' characteristics and livelihood capital assets. Further, the results also indicated that about sixty-three percent of the farmers are likely to be in the low AC class, and twenty-two percent are expected to be in the moderate AC class. However, approximately fifteen percent are expected to be in the high AC class. Consequent on these findings, a sustainable adaptive capacity driven policy is of paramount importance to ensure functioning food systems and agrarian welfare.

INTRODUCTION

Maize represents a major component of food crops that is well adapted to varying ecological situations across South Africa, and many other parts of Africa (Abate et al. 2015). This crop is predominantly grown by the resource-poor smallholder farmers who operate on small holding farmlands. These farmers are vulnerable to multi-dimensional environmental challenges mostly caused by climate extreme events and human explorations, and hence, the need for proper and adequate adaptation (Gilbert 2012). The climate extreme events usually result in fragile and degraded terrain with poor soil quality, as well as depleted ground water (Adimassu et al. 2014; Nkonya et al. 2015). By extension, agricultural productivity, food security, and general farming households' welfare are threatened. Therefore, ensuring both short and long term sustainable food security is central to rural agrarian growth and development (Alliance for Green Revolution in Africa (AGRA) 2014; Tittonell et al. 2012).

The livelihood sustenance of the rural farmers in developing countries like South Africa largely depends on the pattern of farming practices, and importantly, the climate change adaptive capacity of these farmers who are heterogeneous in all ramifications. Adaptive capacity of farmers varies, and at times uncertain (Wood et al. 2014). This is because farmers in the tropics and sub-tropics parts of Africa are vulnerable, with limited adaptation potentials (Harvey et al. 2018). Therefore, capacity to adapt is crucial to fostering sustainable coping mechanisms against extreme weather events among the farmers both at the community and global stages (Alam et al. 2017).

The strategies are however unlikely to be fully understood without delving into the dynamics of farmers' adaptive capacity and how this varies across individuals. In a clear term, rural farmers are prone to be adversely affected because of limited adaptation potentials. The

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farmers are limited in terms of human, financial, social, physical and natural capital assets and resources. Meanwhile, adaptation strategies are context specific and the dynamics differ across different geographical areas (Malone 2009). Consideration of these dynamics is necessary to facilitate formulation of a well-focused climate adaptation policy to assist the vulnerable agrarian communities. According to Ncube et al. (2016), the first point of call is at the local level whenever there are any climate change related events. This perhaps makes the rural farmers a good candidate to focus on in terms of policy driven interventions and research on climate-change events, taking into consideration the farmers' adaptive capacity.

Using the livelihood capital assets "human, financial, social, physical and natural capital" framework, this study investigated the correlates of maize farmers' varying adaptive capacity in the North West Province of South Africa, in response to the warming planet extreme events. More so, in view of the need to ensure good and sustained welfare condition among the populace, this study specifically focused on the following objectives.

Objectives of the Study

1. To describe the farmers' socio-economic and demographic characteristics in Ngaka Modiri Molema district municipality.
2. To profile the farmers into levels of adaptive capacity in the study area
3. To estimate the factors influencing variation in farmers' adaptive capacity.

Review of Literature

Livelihood Capitals and Farmers' Adaptive Capacity to Climate-extreme Events

The African region, particularly, the sub-Saharan Africa countries, according to Perez et al. (2015), are under the threats of high climate variability. In addition to the prevalent food and water insecurity, population explosion, and limited capability in terms of institutional arrangement and economic advancement to cope with the climatic shock events, the African region's livelihood and economic survival and prosperity are also hinged on climate related and sensitive issues (Perez et al. 2015). This suggests that human race and natural systems in this contemporary society are faced with unpredictable and adverse climate events (Sorre et al. 2017; Mengistu and Assefa 2019). However, as documented in Noble et al. (2014), both human race, and natural systems are capable to withstand, cope and adapt to these unpredictable climate extreme events.

A natural system's ability to mitigate and adjust to climate extreme events is known as adaptive potential or capacity, and this is determined by certain features inherent in a system, which is referred to as adaptation determinants (Sorre et al. 2017 citing Olmos 2001). The rate of adaptation largely differs across different affected natural systems, and/or communities (Sorre et al. 2017). Consequently, recognising and improving adaptive capacity reduces the vulnerability of a household, community or population, and ultimately drives development and sustainable environment (Abaje et al. 2015). There is varying adaptive capacity level across individual, groups, and nations. According to Adger et al. (2004), the level of variation is essentially driven by access to resources, which are expected to be abundantly, sufficiently and efficiently available and utilised by the people and natural systems.

Apparently, a household's capacity to mitigate against climate threats depends, to some extent, on the functioning environment, while that of community adaptive ability represents the region's resources and processes, and how these can interplay to combat extreme events (Smit and Wandel 2006; Abaje and Giwa 2010). However, it is important to give clear conceptualisation, so as to understand how adaptive ability can be scaled-up among the farmers (Jones et al. 2010). The Intergovernmental Panel on Climate Change (IPCC) in 2001 held in Geneva, Switzerland recognises "economic wealth, technology, information and skills, services, institutions, and resources" as the key drivers of adaptive potential. Notable reviews (for instance, IPCC 2007 as cited in Sorre et al. 2017) argued that earlier studies have underplayed social factors, in particular power dynamics that take into account the influence of social capital, the pyramid of governance as well as institutional arrangements and functions (IPCC 2007).

Generally, adaptive capacity in any socio-ecological system is linked to the ability to respond to actual or anticipated changes in the natural systems, by altering its processes, activities, or frameworks, and assets, in a bid to minimise vulnerability and impact of the changes (Marshall et al. 2010 as cited in Perez et al. 2015). Accordingly, adaptive capacity concerns the capability of individuals to efficiently use the available as well as the expected resources within the sustainable livelihood frameworks, that is, financial, physical, human, social and/or natural capital, to build resilient future adaptation strategies (Adger et al. 2005). This suggests building resilience cannot be underestimated, as this allows a system to cope with surprising shocks and unexpected stresses (Tompkins and Adger 2004). Hence, the target of development experts is to find intervention points in a framework to improve its resilience to future changes. According to Perez et al. (2015), strength and resistance underpin the initial concept of resilience. Nonetheless, its current use by various fields, such as biodiversity, socio-ecological systems and disaster management believe that the "*normal state of ecological and socio-ecological systems*" is a transition that is often unpredictable (Perez et al. 2015).

Resilience is also construed as the ability of a socio-ecological system to handle, and respond to, financial, political, and environmental changes (Folke 2002; Marshall and Marshall 2007). Suggesting that, resilience preparedness programs do not aim to resist change, but to prepare to live with it (Folke 2006 as cited in Perez et al. 2015), which underlines the following critical components of resilience: "*learning, new knowledge creation and governance; versatility to innovate and adopt new practices; and capacity to reflect, assess and handle risks*" (Marshall et al. 2010; Miller et al. 2010). Fostering sustainable resilience is a necessary action plan by various nations across Africa, and this necessitates creation of a buffer to increasing an individual's adaptive capability to extreme climatic events. Failure to ensure this, the prevailing impact of climate extreme events will continue to grow beyond control, constrain the welfare envelope, and limit development space for proper investment in the five capital resources that constitute the sustainable livelihood frameworks.

Empirical Evidence: Livelihood Capital Assets and Farmers' Adaptive Capacity

Various authors have discussed varieties of adaptive capability determinants, on both counts of context-specific and general factors (Sorre et al. 2017 citing Gbetibouo et al. 2010). Nonetheless, as noted by Jones et al. (2010), most of these works on adaptive capacity assessments are based at the national level, or concentrate on assets and resources as adaptive capacity measures. In general, the national level metrics do not mostly take into account "*the processes and contextual factors*" of individual ability to adapt (Eriksen and Kelly 2007 as cited in Sorre et al. 2017), and are therefore not an accurate representation of adaptive capacity at local level, where the actual adaptation activities are assumed to occur.

According to Bierbaum et al. (2014) as cited in Selm et al. (2018), adaptive behaviour, irrespective of mitigation measures, are very important to any climate change policy, while both "bottom up and top down" coordinated approaches are equally essential to adapting to climate extreme events. Any governmental strategies aimed at mitigating the negative impact of extreme events that do not take households' behaviour and resources into consideration purposely weaken households' inherent adaptive potentials (Dietz et al. 2009) or prevent further household protective measures (Barrett 2006; Toole et al. 2016). As such, the adaptive ability of persons and/or groups of persons should be recognised and clearly understood (Araya-Muñoz et al. 2016). Households are generally regarded as basic social units for adjustment and resilience observation (Toole et al. 2016), and individual's decisions can have both direct and indirect impact on communities and on policy outcomes on a cumulative scale (Elrick-Barr et al. 2016).

Importantly, the factors considered by most studies in an attempt to properly measure adaptive capacity, however, are poorly conceptualised (Nhuan et al. 2016; Toole et al. 2016). Most of these similar studies that sought to measure farmers' adaption potentials are carried out at spatial scales, which is obviously out of context in terms of individuals or households' scale in rural areas (see, Brooks et al. 2005; Araya-Muñoz et al. 2016; Below et al. 2012; Lockwood et al. 2015 as cited in Selm et al. 2018). Selm et al. (2018) citing Engle (2011) pointed to the IPCC's classification of key adaptive potential dynamics to be: "e*conomic resources, technology, information and skills, infrastructure, institutions and equity*". All these important features of adaptive capacity are parts of the widely known five capitals, which make up the framework for rural livelihoods usually applied to capture the resources mix for vulnerability assessment as well as poverty and vulnerability reduction policies (Hammill et al. 2005; Park et al. 2012 as cited in Selm et al. 2018).

Explicitly, economic resources are called "financial capital, and technology and infrastructure are the results of economic activity and are considered physical capital, while institutions and wealth (equity) are considered social capital". On the other hand, the features of human capital include but not limited to, knowledge and abilities, which drive individuals and households' wellbeing and prosperity (Brown et al. 2010; Tinch et al. 2015). More so, critical evaluation of farmers' adaptation potentials adds essential knowledge to the implementation of climate change adaptation policy (Juhola and Kruse 2015). According to Abdul-Razak and Kruse (2017), specific evaluations based on smallholder farmers' adaptive capacities, however provide important background information on the strengths and weaknesses of the systems, and provide the needed guide in the formulation and development of policy associated with climate change adaptation strategies. Therefore, a system's adaptive capacity is determined by combination of different dynamics (mostly driven by notable vulnerability studies), which are not independent or mutually exclusive (McCarthy et al. 2001 as cited in Abdul-Razak and Kruse 2017).

From another perspective, Adger et al. (2007) noted that, in the IPCC's fourth assessment report there are two fundamental constituents of adaptive capability, that is, the general aspect, and the impact specific aspect. The generic aspect of adaptive capacity looks at the system's ability to respond to the general stimuli of climate extreme events, while the impact specific aspect denotes the system's ability to respond to a particular stimulus associated with climate extreme events (Adger et al. 2007 as cited in Abdul-Razak and Kruse 2017). In addition, Schneiderbauer et al. (2013) suggested a third aspect known as the sector-specific aspect of adaptive capacity. This is related to the "ability of a specific economic sector within a mock-up area to respond to the general impact of climate extreme events. A system's generic adaptive ability is driven by dynamics that directly influence the system's operations. Notable studies identified the following as generic drivers of adaptive capacity, that is, "economic development, education, technology, knowledge, infrastructure, institutions, equity, and social capital" (Jones et al. 2010; Kruse and Pütz 2014; Abdul-Razak and Kruse 2017).

In the early work of Brooks and Adger (2005), the ability of socio-ecological systems to adapt to climate change stimuli is dependent on the nature (be it internal or external) of the inherent factors to the system's capacity to respond. According to Abdul-Razak and Kruse (2017), these factors are also governed and predetermined by the unit of analysis. Many adaptive ability correlates are mostly scale-specific, and the capacity to pursue adaptation at local level is determined by such factors namely, "*managerial capacity; access to financial, technical and information resources; infrastructure; the institutional framework within which adaptations take place; political influence and networks of kinship relationships*" (a measure of social capital) (Smit and Wandel 2006 as cited in Abdul-Razak and Kruse 2017).

Most importantly, social capital factor tends to influence smallholder farmers' capacity to access labour resources, especially when considering sector specific based adaptive capacity of smallholder farmers. Notable attributes of smallholder farmers such as "expertise, use, availability, accessibility and consultation" were parts of dynamics considered by Asante et al. (2009), as well as Nakuja et al. (2012) in their research on farmers' adaptive capacity in Ghana. In line with the submission of Abdul-Razak and Kruse (2017) citing Defiesta and Rapera (2014), recent indicators of adaptive capacity revolve around the sustainable livelihood framework, which includes the five capital assets influencing the livelihood of people, and these capital assets are human, social, natural, physical and economic/financial resources (Serrat 2010).

METHODOLOGY

Study Area and Research Design

This research was carried out in the Ngaka Modiri Molema (NMM) district municipality, which is the capital of North West Province of South Africa. The research was conducted in 2018. The west of the province is adjacent to Kalahari Desert and Republic of Botswana, while in the south and east, the province shares boundaries with Free State and Gauteng province, respectively. The five local municipalities within the district surveyed are Mahikeng, Ditsobotla, Ramotshere Moiloa, Tswaing, and Ratlou. The predominant livelihood activity in this area is agriculture. The area under study is regarded as one of the areas where maize is predominantly cultivated in South Africa (Department of Agriculture, Forestry and Fisheries (DAFF) 2012). This justifies the choice of the area for the study.

Cross-sectional data used for this research were collected through a well-structured questionnaire. This was designed to elicit responses bothering on farmers' personal attributes, perceived climate change related events, and components of the five capital assets.

A multistage random sampling technique was applied to select the maize farmers used in this research. In the first stage, a purposive selection of Ngaka Modiri Molema district municipality in South Africa was made, because of maize farming predominance in this area, while sampling in the second stage involved the use of proportionality factor to select villages across the five local municipalities (as highlighted earlier) in the district, simply because of the variation that exist in the number of villages across the local municipalities. More so, proportionate to size, and simple random sampling techniques were also employed to select a total of 346 maize farmers (sample size) across all the villages earlier chosen in the second stage. These farmers therefore represented the unit of analysis for this study.

Data Analytical Techniques

Descriptive analytical techniques such as frequency distribution, percentages and cross tabulation were applied to describe the farmers' socio-economic and demographic characteristics, and to show the distribution of farmers based on the level of adaptive capacity. The adaptive capacity (AC) (the construct) was generated through aggregation of the sub-components of five livelihood capital assets' ownership by the farmers. Similarly, a composite score technique used by Adepoju et al. (2011) and Olawuyi (2018) was adopted to categorise and profile the farmers into a continuum (that is, high, medium and low) of adaptive capacity.

Importantly, the finite mixture model (FMM) was applied to estimate the factors influencing variation in the farmers' adaptive capacity (expressed in continuum). The FMM model was deemed appropriate because of its ability to handle the likely heterogeneous effects arising from the varying level of adaptive capacity among the farmers. Detailed explanations of the composite score, AC construct, and FMM analytical technique are provided in the subsequent sub-sections.

Composite Score Technique

The categorisation into high, moderate and low adaptive capacity was achieved using a composite score technique, as previously used by Adepoju et al. (2011). This technique is given as follows:

High adaptive capacity = scores between highest possible point and (Mean + Standard Deviation) points

Intermediate adaptive capacity = scores between high and low adaptive capacity

Low adaptive capacity = scores between (Mean – Standard Deviation) points to 0 point

Adaptive Capacity Construct

This study adopted and used the estimation procedure of Asante et al. (2012), as well as Kabobah et al. (2018). As mentioned earlier, farmers' adaptive capacities were constructed using the five livelihood capital assets. The sub-components of the livelihood capital assets were identified in each category, and scored 1 for "possession attribute response" and 0 for "non-possession attribute response". The list and pool of sub-components of the five basic capital assets provided in UNDP (2017) served as a veritable guidance and baseline for this study. The factors (sub-components) selected and used were the available sub-components extracted from the survey data when this research was conducted. Therefore, the conceptualisation of livelihood capital assets and the sub-components measured through binary response are highlighted as follows:

- Human capital: Information elicited includes access to formal education, access to information on extension services, and access to climate change awareness information.
- Financial capital: Information elicited includes participation in alternative livelihood activities, access to remittance, and access to credit from formal and informal sources.
- Social capital: Information elicited includes membership of kinship networks, membership of occupational based organisation, and participation in collective actions.
- Physical capital: Information elicited includes ownership of shelter, access to basic amenities such as clean fuel, potable water, electricity, and accessible road network.
- Natural capital: Information elicited includes ownership of farmlands, and access to other natural resources.

It is important to stress that the concept of the adaptive capacity index (AC) approach is based on a "criteria weighing" mechanism. However, the overall adaptive capacity (AC) was constructed by "dividing the total score of the components of each of the capitals for the i^{th} farmer by the sum of the most desirable score of all the capital components; this approach therefore permits the construct of farmers' adaptive capacity to range between a scale of $0 \leq AC \leq 1$" (Asante et al. 2012; Kabobah et al. 2018).

Mathematically, the AC construct is given as:

$$AC = \frac{(H.H_w) + (F.F_w) + (S.S_w) + (P.P_w) + (N.N_w)}{n} \quad (1)$$

Where:
AC = adaptive capacity
H = human capital score
Hw = human capital weighing
F = financial score
Fw = financial capital weighing
S = social capital score
Sw = social capital weighing
P = physical score
Pw = physical capital weighing
N = natural capital score
Nw = natural capital weighing
n = number of attributes (n = 5)

Finite Mixture Model

Finite mixture models (FMMs) are usually applied to classify observations for clustering modification, and to model unobserved heterogeneity. In FMM, "the observed data are assumed to belong to unobserved subpopulations called classes. The mixtures of probability densities or regression models are used to model the outcome of interest (AC). However, after fitting the model, the class/category/component membership probabilities can equally be predicted for each observation" (Deb and Trivedi 1997). The key concept of this model is that "the observed data stems from a distinct, but unobserved sub-population". The finite mixture model gives a natural representation of heterogeneity in a finite number of latent classes. On a global note, FMM involves modelling an unknown or complex statistical distribution by a mixture (or weighted sum) of other distributions. It also allows measuring heterogeneity effects for different classes of observations (Fruhwirth-Schnatter 2006). Essentially, FMM provides a flexible extension to basic parametric models, which can generate both "skewed distributions from symmetric components, as well as leptokurtic distributions from mesokurtic distributions".

Deb and Trivedi (1997) also stated that FMM permits additional population heterogeneity but avoids the sharp dichotomy between the populations of different groups. In this case, the underlying unobserved heterogeneity, which splits the population into latent classes, is assumed to be a function of farmers' latent long-term adaptive capacity with respect to possession/extent of possession of the five capital assets. More specifically, “FMMs are probabilistic models that combine two or more density functions. In this model, the observed responses y are assumed to stem from g distinct classes $f_1, f_2, f_3 \ldots f_g$ in the following proportions of $\pi_1, \pi_2 \ldots\ldots \pi_g$

In an implicit form, the density of a g-component mixture model can be expressed as:

$$f(y) = \sum_{j=1}^{g} \pi_i f_i (y|x'\beta_i) \quad (2)$$

Where π is the probability for the i^{th} class, $0 \le \pi_1 \le 1$ and $\Sigma\pi_1 = 1$ and f_i (.) is the conditional probability density function for the observed response in the i^{th} class model. Since new left indents make use of the multinomial logistic distribution function to model the probabilities of latest classes.”

Therefore, the likelihood to have i^{th} latent class can be expressed as:

$$\pi = \frac{\exp(\gamma_i)}{\Sigma_{j=1}^{g} \exp(\gamma_i)} \quad (3)$$

Where, γ_1 is “the linear prediction for the i^{th} latent class. By default, the first latent class is the base level, such that $\gamma_1 = 0$ and $\gamma_1 = 1$. The likelihood is computed as the sum of the probability-weighted conditional likelihood from each latent class”.

More specifically, the FMM model can be expressed as:

$$f(y) = \pi_i N(\mu_1, \sigma^2_1) + \pi_2 N(\mu_2, \sigma^2_2) + \pi_3 N(\mu_3, \sigma^2_3)$$

Alternatively, the likelihood of a farmer to be observed for each latent class can also be estimated using multinomial logistic regression model, such that:

$$\pi_1 = \frac{1}{1+\exp(\gamma_2) + \exp(\gamma_3)} \quad (4)$$

$$\pi_2 = \frac{\exp(\gamma_2)}{1+\exp(\gamma_2) + \exp(\gamma_3)} \quad (5)$$

$$\pi_3 = \frac{\exp(\gamma_2)}{1+\exp(\gamma_2) + \exp(\gamma_3)} \quad (6)$$

Where, γ_1 the is the slope in the model. In this case, the first latent class is assumed to be the base outcome class, $\gamma_1 = 0$, by default.

RESULTS AND DISCUSSION

The discussion of findings are arranged and expressed in three parts. The first part discussed the distribution of farmers’ socio-economic and demographic characteristics, while the second aspect presented the profiling of farmers into a continuum of adaptive capacity. In the same vein, the results of the finite mixture model and the post estimation analysis, which mirror the factors explaining the variation in the levels of farmers’ adaptive capacity, were also presented in the third part.

Socio-economic and Demographic Characteristics of the Sampled Farmers

The results in Table 1 revealed the cross tabulation analysis on farmers’ specific personal characteristics and capital assets components. The findings indicated that male farmers appeared predominant in farming activities in the study area, and are more endowed in terms of all capital assets than the female counterparts. This clearly shows female marginalisation for access to resources. The gender issue in the agricultural sector constitutes a reoccurring challenge, especially with the appropriation of gender roles in the agricultural production process. This occurs where male and female have clearly defined responsibilities and priorities in the production process, and such comes with its challenges, mainly gender imbalance in resources accumulation and capacity to adjust to shocks. This is in line with what Ejike et al. (2018) described as gender inequality and it poses a big threat to the agrifood system development and transformation, especially the attainment of zero hunger and food sovereignty targets. On the other hand, in terms of age distribution and access to livelihood and capital assets, the results revealed that relatively older people are involved in farming, and expectedly, this group has more access to capital assets than the younger ones. This could suggest that many youths are reluctant to engage in agricultural production as a livelihood activity, perhaps because of non-immediate returns to capital in the sector. Hence, they look for employment that yields immediate return even if such is not sustainable in the long run.

Profiling of Farmers into Levels of Adaptive Capacity

The categorisation of farmers into adaptive capacity levels or a continuum is presented in

Table 1: Cross-tabulation of selected socio-economic characteristics and capital assets

Characteristics/Capital Assets subcomponents	*Gender*		*Age*				
	Male	*Female*	*≤ 30*	*31-40*	*41-50*	*51-60*	*Above 60*
Access to formal education	189	39	23	16	31	39	119
Climate change awareness	289	54	39	68	61	54	121
Access to extension information	227	35	37	55	26	37	107
Access to alternative livelihood	227	41	34	52	50	40	92
Access to remittance	158	30	23	39	32	33	61
Access to credit	95	16	14	25	14	17	41
Kinship network membership	92	14	10	21	19	24	32
Membership of farmers organization	171	34	24	44	40	30	67
Participation in collective actions	185	29	21	39	39	37	78
Ownership of shelter	62	10	10	18	15	10	19
Access to basic amenities	102	26	17	27	23	15	46
Ownership of farmlands	226	40	32	52	46	38	98
Access to other natural resources	160	40	23	49	24	41	63

Source: Field survey, 2018

Table 2. The result reflected the distribution and proportion of farmers that fall into each of the three categories (low, intermediate and high) of adaptive capacity, as defined by the livelihood capital resources. In line with this exposition, and based on the *a-priori* expectations on several factors that may likely contribute to varying levels of adaptive capacity of farmers, as discussed earlier, information relating to the associated components or indicators of each type of livelihood capitals asset were highlighted, and subsequently used to develop the overall farmers' adaptive capacity. The mean adaptive capacity of sampled farmers was 0.67 point as shown in Table 2.

Table 2: Categorization of farmers' adaptive capacity

Categories of farmers' adaptive capacity	*Frequency*
Low AC	74 (21.39)
Intermediate AC	210 (60.69)
High AC	62 (17.92)
Total	346 (100.0)

Remarks: Figures in parentheses are percentage value; Mean AC = 0.67
Source: Field survey, 2018

Specifically, the results indicated in Table 2 revealed that higher proportion of the farmers in the study area fall within the intermediate or moderate adaptive capacity class. Evidently, and in line with Kabobah et al. (2018), this is not surprising, and perhaps because of the vulnerable nature of many of the smallholder farmers in terms of the limited capacity to access productive resources. However, this finding is in contrast with Defiesta and Rapera (2014) who reported low level of adaptive capacity for majority of the farmers in the Philippines.

Factors Influencing Variation in Farmers' Adaptive Capacity

The third, fourth and fifth tables indicated the estimates of the finite mixed model for each of the three latent classes, while the sixth and seventh tables presented the latent classes' marginal means and marginal probabilities respectively as post estimations. All these estimates reflected the factors influencing varying levels of farmers' adaptive capacity in the study area.

In terms of the performance of the fitted model, which is differentiated into three tables, as shown in Tables 3, 4 and 5, the findings indicated that maize farmers varied significantly across the levels of adaptive capacity. In other words, these farmers' adaptive capacities were distinguishable in terms of socio-economic characteristics (age associated with older farmers, marital status, human capital expressed by farmers' educational level, as well as years of faming experience, especially for farmers within the range of 11-20 years and above, mode of land acquisi-

Table 3: Finite mixture model estimates of the synergies between farmers' adaptive capacity and hypothesized correlates

Class: 1 *Response: AC construct* *Model: Regress*	*Coefficient*	*Std. error*	*z*	*p>|z|*
Gender	0.0229	0.0159	1.44	0.15
Age	0.0344	0.0158	2.18^{**}	0.029
Marital status	0.0076	0.0133	0.57	0.568
Household size	0.0138	0.0118	1.17	0.241
Educational level	-0.571	0.0134	-4.26^{***}	0.000
Years of farming experience				
- 11-20 years	0.0238	0.013	1.83^{*}	0.068
- above 20 years	0.0222	0.0163	1.36	0.174
Access to government subsidy	0.0172	0.0109	1.57	0.117
Land acquisition	0.104	0.0136	7.61^{***}	0.000
Access to extension information	0.0868	0.0142	6.08^{***}	0.000
Constant	0.459	0.0224	20.42^{***}	0.000
var (e.AC-construct)	0.0035	0.0005		

Remarks: Log likelihood = 382.79605, number of observations = 346;
***, **, * indicate $p< 0.01$; $p< 0.05$ and $p< 0.1$ probability level of significance respectively.
Source: Field survey, 2018

tion, ownership of farmlands, and institutional arrangement expressed by access to extension information) and the livelihood capital assets. Most importantly, the relevance of extension involvement in agricultural development process was emphasised in the study conducted by Olorunfemi et al. (2020). The study reiterated the crucial role of extension personnel in the area of timely dissemination and diffusion of agricultural information.

Based on a-priori expectations, the third latent class (high adaptive capacity) appeared to be the group/category or class who were better off compared to the other two latent classes. This further suggested that farmers who fall within a high adaptive capacity (Class 3) have a comparative advantage to adapt conveniently to the climate change related hazards compared to the farmers who fall in other latent classes (Class 1 and Class 2) of adaptive capacity. The finding

Table 4: Finite mixture model estimates of the synergies between farmers' adaptive capacity and hypothesized correlates

Class: 2 *Response: AC construct* *Model: Regress*	*Coefficient*	*Std. error*	*z*	*p>|z|*
Gender	-0.01717	0.0248	-0.69	0.489
Age	-0.1436	0.0172	-8.35^{***}	0.000
Marital status	-0.1456	0.0239	-6.09^{***}	0.000
Household size	0.0026	0.0153	0.17	0.862
Educational level	-0.1181	0.018	-6.53^{***}	0.000
Years of farming experience				
- 11-20 years	-0.0206	0.0223	-0.92	0.355
- above 20 years	0.0757	0.0227	3.32^{***}	0.001
Access to government subsidy	0.0275	0.0186	1.48	0.139
Land acquisition	0.1057	0.016	6.57^{***}	0.000
Access to extension information	0.1364	0.0191	7.13^{***}	0.000
Constant	0.6717	0.027	24.88^{***}	0.000
var (e.AC-construct)	0.0012	0.0003		

Remarks: Log likelihood = 382.79605, number of observations = 346;
*** indicates $p<0.01$ probability level of significance.
Source: Field survey, 2018

Table 5: Finite mixture model estimates of the synergies between farmers' adaptive capacity, and hypothesized correlates

Class: 3 *Response: AC construct* *Model: Regress*	*Coefficient*	*Std. error*	*z*	*p>|z|*
Gender	0.021	0.007	3.01***	0.003
Age	0.0376	0.0088	4.24***	0.000
Marital status	0.0049	0.0077	0.63	0.526
Household size	0.0237	0.0076	3.10***	0.002
Educational level	-0.0908	0.0076	-11.91***	0.000
Years of farming experience				
- 11-20 years	0.0203	0.0071	2.85***	0.004
- above 20 years	0.0861	0.011	7.83***	0.000
Access to government subsidy	0.0168	0.0068	2.47**	0.014
Land acquisition	0.1106	0.0077	14.22***	0.000
Access to extension information	-0.0075	0.0073	-1.03	0.303
Constant	0.6764	0.0125	53.90***	0.000
var (e.AC-construct)	0.0003	0.0001		

Remarks: Log likelihood = 382.79605, number of observations = 346;
, * indicate p<0.05 and p<0.01 probability level of significance respectively.
Source: Field survey, 2018

apparently suggested that the farmers in the high adaptive capacity category appear to have a seemingly commensurable stock of capital assets where a deficiency in one capital asset can be compensated for in another capital asset(s) at a certain threshold where the farmers have comparative advantage. This result is in tandem with the submission of Williges et al. (2017) who also emphasised on a similar position in their study, which focussed on the assessment of adaptive capacity of the European agricultural sector to droughts.

Consistent with the estimation procedure of Deb (2007), these three latent classes of adaptive capacity were further considered in depth. Ideally, the latent class marginal was determined from the means of all the three latent classes, and the expected proportion of individual farmers in each class. From the result of latent class marginal means indicated in Table 6, it appeared that the third class (high adaptive class) is the group that sustainably and significantly adapted well enough to climate change extreme events. This is also followed by the second and first latent classes (moderate and low adaptive capacity) in that order.

Considering Table 7, in terms of the latent class marginal probabilities estimates for the proportion of farmers in each class, about sixty-three percent of farmers are likely to be in the first category (low adaptive capacity class). Likewise, about twenty-two percent of farmers are expected to be in the second category (moderate adaptive capacity class). However, approximately fifteen percent of the farmers are expected to be in the high adaptive capacity class (third category). Consequently, it is essential for the farmers to be conscious of the need for sustainable adaptive capacity in response to the cli-

Table 6: Latent class marginal means estimates for farmers' adaptive capacity

Class	*Delta-method*		*z*	*p>|z|*
	Margin	*Std. Error*		
AC- 1	0.6525	0.0054	119.44***	0.000
AC- 2	0.6631	0.0081	81.80***	0.000
AC- 3	0.8091	0.0034	231.81***	0.000

Remarks: ***indicates p<0.01 probability level of significance.

Table 7: Latent class marginal probabilities estimates for farmers' adaptive capacity

Class	*Delta-method*		*[95% Confidence interval]*	
	Margin	*Std.Error*		
AC -1	0.6343	0.0465	0.5393	0.72
AC -2	0.2166	0.0452	0.1408	0.3181
AC -3	0.1489	0.0246	0.1067	0.2038

Source: Field survey, 2018

mate change related hazards and extreme events in the study area and South Africa in general.

CONCLUSION

This study has demonstrated the urgent need for farmers to build sustainable and resilient adaptive capacity in response to the apparent effects of warming planet and the global risks. Every indication from past literature suggested that consequential effects of climate change are monumental challenges facing rural farming households' livelihood activities, food security and welfare. The results of this study also indicated that women are disproportionally marginalised in terms of capital assets accumulation, which is an indication of gender gap and inequality in agri-food sector. More so, aged individuals were found to be actively involved in farming, with higher proportion of access to the livelihood capital assets, while younger ones who are in the active age brackets were somewhat few in the sector owing to non-immediate returns to capital on investment. Further, the findings also revealed that a higher proportion of the farmers in the study area fall within the moderate adaptive capacity latent category, while the farmers who are in the high adaptive capacity category appeared to be better off and have comparative advantage in terms of capital assets, to adapt any risk compared to the farmers who fall within the other two latent categories of adaptive capacity.

RECOMMENDATIONS

The need to foster sustainable adaptive capacity among the smallholder maize farmers in the study area in terms of access to livelihood capital assets is evident due to the farmers' vulnerability and limited capacity in terms of capital assets. Based on this, youth need to be encouraged to massively engage in agriculture to boost production, while there is also a greater need to promote gender equality in terms of women's economic sovereignty through entrepreneurship, capacity building and trainings, because women were significantly deficient in terms of ownership of capital assets and resources accumulation. Therefore, addressing female gender specific needs posing as barriers to their active involvement in agriculture, and ensuring institutional mechanisms that support gender-just sector and equitable sharing of economic and financial benefits are very necessary.

More so, institutional engagement in terms of extension delivery system must be timely and functional**.** Equally, education for all should be promoted among individuals because it assists in the diffusion and internalisation of relevant agricultural information from the extension personnel. Then, the gender issue surrounding allocation and use of land must be addressed by relevant authorities to aid sustained farm productivity growth. While having household members as supportive labour on the family farm is important, it is also necessary for government and non-governmental organisations to intensify campaigns against having a large household size, so as to avoid stretching the farming household's capital assets beyond the threshold it can accommodate. In furtherance to all the recommendations, expanding the scope of this research using country level data could be of immense benefits, with the support of multi stakeholders across the sub-sectors of agri-food industry.

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