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Perceptions of Smallholder Farmers on Climate Change in the uMkhanyakude District of KwaZulu-Natal Province of South Africa

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ABSTRACT This study assesses smallholder farmers' perceptions on climate change using a sample of 400 farmers in the uMkhanyakude district of KwaZulu-Natal, South Africa. Using descriptive statistics, farmers perceived that rainfall had decreased during the study period while temperatures had increased. Principal component analysis (PCA) further revealed that farmers' perceptions could be grouped into: a) natural disasters; b) institutional support; c) decrease in crop yields and loss of assets; d) changes in temperature and rainfall and e) extension on climate change and poor livestock production. In light of these findings, the study recommends that agricultural support for groupings of farmer's perceptions be provided to help farmers cope with the negative effects of climate change.

INTRODUCTION

In South Africa, there are 2.3 million agricultural households, 43.7 percent of these households engage in agriculture to procure the main source of food (Stats SA 2016). Farmers rely on a dryland farming system that is highly sensitive to climate change and variability (Kotir 2011). According to Botai et al. (2018), South Africa is considered as a semi-arid country and receives an annual mean rainfall of about 450 mm, which is less than the world's 860 mm annual mean rainfall. Frequent drought has been a prominent feature in various parts of South Africa during the late 1970s to 2017 (Mahlalela et al. 2020). Between 2014 and 2016 South Africa suffered the worst drought in decades and five provinces were declared as drought disaster regions (Botai et al. 2018). The relatively high poverty levels and low adaptive capacity compounds the vulnerability of farming households (Mudombi et al. 2017). The then Department of Environmental Affairs (DEA 2011) noted that at least 30 percent of South African households were exposed to climate change shocks.

Several studies in South Africa have shown that smallholder farmers perceive that the climate has changed in various ways. Some of the perceived ways are prolonged periods of drought, increasing temperatures, decreasing rainfall and frequent flooding (Spence et al. 2011). Hitayezu et al. (2017) conducted a study in the midlands region of KwaZulu-Natal (KZN) province and found that 68 percent of the surveyed farmers noticed chilly and dry winter seasons and hot and dry summer seasons. Farmers in the Limpopo province of South Africa perceived recurrent drought, late rainfall, and lengthy dry spells as signs of climate change (Phophi et al. 2020). A study conducted by Mandleni and Anim (2011) in the Eastern Cape province revealed that farmers perceived climate change differently, and these perceptions were grouped into: a) drought and windy weather patterns; b) information and adaptation; c) climate change extension services; d) intensive cattle and sheep production and e) temperatures.

Perceptions on climate change determine how farming households respond to climate risks and opportunities, and their behavioural responses shape the choice of adaptation strategies (Debela et al. 2015). Climate change perception is a precursor for climate change adaption. Therefore, misconception of climate change may lead to maladaptation or no adaptation, thus raising the risk associated with the adverse effects

of climate change (Debela et al. 2015). Further, perceptions of farmers on climate change are worth exploring as they could provide the erratic nature of environmental change (Bomuhangi et al. 2016). Climate change perceptions of local communities reflect concerns of farming households that may not be included in general circulation models (GCM). Moreover, the knowledge gained from exploring farmers' perceptions could guide policy and assist in the design of adaptation strategies specific to the needs of local people.

Objective of the Study

The objective of this study was to investigate smallholder farmers' perceptions of climate change in the uMkhanyakude district of KwaZulu-Natal province, South Africa.

METHODOLOGY

Data Collection

The study was conducted in the uMkhanyakude district municipality which is in the northern part of the province of KwaZulu-Natal in South Africa (32, 014489; -27, 622242) (uMkhanyakude District Municipality 2018). Out of 11 districts in KZN, uMkhanyakude district was purposively chosen because it is the most arid district with a sizeable number of smallholder farmers in KZN. The sub-tropical climate of uMkhanyakude district is characterized by a warm and humid summer season (November-March) and a colder and dry winter season between June and August (Lankford et al. 2011).

A structured questionnaire was used to collect quantitative data between November and December 2020. Data was collected in two local municipalities (LMs), that is, Jozini and uMhlabuyalingana. Jozini LM has a population of 198 215 and comprises of 44 584 households while uMhlabuyalingana LM has a population of 172 077 and comprises of 39 614 households (Stats SA 2020). Israel (1992) provides guidelines on how to determine sample sizes based on population size, margin of error and confidence levels. The selected LMs have 84 198 households, based on the guidelines, population sizes of 10 000, 100 000 and 500 000 have corresponding sample sizes of 370, 383 and 388 when the margin of error is 5 percent and the confidence level is 95 percent. A sample size of 400 households was considered adequate for this study. A multi-stage random sampling procedure was used to select participants. In the first stage, 50 percent of the wards in each local municipality were randomly selected. In the second stage, farming households were randomly selected within the wards. Jozini LM has 20 wards while uMhlabuyalingana LM comprises of 18 wards. The survey questionnaire was designed to capture data on demographics, crop production, household assets, livestock ownership, support services and farmer training, land ownership, food security, climate change perception and adaptation.

Data Analytical Methods

This study employed the principal component analysis (PCA) technique to analyse dominant farmers' perceptions on climate change and variability. PCA is a transformation technique and has been widely used to transform a complex set of variables to a reduced canonical form (that is, Essa and Nieuwoudt 2003; Mandleni and Anim 2011; Sinyolo et al. 2014). In this study, PCA has been used to identify a set of intercorrelated variables to examine hidden interrelationships within the variables (Mandleni and Anim 2011). Following on Mandleni and Anim (2011) the criterion can be described as follows:

$$PC_1 = a_{12}X_1 + a_{13}X_2 + ... + a_{1m}X_m$$
$$PC_2 = a_{23}X_1 + a_{24}X_2 + ... + a_{2m}X_m$$
$$\vdots$$
$$PC_m = a_{m1}X_1 + a_{m2}X_2 + ... + a_{mm}X_m$$

Where m variable X_1, $X_2 \ldots X_m$ are observed on n smallholder farmers; a_{12}, $a_{13} \ldots a_{1m}$ are the coefficients generated so that the first PC, that is, PC_1, accounts for the maximum contribution to the variance in the m number of variables in the analysis. Thus, the set of variables X_1, $X_2 \ldots X_m$ are transformed to a given set of variables that are orthogonal and accounts for as much variation as possible in a descending order (Nieuwoudt 1977). The set of variables that are generated are a linear combination of the original variables. The second PC (PC_2) is not correlated to the first PC and accounts for a maximum of the remaining variation in the variables

and this applies to subsequent components. Subsequent components are not correlated with previous components and explain less and less of the variation in the original variables (Sinyolo 2016). As proposed by Jeffers (1967) principal components with Eigen values more than one were selected.

Eigen vectors or Eigen values of the covariance gives weight for each PC. With PC analysis, it is hoped that most of the principal components' Eigen values will be so low such that these are almost negligible. If this is the case, few principal components can explain the variation in the data set where the Eigen values are not negligible. Table 1 presents the variables used in the principal component analysis and their proportions.

Table 1: Description of variables used in the principal component analysis

Variable code	*Variables name and description*	*Proportion*
Training (X_1)	Access to training	
	Yes	0.61
	No	0.39
Extension (X_2)	Extension	
	Yes	0.19
	No	0.81
Exte_CC (X_3)	Extension on climate change	
	Yes	0.70
	No	0.30
Temperature_ Change (X_4)	Temperature changes	
	Yes	0.94
	No	0.06
Rainfall_Change (X_5)	Rainfall changes	
	Yes	0.95
	No	0.05
Drought_Freq (X_6)	Frequency of drought	
	Increased	0.71
	Decreased	0.20
	Stayed the same	0.07
	I do not know	0.02
Floods_Freq (X_7)	Frequency of floods	
	Increased	0.12
	Decreased	0.65
	Stayed the same	0.13
	I do not know	0.09
Strongwinds (X_8)	Strong winds	
	Increased	0.71
	Decreased	0.20
	Stayed the same	0.05
	I do not know	0.04
Poor_LivePro (X_9)	Poor livestock production	
	Yes	0.85
	No	0.15
Decrease_CropY (X_{10})	Decrease in crop yields	
	Yes	0.22
	No	0.78
Loss_Assets (X_{11})	Loss of assets	
	Yes	0.68
	No	0.32

RESULTS AND DISCUSSION

The demographics and socio-economic characteristics of the sampled farmers are presented in Tables 2 and 3. Continuous variables, means, and standard deviations are presented in Table 2, while categorical variables and their proportions are presented in Table 3. The data presented in Table 2 indicates that the average age of smallholder farmers in the uMkhanyakude district is 50 years, implying that smallholder farming is dominated by middle-aged people. This result was expected since in the rural areas young household members tend to migrate to cities and towns in search of employment. This result tallies with other studies focusing on smallholder farming in South Africa (Hitayezu et al. 2017; Maziya et al. 2020; Sinyolo et al. 2018). This result has negative implications on the future and sustainability of smallholder agriculture in the uMkhanyakude district since farming knowledge is not passed down to the younger generation.

The data (Table 2) also indicates that on average, household heads did not progress to secondary school. Approximately 23 percent of the smallholder farmers had no formal education (Table 3). This proportion of farmers with no formal education exceeds the 4.8 percent for KZN (Stats SA 2019). Education is critical as it can enhance farmers' ability to obtain, analyse and process climate change related information (Onyeneke et al. 2018).

The data in Table 2 indicates that households had moderate amounts of livestock units (TLU), household assets (TotAssetV) and annual income (Total_Income). The results show that rural households in the uMkhanyakude district tend to have larger family sizes, bigger average family sizes compared to KZN family sizes in the 2019 General Household Survey (Stats SA 2019). Smallholder farmers indicated that they had access to an average of 1.31 ha of agricultural land (Landsize). Most of the agricultural land was allotted to farmers by the traditional leader

Table 2: Comparison of continuous variables

Variable code	*Variable description and measurement*	*Mean*	*Standard deviation*
Age	Age of household head (years)	50.28	14.07
Education	Years of schooling	7.14	4.74
Land size	Land size in hectares (ha)	1.31	1.20
Farming Experience	Number of years in farming	17.02	13.81
HHtotal	Number of household members	7.59	3.44
Tarred road	Distance to tarmac road (Km)	1.62	0.11
Labour	Number of working age household members engaged in farming	2.06	1.71
TotAssetV	Value of household assets (Rands)	95342.13	135639.7
TLU	Tropical Livestock Units	8.13	12.23
Total Income	Total annual income (Rands)	55674.49	32568.76

(LandAlloc). Inheritance (LandInherit) from relatives is the second largest source of farming land for the households. On average farmers in the uMkhanyakude district had 17 years of farming experience, thus indicating a considerable wealth of farming knowledge.

Further to the comparison of continuous variables, categorical variables were compared to get a better understanding of the sampled households. Results presented in Table 3 indicated that 28 percent of the sampled households were headed by males during the study, implying that smallholder farming in uMkhanyakude was dominated by females. This result tallies with findings of other studies (that is, Sinyolo et al. 2018; Murugani and Thamaga-Chitja 2018; Maziya et al. 2017). Men migrate to cities in search of paying jobs, leaving their spouses in rural areas to engage in farming, and take care of household members.

The data given in Table 3 shows that 19 percent of the farmers received extension services between November 2019 and November 2020. This implies that agricultural related support was extremely limited in the study area. This result conforms with the General Household Survey's findings where it was reported that 13.6 percent of agriculturally active black households received agricultural support in 2017 in the KZN province (Stats SA 2018).

More than half of the sampled farming households indicated that they had access to credit (CreditAccess), training (Training) and improved farming technologies (ImprovedTechAcc). The survey results also show that fewer farmers (35%) were members of farmer associations (FarmAssoc). Membership in farmer associations increases social capital in rural areas and farmers with a strong social network could enjoy better access to resources and information on climate change (Debela et al. 2015).

The data presented in Table 4 summarizes the perceptions of smallholder farmers on climate variables. Most farmers indicated that sum-

Table 3: Comparison of categorical variables

Variable code	*Variable description and measurement*	*Proportion*
Gender	Gender of household head (Male=1)	0.28
Noformal_edu	Household heads who with no form of education (Yes=1)	0.23
LandAlloc	Land allocated by traditional authority (Yes=1)	0.50
LandInherit	Land inherited from family members (Yes=1)	0.33
FarmAssoc	Membership in farmers' association (Yes=1)	0.35
Extension	Access to extension services (Yes=1)	0.19
CreditAccess	Access to credit (Yes=1)	0.53
MarketAccess	Access to output markets (Yes=1)	0.62
Training	Access to training (Yes=1)	0.55
ImprovedTechAcc	Access to improved farming technologies (Yes=1)	0.58
Jozini	Jozini Local Municipality (Jozini=1)	0.53
Umhlabuyalingana	Umhlabuyalingana Local Municipality (Umhlabuyalingana=1)	0.47

Table 4: Proportion of farmers who noticed long term changes in climate variables

Noticed changes in the past 20 years	*Increased*	*Decreased*	*Remained the same*	*I do not know*
Summer season rainfall	14	80.25	4.25	1.25
Winter rainfall	10.50	81.25	6.75	1.00
Length of summer season rainfall	13.25	78.00	6.50	1.75
Summer temperatures	76.75	19.25	2.50	1.50
Winter temperatures	42.25	47.50	9.25	1.00
Frequency of drought	71	19.75	7.00	1.75
Frequency of floods	12.25	65.25	12.75	9.25

mer (80.25%) and winter (81.25%) rainfall has decreased over the period 1999-2019. The majority (76.75%) of the farmers also indicated that winter and summer temperatures have increased. However, farmers perceived the incidence of floods (65.25%) to have decreased in the 20-year period. Conversely, most farmers (71%) indicated that the incidence of drought had increased in the uMkhanyakude district. Similar findings on farmers' perceptions regarding climate change have been reported in South Africa (Shisanya and Mafongoya 2017; Hitayezu et al. 2017; Ubisi et al. 2017), Ethiopia (Asrat and Simane 2018) and Zimbabwe (Moyo et al. 2012).

A further analysis was conducted to determine dominant climate change perceptions in the sample. The results of the PC analysis are presented in Table 5. Using Kaiser criterion (Field 2005), five PCs with Eigen values greater than one were retained, explaining 81.78 percent of the variation in the selected variables. Sufficient proportion in the variables is present if less than five or six of the PCs describe 70-80 percent of the variation in the variables (Mandleni and Anim 2011). Figure 1 shows the scree graph which was used to determine the number of PCs to be retained for analysis. The x-axis displays PC numbers while the y-axis displays Eigen values.

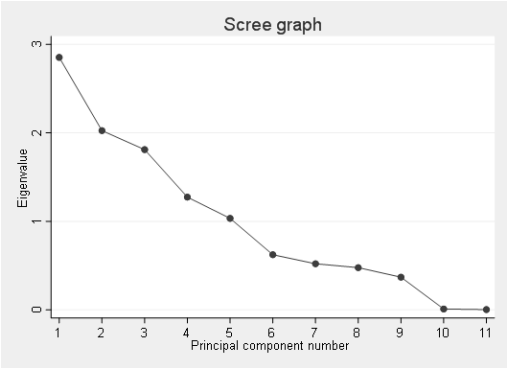

Fig. 1. Scree graph of principal components and Eigen values

Table 5: Principal components retained in the analysis

Variables	*Principal components*				
	PC_1	*PC_2*	*PC_3*	*PC_4*	*PC_5*
Training (X_1)	-0.0414	**0.6532**	-0.2669	-0.0049	-0.0128
Extension (X_2)	-0.0393	**0.6527**	-0.2688	-0.0068	-0.0132
Exte_CC (X_3)	-0.0212	-0.0859	-0.2561	0.3582	**0.7221**
Temperature_Change (X_4)	-0.1945	0.0762	0.2089	**0.6660**	-0.0815
Rainfall_Change (X_5)	-0.3208	0.0422	0.1556	**0.4981**	-0.2109
Drought_Freq (X_6)	**0.5488**	0.0913	0.1371	0.1316	0.0468
Floods_Freq (X_7)	**0.5441**	0.1003	0.1603	0.1274	0.0305
Strongwinds (X_8)	0.4698	0.0715	0.0991	0.2400	-0.0419
Poor_LivePro (X_9)	-0.1224	0.1485	0.3779	-0.2463	**0.5394**
Decrease_CropY (X_{10})	-0.0526	0.2027	**0.5130**	-0.1662	-0.2391
Loss_Assets (X_{11})	-0.1411	0.2137	**0.5126**	-0.0233	0.2722
Eigen value	2.852	2.025	1.811	1.274	1.034
Variance (%)	25.93	18.41	16.46	11.58	9.40
Cumulative %	25.93	44.43	60.80	72.38	81.78

The PCs that were retained for analysis are those on the slope of the graph before the decrease in Eigen values starts to level off. The first principal component (PC1) has an Eigen value of 2.852 and contributed 25.93 percent to the variation in the data and represents farmers who perceived natural disasters (drought and floods). The second principal component (PC2) has an Eigen value of 2.025 and contributed 18.41 percent in the variation in the data and represents farmers who received training and had access to extension services (access to institutions) between November 2019 and November 2020. The third principal component (PC3) has an Eigen value of 1.811 and contributed 16.46 percent in the variation in the data. This PC represents farmers who perceived decreasing crop yields and loss of assets due to climate change. The fourth principal component (PC4) has an Eigen value of 1.274 and contributed to 11.58 percent of the variation in the variables and represent smallholder farmers who perceived long term changes in temperature and rainfall. The fifth principal component (PC5), with an Eigen value of 1.034 contributed to 9.40 percent in the variation in the variables and represent farmers who received extension services related to climate change and farmers who perceived poor livestock production as a result of the changing climate.

CONCLUSION

The aim of this study was to assess the perceptions of smallholder farmers on climate change in the uMkhanyakude district of KwaZulu-Natal, South Africa. Descriptive statistics indicated that smallholder farming was dominated by women and old people in the district. Generally, farmers perceived that rainfall had decreased while temperatures had increased. Further analysis using principal component technique revealed that dominant climate change perceptions could be classified into: a) natural disasters (drought and floods); b) institutional support (training and access to extension services); c) decrease in crop yields and loss of assets; d) changes in temperature and rainfall and e) extension on climate change and poor livestock production. This indicates that farmers in the area had different perceptions of climate change and would respond differently according to how they perceived climate change.

RECOMMENDATIONS

The considerable proportion of smallholder farmers that did not receive extension services between 2019 and 2020 underscores the need to improve agricultural support in rural areas. Since women make up the majority of smallholder farmers in the study area, policy makers should consider gender mainstreaming when devising climate change related interventions. Furthermore, agricultural support for groupings of farmer's perceptions should be provided to help farmers cope with the negative effects of climate change.

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