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Perceptions of Cattle and Sheep Farmers on Climate Change and Adaptation in the Eastern Cape Province of South Africa

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ABSTRACT This study examined the perceptions of cattle and sheep farmers on climate change and adaptation in the Eastern Cape Province of South Africa. Using information from 500 livestock farmers between 2005 and 2009 farming season, preliminary descriptive statistics results indicated that farmers had different perceptions of climate change and adaptation measures. Further analysis using principal components showed that the perceptions could be grouped into: (i) drought and windy weather patterns; (ii) information and adaptation; (iii) climate change extension services; (iv) intensive cattle and sheep production and (v) temperatures.

INTRODUCTION

In the Eastern Cape Province of South Africa, livestock farming is an important agricultural practice. Livestock ownership is the wealth of the farmers whether they are educated or not. Livestock is used when business transactions are undertaken such as paying of dowry and exchanging livestock for cash to carry out household obligations. Farmers also use droppings from livestock as manure for farming. Furthermore, livestock is used for home consumption but on limited basis. Eastern Cape has the highest percentage of livestock, especially cattle and sheep compared to the other eight provinces of South Africa. In this province, particularly in the former homelands of Transkei and Ciskei, small scale livestock farming is quite prominent (Nkonki 2007).

Studies by Deressa et al. (2009) revealed that Africa's agriculture is negatively affected by climate change. This is also confirmed by Apata et al. (2009) who have indicated that Africa is generally acknowledged to be the continent most vulnerable to climate change. The weather is erratic and unreliable to livestock farmers. This calls for livestock farmers to be aware of the effects of weather patterns in the immediate and long terms. It also calls for adaptation measures that can be taken to curb the negative effects of climate change on livestock production. According to Morton (2007), climate change effects are felt in developing countries among livestock farmers that are referred to as subsistence or smallholders. Furthermore, studies have revealed that small farm sizes, low technology and low capitalization increase the vulnerability of livestock production. Fischer et al. (2005) asserted that developing countries have been more vulnerable to climate change than developed countries because of the predominance of agriculture in their economies and scarcity of capital for adaptation measures. Todaro and Smith (2009) have concluded that the worst impact of climate change is felt by livestock farmers.

Several studies conducted to examine perceptions of livestock farmers on climate change have shown that farmers had different perceptions on climate change. Diggs (1991) found out that approximately three-quarters of all livestock farmers surveyed in the Great Plains had different perceptions on change in climate. Another study conducted by Ishaya and Abaje (2008) in Nigeria, revealed that livestock farmers perceived climate change to have occurred over the years due to diverse human activities. A study by Mert et al. (2009) in Sahel, Senegal indicated that livestock farmers were aware of the climate variability and identified wind and occasional excess rainfall as the most significant factors. According to Gbetibouo (2006), 91percent of livestock farmers in the Limpopo basin perceived changes in temperatures over 20 years to be most significant in climate change. In the study by

Kurukulasuriya et al. (2006) it was concluded that livestock farming in African countries with diverse climatic zones have experienced decline in revenues with rise in temperatures. Revenues from livestock sales only increased with increased precipitation. Deressa (2007) indicated that large numbers of livestock farmers' perceived drought and windy weathers to be significant in climate change. Adaptation strategies have been seen to differ among the countries studied but some similarities have been found to exist in certain areas. In Sahel, livestock farmers kept animals in stables and replaced draught horses with cattle which were cheaper to feed as measures of adaptation (Mert et al. 2009). In the case of smallholder livestock farmers in Zimbabwe, adaptation measures undertaken included a change from exotic to indigenous breeds (Mutekwa 2009).

MATERIAL AND METHODS

Data Collection

Questionnaires were used to collect data from 500 cattle and sheep farmers. The questionnaires were completed by the livestock farmers themselves. As part of the study, 500 farmers were selected and these were those who had participated in extension training courses on livestock farming offered by the Department of Agriculture, Eastern Cape Province, during 2005 - 2009. The reason for the selection was that these farmers were most likely to be able to provide information on climate change and adaptation on their cattle and sheep farming during the period of study. Due to great diversity of extension training programmes, a stratified sampling with proportional representation method was employed to select the 500 farmers covering three of the six district municipalities. Experienced enumerators were selected and trained to conduct the interviews. Suitable interview times were arranged with farmers with permission from the rural community heads

Principal Components (PC) Analysis

The PC analysis was used to transform the given set of variables, $X_1, X_2 \ldots Xk$, into a new set of composite variables that were orthogonal to or uncorrelated with each other. The objective was to identify groups of inter-correlated variables in order to examine hidden interrelationships amongst them (Manly 1990). Thus, the PC analysis was employed to discover and finally summarize pattern of inter-correlation among variables. The aim of this analysis was to convert the original set of variables, X_j (j=1,2,...,k) into a new set of uncorrelated variables called *principal components*, PC_i (i=1,2 ...,k), which were linear combinations of the original variables.

$$
\begin{aligned}
PC_1 &= a_{11}X_1 + a_{12}X_2 + \ldots + a_{1k}X_k \\
PC_2 &= a_{21}X_1 + a_{22}X_2 + \ldots + a_{2k}X_k \\
&\;\;\vdots \\
PC_k &= a_{k1}X_1 + a_{k2}X_2 + \ldots + a_{kk}X_k
\end{aligned}
$$

where PC_i= the *i*th principal component, a_{ij}= component loadings (coefficients) and X_j= original variables (Koutsoyiannis 1972). It should be noted that principal components can be extracted from the raw values of the X_j's, or from their standardised values. In this study, the latter method was employed as the units used to measure the original variables differed (Koutsoyiannis 1972). In the PC analysis the component loadings (a_{ij}), are chosen so that the principal components satisfy following two conditions:

(a) principal components are uncorrelated (orthogonal), and

(b) first principal component (PC_1) accounts for the maximum possible proportion of the total variation in the X_j's, the second principal component (PC_2) accounts for the maximum of the remaining variation (var) in the X_j's and so on. Thus, var (PC_1) e” var (PC_2) e” var (PC_3) e”… e” var (PC_p), where var (PC_i) expresses the variance of PC_i in the data set being considered. Var (PC_i) are also called the Eigen values, Eigen vectors, characteristic vectors or latent vectors of PC_i. When using PC analysis, it is hoped that the Eigen values of most of the PCs will be so low as to be virtually negligible. Where this is the case, the variation in the data set can be adequately described by means of a few PCs where the Eigen values are not negligible. Accordingly, some degree of economy is accomplished as the variation in the original number of variables (X variables) can be described using a smaller number of new variables (PCs).

RESULTS AND DISCUSSION

This section summarises farmers' perceptions on climate change and the adaptation that they considered appropriate to these changes. In Table 1, descriptive statistics of the variables were provided. The results indicated that only 60 percent of the respondents received some information on climate change. The type of information that they received was mostly through local radios indicated by 54.3 percent of the respondents. Extension service on climate change was received by only 25.7 percent of the respondents. The increase in temperatures between 2005 and 2009 was observed by 85.7 percent of the respondents and the weather was dominated by drought. Cattle numbers decreased and this was confirmed by 82.9 percent of the respondents.

In this study, the first presentation of results using the PC analysis was to decide how many PCs should be retained. $PC_{1,}$ the first PC, the one with the largest Eigen value of 29.419 that described 29.419 percent of the total variation was considered. This proportion of the first PC was considered to describe an insufficient percentage of the total, hence the second PC to the fifth PC were also considered. In combination with the first PC, this encompassed a larger percentage of the total variation (79.148%). Sufficient percentage is present if no more than 5 or 6 components explain 70 to 80 percent of the total variation.

The second presentation was to assess the adequacy of the number of PCs. The PCs where Eigen values were e" 1 were retained. The rationale for this criterion was that since each observed variable contributed one unit of variance to the total variance in the data set, any component that displayed an Eigen value of greater than 1 was accounting for a greater amount of variance than had been contributed by one variable. Such a component was therefore accounting for a meaningful amount of variance, and was worthy of being retained. On the other hand, any principal component with an Eigen value less than 1 contained less information than one of the original variables and so was not worth retaining. The results of the PC analysis are presented in Table 2.

The third presentation was to determine the number of PCs to be retained from the scree graph or scree plot (Fig. 1). In the scree plot, Eigen values were plotted against PC numbers. The component numbers were listed on the x-axis, whilst the Eigen values were listed on the y-axis. The PCs that were retained were those on the slope of the graph before the decrease of Eigen values levels off to the right of the plot. Using this criterion, 5 PCs were retained in the analysis of this study. The different factors extracted represented different patterns of perceptions of cattle and sheep farmers on climate change and adaptation in the Eastern Cape Province. The grouping of the original variables was done by observing the magnitude of the factor loadings. The dominant loadings were presented in bold (Table 2). Each PC was considered a weighted linear combination of the variables and was written with the heavy loadings and given the most descriptive names. Principal Component 1 (PC_1) contributed 29.419 percent to the variation with an Eigen value of 29.419 in the variables included and represented cattle and sheep farmers who were aware of drought between 2005 and 2009 (Table 1). All the coefficients were positive indicating a positive correlation among the variables. The drought and windy weather PC equation between 2005 and 2009 could be represented as follows.

$(PC_1) = 0.836X_5 + 0.903X_6 + 0.912X_7 + 0.526X_8 + 0.700X_9 + 0.604X_{10}$.

Principal Component 2 (PC_2) contributed 17.874 percent to the variation with an Eigen value of 47.293 in the variables included and represented cattle and sheep farmers who received information about climate change and adapted. The information and adaptation PC equation between 2005 and 2009 could be represented as follows: Information and adaptation $(PC_2) = 0.758X_1 + 0.747X_2 - 0.691X_{12} - 0.678X_{13.}$

Principal Component 3 (PC_3) contributed 13.448 percent to the variation with an Eigen value of 60.741 in the variables included and represented cattle and sheep farmers who re-

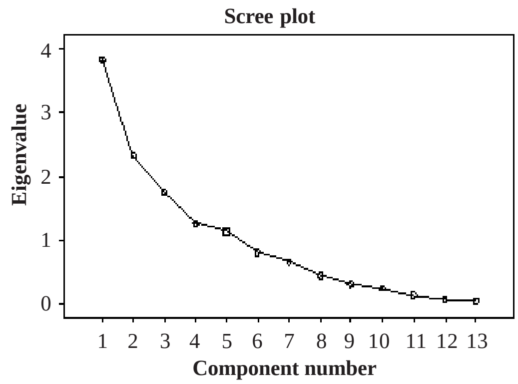

Fig 1. Scree plot of principal components and Eigen values

Table 1: Perceptions of cattle and sheep farmers on climate change and adaptation

Variable	*%*	*Mean*	*Std.Dev*	*Variance*
Do You Have Information About Climate Change (X_1)		0.497	1.40	0.247
Yes	60.00			
No	40.00			
What type of information (X_2)		1.579	4.09	2.492
Flyers	2.90			
Magazines	2.90			
Radio	54.30			
Other	2.90			
None	37.10			
Do You Have Extension Service On Climate Change (X_3)		0.443	1.74	0.197
Yes	25.70			
No	74.30			
How Were Temperatures In 2005 – 2009 (X_4)		0.453	1.17	0.205
Increased	85.70			
Decreased	11.40			
Stayed the same	2.90			
Are you aware of 2003/2004/2005 drought (X_5)		0.458	1.29	0.210
Yes	71.40			
No	28.60			
Type of Weather In 2005 (X_6)		1.114	1.77	1.240
Drought	57.10			
Winds	25.70			
Other	17.10			
Type of Weather In 2006 (X_7)		1.200	1.83	1.440
Drought	60.00			
Winds	17.10			
Floods	2.90			
Other	20.00			
Type of Weather In 2007 (X_8)		1.221	2.74	1.491
Drought	57.10			
Winds	25.70			
Floods	60.00			
Other	17.10			
Type of Weather In 2008 (X_9)		1.105	2.11	1.222
Drought	60.00			
Winds	17.10			
Floods	2.90			
Other	20.00			
Type of Weather In 2009 (X_{10})		1.051	1.89	1.104
Drought	20.00			
Winds	28.60			
Floods	8.60			
Other	42.90			
Cattle Production (X_{11})		1.183	2.31	1.398
Increased	5.70			
Decreased	82.90			
Numbers stayed the same	2.90			
Adaptation Measures (X_{12})		1.445	1.83	2.087
No adaptation	71.40			
Sold livestock	5.70			
Planted supplementary feed	14.30			
Other	8.60			
Reasons For Non Adaptation (X_{13})		1.888	4.71	3.563
Lack of information	2.90			
Lack of money	22.90			
Lack of inputs	45.70			
Lack of property	8.60			
Lack of other information	17.10			
Other	2.90			

Table 2: Principal component (PC) retained and percentages of variance explained/factor analysis

Variables	*Factor loadings*				
	PC_1	PC_2	PC_3	PC_4	PC_5
Information about climate change (X1)	-0.335	0.758	0.445	0.117	0.115
What type of information (X2)	-0.358	0.747	0.352	0.263	0.255
Extension service on climate change (X3)	-0.008	0.161	0.809	-0.138	-0.254
Temperature (X4)	0.017	0.367	-0.495	-0.106	0.637
Aware of drought (X5)	0.836	0.159	0.084	0.273	0.033
Type of weather in 2005 (X6)	0.903	0.051	0.150	0.143	-0.061
Type of weather in 2006 (X7)	0.912	-0.033	0.059	0.090	-0.037
Type of weather in 2007 (X8)	0.516	-0.031	0.302	-0.434	0.550
Type of weather in 2008 (X9)	0.700	0.211	-0.164	-0.184	0.001
Type of weather in 2009 (X10)	0.604	0.127	-0.009	0.432	0.033
Livestock production (X11)	-0.275	0.040	-0.314	0.670	0.093
Adaptation measures (X12)	-0.199	-0.691	0.370	0.043	0.454
Why not adapt(X13)	-0.049	-0.678	0.374	0.440	0.223
Eigen value	29.419	47.293	60.741	70.506	79.148
%variance	29.419	17.874	13.448	9.765	8.642
Cumulative %	29.419	47.293	60.741	70.506	79.148

N= 500

ceived extension services on climate. Among these farmers 25.7 percent received extension services on climate change and adaptation. The information on the provision of extension serves on climate change and adaptation PC equation between 2005 and 2009 could be represented as follows: Climate change extension service (PC_3) = 0.8

Principal Component 4 (PC4) contributed 9.765 percent to the variation with an Eigen value of 70.506 in the variables included and represented cattle and sheep farmers who with intensive cattle and sheep farming as indicated by the heavy loading (67%) of the coefficient. The wind and drought conditions between 2005 and 2009 heavily affected these farmers as indicated by 82.9 percent of farmers indicating that their cattle and sheep production decreased during the period (Table 1). The information on intensive cattle and sheep production PC equation between 2005 and 2009 could be represented as follows: Cattle and sheep production (PC4) = 0.670X11.

Principal Component 5 (PC5) contributed the least (8.642%) to the variation with an Eigen value of 79.148 in the variables included and represented cattle and sheep farmers who regarded temperature to be the dominant factor affecting climate change between 2005 and 2009. From Table 1, 85.7 percent of farmers perceived increase in temperature to dominate during the study period. The perception on temperature change and adaptation PC equation between 2005 and 2009 could be represented as follows: Temperatures (PC5) = 0.637X4.

CONCLUSION

In this study, perceptions of cattle and sheep farmers on climate change and adaptation were analysed using information from livestock farmers between 2005 and 2009 farming season. Preliminary descriptive statistics indicated that farmers interviewed had different perceptions on climate change and adaptation measures. Findings also revealed that cattle production decreased during this period. Further analysis using principal components showed that the different perceptions of factors affecting climate change could be grouped into: (i) drought and windy weather patterns; (ii) information and adaptation; (iii) climate change and extension services; (iv) cattle and sheep production and (v) temperature. The results call for further analysis to investigate the different adaptation measures that could be used by cattle and sheep farmers during those weather conditions.

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