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Assessing rural farmers' perceptions and vulnerability to climate change in uMzinyathi District of Kwazulu-Natal, South Africa

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There is little awareness among rural farming communities on their vulnerability to climate change. This paper examined the vulnerabilities of the rural small scale farming communities in the uMzinyathi District of KwaZulu-Natal, South Africa to climate change. A survey among 200 households who were randomly chosen but who had lived in the community for over twenty years was conducted. Focus group discussions and key informant interviews were carried out to obtain qualitative data. Over the period 1993 to 2010, average annual temperature had increased by 1.5°C. Rainfall generally decreased over the period 1981 to 2010 with a range of 907 mm. Household perception on extreme climate conditions were a reflection of the quantitative climate data collected. Households were anxious (76%) that they will face negative impacts of climate change in future. Households were evenly distributed across the five vulnerability categories. Perceptions of communities to climate change should be considered by policy makers in advancing strategies to mitigate impacts of climate change. Vulnerability of farmers to climate change could be reduced by investing in early warning systems, providing farmers with information on climate change and farmers seeking alternative livelihood options rather than agriculture. Household specific interventions should be considered in mitigating climate change.

Key words: Local knowledge, adoptive capacity, early warning systems, agriculture, mitigation.

INTRODUCTION

Our climate is important because it determines our localities and in general our livelihoods and how we are organised in our societies. It has been shown that our climate will change over time and this may occur both naturally, as integral parts of how the global and regional climate systems function, as well as in response to additional influences due to human activity (Intergovernmental Panel on Climate change (IPCC), 2008). These changes that may occur over time may pause major challenges to humanity. The Fourth

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Assessment Report of the IPCC has projected that even with immediate implementation of climate mitigation policies, the global climate system will continue to shift and change for decades (Fussel and Klein, 2006; IPCC, 2007a). It is predicted that in the tropics, temperature will continue to increase, rainfall will decrease and frequency of floods and droughts will increase over time (IPCC, 2001).

The state and dynamics of climate change processes differ from place to place and generate conditions that differ in character and degree to an extent that populations that are exposed to similar climatic phenomenon are not impacted the same (IPCC, 2001). Sub-populations or groups inhabiting a region, and even from household to household within a group may experience changes in climate differently. For household to react to a changing climate, it will require that household will have to notice that climate has changed. Local knowledge about climate change will become very important in determining the way in which households will respond to climate change. This knowledge will be used to shape the practices that communities will be engaged in. Local knowledge assists communities to make decisions on how to respond to changes in their environment and how they will act to minimise loses or take advantage of the change (Cabrera et al., 2006).

Limited studies have been done on the social aspects of vulnerability to climate change (Gbetibouo and Ringler, 2009). Available information on vulnerability of specific communities to climate change and potential adaptation measures is still insufficient (Chikozho, 2010; IPCC, 2007a). Such information is necessary to enable policy makers to tackle climate change with some level of accuracy.

There is at present scanty consensus on the conceptual framework on how to define and measure vulnerability (Scaramozzino, 2006). There is need for more comprehensive studies that reveal vulnerability of communities, in order to come up with timely information and options for adaptation.

Vulnerability is therefore a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (Adger, 1996; Aandahi and O'Brien, 2001). Vulnerability to climate change does not manifest due to climate alone, but rather arises in the presence of multiple stressors which include socio-economic factors and environmental factors (Deressa et al., 2008). The socioeconomic factors include the level of technological development, infrastructure, institutions and the political environment (McKenzie, 2003). The environmental factors cited in literature include climatic conditions, quality of soil and water availability (IPCC, 2007b). The variations of these socioeconomic and environmental factors across different social groups are responsible for the differences in their levels of vulnerability to climate change. Vulnerability is also mediated by institutional factors including rules, norms and policies (Gbetibouo and Ringler, 2009). However, vulnerability is still a contested concept, and there is little agreement about how to convert it into policy and relevant measures for priority setting (Nelson et al., 2010).

This paper attempts to analyse vulnerabilities of the rural small scale farming communities to climate change in the uMzinyathi District Municipality of South Africa with the aim of expanding the knowledge on vulnerability analysis through the lens of individual household perceptions. Factors that contribute to individual household vulnerability to climate change are also investigated.

LITERATURE REVIEW

Climate change will continue to be a major threat to rural livelihoods (Nhemachena, 2009). Southern Africa is widely recognised as one of the most vulnerable regions to climate change because of low levels of adaptive capacity (particularly among rural communities), combined with a high dependence on rain-fed agriculture (IPCC, 2007b). With a changing climate, it is predicted that by mid-21st century, South Africa will have a broad rainfall reduction in the range of 5 to 10% with adverse negative impacts on agriculture especially in the rural areas accompanied with droughts and floods (Gbetibouo and Ringler, 2009). Comprehensive studies have been done in South Africa on the impact of climate change on quantitative agricultural production and economic implications (Challinor et al., 2007). Limited studies have been done on the social aspects of climate change (Gbetibouo and Ringler, 2009).

Key for communities to adapt to a changing climate is their ability to perceive climate change (Gbetibouo, 2008). A number of studies have shown that communities' perception of climate change have matched quantitative data of climate elements. In a study conducted by Vedwan and Rhoades (2001) on the perception of apple farmers in the western Himalayas, they found that farmers' perceptions to climate change indeed corresponded to climatic data records. A similar study conducted by Hageback et al. (2005) on how small scale farmers of Danagou watershed in China perceived climate change also concluded that there was a strong correlation between farmers' perception and meteorological data. Slegers (2008) had similar findings in his study with farmers in semi-arid central Tanzania. However, other studies like the one carried out by Rao et al. (2011) in the semi-arid parts of Kenya showed that communities' perception of climate change did not match quantitative data collected for the area.

Adoptive capacity of rural communities can be enhanced if practices that are already being implemented by farmers are incorporated into national strategies on climate change. Many scholars have pointed out the importance of local knowledge in developing effective strategies to a changing climate (Newsham and Thomas, 2011; Mertz et al., 2009). Unfortunately, many development agencies including national governments, Non-governmental Organizations (NGOs), international donor communities do not consider rural communities' perceptions to climate change for inclusion in their interventions (FAO, 2011).

The IPCC's (2001) considers vulnerability to climate change to be the degree to which a system is susceptible or unable to cope with adverse effects of climate change, including climate variability and extremes. Climate change has been the subject of intense debate in the global environment with the need to understand communities' vulnerabilities arising from these debates. Whilst definitions of vulnerability are plentiful, the main area of contest has been finding a robust measurement of vulnerability that puts into account the basics of risk analysis. In general, Nelson et al. (2007) and IPCC (2001) looks at vulnerability as the susceptibility of a system to disturbances determined by exposure to perturbations, sensitivity to perturbations, and the capacity to adapt. Specific to climate change, IPCC (2001) defines vulnerability as "the degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes". In addition to the challenge of defining vulnerability, it is also difficult to measure quantitatively (Schwarz et al., 2011; IPCC, 2007a). To a large extent, vulnerability concept remain largely academic and theoretical, and not of a great help in improving the way natural resources are managed or used in planning and management (Schwarz et al., 2011). Chambers (1989) has argued that the primary goal of applied vulnerability assessment should be to create contextually relevant measures of vulnerability that trigger action to reduce it. Scaramozzino (2006), Aandahi and O'Brien (2001), and Adger (1996) continue to emphasize that vulnerability is influenced by both physical and socioeconomic characteristics which are themselves not static, implying that vulnerability is context specific, and specific to place, time and the perspective of those assessing it. The context specific nature of vulnerability means that there can be no single, unified or general purpose approach to conceptualising it. Vulnerability analysis ranges from local or household Adger (1999) levels to the global level (Brooks et al., 2005).

IPCC (2001) and Deressa et al. (2008) observed that vulnerability can be conceptualized in many different ways along a continuum from outcome to contextual vulnerability. Outcome vulnerability is characterized by the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes i.e. existent state (Kelly and Adger, 2000). Contextual vulnerability assesses 'the susceptibility of a system to disturbances determined by exposure to perturbations, sensitivity to perturbations, and the capacity to adapt (Kelly and Adger, 2000). Schwarz et al. (2011) cautions of the importance of understanding people's perception about a particular climate event e.g. cyclone. It is important to note that communities are not homogenous in terms of exposure to the threat or resilience and will respond differently to different stimuli (Schwarz et al., 2011).

Deressa et al. (2008) identifies three major conceptual approaches to analysing vulnerability to climate change: the socioeconomic (focuses on socio-economic variations in the community, ignoring the environmental variation), the bio-physical (considers the level of damage from a given environmental stress, ignoring the individuals' capacity to adapt), and the integrated assessment approaches. Although, each has its strong points and weaknesses, the integrated approach has much to offer in terms of policy decisions (Nelson et al., 2010; Fussel, 2007). The integrated approach combines both socio-economic and bio-physical approaches to determine vulnerability. As regards IPCC (2001) definition of vulnerability, Deressa et al. (2008) cautions that although the integrated approach corrects the weaknesses of the other approaches, its limitation is that there is no standard method for combining the biophysical and socioeconomic indicators, requiring care in the ranking of variables. Luers (2003) observed that the use of indicators is limited by considerable subjectivity in variable selection and their weighting. However, Leichenko and O'Brien (2002) showed that composite indices method captures the multi-dimensionality of vulnerability comprehensively and has more to offer practical decision making processes in terms of policy. Thus, this study adopted this method to analyse the vulnerability of rural farming households of uMzinyathi District Municipality of KwaZulu-Natal.

Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adoptive capacity (IPCC, 2001). Since IPCC definition accommodates the integrated vulnerability assessment approach, this study is based on this approach that considers both biophysical and the socioeconomic indicators in assessing vulnerability of rural small-scale farming communities in uMzinyathi District Municipality to climate change.

Deressa et al. (2008) showed that sensitivity and adaptive capacity are linked. Given a fixed exposure, the adaptive capacity influences the level of sensitivity; higher adaptive capacity (socio-economic vulnerability) results in lower sensitivity (bio-physical vulnerability) and vice versa. Exposure relates to the degree of climate stress upon a particular unit of analysis which may be represented by frequency of climate extremes or predicted change in temperature or rainfall (Gbetibouo and Ringler 2009). Sensitivity is the degree to which a system is modified or affected by an internal or external disturbance or set of disturbances which reflects the responsiveness of a system to climatic influences, as shaped by both socio-economic and ecological conditions (Gallopín, 2003). Brooks (2003) and IPCC (2001) describe adaptive capacity as the potential or ability of a system, region, or community to adjust to the effects or impacts of climate change (including climate variability and extremes). Analysing vulnerability involves identifying not only the threat, but also the "resilience," or the responsiveness of the system and its ability to exploit opportunities and resist or recover from the negative effects of a changing environment (Gbetibouo and Ringler, 2009).

MATERIALS AND METHODS

Data collection

Meteorological data was collected from the meteorological department of South Africa for the nearest weather station, Greytown station (0270155 9 – GREYTOWN) with latitude and longitude of -29.0830 and 30.6000, respectively and an altitude of 1029 m above sea level. Meteorological data for the different weather elements was available only over the indicated periods; rainfall (1981 to 2010), temperature (1993 to 2010). This data was analysed for trends and variability. A survey was conducted among 200 households purposively sampled to have respondents of 40 years old or more and who have lived in the area for at least 20 years and participating in agricultural activities. A questionnaire was used to seek quantitative information while qualitative information was collected through focus group discussions and key informant interviews. Topics of inquiry included in the interviews were: (a) crop production involvement; (b) means of coping with past and current climatic conditions; (c) foresight into future climatic conditions; (d) direction of future adaptive strategies; (e) aids and constraints to adaptation, and (f) access to information. Quantitative data was captured and analysed using SPSS.

Analysis of the weather elements and community responses to their perceptions on changes in climate was then analysed using the SPSS programme. A comparison was then made between the actual changes in weather patterns and the communities' perception on climate change. Further analysis was also done on the characteristics of households who perceived climate had changed compared to those who did not perceive that climate had changed.

Construction of vulnerability indices

From our conceptual framework, vulnerability indexwas calculated using the formula:

V = f (I - AC)

(-) or (+)

where V is vulnerability index, I is potential impact and AC is adaptive capacity. In the calculation, both exposure and sensitivity were given negative signs. The justification is that areas that are exposed to damaging climate are more sensitive to damages given that the livelihoods of the community is agriculture based, assuming constant adaptive capacity (Deressaet al., 2008). In this relationship, the higher the net value indicates lesser vulnerability and vice versa. The methodology used in UNDP's Human Development Index (HDI) (UNDP, 2006) is followed for normalization. Indicators that have positive $(\uparrow)$ functional relationship with vulnerability e.g. variance in rainfall, their index values are calculated using the formula:

$$x = \frac{xi - Min(xi)}{Max(xi) - Min(xi)}$$

Indicators with negative $(\downarrow)$ functional relationship with vulnerability, e.g. adult literacy, their index value is calculated using the formula:

$$y = \frac{max(xi) - xi}{Max(xi) - Min\ (xi)}$$

After standardization of the indicators, weights were assigned to the indicators using the Principal Component Analysis (PCA) technique (Filmer and Pritchett, 2001; McKenzie, 2003). PCA technique was used to develop principle components that will account for most of the variance in the observed variables which were then used as predictor or criterion variables in subsequent analyses (McKenzie, 2003). The PCA is a multivariate statistical technique used to reduce the number of variables without losing too much information in the process (Sarbu and Pop, 2005). The PCA technique achieves this by creating a fewer number of variables which explain most of the variation in the original variables (Giri, 2004). The new variables which are created are linear combinations of the original variables. Those Principle Components (PCs) with Eigen values greater than one were selected as proposed by (Jeffers, 1967). Rousson and Gasser (2003) cautions that in some cases, principal components often lack interpretability and may define some abstract scores which often are not meaningful, or not well interpretable in practice. However, in order to enhance interpretability, principal components are often rotated according to the varimax criterion of Kaiser (1958).

For classificatory purposes, Iyengar and Sudarshan (1982) showed the suitability of the beta distribution in classifying levels of vulnerabilities characterized into the following fractile intervals:

(1) Very highly vulnerable if $0 < y_i < z_1$
(2) Highly vulnerable if $z_1 < y_i < z_2$
(3) Vulnerable if $z_2 < y_i < z_3$
(4) Moderately vulnerable if $z_3 < y_i < z_4$
(5) Less vulnerable if $z_4 < y_i < 1$

where y_i is the normalised vulnerability index and $(0,z_1)$, (z_1,z_2), (z_2,z_2), (z_3,z_4) and $(z_4,1)$ are the linear intervals such that each interval has the same probability weight of 20%.

RESULTS

Rainfall pattern in uMzinyathi District (1981 – 2010)

uMzinyathi District received an average annual rainfall of 784.29 mm (Average 1981 to 2010) but with quite large differences between years of low and high rainfall (Figure 1). Over the period (1981 to 2010), there was a generally decreasing rainfall in the study area.

The year 1987 registered the highest amount of rainfall (539 mm above average), while the year 2003 recorded the least volume of rainfall (368 mm below average). The years 1985, 1987 and 1988 had generally high rainfall records, 296, 538 and 395 mm above average,

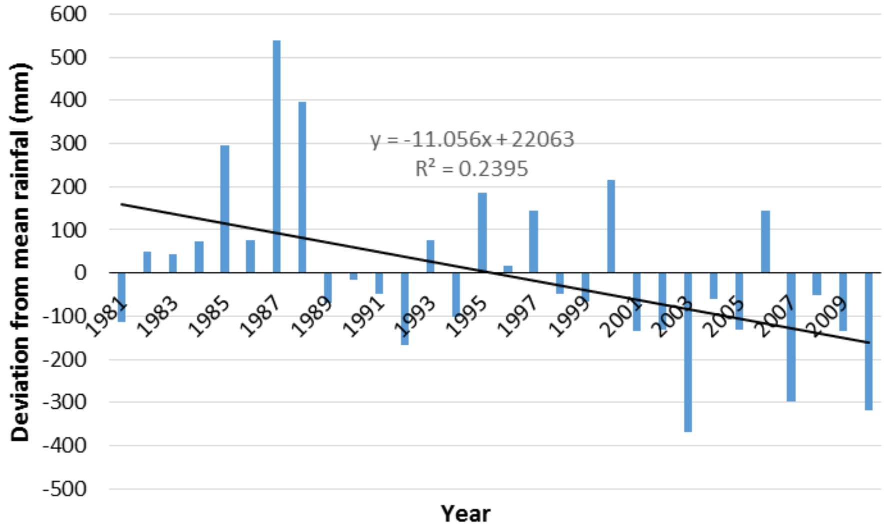

Figure 1. Annual deviation of rainfall from the mean (1981-2010).

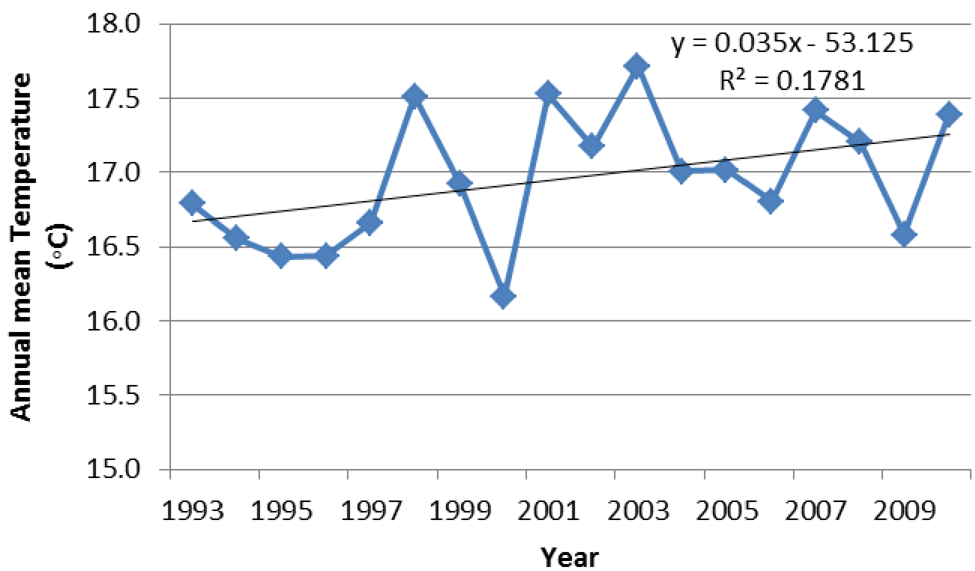

Figure 2. Annual average temperature (1993-2010).

respectively. The years 2004, 2007 and 2010 recorded the least rainfall with amounts of 368, 296 and 319 mm below average rainfall, respectively. The average annual rainfall over the period was 784.29 mm.

Temperature pattern of uMzinyathi District (1993 – 2010)

Over the period of 1993 to 2010, uMzinyathi District Municipality experienced annual average temperature range of between 16.2 and 17.7°C, with a period average annual temperature of 17.0°C. Generally, annual temperature increased over the period under review (Figure 2).

The year 2003 registered the highest temperature of 17.7°C and the year 2000 registered the least temperature of 16.2°C. Over the 17 years under review, temperature had increased by 1.5°C.

Community perceptions of climate change

Through focus group discussions and interviewing key informants, the local community was able to recollect precisely the years that had extreme events that affected their agricultural activities and this was compared to the meteorological data of the area (Table 1).

Table 1. Years of extreme climate conditions of relevance to agricultural production in UMzinyathi District Municipality.

Year	Observation by local community	Official records of annual rainfall (Data Source: SA Weather- Station [0270155 9] - GREYTOWN -29.0830 30.6000 1029 m)
1981-1982	Drought	1981 rainfall was below average with 1982 having slightly above average rainfall (Average rainfall = 784.29)
1985-1988	Intensive rains with floods during the summer cropping seasons	1985-1988 were all above average rainfall period. Most of the rains in 1985 and 1988 intensified over the period December - February. In 1986 most of the rain was received in January (234 mm) and in September for 1987 (385 mm)
1992	Drought	1989- 1994 were dry years with below minimum rainfall. 1992 was most severe (619 mm)
2003	Drought	2003 was a dry year(416 mm), the driest since 1981
2007-2010	Dry years	The periods 1998-2010 experienced below average rainfall except for years 2000 (1000 mm) and 2006 (929 mm) that received above average rainfall
2007	Drought	2007 was a dry year (488 mm) and most of the rain was received in October and November (288 mm)
2010	Drought	2010 was a dry year (465 mm) with only January receiving most rain (140 mm)

Table 2. Percentage of households' perceptions of climate change parameters in uMzinyathi District Municipality over the last 20 years (n=200).

Climate change parameters		Increase	Decrease	No change	Don't know
Noticed long term changes in the temperature in the last 20 years	Summer season temperature	78.0	11.0	5.0	6.0
	Winter season temperature	70.0	16.0	3.0	11.0
	Length of cold periods	19.0	55.0	23.0	3.0
	Length of hot periods	62.0	15.0	20.0	3.0
Noticed long term changes in rainfall in the last 20 years	Summer season rainfall	13.0	84.0	2.0	1.0
	Winter season rainfall	17.0	76.0	3.0	4.0
	Length of summer season rainfall	10.0	74.0	12.0	4.0
	Length of winter season rainfall	16.0	69.0	1.0	4.0
	Fluctuation in timing of rains	53.0	26.0	16.0	5.0
	Frequency of droughts	73.0	8.0	14.0	5.0
	Frequency of floods	39.0	52.0	8.0	1.0

Community observations did match the data that was recorded from the meteorological station. Community members were able to recollect the periods of extreme events of droughts and floods. Though some years were indicated as having exhibited extreme condition, in some instances these were carryover effects of the previous year.

From Table 2, households (78.0%) indicated that summer temperatures had generally increased and 62.0% said that hot periods had also increased.

A majority (70.0%) of households indicated that winter temperatures were becoming warmer and 55.0% indicated that the length of cold season was getting shorter. Most of the households (84.0%) indicated that summer season rainfall had decreased and so was the rains received during the winter season (76.0%).

Table 3. Results of unrelated probit model of households' perception of change in the climate, uMzinyathi District (n = 200).

Household characteristic	Perceive change in temperature	Perceive change in rainfall
Age	0.321**	0.5365**
Sex of household head	0.587	0.452
Education	0.369	-0.257**
Years of farming experience	0.213	0.118***
Access of information on climate change	0.025*	0.348**
Irrigation	-0.258**	0.310**
Visited by extension officer	0.756**	0.467**
Received training on climate change	0.015**	0.384***
Intercept	2.333**	1.798**
Log likelihood: -178.352	-	-
Athrho: 0.453***	-	-
Rho: 0.687	-	-

***Significant at 1% level; **Significant at 5% level; *Significant at 10% level.

Households indicated that both the summer and winter rainfall periods had decreased over time (74.0 and 69.0%) respectively. Households (53.0%) also indicated that there was an increased fluctuation in timing of rains and that there was increased frequency (73.0%) of droughts while incidences of floods had decreased over time (52.0%).

Further analysis was carried out to characterise households that were likely to notice climate change (temperature and/or rainfall changes) compared to those who were not likely to notice climate change by running a probit model.The independent variables used in this study included age, sex of household head, education, years of farming experience, access to information on climate, irrigation, visited by extension officers, received training on climate change. The results presented in Table 3 shows that age of household heads seemed to increase the probability that households were more likely to perceive long term changes in both rainfall and temperature.

Households who had access to irrigation water were also more unlikely to perceive changes in both rainfall and temperature. Households with longer farming experience were more likely to perceive long term changes in rainfall. On the other hand household who had received training on climate change were more likely to perceive changes in climate whether in temperature or on rainfall. Households who received extension services were likely to perceive changes in rainfall and temperature.

Categories of vulnerability indicators

The conceptual framework for this study was used to categorise the bio-physical and the socio-economic vulnerabilities into vulnerability indicators (Table 4) showing the selected indicators for the study, how they impact on community vulnerability and their units of measurement.

Community exposure was determined by the indicators, change in temperature and change in precipitation and these were measured by community perceptions. Community sensitivity was determined by frequency of droughts and floods and similarly measured by community perceptions. On the other hand, adoptive capacity was considered to include two of the livelihood assets, human and social capital.

Household anxiety to climate change

When asked about the feeling about future climate (Table 5), most households indicated that they were worried that they will face droughts and floods (78.0 and 64.0%, respectively). Interestingly most households (71.0%) indicated that they may not face crop failure.

Most households (69.0%) were not anxious that they may face price decline of their farm products. Household were not concerned about soil fertility decline (69.0%) and increase in cost of farm inputs (74.0%). Households were also anxious that they could face crop and animal disease outbreaks (58.0 and 56.5% respectively) with the anticipated future change in climate. Overall, households (76.0%) were anxious that they will face adverse change in climate in future.

Principal component analysis

The result of the Principal Component Analysis (Table 6) shows that 14 components with Eigen value of 1 or greater accounted for 67.5% of the total variance.

The first component has an Eigen value of 6.818 and

Table 4. Vulnerability indicators and possible impact on level of vulnerability of rural farming community in uMzinyathi District Municipality.

Determinants of vulnerability	Vulnerability indicators	Indicator description	Unit of measurement	Relationship between indicator and vulnerability
Exposure	Change in climate	Change in temperature	Community perception	The higher the change from normal the higher the vulnerability level
		Change in precipitation	Community perception	The higher the change from normal the higher the vulnerability level
Sensitivity	Extreme climate *(Land degradation index)*	Frequency of droughts and floods	Community perception	The higher the frequency, the higher the vulnerability level
Adoptive capacity	**Human capital** Literacy level Knowledge on Crop and water management	Quality of education	% of population	The higher the literacy level the lesser the vulnerability
	Irrigation potential **Social capital**	-	% of population in community relationships	The more a household is involved in community relationships the lesser the vulnerability

Table 5. Percentage of households response to anxiety on future climate change (n=200).

Household worry to:	Never	Rarely	Sometimes	Often
Recurrent droughts	15.5	6.0	38.5	39.5
Recurrent flood	12.0	24.0	38.5	25.5
Crop failure	25.0	46.0	12.5	16.5
Crop diseases	17.0	25.00	39.0	19.0
Livestock diseases	19.0	24.5	33.5	23.0
Price decline of farm products	51.0	18.0	20.5	10.5
Soil fertility decline	49.5	20.0	17.0	13.5
Price increase of inputs	51.50	22.5	18.5	7.5
Late on-set of rains	18.0	32.5	32.5	17.0
Shorter rainy seasons	17.5	22.5	38.0	22.0
Climate variability	19.0	5.0	35.5	40.5

explains 15.4% of the variation in the original variables and each subsequent component explains a decreasing proportion of variance. The screen plot test (Cattell, 1966) in Figure 3, shows a plot of the Eigen values associated with each component and indicates a “break” between the components with relatively large Eigen values and those with small Eigen values.

The components that appear before the break are assumed to be meaningful and are retained for rotation; those appearing after the break are assumed to be unimportant and are not retained (Cattell, 1966). In this case only components 1, 2 and 3 were used in the computation of household vulnerability indices. The component scores are shown in Table 7. Component 1 has got four component indicators; component 2 has eight indicators while component 3 has two indicators.

Household vulnerability index

Figure 4 shows the computed household vulnerability index. Fewer households, 40 (20%) had positive

Table 6. Total variance explained on the coping strategies to climate change (n = 200).

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.818	15.496	15.496	3.531	8.025	8.025
2	4.814	10.940	26.436	3.444	7.828	15.854
3	2.635	5.988	32.424	3.271	7.433	23.287
4	2.022	4.594	37.019	2.444	5.554	28.840
5	1.853	4.211	41.230	2.428	5.518	34.358
6	1.626	3.695	44.925	2.035	4.625	38.983
7	1.525	3.466	48.392	1.918	4.358	43.341
8	1.424	3.235	51.627	1.690	3.841	47.183
9	1.337	3.040	54.667	1.645	3.738	50.921
10	1.254	2.849	57.516	1.586	3.604	54.525
11	1.175	2.671	60.188	1.563	3.553	58.078
12	1.133	2.575	62.762	1.508	3.426	61.505
13	1.067	2.425	65.188	1.438	3.269	64.773
14	1.028	2.335	67.523	1.210	2.750	67.523

Extraction Method: Principal Component Analysis.

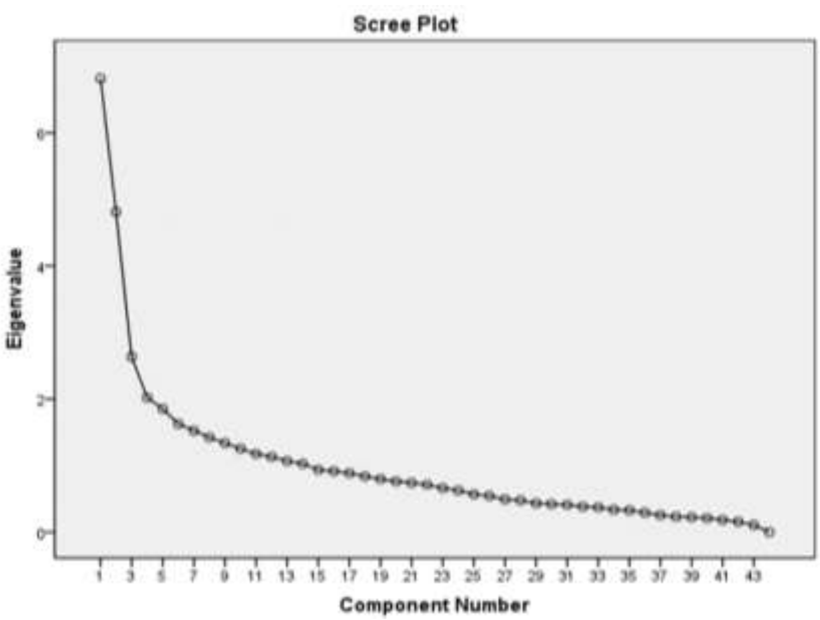

Figure 3. Screen plot showing the proportion of variance explained by each principal component.

household vulnerability index indicating that they were relatively not vulnerable to climate change while the rest 160 (80%) had negative household vulnerability index implying that they were relatively vulnerable to climate change.

Household vulnerability categories

Table 8 shows household vulnerabilities distributed across the five categories. There seem to be an even distribution of households among the different levels of vulnerability.

Category 3 (vulnerable) had the least number of households (17.0%), while category 4 (moderately vulnerable) had the most households (23%). 18.5% of households were very highly vulnerable, while 20% were less vulnerable.

A Chi-square test was carried out between household vulnerability categories and nominal household

Table 7. Rotated component matrix.

Component indicators	1	2	3
Rain water harvesting for irrigation	0.797	-	-
Crop diversification	0.699	-	-
Cover cropping	0.490	-	-
Across slope cultivation	0.468	-	-
Minimum tillage	-	0.680	-
Crop residue management	-	0.672	-
Tree planting alongside crops	-	0.596	-
Intercropping	-	0.557	-
Mixed farming	-	0.544	-
Diversifying to non-farming activities	-	0.488	-
Using organic manure	-	0.448	-
Using moist valley bottoms	-	0.347	-
Out migration	-	-	0.742
Leasing out land	-	-	0.698

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 14 iterations.

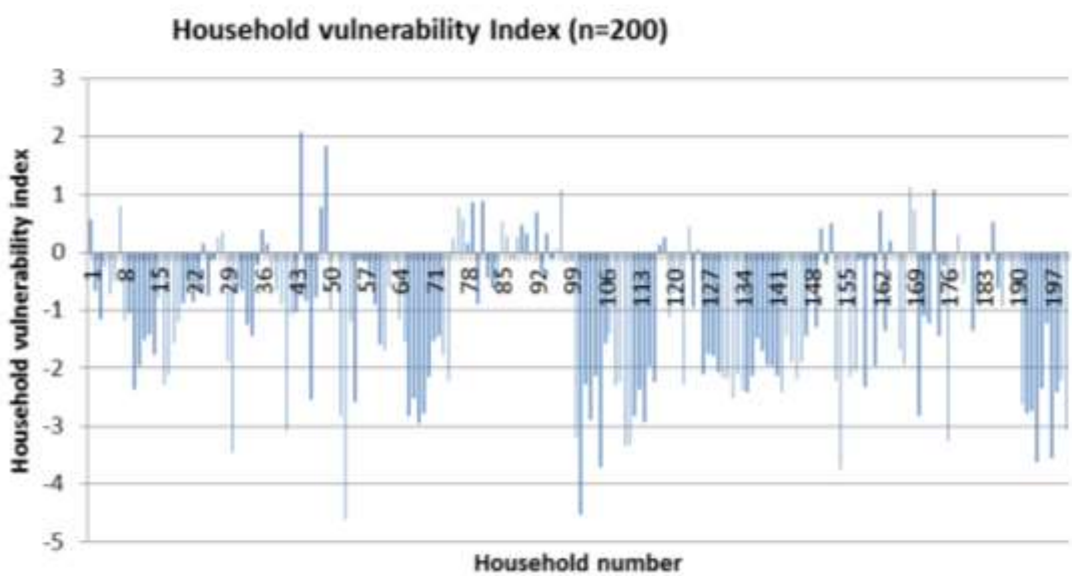

Figure 4. Individual household vulnerability index.

characteristics (Table 9). Level of education of household head and households owning a radio had significant ($p < 0.05$) relationships to vulnerability to climate change. Other household characteristics considered did not have a significant relationship to household vulnerability.

A Pearson's correlation was carried out to establish if there existed any relationship between household ordinal characteristics and household vulnerability (Table 10). There was a negative and significant relationship between household vulnerability and old age and disability grants (-0.155* and -0.185**), respectively. Other household characteristics considered in the study did not have significant relationships to household vulnerability.

DISCUSSION

Analysis of temperature (1993 to 2010) showed an annual increase by 1.5°C. Rainfall records showed generally decreasing levels of precipitation over the period of 1981 to 2010. The results are in agreement with

Table 8. Household vulnerability categories (normalized).

Statistics		Value	
A		3.2801	
B		3.09	
Mean		0.5173	
STD DEV		0.1926	
Median		0.5225	
LQUARTILE		0.3727	
UQUARTILE		0.6650	
Vulnerability categories		**n=200**	**Percentage**
Very highly vulnerable	0.00 <yi< 0.34	37	18.50
Highly vulnerable	0.34 <yi< 0.46	43	21.50
Vulnerable	0.46 <yi< 0.56	34	17.00
Moderately vulnerable	0.56 <yi< 0.68	46	23.00
Less vulnerable	0.68 <yi< 1.00	40	20.00

Table 9. A Chi-square test of household vulnerability and nominal household characteristics (n = 200).

Nominal household characteristic	Vulnerability index		
	Chi-square	Degrees of freedom	Asymp. Sig (2 sided) (*p* – value)
Sex of household head	200	199	0.467
Highest level of education of household head	600	597	0.042**
Household head can read and write	200	199	0.467
Household owns TV	235	230	0.467
Household owns radio	200	199	0.026**
Household owns mobile set	200	199	0.467
Anxiety over climate change	5200	5174	0.397

Table 10. Pearson's correlation between ordinal household characteristics and household vulnerability (n = 200).

Ordinal household characteristic	Household vulnerability
Total number of household members	0.064
Income per month from old age grant	-0.155*
Income per month from disability grant	-0.185**
Total Household income per month	0.020
Total area cultivated in square metres	0.420
Total money spent on food purchase in a month	-0.091
Value of inputs used in agricultural production	0.040
Value of livestock owned by household	-0.108
Number of children in household	0.027
Number of adults in household	0.039

**Significant at 5% level; *Significant at 10% level.

(IPCC, 2001) indication that with climate change, temperatures will increase while total rainfall will generally decrease. Communities of uMzinyathi District are very much aware of what climate is and they are able to share their experiences on a changing climate. From both the focus group discussions and the household surveys, temperature and rainfall seemed to be the main climate elements of concern. Relative humidity was not of critical concern among the respondents. The overall results showed that communities of uMzinyathi District recognise that climate has changed over the past 20 years. The perceived climate change does correspond to the meteorological data of the study area. These findings are in agreement with similar studies including Vedwan and Rhoades (2001) who examined how apple farmers in the western Himalayas of India perceive climatic change and Hageback et al. (2005) who assessed small-scale farmers' perceptions of climate change in the Danagou watershed in China. Other studies that are in agreement with this finding include Slegers (2008), working with semi-arid communities in Central Tanzania.

The results show that uMzinyathi communities perceive that climate has become hotter and drier. This confirms the meteorological data presented earlier for the study area and (Hanjra and Qureshi, 2010) observations that climate change will increase water scarcity. The implications could be decreased stream flow and groundwater recharge (IPCC, 2001; Blignaut and van der Elst, 2009) and generally insufficient water to sustain both crop and animal production consequently leading to high levels of food insecurity. Having access to water for irrigation provided a back-up system for households as such fluctuation in temperature and rainfall is not of concern. A similar observation was made by Gbetibouo (2008) among a farming community in the Limpopo River Basin. Households who received extension services were likely to perceive climate change since they were exposed to information about climate. Experienced farmers in farming were more likely to perceive changes in climate because of the sensitivity they may have developed over time.

Increasing temperatures may lead to increased levels of pest and disease manifestation, further diminishing the already precarious household food levels. This result confirms (Hunter, 2011) fears that with rural households relying heavily on climate-sensitive resources such as local water supplies and agricultural land, climate-sensitive activities such as rain-fed agriculture and livestock husbandry, and natural resources, the impact of climate change will be profound among these households.

Households' fear that in future floods and droughts will negatively impact on their livelihoods confirming Trobe (2002) and United Nations Environmental Programme (UNEP, 1999) observations that climate change will negatively impact on rural farming communities who rely largely on climate sensitive resources. Floods will wipe away crops and animal investments with direct consequence on decreasing household food security. Floods may be accompanied with waterborne diseases and this will further exacerbate household food insecurity.

Three components were found to significantly influence household vulnerability. In the case of the first component which explained 15.4% of the whole dataset, has strong positive loadings on adapting to climate variability through coping strategies including rain water harvesting for irrigation, growing different crop varieties, crop diversification, praying for rainfall, cover cropping and across slope cultivation. This component may be described as crop management coping strategies. The second component that explains 10.9% of the dataset has a positive loading on adapting to climate change through eight factors that can similarly be categorised as crop management coping strategies. Among other component factors included are minimum tillage, crop residue management, tree planting alongside crops etc. The third component accounting for 5.9% of the dataset is composed of two factors that can be categorised as farm management coping strategies. Component factors included out-migration, leasing out land and buying of insurance.

In considering household characteristics and household vulnerability to climate change, households with household heads who had higher level of education were less vulnerable to climate change, confirming (International Food Policy Research Institute (IFPRI) 2006) observation that better access to information by households will contribute to reduced vulnerability. It was observed that increased household incomes reduced household vulnerability. Incomes diminish dependency on climate sensitive resources like agriculture thus reducing household vulnerability to climate change as observed by IFPRI (2006).

It was observed that households are nearly evenly distributed in all the five vulnerability categories. The indication is that even within the same locality vulnerability to climate change will vary significantly. This may imply that blanket recommendations on dealing with vulnerabilities to climate change may not be effective even at household level. This confirms Kristie and Semenza (2008) observation that addressing vulnerability need to be context specific even at household level. Households may need tailor made interventions to address their vulnerability situation.

Conclusion

This paper has attempted to look at how household perceptions to climate change in relation to quantitative meteorological data and the impacts on household vulnerabilities. Climate data analysed for uMzinyathi District shows a general warming trend with a 1.5°C annual temperature increase over the period 1993 to 2010. The area is becoming drier with a general trend of decreasing rainfall over the period 1981 to 2010. Households' perceptions to climate change were a reflection of climatic data records. Households were able to recognise that temperature had indeed increased while there was a reduction in the volumes of rainfall received.

There is urgent need to incorporate indigenous knowledge in formulating climate change mitigation policies to further support communities' response to climate change. Due to the heterogeneity of climate factors for different areas, local knowledge will become more important for development agencies hence the need for such agencies to incorporate such knowledge in their interventions.

Although, farmers were well aware of climatic changes and the different crop management practices to adapt to the changing climate, the famers remained very vulnerable to climate change in future. Farmers vulnerability could be drastically reduced if there were mechanisms in place to forewarn famers of impending climate changes. This could allow them to take the necessary measures. The main coping strategies of farmers in the uMzinyathi District Municipality included growing of different crop varieties, planting different fields at different times, use of organic fertilizers, leaving some of their fields fallow, practice of minimum tillage, planting trees alongside slopes, cropping of valley bottoms and carrying out mixed cropping. It is one thing for farmers knowing about the different mitigating practices and it is another to effectively practice them. Further research is required to investigate to what extend farmers are effectively undertaking the different mitigating practices.

Technology will play a greater role in reducing farmers' vulnerability to climate change. Selection of varieties and crops that can cope with the changing crops growing environment may significantly reduce households' vulnerability. Support to the farming communities through appropriate and effective extension services were necessary to deal with the new crop growing conditions arising among the agricultural community. Possibilities of utilizing the Tugela River for crops irrigation need to be investigated in order to compensate for the generally decreasing levels of rainfall in the region.

The analysis revealed a rural community that is vulnerable at different levels to climate change now and in the future. The results indicated that vulnerability to climate change is highly masked by the fact that the community rely on government grants for their livelihoods and that agricultural activities are generally shrinking and becoming unimportant to the communities. This situation makes poor households vulnerable to national policy choices and politics. It is essential that creative and meaningful solutions are found to enable the rural community in the uMzinyathi District Municipality become self-reliant and look beyond government grants that can be abolished by a simple change in government policy. These results do not tell policy makers how to design adaptation interventions. The results do suggest, though, that activities other than agricultural might usefully form part of overall adaptation strategies including engaging in alternative income generating activities to compensate for the delicate agricultural activities that are totally reliant on the decreasing levels of rainfall. Other mitigation strategies might include water harvesting, resource conservation and management of especially land, irrigation systems, provision of agro-ecological extension packages, supporting social networks already existing in the areas in form of self-help groups and a system of drought early warning systems.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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