Climate Change Awareness in Mpumalanga Province, South Africa

Phokele Maponya[1], Sylvester Mpandeli[2] & Samuel Oduniyi[1]

[1] Department of Geography, Environmental Management and Energy Studies, University of Johannesburg, Johannesburg, South Africa

[2] Water Research Commission of South Africa, Pretoria, South Africa

Correspondence: Phokele Maponya, Department of Geography, Environmental Management and Energy Studies, University of Johannesburg, Johannesburg, South Africa. E-mail: phokelemaponya@gmail.com

Abstract

Climate change is one of the most important environmental issues facing the world today. The impact of climate change is a reality and it cuts across all climate-sensitive sectors including the Agriculture sector. It is well documented by several scientists, Intergovernmental Panel on Climate Change and other experts that climate change threatens sustainable economic development and the totality of human existence. This study will enable small scale maize farmers in Mpumalanga province to understand the challenges and the threat posed by climate variability and climate change. The study was conducted in Nkangala District, Mpumalanga province. Mpumalanga province remains the largest production region for forestry and the majority of the people living in Mpumalanga are farmers and they have contributed immensely to promote food security. However, due to the threat by climate variability and change, sectors such as the Agriculture, Water etc are experiencing the following pattern: (a) Putting livelihoods and food production at serious risks due to extreme climatic events, climate variability and change. It was noted that there is a need for climate change awareness across the agriculture sector. Currently, there is enough evidence that shows that climate change is affecting different elements of agriculture such as crops and livestock. Random sampling technique was used to select two hundred and fifty farmers to be interviewed. The questionnaires were administrated to household head farmers and included matters relating to household general information, climate change awareness, land characteristics, observation on climate change and agronomic practices including maize production. Data was analysed using the statistical for social sciences (SPSS version 20). Descriptive statistics was used to describe data and Univariate regression analysis was conducted to demonstrate the relationship and association of variables. It was noted that the majority of farmers in this province need capacity building and also climate change awareness initiatives which would assist these farmers to build the adaptive capacity, increase resilience and reduce vulnerability. By coming up with these kind of interventions it is believed that some of these farmers would be able to change their farming methods, diversify their cropping systems and also introduce drought tolerant crops in order for them to have good yields and also be able to generate good income.

Keywords: climate change, climate variability, vulnerability, awareness, mpumalanga province, South Africa, nkangala district, small scale farmers and maize

1. Introduction

According to Hougton (2002), climate change is possibly the greatest environmental challenge facing the world today. Presently, there is widespread consensus in the scientific community and even among farmers that climate change is a reality and that the impacts are already being felt. The impact of climate change varies globally; however, the problem and the challenges of climate change are becoming more threatening to sustainable economic development and the totality of human existence (Adejuwon, 2004). Small-scale farmers suffer the most because of their dependence on rain-fed agriculture, limited financial capacity, low adaptive capacity, high dependence on natural resources, inability to detect the occurrence of extreme hydrological and meteorological events due to low technology adoption, limited infrastructure, illiteracy, lack of skills, level of awareness and lack of capacity to diversify (Kurukulasuriya & Mendelsohn, 2006b).

The IPCC (2001) predicted that climate change will have both positive and negative effects, but the adverse effects will predominate with greater rates of climate change. Research has estimated that agriculture, which is

the main source of income to the majority of countries in Africa, is facing serious threat due to extreme climatic events, climate variability and change. Agriculture also provides employment for over 70 percent of the labor force in African countries. In South Africa, between 1960 and 2003, the mean temperature increased by 0.13 degrees Celsius (Kruger & Shongwe 2004), and mean rainfall is expected to decrease by 5-10 percent within the next 50 years (Hewitson, 1999; Durand, 2006). The expected reduction in rainfall would have significant impact on South Africa's agriculture due to the fact that a large portion of the country is semi- arid and experiences varying and low mean rainfall of 464 millimeters (mm) annually, relative to the world average of 857 mm (BFAP, 2007).

Maize constitutes about 70 percent of grain production and covers about 60 percent of the cropping area in South Africa. It is a summer crop, mostly grown in semi - arid regions of the country, and is highly susceptible to changes in precipitation and temperature (Durand, 2006; Benhin, 2006). Although the maize plant is adaptable to harsh conditions, a drier or warmer climate and lower precipitation could have detrimental effects on its yield (BFAP, 2007). In addition, maize is the main staple food in Southern Africa, and maize production in the country constitutes about 50 percent of the output within the Southern African Development Community (SADC) region (Durand, 2006). Consequently, maize is one of the key drivers of food inflation in South Africa (BFAP, 2007). Durand (2006), further emphasize that although a decrease in maize production may result in increased total revenue because of its inelastic demand, it would increase food insecurity within the Southern African region. A considerable number of studies have been carried out to investigate the impact of climate change on yields of grain crops such as maize under controlled experiments (e.g., Du Toit et al., 2002; Durand, 2006).

Climate change awareness is being conscious of the environment and is an emerging issue in developing countries, which are more concerned with poverty alleviation, food insecurity and among others. There is very little awareness on climate change in the developing countries (IPCC, 1996).The overall objective of the paper is (i) to describe the status of climate change awareness across households/farmer's age, education, gender and information. The following questions were also formulated: (a) what is the statistical significant difference in the level of awareness of climate change by the farmers/households? (b) What is the statistical significant difference in the factors which influence the level of awareness of climate change?

2. Methodology

This paper used descriptive statistics as well as detailed structured questionnaires as part of the data collection methods. The questionnaires consist of a logical flow of closed ended questions which address issues related to climate change, agricultural production, yields etc. Data was collected through face to face interviews with the farmers and also the help of the extension officer where 251 questionnaires were administered in the study area. The questionnaire consisted of sections A, B, C and D, where section A was for general information like district name, the date of the interview, the characteristics of household and information on climate change awareness. The section B was land characteristics while the section C talks as about farmers' observation on climate change. The last section, which is section D, entails how productive they are in relation to climate change.

The study was carried out in the Mpumalanga province of South Africa, Mpumalanga lies in the eastern part of the country and covers a total area of 76 495 square kilometers (StatsSA, 2011). It is the second-smallest province after Gauteng, taking up 6.3 percent of South Africa's land area and with a population of over 4-million people (Census, 2011). It occupies about 6.3 percent of South African's lands mass. According to StatsSA (2011), Mpumalanga Province has a total number of 18 local municipalities and three district municipalities, namely: Ehlanzeni, Gert Sibande and Nkangala Districts. The study was conducted in Emakhazeni local municipality within the Nkangala district municipality. The district office is located at Belfast area. Random sampling technique was used to select two hundred and fifty one farmers to be interviewed.The towns include: *Belfast, Dullstroom, Machadodorp, Noodgedarht, Stoffberg, WatervalBoven, and Wonderfontein* (Figure 1). Data was captured and analysed using software package for social science (SPSS version 20). Descriptive analysis was used to describe data and Univariate regression analysis was conducted to demonstrate the relationship and association of variables. The following econometric model was used to determine association of variables:

$$Wi = \_ + \_Xi + \_i \tag{1}$$

$$Wi \text{ is the dependent variable value for person I} \tag{2}$$

$$Xi \text{ is the independent variable value for person I} \tag{3}$$

$$\_ \text{ and } \_ \text{ are parameter values} \tag{4}$$

$$\_i \text{ is the random error term} \tag{5}$$

$$\text{The parameter } \_ \text{ is called the intercept or the value of W when X = 0} \tag{6}$$

$$\text{The parameter } \_ \text{ is called the slope or the change in W when X increases by one} \tag{7}$$
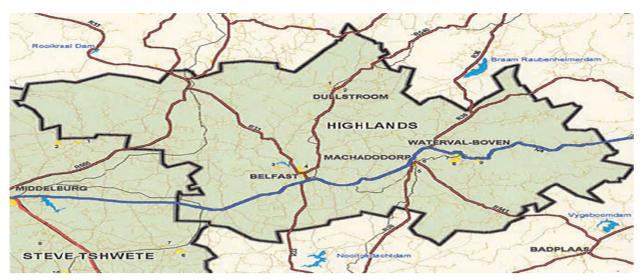
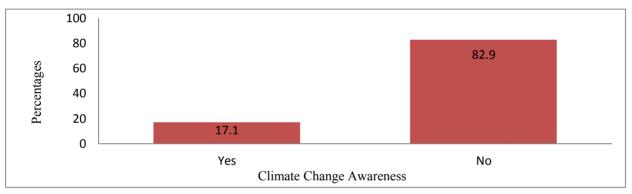Figure 1. Map of Study area (Source: StatsSA, 2011)

Figure 2. Households Climate Change Awareness

3. Results and Discussion

A representative sample of 251 households was interviewed. It was noted that 79 percent were males and 21 percent females participated in the study. The study was conducted in Nkangala district (Table 1). The following 7 towns were visited: Belfast, Dullstroom, Machadodorp, Noodgedarht, Stoffberg, Watervalboven and Wonderfontein (Table 1). The number of households visited is shown in table 1. The selection of the district were based on different agricultural setups and different climatic condition.

As indicated in table 2, farming was noted as a major contribution in most of the households, it was noted that at least 61.8 percent of households are engaged in farming, percent employed by other sectors such as Mining, Tourism etc), percent of the respondents are housewives, 3.2 percent of the respondents are pensioners and only 4.4 percent of the respondents have no occupation. These results clearly demonstrate that the majority of the households are small scale farmers who have no other form of occupation except farming. These results also complement what Fleshman (2007) reported that farming in Africa provides employment for over 70 percent of the labor force and 30 percent of Africa gross domestic product. So the situation in Mpumalanga province is not surprising as reported in other studies done by Makhura (2001); Mpandeli (2005); Maponya and Mpandeli (2012).

Table 1. Summary characteristics of sample in 7 towns

Local Municipalities	Number of Households	Percentages
Number of Households per town		
Belfast	50	19.9
Dullstroom	45	17.9
Machadodorp	40	15.9
Noodgedarht	30	12
Stoffberg	30	12
Watervalboven	30	12
Wonderfontein	26	10.3
Total	251	100
Gender		
Male	199	79
Female	52	21
Total	251	100

Table 2. Occupation of Households

Occupation	Number of Households	Percentages
Farming	155	61.8
Employed	58	23
Housewife	14	5.6
Pensioner	8	3.2
Business	5	2
No Occupation	11	4.4
Total	251	100

Table 3. Maize as source of income

Source of income	Number of Households	Percentages
Yes	179	71.3
No	72	28.7
Total	251	100

The majority of the respondents generate their income from the maize crop. This shows that maize crop is predominant in Mpumalanga province. This was also confirmed by the StatsSA (2011) that , Mpumalanga produced 23 percent of the total commercial maize production in South Africa, of which 53 percent was white maize and 47 percent yellow maize. According to the report, Mpumalanga is the second province producing maize commercially in South Africa making the province an important contributor to the country's total maize production. The concern here is that by planting maize only, the danger is that during drought, the majority of these farmers are going to loose production and this monocropping system is not adviseable especially if you are dealing with climate change challenges. Farmers from the Mpumalanga area need to be adviced to start diversifying in their farming business by planting maize, groundnuts, sorghum etc. If farmers are applying multicropping system there great potential of minimizing loss of production, loss income etc. The risk aversion strategy is very important in area such as Mpumulanga. It has been reported in several studies that crop diversification is good in an area where the rainfall distribution is below normal as was indicated by Maponya and Mpandeli (2012). It looks like farmers in the Belfast area are not worried about the impact of climate variability and change unless if they are

ignoring the threats posed by climate change. In Limpopo Province for example, the majority of these farmers are beginning to use seasonal forecast information in order to manage climatic risk (Mpandeli, 2005). Farmers are using seasonal climate forecast information in order to: (a) To prepare a seasonal calendar for agricultural activities. (b) To make informed decisions for farm planning management and decision-making. (c) To manage risk due to the variable environment in which they operate.

As shown in figure 1, 82.9 percent of the households are not aware about climate change and only 17.1 percent households indicated that they are aware of climate change. This is not surprising because the majority of households indicated that they are not aware about climate change issues due to: (a) Lack of information especially climate advisory, (b) lack of education and lack of assistance from the extension officers. According to Olayinka et al., (2013) awareness of the various causes of climate change is generally below average and less than 50 percent however sees it in terms of reduced agricultural productivity or ozone layer depletion.

As shown in Table 4, there is association among the following variables: gender, age, occupation, education, source of income, information on climate change, extension service, importance of information on climate and quantity of harvest. This is supported by the fact that their estimate values are more than 1 at 95% confidence interval.

Gender (Female) had significant impact on the level of climate change awareness. According to Table 1, the odds of climate change awareness are 1.00 percent higher for female households than male households. It is widely recognised that climate change does not affect people equally (UNEP, 2002). The related disasters and impacts often intensify existing inequalities, vulnerabilities, economic poverty and unequal power relations (Brody et al., 2008). It was reported that women and men perceive and experience climate change in diverse ways because of their distinct socially constructed gender roles, responsibilities, status and identities, which result in varied coping strategies and responses (Lambrou & Nelson, 2010). A study done by Nhemachena and Hassan (2007) acknowledged women contribution in agricultural sector in relation to climate change especially women's leadership in natural resource management in developing countries.

The situation observed in Mpumalanga province is not different from a research conducted in Limpopo province by Maponya & Mpandeli (2012) that women play a vital role in supporting households and communities, thus, they are more aware and adapt to climate change through experience gained in agricultural production and the fact that the majority of these women spend most of their time in the field ploughing, removing weeds, monitoring the crops, harvesting etc. Often, women are more vulnerable to climate change than men. This is because they make up the majority of the worlds economically poor, do most of the agricultural work, bear unequal responsibility for household food security, carry a disproportionate burden for harvesting water and fuel for everyday survival, and rely on threatened natural resources for their livelihoods. The situation is also supported by Epule et al. (2012) who emphasized that women are more vulnerable to famine and water scarcity than men. This high level of vulnerability has been associated to the fact that women have family care responsibilities which ties them more to issues such as providing food and water to their families (Epule et al., 2012). It is this responsibilities that make women more aware to climate change than men.

Age is another significant variable which is associated to climate change awareness. According to Table 1 the odds of climate change awareness are 1.00 percent higher across all age categories. This is not surprising because climate change awareness is made across all age categories even in the schools and out of the school through the use of fliers, posters and many medium. This conforms to the finding of Olajide et al. (2011) who found a significant association between age and knowledge of global warning among undergraduate students of Obafemi Awolowo University (OAU), Ile Ife, Nigeria. According to Bayard et al. (2007) age is positively related to some climate change adaptation measures that are related to agricultural activities. Okeye (1998) found that age is positively related to the awareness and adoption of conservation measures. Others, however, found that age is significantly and negatively related to farmers' decision to adopt (Gould et al., 1989). The result of this research agrees with the findings of Yusuf (2005) that most farmers are within their active years and can make positive contribution to agricultural production, thus farmers' age had a significant impact on the awareness of climate change.

According to Table 4 the odds of climate change awareness are 1.10 percent higher across all occupations. The study shows that occupations of the respondents have significant impact on the level of climate change awareness. This could be from the fact that some farmers take farming as a full time and some farmers take farming as part timeactivity but in each case, they all come across awareness either through indigenous knowledge or at their various place of work through adverts. According to Adebayo et al. (2003) occupation has a significant association with awareness of climate change. The more they carry out farming activities, the more the awareness and

adoption to climate change. According to Table 4 the odds of climate change awareness are 1.01 percent higher across all educational levels. Many research studies have shown that education increases ones's ability to receive, decode, and understand information relevant to perception and making innovative decisions (Wozniak, 1984). The result from the study area showed that education increases the probability of the level of climate change awareness. This is in conformity with Noor (1981), who documented the relevance of the literacy level of a farmer to farm productivity and production efficiency. According to Noor (1981) a education facilitates farmers' understanding and use of improved crop technologies.

Table 4. Univariate regression analysis of potential determinants of climate change awareness and maize production

Variable	Total	(%)	OR [95%CI]
Females	52	20.7	1.00[0.508 – 2.711] 1
Age	251	100	0.99 [0.440 – 2.567] 1
Occupation	251	100	1.10 [0.675 – 3000] 1
Education	251	100	1.01[0.599 – 2899] 1
Source of income (Yes)	179	71.3	0.97[0.127 – 2.112] 1
Climate change info	251	100	1.53[0.76 – 3.555] 1
Extension Service	251	100	1.50[0.68 – 3.44] 1
Importance of info	251	100	1.12[0.576 – 2.666] 1
Quantity of harvest	251	100	101[0.11- 2011] 1

OR= Odds ratio; 95%CI = 95% confidence intervals; 1< = no association; 1> = association.

According to Anley et al. (2007) improving education and employment is key to stimulate local participation in various adaptation measures and natural resource management initiatives. It was further emphasised by Maddison (2006) that educated and experienced farmers are expected to have more knowledge and information about climate change and adaptation measures to use in response to climate challenges. Extension education was found to be an important factor motivating increased intensity of use of specific soil and water conservation practices (Bekele & Drake, 2003). According to Table 4 the odds of climate change awareness are 1.00 percent higher across for households who rely on maize as source of income than households who don't rely on maize as source of income. From the study, farmers who rely on maize as a source of income have no other job or extra source of income, than farming activities, thus, they are involve and concern about their environment in relation to their faming activities because they need to provide for the household thereby tends to be more aware of the climate change as an environmental factor responsible for production, unlike farmers who have other source of income apart from farming.

Evidence from regression analysis reveals income as significant predictors of the awareness of climate change. The variable of income source being relied on by the farmers was positive, and it was emphasized that a positive sign of a variable indicates that high values of the variables tends to increase the probability of the awareness of climate change. According to Table 4 the odds of climate change awareness are 1.53 percent for households with climate change information. This is shows that climate change information is significantly associated with

awareness level of climate change. This is not surprising because a study reported by Luseno et al. (2003) said the more the farmers had access to extension services and information about climate change, the more they adapt to climate change. From this study, the amount on climate change information at farmers' disposal determines the level of awareness of climate change.

Accordingly to Pender et al. (2004), it is hypothesized that farmers who have significant extension contacts have better chances to be aware of changing climatic conditions and as well as adaptation measures in response to climatic changes. Extension education was found to be an important factor motivating increased intensity of use of specific soil and water conservation practices (Bekele & Drake, 2003). However, apart from the fact that information at farmer's disposal brings awareness to climate change, perceived change in climate variables and access to climatic change information are also important pre- conditions to take up adaptation measures (Maddison, 2006). Access to extension services is another significant variable which is associated to climate change awareness. According to Table 4 the odds of climate change awareness are 1.50 percent for households with access to extension services. The study shows that access to extension services significantly affects awareness to climate change. Extension services provide an important source of information on climate change as well as agricultural production and management practices. Farmers who have significant extension contacts have better chances to be aware of changing climatic conditions and also of the various management practices that they can use to adapt to changes in climatic conditions.

The role of extension service is to provide information to extension clients in order to allow them to use available resources by increasing technological options and organizational skills that in turn allow them to take greater advantage of production and market opportunities (GoK, 2001). In addition, Benhin (2006) noted further that farmers' level of education and access to extension service are major determinants of adaptation measures to climate change. Improving access to extension services for farmers has the potential to significantly increase farmer awareness of changing climatic conditions as well as adaptation measures in response to climatic changes (IFPRI, 2007). According to Hassan and Nhemachena (2008), Apata et al. (2009), Deressa et al. (2010) and Bryan et al. (2009) access to extension services had a strong positive influence on adapting to climate change and awareness. Similar research conducted by D'Emden et al. (2008) revealed that extension attendance had significant effect on adoption of conservation tillage in the cropping regions of Australia.

According to Table 4 the odds of climate change awareness are 1.12 percent for households who recognise the importance of climate change information. According to Nhemachena and Hassan (2007) farmers that perceive change in climatic conditions and farmers who have access to climate change information have higher chances of taking adaptive measures in response to observable changes. Importance of climate change information brings about awareness on climate change and enhances farmer's knowledge on adaptation to climate change. According to Table 4 the odds of climate change awareness are 1.01 percent for households who received good quantity of harvest. Good quantity of harvest is another significant variable which is associated to climate change awareness. There is no doubt that climate change awareness plays a very important role in the agriculture sector and if farmers have information in their disposal, the majority of these farmers can make good decisions as it was noted by Mpandeli (2005). Though the relationship between seasonal climate variables can be quite complex, we expected that farm revenues would have a significant relationship with climate change awareness (Kurukulasuriya & Mendelsohn, 2006).

4. Summary and Conclusion

Due to prevailing problems associated with changes in weather patterns such as high temperatures, changes in rainfall patterns and effect of greenhouse gases (GHGs), which has resulted in low crop production, food insecurity, low income for farmers, there is a need to investigate whether small scale maize farmers are aware about the impact and threats' posed by climate change. A report from The South Africa Grain Laboratory (SAGL) emphasized that Mpumalanga produced 23 percent of the total commercial maize production in South Africa, of which 53 percent was white maize and 47 percent yellow maize. According to the report, Mpumalanga is the second province producing maize commercially in South Africa making the province an important contributor to the country's total maize production.So this study will enable small scale maize farmers and households in Mpumalanga province to understand the complex issues regarding climate change and also the challenges caused by both climate variability and change in their areas, however, during the survey, it was found that climate change awareness, capacity building, technology transfer, adaptive capacity etc are needed in order for these farmers to be able to cope and adapt due to the impacts of climate change. If is envisaged that these farmers are capacitated with climate advisory information, training and farm planning most of these farmers will improve their climate change adaptation strategies and also be able to increase their agricultural production, also improve their livelihoods, income and also reduce vulnerability in their farming set ups. It was also noted that the majority of these farmers

have limited ability to deal with climate change issues due to limited financial sources, lack of access to technology and also inadequate income.

5. References

Adebayo, A. A., & Tukur, A. L. (2003). Farmers' Perception of Environmental Problems in Adamawa State, Nigeria. *African Journal of Environmental Management, 1*.

Adejuwon, S. A. (2004). *Impact of climate variability and climate change on crop yield in Nigeria*. Contributed paper to Stakeholders workshop on Assessment of Impact & Adaptation to Climate Change (AIACC).

Anley, Y., Bogale, A., & Haile-Gabrile, A. (2007). Adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers in Dedo district, western Ethiopia. *Land degradation and development, 18*, 289-302. http://dx.doi.org/10.1002/ldr.775

Apata, T. G., Samuel, K. D., & Adeola, A. O. (2009). *Analysis of climate change perception and adaptation among arable food crop farmer's in South West Nigeria*. Contributed paper prepared for presentation at International Association of Agricultural Economists' 2009 conference, Beijing, China.

Bayard, B., Jolly, C. M., & Shannon, D. A. (2007). The economics of adoption and management of alley cropping in Haiti. *Journal of environmental management, 84*, 62-70. http://dx.doi.org/10.1016/j.jenvman.2006.05.001

Bekele, W., & Drake, L. (2003). Soil and water conservation decision behaviour of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area. *Ecological Economics, 46*, 437-451. http://dx.doi.org/10.1016/S0921-8009(03)00166-6

Benhin, J. K. A. (2006). Climate change and South African agriculture: Impacts and adaptation options. *CEEPA Discussion paper No. 21*. CEEPA, University of Pretoria, South Africa.

BFAP (Bureau for Food and Agricultural Policy). (2007). Modeling the economic impact of climate change on the South African maize industry. *BFAP report # 2007 – 02*.

Brody, A., Demtriades, J., & Esplen, E. (2008). *Gender and Climate Change: Mapping the Linkages – A Scoping Study on Knowledge and Gaps*. BRIDGE, University of Sussex, Sussex.

Bryan, E., Deressa, T. T., Gbetibouo, G. A., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science and Policy, 12*, 413-426. http://dx.doi.org/10.1016/j.envsci.2008.11.002

D'Emden, F., Llewellyn, R. S., & Burton, M. P. (2008). Factors affecting adoption of conservation tillage in Australian cropping regions. *The Australian Journal of Agricultural and Resource Economics, 52*, 169-182. http://dx.doi.org/10.1111/j.1467-8489.2008.00409.x

Deressa, T. T., Hassan, R. N., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change, 19*, 248-255. http://dx.doi.org/10.1016/j.gloenvcha.2009.01.002

Du Toit, A. S., Prinsloo, M. A., Durand, W., & Kiker, K. (2002). Vulnerability of maize production to climate change and adaptation assessment in South Africa. Combined Congress: South African Society of Crop Protection and South African Society of Horticulture Science; Pietermaritzburg, South Africa

Durand, W. (2006). Assessing the impact of climate changeon crop water use in South Africa. *CEEPA Discussion Paper #28*. University of Pretoria, South Africa

Epule, T. E., Peng, C., Lepage, L., & Chen, Z. (2012). Poverty and Gender oriented vulnerabilities to food and water scarcity in Touroua, Cameron, *Journal of Human Ecology, 38*(2), 81-90.

Fleshman, M. (2007). Climate change: Africa gets ready. *Africa Renewal (July 2007), 21*(2), 14-18.

GoK (Government of the Republic of Kenya). (2001). National Agricultural Extension Policy-Ministry of Agriculture and Rural Development.

Gould, B. W., Saupe, W. E., & Klemme, R. M. (1989). Conservation tillage: The role of farm and operator characteristics and the perception of soil erosion. *Land Economics, 65*, 167-82. http://dx.doi.org/10.2307/3146791

Hassan, R., & Nhemachena, C. (2008). Determinants of African farmers' strategies for adaptation to climate change: Multinomial choice analysis. *African Journal of Agricultural and Resource Economics, 2*(1), 83-104.

Hewitson, B. (1999). Regional climate scenarios.Prepared for the SA Country Studies Programme, South Africa.

Houghton, D. (2002). *Introduction to climate change: Lecture notes for meteorologists page 13-15*.

IFPRI (International Food Policy Research Institute. (2007). Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa. Charles Nhemachena, Centre for Environmental Economics and Policy in Africa (CEEPA) & Rashid Hassan, Centre for Environmental Economics and Policy in Africa (CEEPA). Environment and Production Technology Division. *IFPRI Discussion Paper 00714 Pg 25*.

IPCC (Intergovernmental Panel on Climate Change). (1996). In J. T. Houghton et al. (Eds.), *Climate Change 1995: The Science of Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (Intergovernmental Panel on Climate Change). (2001). In J. J. McCarthy, O. F. Canziani, N. A. Leary, D. J. Dokken, & K. S. White (Eds.), *Climate Change 2001: Impacts, Adaptation and Vulnerability*. IPCC working group II, Third assessment report. Cambridge University Press.

Kruger, A. C., & Shongwe, S. (2004). Temperature trends in South Africa: 1960–2003. *International Journal of Climatology, 24*(15), 1929-1945. http://dx.doi.org/10.1002/joc.1096

Kurukulasuriya, P., & Mendelssohn, R. (2006a). *Endogenous irrigation: the impact of climate change on farmers in Africa.CEEPA Discussion Paper No. 18*. Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa.

Lambrou, Y., & Nelson, S. (2010). Farmers in a Changing Climate: Does Gender Matter? – Food Security in Andhra Pradesh, India. *Food and Agricultural Organisation (FAO), Rome*.

Luseno, W. K., Mcpeak, J. G., Barrett, C. B., Little, D., & Gebru, G. (2003).Assessing the value of climate forecast information for pastoralists: Evidence from Southern Ethiopia and Northern Kenya. *World Development, 31*(9), 1477-1494. http://dx.doi.org/10.1016/S0305-750X(03)00113-X

Maddison, D. (2006). The perception and adaptation to climate change in Africa. *CEEPA Discussion Paper No. 10*. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Makhura, M. T. (2001). *Overcoming transaction costs barriers to market participation of smallholder farmers in Limpopo province of South Africa*. Published PhD Thesis, University of Pretoria.

Maponya, P., & Mpandeli, S. (2012). Climate Change and Agricultural Production in South Africa: Impacts and Adaptation options. *Journal of Agricultural Science, 4*(10), 48-60. http://dx.doi.org/10.5539/jas.v4n10p48

Mpandeli, S. N. (2005). Coping with climate variability in Limpopo Province. *Sustainable Rural Livelihoods Technical Report*.

Nhemachena, C., & Hassan, H. (2007). Micro-level analysis of farmers' adaptation to climate change in Southern Africa. *IFPRI Discussion Paper No. 00714*. International Food Policy Research Institute, Washington, D. C.

Noor, A. (1981). Educational and Basic Human Needs. *World Bank Working Paper No. 450*.

Okoye, C. U. (1998). Comparative analysis of factors in the adoption of traditional and recommended soil erosion control practices inNigeria. *Soil & Tillage Research, 45*, 251-63. http://dx.doi.org/10.1016/S0933-3630(96)00137-7

Olajide, F. O., Afolabi, O. A., Olajide, A. O., Omisore, A. G., Odunlade, A. O., & Omobuwa, O. (2011). *Knowledge about the causes, consequences and control of climate change among undergraduates of ObafemiAwolowo University, Ile Ife*. In A. T. Salami & O. O. I. Orimoogunje (Eds.), *Environmental Research and challenge of sustainable development*. Ile Ife: OAU Press.

Oloke, O. C., Ijasan, K. C., Ogunde, A. O., Amusan, L. M., & Tunji-Olayeni, P. F. (2013). Improving Urban Residents' Awareness of the Impact of Household Activities on Climate Change in Lagos State, Nigeria. *Journal of Sustainable Development, 6*(4), 56. http://dx.doi.org/10.5539/jsd.v6n4p56

Pender, J., Ssewanyana, S., Kato, E., & Nkonya, E. (2004). Linkages between poverty and land management in rural Uganda: Evidence from Uganda National Household Survey, 1999/00. *EPTD Discussion Paper No. 122*.

StatsSA (Statistics South Africa). (2011). *Mid-year population estimates*. Statistics South Africa, Pretoria.

UNEP (United Nations Environmental Program). (2002). *UNEP Environmental Impact Assessment Manual* (2nd ed.). Geneva.

Wozniak, G. D. (1984). The adoption of interrelated innovations: A human capital approach. *Review of Economics and Statistics, 66*(LXVI), 70-79. http://dx.doi.org/10.2307/1924697

Yusuf, O. (2005). *Economics analysis of 'egusi' melon production in Okehi Local Government Area of Kogi State* (40-41). published M.Sc. Thesis, Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria.