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Research Article

Climate Change: Matching Growing Season Length with Maize Crop Varietal Life Cycles in Semi-Arid Regions of Zimbabwe

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ABSTRACT

Climate change is set to increase the risk and uncertainty of maize production in the semi-arid Regions of Zimbabwe. The study had the objective to determine the existence of climate change in Masvingo District using the long term behaviour of the growing season length and its parameters over a period of 31 years (1970-2001), and to match the life cycle period of locally available maize, sorghum and pearl millet varieties with growing season length. The onset of the rain season was found to be an important indicator of growing season length and was observed to have changed from late October to late November. The growing season length for the District was noted to have changed significantly ($P < 0.01$) from 120 days during the early 70s to 100 days in the year 2001. With the seasonal length now averaging at 100 days, the results show that the current climate is no longer suitable for growing maize when considering the average life cycle of maize in terms of days from planting to harvesting, but is now marginally suitable for Sorghum and Pearl Millet production. Farmers in Masvingo Province are advised to stop growing rain fed maize for livelihood but focus on growing sorghum and pearl millet crops.

1.0 INTRODUCTION

Climate change is a reality and the impacts are with us (FAO, 2004; IPPC report, 2007; Simba *et al.,* 2013). Average global temperatures are rising. 20th century was the warmest the world has seen in 1000 years (Barry *and* Chorley, 2003; IPPC report, 2007; Environmental Alert, 2010). Research has shown that the threat of related extreme conditions like changes in temperature, precipitation, water availability and shortening of the length of growing season have major implications for sustainable development, particularly in Southern Africa (Edoga, 2007; Tadross *et al.,* 2007; Rhines and Huyber, 2013). Gathered meteorological records now concur with farmer's perceptions that extreme weather events are becoming frequent (Linderholm *et al.,* 2008), that the onset and cession of the rain season seem to have shifted and will shift even feather from their normal calendar dates (ICSU, 2008; Hansen *et al.,* 2012a).

The relationship between climate and growing season parameters (onset and cessation of rains), makes growing season variability an important indicator of climate change (Linderholm *et al.,* 2008). The onset of the rain season determines the starting of the growing period and date of planting for the farmer. A delay in the onset of the rain season, particularly in semi-arid Southern Africa Region will delay the date of planting and will result in crops extending their growing period into the winter season, where the prevailing lower temperatures will negatively affect cereal yield. An early cession of the rain season has an effect of cutting short the growing period of crops and consequently will result in crops failing to reach their physiological maturity stage. The length of the growing season is defined as the period in days from the date of the onset of the rain season to the date of cession of the rain season (Mhizha *et al*, 2012). Previously, it has been noted that the length of the growing season is correlated to the onset of the rain season (Sivakumar, 1988; Kanemasu *et al*., 1990; Oladipo and kyari, 1993; Chiduza, 1995; Mupangwa, 2011).

Various authors have reported different approaches that are used when determining the onset and cession of the rain season (Raes *et al.,* 2004; Bello *et al.,* 2010; Zinyengere et al., 2011). In Zimbabwe for example, two criterions are used in coming up with the onset of the rain season. The first criterion determines the onset of the rain season following a cumulative rainfall exceeding 25 mm occurring during a maximum time span of 7 days (Raes *et al.,* 2004). Whilst the other criterion determine the onset of the rain season following a cumulative rainfall exceeding 40 mm but having been received in a maximum of 15 days (Raes *et al.,* 2004). The cession of the rain season is normally determined as the first dry day after mid – February in a period of 1 4 days whose cumulative rainfall total is less than 40 mm. In this criterion, a dry day is considered to be one with less than 0.3 mm of total rainfall (Raes *et al.,* 2004).

Over the years, research on the onset and cession of the rain season has been done (Sivakumar, 1988; Balogun and Ogunjobi, 2000; Odekunie, 2004; Bello *et al.,* 2010; Mhihza *et al.,* 2011), but the studies have not been exhaustive and at times confusing with most authors reporting no significant changes in climate over Southern Africa (Raes *et al*., 2004; Mupangwa *et al.,* 2008). In some cases, information on the effect of the length of the growing season (LGS) in rain fed cereal grain yield is still limiting and not exhaustive for a full understanding to the farmer in terms of crop varietal selection in a locality.

Following the earlier studies, this research sought to add weight to their contentions through investigating the possibility of any changes to the climate with specific attention being given to changes in the onset and cessation of the rain season dates under semi-arid conditions of sub Saharan region. Furthermore, it was seen necessary to understand the likely effect of this possible change in climate on rain fed cereal yield. Effort was also made to investigate if the current locally produced cereal varieties (as examples) do fit well into the current average growing season length.

The study was of the hypothesis that the length of the growing season would become shorter with increase in years from 1971 up to the 2001. The onset of the rain season would migrate from the month of October into the Month of December, and the cession of the rain season would also shift backwards from end of March towards the month of February.

2.0 OBJECTIVES OF THE STUDY

The study had the overall objective to investigate the changes in the onset and cessation of the rain season and relate it to climate change and to identify locally produced maize and sorghum and Pearl millet varieties that fit well into the average growing season length.

3.0 MATERIALS AND METHOD

3.1 Study Area

The study was conducted in Zimbabwe, Masvingo Province and in Masvingo district, where agriculture is primarily rainfed (Raes *et al*., 2004). The study area is shown in fig 3.1 below.

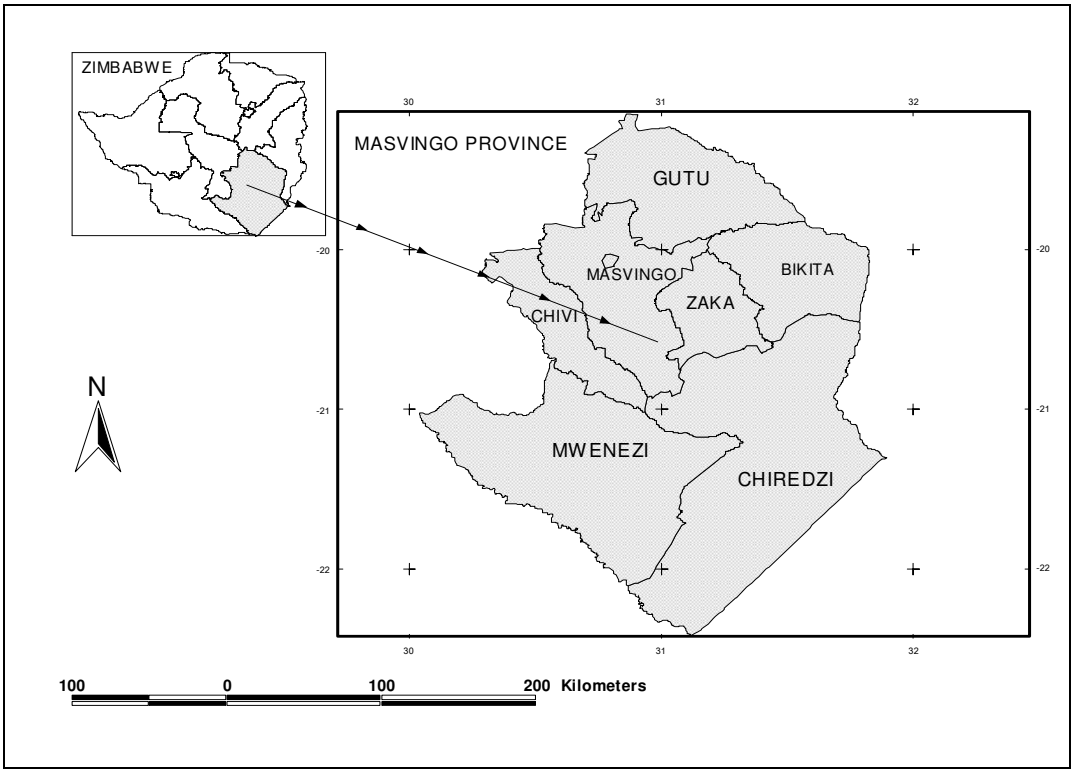

Fig. 3.1: Location of the study area

The rainfall season for Masvingo district is unimodal and spans from the month of November to March (Raes *et al.*, 2004; Zinyengere *et al.,* 2011; Mhizha *et al*, 2012). The prevailing climate is characterised by high inter-annual rainfall which is inherently variable and unreliable. Mean annual rainfall for the District is averaging between 450 to 650 mm (UNEP and ICRAF, 2006). with annual potential evaporation exceeding 2000 mm. Annual temperature is 22.5ºC, with an altitude of below 500 m above sea level.

3.2 Methodology

The study was designed as a desk study and incorporated a combination of historical meteorological data for Masvingo District, data from Regional and International Climate centres and cereal crop varietal life cycle length from three prominent seed houses in Zimbabwe. Collected data was cleaned, coded before use and was used to determine onset and cession dates for the rain seasons that spans from 1971 - 2001. The data was processed into line graphs and analysed using Microsoft Excel; Statistical differences were analysed using SPSS package.

3.3 Climatic Characterization

3.3.1 Criteria for determining the onset of the rain season

In this study, the onset of the rain season was determined following the AGRITEX (1989) criteria explained by Raes *et al.* (2004), where a cumulative rainfall exceeding 25 mm occurring during a maximum time span of 7 days was identified as the beginning of the rain season. Efforts to use the DEPTH method proposed as a more accurate criterion for Zimbabwean climate rain season onset determination (Raes *et al.,* 2004) was not feasible following some years totally failing to meet a condition of a cumulative 40 mm total rainfall received in 4 consecutive days during the whole season.

3.3.2 Criteria for determining the cessation of the rain season.

The cessation of the rainfall season was determined as being the first dry day after mid-February in a period of 14 days whose cumulative rainfall total was less than 40 mm. A dry day was considered to be one with less than 0.3 mm of total rainfall.

3.3.3 Length of the growing Period

The length of the growing period (LGP) was calculated as the number of days between the dates of onset and cessation of the rainfall season.

3.4 Classification of Cereals (maize, Sorghum and Millet) according to length of growing period

Brochures/ seed catalogues of the country's three main seed houses (Seed-Co, Pannar, Pioneer and Agri-seeds) were acquired and studied on the basis of their variety's number of days to maturity. The number of

days to maturity for different varieties was then compared with the calculated average length of the growing season so as to identify varieties which falls within the average length of the growing season in terms of their life cycle.

4.0 RESULTS

4.1 Growing periods of Cereals

Table 1 below illustrates the days to maturity of different locally produced maize, sorghum and pearl millet varieties that are commonly found in the Zimbabwean market. In general all the seed houses classify maize varieties as early maturing (120-140 days), medium maturing (120 - 150 days) and late maturing (135- 150 days). Seed-Co has a fourth group called very early maturing whose growing period is estimated to be between 120 and 132 days. Early maturing sorghum varieties were found to take between 90 and 110 days to mature. Late maturing Sorghum varieties were observed to take between 110 -127 days to mature. Pearl Millet varieties were found to take between 80 and 100 days to mature.

Table 1: Days to Maturity for different local maize and sorghum varieties in Zimbabwe

Crop Type	Variety	Days to Maturity
Maize	Very early maturing variety	120 -132 days
	Early maturing variety	120 – 140 days
	Medium maturing varieties	120 -150 days
	Late maturing varieties	135 – 150 days
Sorghum	Early maturing varieties	90 -110 days
	Late maturing varieties	110 -127 days
Pearl Millet	Early maturing varieties	80 -90 days
	Late maturing varieties	90 -100 days

(Monyo, 2002; Seed-Co manual, 2004; Mgonja *et al*., 2005; Nyabako and Manzungu, 2012).

4.2 Onset of the Rain Season

Fig 1 below shows the study results of the onset of the rain season for the years from 1971 – 2001. The onset dates are scattered and poorly correlated with an R^2 value of 0.5806. Although the regression analysis is not very good, the results can still be used in showing the likely future trends of climate. Similar changes in the start of the rain season have been reported by Tadross *et al.* (2009) and this gives a certain degree of reliability in the results. The results show that during the early 70s, the rain season used to start in late October, but it gradually changed over the years until the rain season starts averagely in late November during the 2001 period. This scenario shows a shift ($P< 0.01$) in the date of the onset of the rain season from late October to late November.

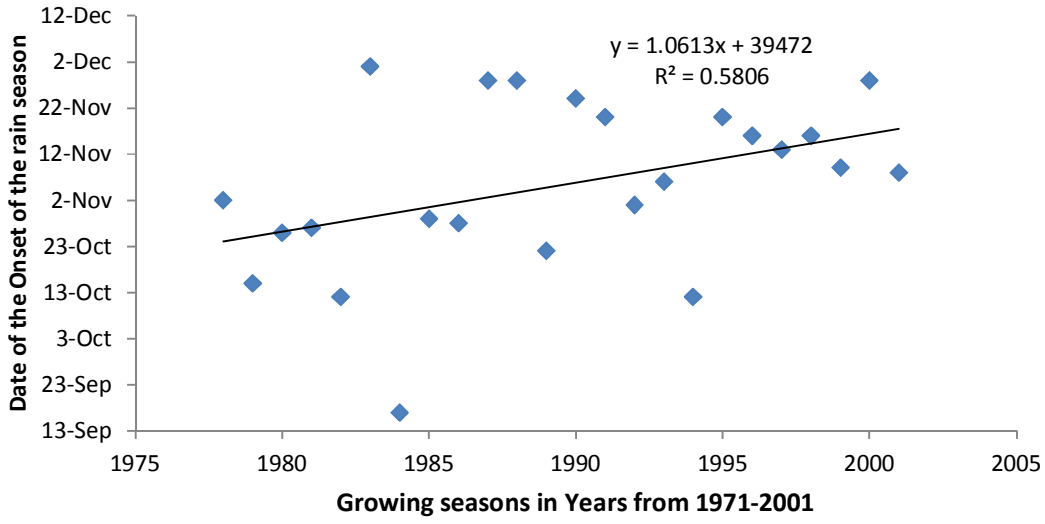

Fig 4.1: The onset of the rain season from 1971 – 2001

4.3 Length of the Rain Season

The study results show an average length of the growing season of 118 days during the early 1970s. The growing season length was steadily falling since 1971 until it reached an average of 100 days in the year 2001. The trend of the length of the growing season followed a sinusoidal pattern, with an alternative frequency of high and low growing season length. The highest growing seasonal length was 154 days and was recorded in the 1977-78 season. The lowest growing season length was 77 days and was recorded in the 1983-84 season. The results showed a 30 % probability of receiving a seasonal length of less than 100 days in 30- year period. The results are in agreement to earlier studies (Mugandani *et al.,* 2012) where growing seasonal length of around 105 days was noted in the early 2000s and this shows that the results may be relied upon.

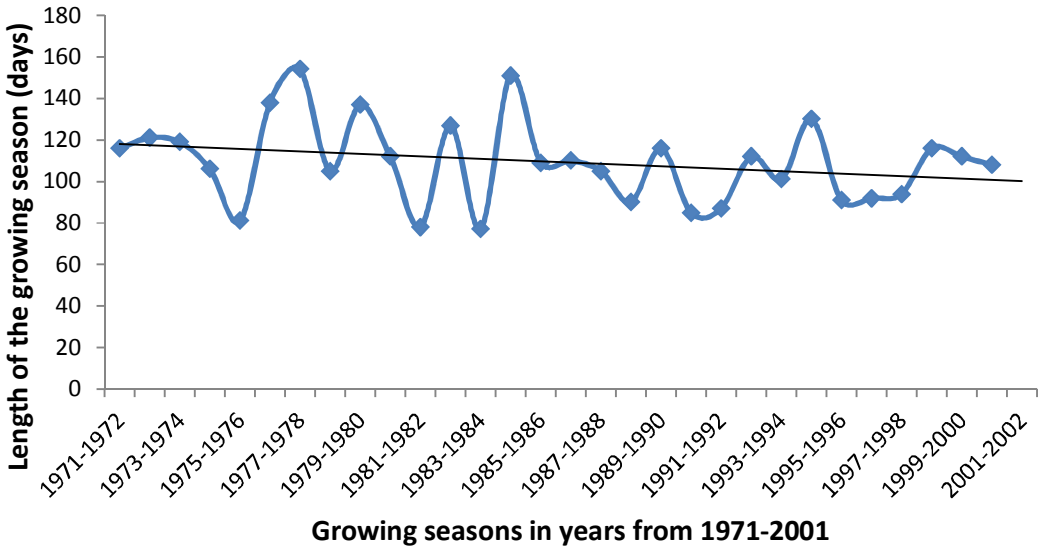

Fig 4.2: Average length of the growing season trend for the years from 1971 -2001

4.4 The Relationship between the length of the growing season and the onset of the rain season

A regression analysis between the length of the growing season and the onset of the rain season over the years from 1971 to 2001 showed a linear correlation (R^2 = 0.7379). This compare well with related previous studies (Sivakumar, 1988; Oladipo and Kyari, 1993; Chiduza, 1995), and therefore shows that the results may be correct and can be relied upon. The length of the growing season was increasing whenever the rain season started earlier. The longest growing season length of 150 days was observed when the rain season had started very early in late September. The shortest growing season length of 77 days was observed when the rain season had started on the 1st of December.

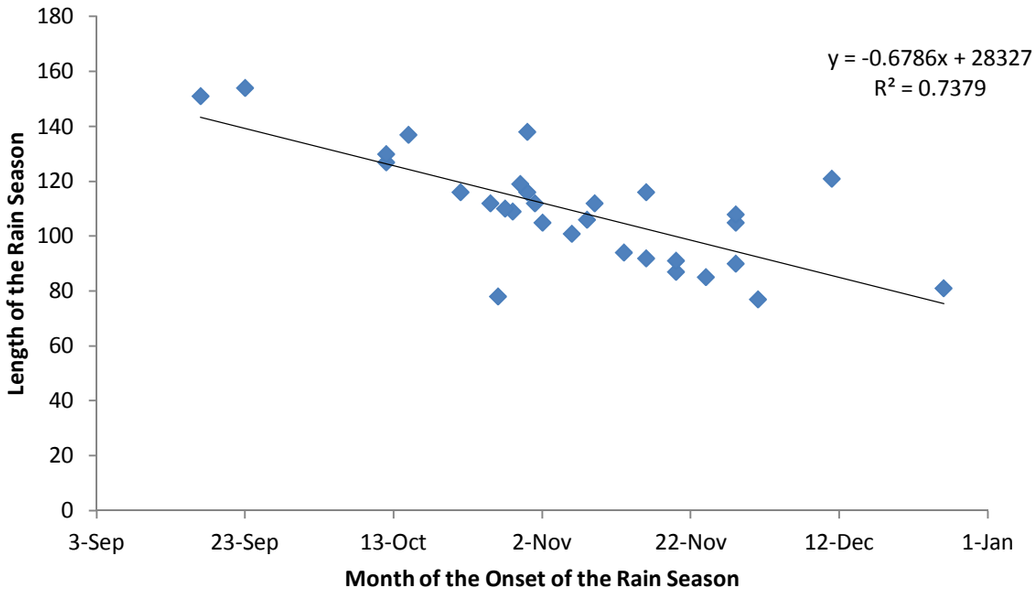

Fig 4.3: Relationship between the length of the growing season and the onset of the rain Season for the years from 1971 -2001

5.0 DISCUSSION

The study results indicate a shift of the onset of the rain season from late October to late November in the years 1971- 2001. This change in climate is significant ($P < 0.01$) and shows that much of the District and all other areas with similar climate are getting dryer and less suitable for growing maize. No significant changes in cessation of rains were noted. This absents of changes may be a result of the methodology that was used. The rain season length shifted from an average of 120 days to about 100 days, reflecting a change in climate. Such a growing season length is supported by findings by Mugandani et al. (2012), where the Natural farming Region IV had a growing period of around 105 days. No locally available maize varieties including all "very early maturing varieties" have a growing period that fit in well into the 100 days seasonal length. With the seasonal length averaging at 100 days, the results shows that the current climate is not suitable for growing maize when you consider the average life cycle of maize in terms of days from planting to harvesting, but is marginally suitable for Sorghum production. Such results compare well with findings by Nyabako and Manzungu (2012), who reported a climate shift of the growing season length, and a future forecast of a climate condition which is not suitable for maize production in Masvingo district by 2020 (seven years from the current date). In addition, existing model experimental findings also concurs with the study findings and suggests that annual rainfall, particularly early and late rains will decrease across Zimbabwe by 50 % in 2020s (Hulm and Sheard, 1999). However, Rease (2004) and Mupangwa (2011) also studied the start, end and dry spells of the growing season in semi-arid southern Zimbabwe and concluded that growing seasons have not changed significantly over the past 50–74 years in southern Zimbabwe (including this study area). However many researchers have also reported that the climate is changing in Masvingo District. In fact, evidence of climate change in Masvingo and Zimbabwe is overwhelming (Unganai, 1996; Phillips *et al*., 1998; Makarau, 1999; Low, 2005; Zinyengere *et al.,* 2011; Mugandani *et al.,* 2012). We therefore suggest a more rigorous study that investigates climate change in terms of variability on year to year basis and over a long period of time.

A regression analysis between the length of the growing season and the onset of the rain season over the years from 1971 to 2001 showed a linear correlation ($R^2 = 0.7379$) and is in agreement with previous studies (Sivakumar, 1988; Oladipo and Kyari, 1993; Chiduza, 1995). The results show that growing season is more sensitive to the start of the rains (Oladipo and Kyari, 1993; Mupangwa, 2011) In addition, a strong relation between growing season length and the onset of the rain season has been observed by many scholars (Kanemasu *et al*., 1990; Chiduza, 1995). It is therefore important for farmers to argument the early rains with an early irrigation just before the rains so as to artificially increase the growing season length. Such an intervention would increase the growing season length and marginally accommodate very early maturing maize varieties in the District.

6.0 CONCLUSION AND RECOMMENDATIONS

The rain season length shifted from an average of 120 days to 100 days, reflecting a change in climate and was found not suitable for maize production but marginally suitable for Sorghum production. There is a strong correlation between the onset of the rain season date and the length of the growing season. The growing season length increases with the earlier onset of the rain season. Farmers in Masvingo Province are advised to stop growing rain fed maize for livelihood but focus on growing sorghum and millet crops.

REFERENCES

AGRITEX, 1989. Agro-climatological Analysis of Growing Season in Natural Region I, II, III, IV and V of Zimbabwe. Ministry of Lands and Agriculture, Harare, Zimbabwe.

A. A. Balogun, and K. Ogunjobi,: Predicting monthly and seasonal rainfall, onset and cessation of the rainy season in West Africa using only surface data. Int. J. Climatol., Vol 20, 2000, pp 865–880.

R. G. Barry and J. R. Chorley, Atmosphere Weather and Climate. 8th edition. Routledge 11 New Fetter lane, London.(2003).

N. J. Bello, A. O. Eruola, G. C. Ufoegbane and J. A. Awomeso. "Evaluation of some empirical methods of estimating potential evapotranspiration for determination of length of growing season in a tropical wet and dry climate". African Journal of Agricultural Research Vol 5, No 16, 2010.

C. Chiduza, 1995. "Analysis of rainfall data and their implication on crop production: A case of Northern Sebungwe," Zimbabwe Journal of Agricultural Research, Vol 33 No. 2, 1995, pp. 175-189.

R.N. Edoga. Determination of length of the growing season in Samaru using different Potential Evapotranspiration Models". AUJT. Vol 11, No 1, 2007. Pp 28-35.

Environmental Alert, "Climate Change in Uganda: Insights for Long Term Adaptation and Building Community Resilience July 2010 issue paper.

FAO, "Drought impact mitigation and prevention in the Limpopo River Basin. Land and Water Discussion Paper 4. Food and Agriculture Organisation of the United Nations," 2004, Rome. http://www.fao.org/docrep/008/y5744e/y5744e00. HTM

J. Hansen, M. Sato, R. Ruedy, "Perception of climate change." Proc Natl Acad Sci USA 109(37):E2415–E2423, 2012.

J. Hansen, M. Sato, R. Ruedy, "Increasing climate extremes and the new climate dice". Columbia University Web site. Available at http://www. Columbia. Edu/jeh1 mailings/2012/20120811. DiceData Discussion.pdf. Accessed August 10, 2012.

M. Hulm and N. Sheard, "Climate change scenarios for Zimbabwe," Climatic Research Unit, Norwich, pp 6, 1999.

International Council for Science, ICSU, "Global environmental change (including climate change and adaptation) in Sub-Saharan Africa", Science Plan, ICSU Regional Office for Africa, 2008.

Intergovernmental Panel on Climate Change (IPCC), "Climate change: Impacts, Adaptations and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Inter-governmental Panel on Climate Change, 2007.

E. T. Kanemasu, J. I. Stewart, S. J. Van Donk and S. M. Virmani, "Agroclimatic approaches for improving agricultural productivity in semi-arid tropics," Advances in Soil Science, Vol 13, 1990, pp. 273-309.

H. W. Linderholm, A. Walther and D Chen, "Twentieth-century trends in the thermal growing season in the Greater Baltic Area," 2008.

S. M. Low, "Climate Change and Africa. Cambridge University Press, , New York, USA pp. 34-294, 2005

A. Makarau, "Zimbabwe climate: Past Present and Future. In: Water for Agriculture: Policy and management options for the smallholder sector, 1999, University of Zimbabwe Publications.

M. A. Mgonja, A. B. Obilana, M. Chisi, H. M Saadan, S.A. Ipinge, L. Mpofu, E. Chintu, P. Setimela, J. Pali-Shikhulu and E. Joaquim, 2005. Improved sorghum cultivars released in the SADC region, 2005, International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Bulawayo, Zimbabwe, pp. 60.

Mhizha T, Geerts S, Vanuytrecht E, Makarau A and Raes D (2012). "Relative transpiration as a decision tool in crop management: a case for rainfed maize in Zimbabwe". African Crop Science Journal, Vol. 20, No. 1, pp. 47-57.

E. Monyo, "Pearl millet cultivars released in the SADC region. International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Bulawayo, Zimbabwe, 2002, "pp. 40.

R. Mugandani, M. Wuta, A. Makarau and B. Chipundu, 2012. Re-Classification of Agro-Ecological Regions of Zimbabwe in Conformity with Climate Variability and change. African Crop Science Journal, Volume 20, Issue Supplement S2, pp 361-369.

W. Mupangwa, S. Walker and S. Twomlow, "Start, end and dry spells of the growing season in semi-arid southern Zimbabwe," Journal of Arid Environments Vol 75, 2011, pp. 1097-1104.

M. Tadross. (2009) Climate change modelling and analyses for Mozambique Final report detailing the support provided to the Instituto Nacional de Gestãde Calamidades (INGC) adaptation to climate change project . INGC, Mozambique. pp 27

T. Nyabako and E. Manzungu. " An assessment of the Adaptability to Climate Change of Commercially Available Maize Varieties in Zimbabwe." Environment and Natural Resources Resources Research, Vol 2. No 1, 2012. Doi: 10. 5539/enrr. V2nl pp 32.

E. O. Oladipo and J. D. Kyari, J.D. 1993. “Fluctuations in the onset, termination and length of growing season in northern Nigeria,” Theoretical and Applied Climatology, Vol. 47, 1993, pp. 241-250.

J. G. Phillips, M. A. Cane and C. Rosenzweig, “ENSO, seasonal rainfall patterns and simulated maize yield variability in Zimbabwe,” Agricultural and Forest Meteorology, Vol. 90, 1998, pp.39- 50

D. Raes, A. Sithole, A. Makarau and J. Milford, “Evaluation of first planting dates recommended by criteria currently used in Zimbabwe. Agricultural and Forest Meteorology, Vol. 125, 2004, pp. 177-185.

A. Rhines and P. Huybers, “Frequent summer temperature extremes reflect changes in the mean, not the variance”. Proc Natl Acad Sci USA 110:E546, 2013.

Seed Co. 2004. “Seed Co crop growing manual.

F. M. Simba, M. Mubvuma, T. Murwendo, and D. Chikodzi. “Prediction of yield and biomass productions: A remedy to climate change in semi-arid regions of Zimbabwe.” International Journal of Advance Agricultural Research. 2013. Vol 1, pp 14-21.

M. V. K. Sivakumar, “Predicting rainy season potential from the onset of rains in Southern Sahelian and Sudanian climatic zones of West Africa,” Agricultural and Forest Meteorology, Vol. 42, 1988, pp. 295-305.

M. Tadross, P. Suarez, A. Lotsch, S. Hachigonta, M. Mdoka, L. Unganai, F. Lucio, F. Kamdonyo and M. Muchinda. “Growing-season rainfall and scenarios of future change in southeast Africa: implications for cultivating maize”. Climate Research. Vol 40: 147-161, 2009. DOI: 10. 3354/ cr 00821

L. Unganai, “Historic and future climatic change in Zimbabwe,” Climate Change Vol 6, 1996, pp. 137-145.

UNEP and ICRAF, “Climate change and variability: impacts and adaptation strategies,” UNEP and ICRAF, 2006.

N. Zinyengere, T Mhizha, E. Mashonjowa, B. Chipindu, S. Geerts, and D. Raes. 2011. Using Seasonal Climate Forecasts to improve maize production decision support in Zimbabwe. Agricultural and Forest Meteorology 151 (2011) 1792-1799.

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