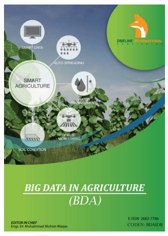
ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2682-7786 (Online)
CODEN: BDAIDR

Big Data In Agriculture (BDA)

DOI: http://doi.org/10.26480/bda.01.2020.01.04



CrossMark

RESEARCH ARTICLE

INVESTIGATION THE IMPACT OF CLIMATE CHANGE ON PRODUCTIVITY OF COTTON: EMPIRICAL EVIDENCE FROM COTTON ZONE

Shahbaz Bhatti[a*], Sarfraz Hassan[a], Khalid Mushtaq[a], Khalid Bashir[a], Kamran Javed[b]

[a]Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad.
[b]Cotton Research Station, Vehari
**Corresponding author e-mail: bhattimphil@gmail.com*

ARTICLE DETAILS

Article History:

Received 01 December 2019
Accepted 05 January 2020
Available online 11 February 2020

ABSTRACT

Climate is one of the venerable factors of environment. Climate of Punjab is changing over-time due to the global warming, increasing temperature, melting of glaciers and changes in the rainfall pattern. Cotton crop is very sensitive and risky to climate and intensive inputs and huge investment is required for the production of cotton. The aim of the research is to investigate the impact of climate change on the productivity of cotton. The Secondary data of cotton zone (Bahawalpur, Bahawalnagar, Multan and Rahim Yar Khan) was collected from meteorological departments. ARIMA model was used for forecasting whereas regression analysis was used for impact analysis. Evolving and disseminating cotton varieties having adaptation to climate change should be the focus of future research and development. Improving the practices of farm management, developing awareness among farmers about climate change and strengthening extension department are some measures to be taken for adaptation to climate change in the cotton zone.

KEYWORDS

Climate, Cotton, Rainfall, Temperature, Humidity.

1. INTRODUCTION

The productivity of cotton is influenced by two kinds of factors i.e. climatic and non-climatic factors. Climatic factors include temperature, rainfall and humidity. Temperature is a measure of the intensity of heat energy produced by solar radiations. Temperature influences plant growth as it affects physiological process such as photosynthesis, transpiration, respiration, germination and flowering. Air temperature is more important for crop growth than soil temperature (PARC, 2010). Rainfall is an important factor which affects the acreage and yields of crop. Rain-fed Barani zone has the highest quantity of rainfall, followed by rice zone, mixed zone and cotton zone respectively. Rainfall fluctuated between 697 to 1401 millimetres, 491 to 1403 millimetres 219.5 to 718 millimetres and 72.8 to 462.5 millimetres in Barani, rice, mixed and cotton zones respectively over the period 1970-2001 (World Bank, 2010).

Changes in climate especially increase in temperature and also decrease in rainfall would have a negative impact on the future projections of major crop production in Pakistan. It is said that north is the driver for the carbon emissions but south is the victim. In Pakistan, inadequate monitoring system, assessment of the likely changes in the weather patterns and its impacts on agricultural sector make it difficult to have an effective national agro-climate policy (Roohi, 2004). In the developing countries like Pakistan, impact of climate change is expected to affect severely because of lack of resources and infrastructure. Further, no significant development and less implementation on new adaptation strategies and policies to tackle climate change are being exploited. Development activities lack proper measures and stress on the importance of taking into account of climate change in planning, designing and implementation stage (Farooqi et al., 2005). Agriculture is more vulnerable to climate change as a little effect of climate leads to greater change in the agriculture production (Adams et al., 1988).

The impact of climate change on agriculture production is an empirical issue, and the extant literature, in general, concludes that climatic changes are affecting agricultural production negatively (Adams et al., 1988; Cline and William, 1996; Parry et al., 2004; Lobell and Field, 2007; Cabas et al., 2010). Nonetheless, a handful of studies find the evidence for positive association between increased temperature and agricultural output (Gbetibouo and Hassan, 2005).

Pakistan is a disaster-prone country which is vulnerable to climate change. So the yield of major crops (Wheat, Rice, Cotton and Sugarcane) will be directly affected by climate change. It will also cause the food and fibre security challenge. Cotton is a major contributor of GDP and value addition. However, very little research work has been done on estimating impact of climate change on wheat and which are available they merely focused on wheat and rice (Ahmad et al., 2012; Mahmood et al., 2012). The present study aims at determining the extent of the impact of climate change on productivity of cotton in the cotton zone and forecasting the productivity of cotton.

Quick Response Code	Access this article online	
	Website: www.bigdatainagriculture.com	**DOI:** 10.26480/bda.01.2020.01.04

Cite the Article: Shahbaz Bhatti, Sarfraz Hassan, Khalid Mushtaq, Khalid Bashir, Kamran Javed (2020). Investigation The Impact Of Climate Change On Productivity Of Cotton: Empirical Evidence From Cotton Zone. *Big Data In Agriculture, 2(1): 01-04.*

2. MATERIAL & METHODS

The present study was conducted in the cotton zone of Punjab province where the cotton fibre is produced to fulfil the domestic use and export to the others countries of the world. The critical issue of determining the impact of climate change on agricultural output attracted special attention of researchers after the seminal work (Nordhaus, 1977). Production function approach has been widely used to analyse the climate change agriculture nexus. A good volume of literature use simulation models to look into the future changes in climate and their impacts on agriculture (Tubiello et al., 2002; Luo et al., 2003; Luo et al., 2005; Lobell et al., 2005; Magrin et al., 2005; Ludwig et al., 2009; Lea et al., 2012).

Incapacity of above-mentioned models to accommodate crops substitutions and adaptations to climate led the formulation of Ricardian approach pioneered wherein the impact of climate change is analysed using value of farmland or net rent as dependent variable (Mendelsohn et al., 1994). The major advantage of this technique is that it allows crop substitutions and farm-level adaptations—making it most attractive in evaluating the impact of climate change on agriculture. However, the major drawbacks of this approach include unavailability of reliable data for agricultural farm values and the existence of imperfect land markets in developing countries (Gbetibouo and Hassan, 2005; Guiteras and Raymond, 2009). This approach has also been criticised on the grounds of its implicit assumptions of constant prices and zero adjustment cost making the welfare calculations biased, and provides lower-bound estimates of the costs of climate change (Cline and William, 1996; Quiggin et al., 1999).

Following, the above deficiencies can be avoided using modified production function approach (Cabas et al., 2010; Segerson and Dixon, 1999; Cheng and Chang, 2002). Some studies introduced quadratic terms of climatic variables to examine whether the impact of climate change on crop production is non-monotonic or not (Adams et al., 2003; Felkner et al., 2009). In order to account for the joint impact of temperature and precipitation further extended the production function by introducing the interaction terms (Cabas et al., 2010; Hansen, 1991; Ludwig and Asseng, 2006; Weersink et al., 2010).

In order to investigate the impact of climate change on the productivity of cotton zone, secondary data of climatic variables (mean maximum and mean minimum rainfall, humidity and mean maximum and mean minimum temperature) was collected for the period of 1984-2014. There are nine districts (Sahiwal, Bahawalnagar, Bahawalpur, Rahim Yar Khan, Multan, Vehari, Lodhran, Khanewal, and Pakpattan) in the cotton zone of Punjab but only four districts were selected by random selection method.

2.1 Data Sources

Followings are the main Sources of data are
1-Regional Metrological Department, Lahore.
2-Punjab Development Statistics
3-National Fertilizer Development Center, Islamabad.
4-Pakistan Bureau of Statistics
5-Economic Survey of Pakistan

2.2 Analysis of the General Trend of Variables

Generally speaking, a graph connects the related points of the data under consideration, to give a meaningful picture. Graphs were plotted for each of the climate variables i.e. rainfall, humidity and temperature by taking them along Y-axis and time period will be taken along X-axis. Time interval on X-axis will be taken to feasibly plot the graph for the data of available years. These graphs conveniently expressed the hidden message of the climatic changes. Moreover, we explained the increase and decrease of data feasibility via pictorial aid of the graph. After the trend analysis forecasting of cotton was made using ARIMA (Auto Regressive Integrated Moving Average) Model to have a glimpse of future.

2.3 Model Specification

The general production function that will be used for the analysis is

$Y = f(\text{Cl, NCl})$

Where, Y is cotton production per-hectare (yield), Cl is the vector of climatic variables including temperature, humidity and precipitation while NCI is the vector of non-climatic variables such as fertilizer area under cotton and technological change. We will use linear function form from the production model (Houck and Gallagher, 1976; Choi and Helmberger, 1993; Kaufmann and Snell, 1997; Deschenes and Greenstone, 2007; McCarl et al., 2008).

$\text{Ln } Y = \beta_o + \Sigma\beta_i \ln X_i + \mu_i$

Application of OLS to pooled/panel data provides inconsistent results as it requires the random and/or fixed effect models (Baltagi, 2005; Asteriou and Hall, 2000; Wooldridge, 2009). This study used the appropriate model. There is possibility of correlation between unobserved time invariants and regressors (Baltagi, 2005; Wooldridge, 2009; Stock and Watson, 2003). Furthermore, if needed it will also account the district specific effects that is preferred over pooled least square and random effect methods (Cabas et al., 2010; McCarl et al., 2008; Kim and Pang, 2009; Barnwal and Kotani, 2010; Sarker, 2012).

3. RESULTS AND DISCUSSION

The figure given below shows the cotton production from 1948 to 2014. Cotton shows a fluctuating pattern. Till 1980s the production is gradually increasing over time and an additive trend is predictable. In late 1990s till end the fluctuation is conspicuous, but trend is again additive and predictable. But in mid of 1980s a robust increase is seen which is extremely unpredictable.

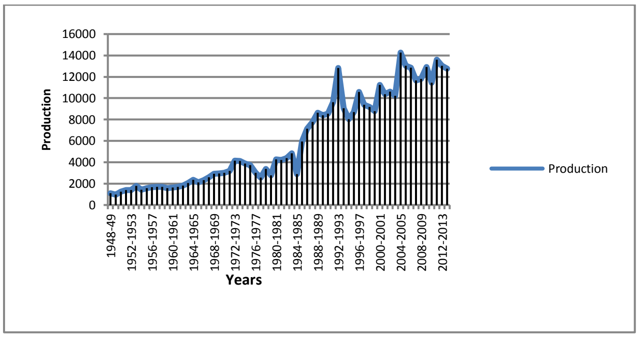
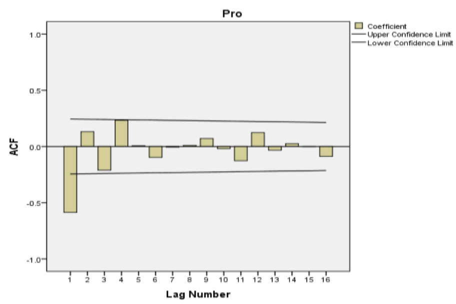


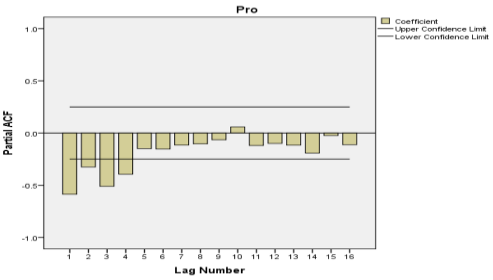
Figure 1: Annual Production of Cotton

This region can be possible break or set of breaks. Due to this outlier type observation the trend seems exponential. Fluctuations endorse the mean shifting and as the amplitude of variation is also increasing so presence of unit root is also predictable. So, this time series is looking on stationary, having means changing.

The following figure shows the autocorrelation and partial auto-correlation function of cotton time series. As the both graphs show indication of unit root. ACF spikes exponentially decaying and one large spike is present at one lag so non stationarity is evident. Results of ADF test also showing presence of unit root.



Cite the Article: Shahbaz Bhatti, Sarfraz Hassan, Khalid Mushtaq, Khalid Bashir, Kamran Javed (2020). Investigation The Impact Of Climate Change On Productivity Of Cotton: Empirical Evidence From Cotton Zone. *Big Data In Agriculture, 2(1): 01-04.*



Fixed effect estimates for cotton crop are explained in this research. General to specific approach (G2S) is being used in this research. Keeping in view the specification test the model being used for Bahawalpur is selected as final model of this research. It depicts the non-linear impact of temperature and rainfall on the production of cotton. It is very much crystal clear that rainfall and temperature both make a significant joint impact to the various growth stages of crop. It is also evident from the results that the impacts of all the three climatic variables are not separable.

The results of the this model also guides us that decrease in mean minimum and mean maximum temperature during the first growth stage (May-June) and second growth stage (July-August) harms the productivity of cotton crop because cotton is a crop of hot temperature and decrease in temperature cause its partly and completely damage. The joint impacts of rainfall, humidity and temperature have significant influence on cotton. Higher temperature with greater intensity of rainfall and temperate humid climate is very beneficial for the productive stages of cotton.

The marginal impacts, assessed at the mean of temperature normal, are 0.0014 and 0.0012 for the first and second stages of crop growth, respectively. This result could be due to the increased erratic rains that may cause submergence of newly grown cotton crop and overflow of fertilizer nutrients which are crucial for vegetative growth. Also increase precipitation results in high humidity that can cause high pests and disease infestation of the crop and ineffectiveness of weed control measures. The marginal impact of precipitation normal during the maturity stage, evaluated at the mean levels of precipitation and temperature normal, turned out to be positive (0.0006) implying that better precipitation helps the crop productivity if the temperature stays at the historical mean.

Deviations of temperature and precipitation from their respective long-run means (variations) are incorporated to gauge the impact of weather shocks on cotton yield. Temperature variation at first stage enters statistically insignificant showing that heat Marginal impacts can be computed by taking the partial derivative of the estimated version of Equation with respect to the targeted variable, and then be evaluated at the mean of the other variable(s) involved. Waves during June-July had not significantly affected the yield in case of Cotton. Statistically significant coefficients for the deviations of temperature from historic mean during the second and third stages imply that the temperature variations from their respective normals would influence yield adversely when the crop is in vegetative growth, flowering, and milking stages and positively during the maturity and harvesting stages.

Deviation of precipitation from its long-run mean during June-July yields statistically significant positive effect indicating that a cool wave or positive precipitation shock would affect cotton yield positively. According to some study, cotton crop requires water at initial stage which is evident from the sign and significance of the precipitation term at first stage (Hussien et al., 2005; GOP, 2014a; GOP, 2014b; Huang and Khanna, 2020; Iqbal, 2016). The precipitation shocks may decrease cotton yield which is evident from the floods and drought prevailed in Pakistan. During the third stage (maturing/ripening and harvesting) precipitation variation is found affecting Cotton yield positively and significantly.

Fertilizers use has significant positive impact on Cotton yield. The response coefficient for fertilizer is low—may be due to unbalanced use of fertilizer. The coefficient of area under Cotton is negative and statistically significant supporting the evidence of decreasing returns to scale. The plausible explanation of decreasing return may be that major proportions of the farmlands are under cotton cultivation during Kharif season in cotton growing districts of Pakistan with little opportunity for fallowing the land and/or crop rotation (Kayam et al., 2000; Knight et al., 1978; Sasendran et al., 2000; Rosenzweig, 1990; Gregory et al., 2005). Allocation of additional farm area to cotton production thus amounts to intensification of mono cropping agriculture that in turn results in land degradation and pest/insect build-up reducing productivity. The technological improvement, captured through time trend, contributes positively to yield of Cotton.

References

Adams, R.M., McCarl, B.A., Dudek, D.J., Glyer, J.D., 1988. Implications of Global Climate Change for Western Agriculture. Western Journal of Agricultural Economics, 13 (2), 348-356.

Adams, R.M., McCarl, B.A., Mearns, L.O., 2003. The Effects of Spatial Scale of Climate Scenarios on Economic Assessments: An Examples from U.S. Agriculture. Climatic Change, 60, 131-148.

Ahmad, M., Iqbal, M., Samad, G., 2012. Climate change, agriculture and food security in Pakistan: adaption options and strategies. Available online at www.pide.org.pk/pdf/Broucher-Climate%20Change.pdf

Asteriou, D., Hall, S.G., 2000. Applied Econometrics: A Modern Approach Using EViews and Microfit. Palgrave Macmillan.

Baltagi, B.H., 2005. Econometric Analysis of Panel Data. West Sussex: John Wiley and Sons.

Barnwal, P., Kotani, K., 2010. Impact of Variation in Climatic Factors on Crop Yield: A Case of Rice Crop in Andhra Pradesh, India. IUJ Research Institute, International University of Japan, Economics & Management Series EMS-2010-17.

Cabas, J., Weersink, A., Olale, E., 2010. Crop Yield Response to Economic, Site and Climatic Variables.Climatic Change, 101, 599-616.

Cheng, C., Chang., 2002. The Potential Impact of Climate Change on aiwan's agriculture. Agricultural Economics, 27, 51-64.

Choi, J.S., Helmberger, P.G., 1993. How Sensitive are Crop Yields to Price Changes and Farm Programs?. Journal of Agricultural and Applied Economics, 25, Pp. 237-44.

Cline, William, R. 1996., The Impact of Global Warming of Agriculture: Comment. The American Economic Review, 86 (5),1309-1311.

Deschenes, O., Greenstone, M., 2007. The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather. The American Economic Review March, 97.

Farooqi, A.B., Khan, A.H., Mir, H., 2005. Climate change perspective in Pakistan. Pak. J.Met., 2, 11-21.

Felkner, J., Tazhibayeva, K., Townsend, R., 2009. Impact of Climate Change on Rice Production in Thailand. American Economic Review: Papers & Proceedings, 99 (2), 205-210.

Gbetibouo, G.A., Hassan, R.M., 2005. Measuring the Economic Impact of Climate Change on Major South African Field Crops: A Ricardian Approach. Global and Planetary Change 47, 143-152.

GOP. 2014a. Economic survey of Pakistan 2013-14, Economic Advisor Wing, Finance Division, Islamabad, Pakistan.

GOP. 2014b. Agricultural Statistics of Pakistan, Economic Advisor's Wing, Finance Division, Islamabad, Government of Pakistan.

Gregory, P.J., Ingram, J.S.I., Brklacich, M., 2005. Climate change and food security. Phil Trans. R. Soc. B., 360, 2139-2148.

Guiteras, Raymond., 2009. The Impact of Climate Change on Indian Agriculture. Department of Economics, University of Maryland, College

Park, Maryland.

Hansen, L., 1991. Farmer Response to Changes in Climate: The Case of Corn Production. Journal of Agricultural Economics Research, 43 (4), 18-25.

Houck, J.P., Gallagher, P.W., 1976. The price responsiveness of U.S. Corn Yields. American Journal of Agricultural Economics, 584 (4), 731-734.

Huang, H.S, Khanna. H., 2010. An Econometric Analysis of U.S. Crop Yield and Cropland Acreage: Implications for the Impact of Climate Change University of Illinois at Urbana-Champaign Selected Paper prepared for presentation at the Agricultural & Applied Economics Association 2010 AAEA, CAES, & WAEA Joint Annual Meeting, Denver, Colorado, 25-27.

Hussain, S.S., Mudasser, M., Sheikh, M.M., Manzoor, N., 2005. Climate Change and Variability in Mountain regions of Pakistan Implications for Water and Agriculture. Pakistan journal of meteorology, 2 (4).

Iqbal, M., 2016. Climate Change Impacts on Agriculture and Building Resilience in Pakistan Global Change Impact Studies Centre (GCISC), National Centre for Physics (NCP) Complex Quaid-i-Azam University Campus, Shahdra Road, Islamabad 13-AG-16-GE-WSP-B Workshop on Developing Farming Systems for Climate Country Paper from Pakistan.

Kaufmann, R.K., Snell, S.E., 1997. A biophysical model of corn yield: integrating climatic and social determinants. Am. J. Agric. Econ., 79, Pp. 178–90.

Kayam, Y., Ozsoy, U., Lomas, J., Oden, O., Mandel, M., Gurbuz, M., 2000. The impact of climatic change on wheat production of Aegean region in Turkey: The effect of a reduction of rainfall and the increase of temperature on wheat yields.

Kim, M.K., Pang, A., 2009. Climate Change Impact on Rice Yield and Production Risk. Journal of Rural Development, 32 (2), 17-29.

Knight, C.W., Wooding, F.J., Lewis, C.E., 1978. Relationships between temperature and wheat adaptation in Alaska. Agronomy Abstracts 11.

Lea, Jaehyuk, Nadolnyak, D., Hartarska, V., 2012. Impact of Climate Change on Agricultural Production Asian Countries: Evidence from Panel Study. Selected paper presented all the Southern Agricultural Economics Association, Annual Meeting, Birmingham, Al, Feb. 4-73.

Lobell, B.D., Field, B.C., 2007. Global Scale Climate Crop Yield Relationships and the Impacts of Recent Warming. Environmental Research Letter, 2, 1-7.

Lobell, B.D., Ortiz-Monasterio, J.I., Asner, G.P., Matson, P.A., Naylor, R.L., Falcon, W.P., 2005. Analysis of Wheat Yield and Climatic Trends in Mexico. Field Crops Research, 94 (2), 250-256.

Ludwig, F., Asseng, S., 2006. Climate Change Impacts on Wheat Production in a Mediterranean Environment in Western Australia. Agricultural Systems, 90 (1-3), 159-179.

Ludwig, F., Stephen, P.M., Asseng, S., 2009. Impacts of Recent Climate Change on Wheat Production Systems in Western Australia. Climatic Change, 92 (3-4), 495-517.

Luo, Qunying, Bellotti, W., Williams, M., Bryan, B., 2005. Potential Impact of Climate Change on Wheat Yield in South Australia. Agricultural and Forest Meteorology, 132 (3), 273-285.

Luo, Qunying, Martin, A.J., Williams, Bellotti, W., Bryan, B., 2003. Quantitative and Visual Assessments of Climate Change Impacts on South Australian Wheat Production. Agricultural Systems, 77 (3), 173-186.

Magrin, Graciela, O., Travasso, M.I., Rodríguez, G.R., 2005. Changes in Climate and Crop Production during the 20th Century in Argentina. Climatic Change, 72 (1-2), 229-249.

Mahmood, N., Ahmad, B., Hassan, S., Bakhsh, K., 2012. Impact of temperature and precipitation on rice productivity in rice-wheat cropping systems of Punjab province. The J. An. Plant Sci., 22, 993-997

McCarl, B.A., Villavicencio, X., Wu, X., 2008. Climate Change and Future Analysis: Is Stationarity Dying? American Journal of Agricultural Economics, 90 (5), 1241-7.

Mendelsohn, R., Nordhaus, D.W., Shaw, D., 1994. The Impact of Global Warming on Agriculture: A Ricardian Analysis. The American Economic Review, 84 (4), 753-771.

Nordhaus, W.D., 1977. Economic Growth and Climate: The Case of Carbon Dioxide. The American Economic Review 67:1, Papers and Proceedings of the Eighty-ninth Annual Meeting of the American Economic Association, pp. 341-346.

PARC. 2010. National coordinated wheat programme. Available online: http://www.parc.gov.pk/1SubDivision/NARCCSI/CSI/Wheat.html

Parry, M.L., Rosenzweig, C., Iglesias, A., Livermore, M., Fischer, G., 2004. Effects of Climate Change on Global Food Production under SRES Emissions and Socio-economic Scenarios Global Environmental Change, 14 (1), 53-67.

Quiggin, John, C., Horowitz, J.K., 1999. The Impact of Global Warming on Agriculture: A Ricardian Analysis-Comment. American Economic Review, 89 (4), 1044-1045.

Roohi, R., 2004. Farm Mechanism Options under Climate Change Scenario in Pakistan. National Agricultural Research Centre.

Rosenzweig, C., 1990. Crop Response to Climate Change in the Southern Great Plains: A Simulation Study. Professional Geographer, 42 (1), 20-37.

Sarker, A.R.M., 2012. Impacts of Climate Change on Rice production and armers Adaptations in Bangladesh PhD Thesis, submitted in University of Southern Queensland, Australia.

Sasendran, S.A., Singh, K.K., Rathore, L.S., Singh, S.V., Sinha, S.K., 2000. Effects of climate change on rice production in the tropical humid climate of Kerala, India. Climate Change, 4, 495-514.

Segerson, K., Dixon, B.L., 1999. Climate Change and Agriculture: The Role of Farmer Adaptation. In R. Mendelsohn and J. E. Neumann (eds.) The Impact of Climate Change on the United States Economy. Chap 4. Cambridge University Press, Cambridge, Pp. 75-93.

Stock, J.H., Watson, M.W., 2003. Introduction to Econometrics. Singapore: Pearson Education.

Tubiello, F.N., Rosenzweig, C., Goldberg, R.A., Jagtap, S., Jones, J.W., 2002. Effects of Climate Change on US Crop Production: Simulation Results using Two Different GCM Scenarios. Part I: Wheat, Potato, Maize, and Citrus. Climate Research, 20 (3), 259-270.

WB (World Bank). 2010. World Development Report: Development and Climate Change, The World Bank, Washington, DC.

Weersink, A., Cabas, J.H., Olale, E., 2010. Acreage Response to Weather, Yield, and Price. Canadian Journal of Agricultural Economics, 58 (1), 57-72.

Wooldridge, J.M., 2009. Introductory Econometrics: A Modern Approach. Mason, USA:` South-Western Publications.