Paper presented in

Seventh Biennial Conference

Indian Society for Ecological Economics (INSEE)

Global Change, Ecosystems, Sustainability

Host:
Tezpur University

Cohost:
OKD Institute of Social Change and Development

December 4-8, 2013

Climate Sensitivity and Agriculture Productivity in India: A Crop Wise Analysis

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Abstract- *This study investigate the impact of climate sensitivity on crop wise productivity by utilizing panel data for time period, 1980-2009 by Cobb-Douglas production function model. The main goal of this study was to analysis the impact of climate sensitivity on food grain and non-food grain productivity. Crop wise per unit land production as a dependent variable, regressed with 11 different socio-economic and climatic factors. To identify the state and time effect in panel, fixed effect regression model was used. Random effect regression model was applied to identify the year and state effect on output. To check the quandary of fixed and random effect regression model, Hausman specification estimation and Breusch-Pagan Lagrange multiplier (LM) was incorporated. Pesaran's test was used to identify the cross sectional independence; and for group-wise heteroskedasticity, Modified Wald test was applied. For serial correlation/autocorrelation***,** *Lagram-Multiplier test (Wooldridge test for autocorrelation) was applied. Linear regression, correlated panels corrected standard errors (PCSEs) model was applied to remove the presence of heteroskedasticity and multicollinearity. Driscoll-Kraay standard errors estimation model was used to remove the presence of heteroskedasticity, serial correlation, cross-sectional dependence, and multicollinearity in panel data series. Empirical findings shows that climatic factors have a negative and statistically significant impacts on per unit land production of wheat, barley, sorghum, arhar (pigeon pea), maize, sugarcane, cotton and sesamum. Hence, we can conclude that the agricultural productivity in India is sensitive to climate change that is adversely affecting the food grain and non-food grain productivity and thus it may become a serious threat to food security and other sector of the economy. Irrigation is a crucial factor to mitigate the adverse effect of climate sensitivity for rice, wheat, sorghum, arhar, bajra, potato, cotton, groundnut, sesamum, and linseed crops. In case of rice, wheat, barley, maize, gram crops there is still scope for increasing productivity with increased use of fertilizers.*

***Keywords* -** Climate sensitivity, Crop wise productivity and India

JEL Classification:-Q54 and Q18

1.0. Introduction

Climate change is not a new phenomenon in the world. There are many examples that give the clear evidence about changing in climatic factors in the world. Rising temperature of earth surface, declining ground water, drought, fluctuation in rainfall, changing precipitation, flooding, soil erosion, fluctuation in wind, rising sea level due to melting of glacier, cyclone, hail storm, fog, earthquake and landslide, increasing ocean temperature, acidification of the oceans due to elevated carbon dioxide in atmosphere these all are the clear evidence of climate change related phenomenon at global level.[1] Natural and human activities both are responsible for climate and its variability. Natural activities include earth motion, sun's intensity volcanic eruption, forest fires and the circulation of the ocean etc. The earth's climate is dynamic; it is changing since ancient era; and it is most important natural factor that responsible for climate variability. Volcanic eruption is another natural cause that contributes to short term changes for its variability and it also increases the large volumes of SO_2 (sulphur dioxide) and fires in forest area increase the carbon dioxide and carbon mono-oxide. Sun's intensity also increases the many harmful gases in the atmosphere.

Human activities also responsible for climate change and environmental degradation such as growing population, rapid urbanization, higher industrialization, use of modern technology, innovation, higher economic growth and development, transport, building construction, reduction in forest area, burning fossil fuels, increasing development of land for farms, grazing cattle, development of cities, and others (Ahmad *et al.*, 2011; and Patnaik and Narayanan, 2010). These all activities emit green house gases (GHGs) in the atmosphere; and these also make the global carbon cycle in the world. Rising quantity of green house gases (GHGs) in the atmosphere is key determinant factor for climate variability. Human driven activities are increasing the quantity of carbon dioxide, methane, nitrous oxide, chloro fluorocarbons (CFCs) and other gases has lead to global climate change. The concentrations of methane (CH_4) have increased in atmosphere more than two-and-half times pre-industrial levels due to human activities and atmospheric CO_2 concentrations have increased by almost 40% since pre-industrial times, from approximately 280 parts per million by volume (ppm) in the 18th century to 390 ppm in 2010 and human activities currently release over 30 billion tons of CO_2 into the atmosphere every year.[2] Nitrous oxide is another green house gas produced by natural and human activities; mainly through agricultural activities and natural

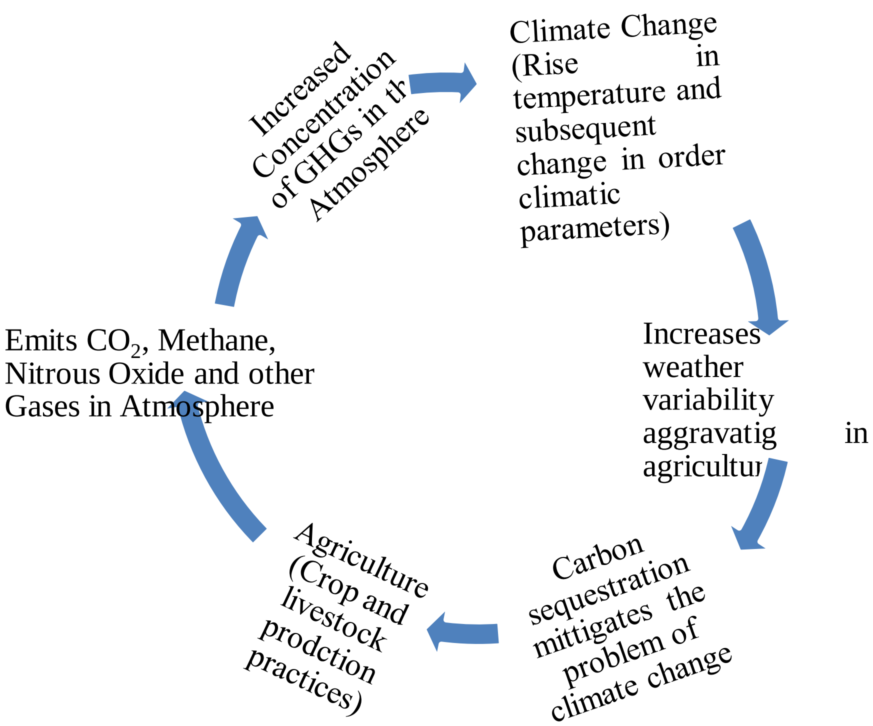
[1] http://www.epa.gov/climatechange/science/indicators/
[2] http://www.epa.gov/climatechange/science/causes.html

biological processes, fuel burning and some other processes also create N_2O. Nitrous oxide also have risen around 18% since the start of the industrial revolution, with a relatively rapid increase towards the end of the 20th century.[3]

1.1. Agriculture as a Cause of Climate Change

Agriculture is a cause and consequences of climate change and they have directly link to each other (Ranganathan *et al.*, 2010). Agriculture contributes 70-80% green house gases like nitrogen oxide, nitrous oxide, carbon dioxide, ammonia and methane (Masters *et al.*, 2010; and Gregory *et al.,* 2012). First, any variation in climatic factors adversely affect to agriculture production and again use of adaptation or mitigation methodologies in agriculture; and second these mitigation techniques increase the probability to changing of climate.

Figure 1 -Inter-linkages between agriculture and climate change



Source- Adapted from Pant (2009)

Pant (2009) also showed the cause and effect relationship between agricultural sector and environmental degradation in the economy, i.e., firstly agriculture increases GHGs in the atmosphere and secondly GHGs affect environmental condition and agriculture productivity, the inter–linkages between agriculture and climate change is shown in Figure 1. Pant (2009)

[3] http://www.epa.gov/climatechange/science/causes.html

found based on multiple regression analysis in his study relating carbon emissions, energy consumption and other agriculture productivity related variables for 120 countries their results were based on obtained data from the World Bank's Green Data Book, show that agricultural land, irrigation, forest area, biomass energy and efficient energy use reduce the carbon dioxide emission and fertilizers use. Use of inorganic fertilizers and pesticides in agricultural sector is also a another cause for environmental problem because this lead to increase in emission of GHGs (Wallace, 1997; Ranuzzi and Srivastava, 2012); and it have a short-term positive effect on agricultural productivity but in long-term it will negatively affect on agriculture and environment like crop yields, contaminating ground water and surface water (Chandrashekar, 2010). Another harmful effect of overuse of fertilizers increase presence of fluoride, heavy minerals, arsenic; and these all are toxic for soil; and it may make agriculture to fade quickly (Srisubramanian and Sairavi, 2009).

In mid, high latitude and higher income countries, climate change has positive impact on agricultural production or crop yields; and lower-latitude and lower income countries experience a negative effect on agricultural production due to climate variability (Lee, 2009). It has significant negative impacts on agriculture production and it is very harmful for developing countries compared to developed countries; and it is expected that it may increase the number of food insecure children to 50 million by 2050 in South Asia (Greg *et al.*, 2011; Gbetibouo and Hassan, 2005; Rosegrant, 2008; and Masters *et al.*, 2010). This would increase the severity of disparities in cereal yields between developed and developing countries (Parry *et al.*, 2004; and Fischer *et al.*, 2005). In case of normal condition of ecosystem such as temperature, rainfall and other climatic variables, it will increase the crop growth positively. On the other hand, high fluctuation in the state of climatic variables will affect crop growth negatively. Hence, any change in the climatic variables such as temperature, rainfall and humidity that govern crop growth will have direct impact on the quantity of food production.

1.2. Climate Sensitivity and Indian Agriculture

In India, there are many reasons that make to most vulnerable to Indian agriculture due to climate variability; first around more than 60% of India's total agricultural areas are rain-fed; second more than 80% Indian farmers are small and marginal (having less than 1 ha of land) thus having less capacity to cope with climate change impacts on agriculture (Ranuzzi and Srivastava, 2012); and third more than 52% populations (around 700 million) depend on climate-sensitive sectors like agriculture, forestry and fishery for their livelihood (Sathaye *et al.*, 2006). Current emission of CO_2 concentration around 575 ppm (parts per million) to 740 may expected to result in large shifts in Indian forests by the end of the century (Ranuzzi and Srivastava, 2012).

It is also serious issues for food perceptive because India is home to largest number of hungry and deprived people in the world to be precise 360 million undernourished; and it has more than 40% child malnutrition and around 325 million hunger population (Dev and Sharma, 2010). More than 320 million Indian go to bad without food every night (Ahmad *et al.*, 2011; and Singh, 2009). India's malnutrition level is almost just double compared to many countries in Africa (Dev and Sharma, 2010). Food demand will increase just double by 2050 due to high growth rate of population and it may increase the competition for resources such as land, water, capital, labour and other precious natural resources in India (Ahmad *et al.*, 2011). India has a 17.5% global population but just 2.1% of the world's arable land (Census, 2011; and Planning Commission (Government of India). In India food security is major concern in many perspectives like more demand of food due to growing population, poverty, lack of education level of farmers, higher industrialization, building construction, declining agriculture productivity due to climate change or another socio-economic factors. Thus climate sensitivity and its impact on agriculture is serious issue for India.

2.0. Empirical Review

Numerous of studies are already done about climate change and its impact on agricultural in India. Empirical and descriptive studies give the evidence that climate change negatively affect the agricultural production as well as productivity (in term of quantity and monetary) of major food grain and non-food grain crops. Gupta *et al.* (2012) and Kavikumar (2009) undertaken a macro level study in India about climate change and its impact on agriculture productivity; and another many researchers also done research at micro level in different regions/states of India. Gupta *et al.* (2012) mentioned that climate change is likely to reduce the yields of rice, sorghum, and millet crop productivity in 16 major agriculture intensive states of India. Kavikumar (2009) also observed that climate change is result in 9% reduction in agricultural revenues in 13 states of the country. Kalra *et al.* (2008) also found in northern states of India; namely Punjab, Haryana, Rajasthan, and Uttar Pradesh; and shows that productivity of wheat, mustard, barley, and chickpea has decreased due to rise in seasonal temperature. Geethalakshmi *et al.* (2011) also represents similar result for rice; and productivity of rice has declined by 41% with 4^0C increase in temperature in Tamil Nadu (India).

Kumar *et al.* (2011b) reached at different argument based on their study in Uttarakhand and Uttar Pradesh (India), climate change has already shifted the weather condition; and it is affecting to seasonal crops and reduced the available growing period for many crops like rice and sugarcane. Kaul and Ram (2009) examine about the impact of rains and temperature on productivity of jowar production; and found that excessive rain and extreme variation in temperature is adversely affect the jowar production, thereby this negatively affects the incomes as well as food security of farming families in Karnataka (India). Kar and Kar (2008) (based on Cobb-Douglas production model) observed that low rainfall in Orissa (India) affects the crop production and income of the poor farmers and they suggest that investment in irrigation would be improve farm income. Nandhini *et al.* (2006) mentioned that rice cultivable land has declined due to scarcity of inputs and scanty rainfall and majority of the population were living under poverty condition in Tamil Nadu (India).

Hundal and Prabhjyot-Kaur (2007) shows (by simulation method) that an increase in minimum temperature up to 1.0^0C the yield of rice and wheat has decreased by 3% and 10% respectively in Punjab (India). Saseendran *et al.* (2000) investigated (by CERES model for duration 1980 -2049) that change in temperature up to 5^0C can lead to continuous decline in the yield of rice and every one degree increment of temperature leads to a 6% decline in yield of rice in Kerala (India). Simulation model was used by Kumar and Parikh (2001) for two crops, viz., rice and wheat, and projected large-scale changes in the climate would lead to significant reductions in crop yields, which in turn would adversely affect agricultural production by 2060 and may affect the food security of more than one billion people in India.

Kumar *et al.* (2011a) mentioned (Info-crop simulation model) that irrigated area for maize, wheat and mustard in northeastern and coastal regions; and rice, sorghum, and maize in western ghats of India may lose production due to climate change. Hariss *et al.* (2010) found (based on Info-crop simulation model) that rice production may decline of 31% in 2080 due to climate change in Bihar (India). Srivastava *et al.* (2010) shows (by Infocrop-sorghum simulation model) that climate change is to be reduce monsoon sorghum grain yield up to 14% in central zone (CZ) and up to 2% in south central zone (SCZ) by 2020; and this model also indicates that yields are likely to be affected even more in 2050 and 2080 scenarios; climate change impacts on winter crop are projected to reduce yields up to 7%, 11%, and

32% by 2020, 2050, and 2080 respectively in India. Ninan and Bedmatta (2012) (based on cross section analysis of crops) found that climate change will vary across crops, regions; and increase in temperature is most responsible cause for declining agricultural production of crops in different parts of India; and this paper argues that there is require better understanding of the long term path of innovation, land use and dynamic behavior of managed ecosystem to mitigate the adverse effect of climate change.

Bhatia *et al.* (2008) indicates (by CROPGRO-Soybean model) that the average water non-limiting potential of soybean crop across locations was 3020 kilogram/hectare, while water limiting potential was 2170 kilogram/hectare that is indicating that a 28% reduction in yield due to adverse soil moisture conditions in India. Srivastava and Rai (2012) mentioned that change in global climate is a matter of serious concern to sugarcane cultivators for sustainable development of the crop; and sugarcane is very sensitive to temperature, rainfall, and solar radiations. Asha *et al.*, (2012) found that the yields of sorghum, maize, tur, groundnut, wheat, onion, and cotton has decreased up to 43.03, 14.09, 28.23, 34.09, 48.68, 29.56, and 59.96 kilogram per hectare respectively in rainfed area; and they also mentioned that almost 100% and 92.22% small and sample farmers respectively reported that the reduction in the rainfall was the major reason for reduction in the yield levels over the period followed by pest and disease to extent of 72.22%; and changes in temperature and seasonal patterns were also reason for the reduction in the yield by 42.22% in Dharwad district in Karnataka (India). The impact of rainfall is not significant for sugarcane crop in Andhra Pradesh (Ramulu, 1996). In India, projected surface warming and shift in rainfall may decrease crops yields by 30% by the mid 21st century, due to this reason there may be reduction in arable land resulting into pressures on agriculture production (Kapur *et al.*, 2009).

2.1. Motivation and Objectives of the Paper

Above review provides the evidence that agricultural is very sensitive to climate change. Most of these studies show that climate change has decreased the agricultural productivity or net revenue of mostly food grain crop in different regions of India. These all studies are analysis the impact of climate change on agricultural productivity or net revenue with specifically one to four crops for a particular regions of India but any study is not available in the literature that analysis the impact of climatic sensitivity on overall land productivity of the country. Due to this drawback this study analysis the impact of climate sensitivity on food grain and non-food grain productivity of thirteen states of India with utilizing panel data for time period, 1980 -2009. This study also tries to find that which food grain and non-food grain crops are most sensitive in presence of climate variability.

3.0. Research Methodology

3.1. Source and Description of Data

The data set is used in present study is a time series covering 30 years for time period 1980-2009. The data for agricultural, socio-economic and climatic variables was taken from following sources-

Agricultural Data -State wise and crop wise total production, area sown, irrigated area; use of fertilizers, tractors and pump set; and forest area were taken from Centre for Monitoring Indian Economy (CMIE). Agricultural labour related information was taken from the different publication of Census (Government of India); it was available in decadal period in 1981, 1991, 2001 and 2011; and this was converted into time series data by interpolation and graphical method. Crop wise farm harvest price was taken from Directorate of Economics and Statistics Ministry of Agriculture (Government of India) and Agricultural Informatics Division National Informatics Centre Ministry of Communications and Information Technology (Government of India); this data was available for current prices so this was convert into constant prices at 1993-1994. These all data were taken for 13 states of India; namely Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. Crop wise group of states was taken to make a panel for food grain and non-food grain crops. Total sixteen crops were taken like rice, arhar, maize, bajra, gram, wheat, jowar (sorghum), ragi, and barley crops are undertaken as a food grain crops and sugarcane, linseed, soyabeans, groundnut, cotton, sesamum, and potatoes crops are undertaken as a non-food grain crops (cash crops) for the regression analysis. These all crops cover more than 75% of the total agricultural cropped area of the country.

Demographic Data -State-wise overall literacy rate was taken from different publication of Planning Commission (Government of India). It was also available in decadal period; 1971, 1981, 1991, 2001 and 2011. To convert this data into time series, interpolation method was applied.

Climatic Data -Minimum and maximum were taken from the Indian Meteorological Department (IMD) (Government of India) database. This data was available on daily intervals with latitude and longitude information of monitoring stations. Due to unavailability of city wise data of temperature, the stations pertaining to specific latitude and longitude information were identified. Based on this information so generated, geographical regions were identified. Then from the groups of such stations different geographical region were linked to arrive at the state level data points. Monthly district wise rainfall information also was taken from Hydromet Division, Indian Meteorological Department (IMD) (Government of India). These all data were converted in monthly averages city wise, after that data transformed in state wise monthly maximum and minimum temperature for selected specific city, it was collected from the 354 meteorological stations for the thirteen states of India. To process basic information on climatic factors like rainfall, minimum and maximum temperature data; the C^{++} software was used. The SPSS software was used to extract and bring data to excel format. For each crops annual average actual minimum and maximum temperature; and rainfall in entire crop duration was taken for the regression analyses.

3.2. Empirical Analysis

To evaluate the impact of climate change on crop wise production for per unit land was taken as dependent variable utilizing panel for time period, 1980 to 2009. For regression analysis Cobb-Douglas production function model is incorporated. Agricultural production is a function of many endogenous and exogenous variables like cultivated area, irrigated area, fertilizers, labours, tractors and pumpset; this is also function of many exogenous factors like forest area, literacy rate, etc. In functional form this may be-

$$(TP)_{it} = f\{(AS)_{it}, (IA)_{it}, (TF)_{it}, (AL)_{it}, (TT)_{it}, (PS)_{it}, (FA)_{it}, (LR)_{it}\ (FHP)_{it}\} \quad (1)$$

Where, *TP* is total production for each food grain crop; and *i* is cross sectional groups of states 1 to 13 for separate crop and *t* is the time period for 1980-2009. *AS, IA, TF, AL, TT* and *PS* are the area sown, irrigated area, agricultural labour, tractors and pumpset respectively for each crop. *FA* is the share of forest area for each crop with respect to gross sown area. *LR* is the share of literacy rate for respective crops. *FA* is crop wise share of forest area {*FA*= (Gross Forest Area/Gross Sown Area)*Respective Crop Area)}; *LR* is literacy rate {*LR*= (Overall Literacy Rate/Gross Sown Area)* Respective Crop Sown Area}. *FHP* is farm harvest price for respective crops (at constant level 1993-94). Now, divide by *TP* to *AS* (for production per unit land or land productivity) than equation (1) will become-

$(TP/AS)_{it} = f\{(IA)_{it}, (TF)_{it}, (AL)_{it}, (TT)_{it}, (PS)_{it}, (FA)_{it}, (LR)_{it}, (FHP)_{it}\}$ (2)

$(TP/AS)_{it}$ is production of per unit land for each crop in the equation (2). Cobb-Douglas production model assume that climatic factors are input factor for growth of crop (Nastis *et al.*, 2012). After incorporate the climatic factor equation (2) will be following form-

$(TP/AS)_{it} = f\{(IA)_{it}, (TF)_{it}, (AL)_{it}, (TT)_{it}, (PS)_{it}, (FA)_{it}, (LR)_{it}, (FHP)_{it}, (AARF)_{it}, (AAMAXT)_{it}, (AAMINT)_{it}\}$ (3)

Where, *AARF, AAMAXT and AAMINT* are the annual average rainfall, annual average maximum and annual average minimum temperature in entire crop duration respectively. In the original form of Cobb-Douglas production function model, equation (3) will be in following form-

$ln\ (TP/AS)_{it} = \beta_0 + \beta_1\ ln\ (IA)_{it} + \beta_2\ ln\ (TF)_{it} + \beta_3\ ln\ (AL)_{it} + \beta_4\ ln\ (TT)_{it} + \beta_5\ ln\ (PS)_{it} + \beta_6\ ln\ (FA)_{it} + \beta_7\ ln\ (LR)_{it} + \beta_8\ ln\ (FHP)_{it} + \beta_9\ ln\ (AARF)_{it} + \beta_{10}\ ln\ (AAMAXT)_{it} + \mu_i$ (4)

Where, β_0 is constant coefficient; $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9$, and β_{10} are the regression coefficient for respective variables and μ_i is intercept term in the model. Equation (4) represents the real functional form of Cobb-Douglas production function model. This model was also used by Nastis *et al.* (2012) to analysis the climatic impact on agricultural productivity in Greek. Cobb-Douglas production model was used by Gupta *et al.* (2012) to investigate the climatic impact on rice, sorghum and millet productivity utilizing panel in India.

Regression analysis was run on STATA and SPSS softwares to fit the equation (4). Several regressions model were done to fit the equation (4). To identify the cross sectional independence Pesaran's test was used. For group-wise heteroskedasticity, Wald test is used to know the fixed effect in the panel data set. To address the presence the autocorrelation, Wooldridge test is applied. Finally, to remove the presence of serial correlation, heteroskedasticity, cross sectional autocorrelation and serial autocorrelation in panel data; the linear regression, heteroskedastic panels corrected standard errors estimation model was applied. Finally, to remove the presence of Heteroskedasticity, serial correlation, cross-sectional dependence and multicollinearity, Driscoll-Kraay standard errors estimation model is used in regression model.

4.0. Empirical Results

Table 1 -Regression results for impact of different factor on various crops with Driscoll-Kraay standard errors model

Variable	Rice	Arhar	Gram	Wheat
No. of Observation	390	390	390	360
No. of Groups	13	13	13	12
F-Value	2418.42*	88.67*	148.27*	988.00*
R-squared	0.7411	0.4694	0.3758	0.8654
IA	0.1389668***	0.0592594 *	-0.0394102*	0.206481*
TF	0.1573676*	0.0766149***	0.0874326*	0.1784687*
AL	-0.1775249*	0.1524533*	0.1019586*	0.0490914*
TT	-0.007702	0.0546441***	0.0501294*	-0.0159599
PS	0.0430818	-0.1560596*	-0.0890603*	-0.3016264*
FA	-0.1628785*	-0.1959318*	-0.0290008*	-0.1213848*
LR	0.0609228	0.114658**	-0.0857079*	0.0869473*
FHP	0.117931**	-0.0719933	0.0753251*	0.2518352*
AARF	-0.0625444	0.1718052*	0.0157571	0.0174774
AAMAXT	-2.63979*	0.0549597	-0.1446674	2.717306
AAMINT	0.0455405	-0.7777738**	-0.2181449**	-1.730916*
Con. Term	4.594237*	0.2804212	-0.2025993	-1.851947*

Source -*Estimated by Authors; and *, ** and *** indicates the 1%, 5% and 10% significance level of regression coefficient for respective variables in the table*

Table 1 indicates the regression results for impact of climatic and non-climatic factors on rice, arhar, gram, and wheat crops. Any increment in maximum temperature has a negatively and statistically significant impact on rice productivity and if it increases up to 1% than rice productivity may go down by 2.63%. Arhar, gram and wheat productivity negatively affect due to any variation in minimum temperature and the productivity of these crops may decline by 0.78%, 22%, and 1.73% respectively with 1% increment in minimum temperature. Rainfall is beneficial for arhar productivity and it has a positive and statistically significant impact on arhar; and it means more rainfall more productivity of arhar. Irrigation is crucial factor for rice, arhar and wheat crops and it may improve the productivity of these crops; and 1% increment in irrigated are for these crops than productivity of these crops may rise by

0.14%, 0.06%, and 0.21% respectively; and it could be better option to reduce the adverse effect of climate variability for these crops. More utilization of fertilizers for rice, arhar, gram and wheat crops could be another option to improve the productivity of these crops since 1% more utilization of fertilizers for these crops, than it may increase the productivity of these crops by 0.16%, 0.08%, 0.09%, and 0.18% respectively. Number of agricultural labours on per unit land for arhar, gram and wheat crops is also may be beneficial to increase the productivity of these crops. Arhar and gram crops also get benefits from mechanization i.e. use of tractor for these crops are good indicator to improve arhar and gram productivity. Increment in forest area may be harmful for rice, arhar, gram, and wheat productivity and there could be one reason that any rising in forest area may reduce the area for these crops; and resulting that productivity may go down. Increases of participation of literate persons are important for arhar and wheat crops. Appropriate price of the crops are also important variables to improve the productivity of rice, gram, and wheat crops and it is very interesting that 1% increase in farm harvest price than it may increase the productivity of rice, gram, and wheat by 0.25%, 0.12%, and 0.8% respectively.

Table 2 shows the regression results for effects of climatic and non-climatic factors on maize, bajra, sorghum, and ragi crops. Here increase in rainfall negatively affects the maize; while it positive affects the bajra sorghum productivity. If rainfall increases 1% than maize productivity may go down by 0.17%. Fluctuation in maximum temperature also harmful for maize, bajra, and sorghum crops; and 1% increment in maximum temperature it may reduce productivity of maize, bajra, sorghum crops by 2.73%, 0.17%, and 0.93% respectively. Increase in irrigated area is beneficial for bajra and sorghum productivity since these crops have a positive and statistically significant relationship to each other. Utilization of 1% more fertilizers for maize, sorghum, and ragi crops; and it could be increase productivity of these food grain crops by 0.44%, 0.07, and 0.45% respectively. Use of agriculture labours and tractors are not beneficial for mostly crops. In case of increment in forest area, it has positive and statistically significant effects on maize and sorghum productivity; while ragi productivity has negatively affects due to more forest area. Farm harvest price is a most important factor to increase the productivity of maize, bajra, and sorghum productivity; and productivity of these crops may go by 0.38%, 0.27%, and 0.13% respectively with increase in 1% farm harvest price of respective crops. Literacy rate do not have any positive and statistically significant effects on these crops.

Table 2 -Regression results for impact of different factor on various crops with Driscoll-Kraay standard errors model

Variable	Maize	Bajra	Sorghum (Jowar)	Ragi
No. of Observation	390	390	360	270
No. of Groups	13	13	12	9
F-Value	369.40*	77.49*	235.82*	786.78*
R-squared	0.5257	0.4148	0.5346	0.7866
IA	-0.030496	0.2326374*	0.040406**	-0.0270496**
TF	0.4396549*	-0.0366419	0.0726855***	0.4474094*
AL	-0.3548917*	-0.0953908*	-0.0712503***	-0.00072763
TT	-0.0379894	0.0100231	-0.0102297	-0.0853395 *
PS	-0.0046028	0.0082368	0.1293545**	-0.0005272
FA	0.1125156*	-0.0272639	0.2119613*	-0.2528327*
LR	-0.201911*	-0.02843	-0.3899554*	0.0541629
FHP	0.3842181*	0.2689615*	0.1259395*	-0.0280944
AARF	-0.1656763*	0.1410577*	0.1590452**	-0.0835979
AAMAXT	-2.734031*	-0.1700164***	-0.9274882***	-0.8214893
AAMINT	-0.3209142	-0.1565812	0.7593738**	0.5838598
Con. Term	5.756559*	-0.4802868	-1.094372	1.049845

Source -*Estimated by Authors; and *, ** and *** indicates the 1%, 5% and 10% significance level of regression coefficient for respective variables in the table*

Table 3 reveals that any fluctuation in rainfall has negative and statistically significant impacts on barley and sugarcane crops and it may reduce the productivity of these crops by 0.60% and 0.11% respectively with 1% rise in rainfall. Any variation in maximum temperature has negative and statistically significant effects on barley, sugarcane, and cotton crops; and if maximum temperature increases 1% than productivity of barley, sugarcane, and cotton may go down by 0.77%, 1.62%, and 1.54% respectively. While minimum temperature has positive and statistically significant impacts on sugarcane and cotton crops; and only potatoes crops negatively affect due to any rise in minimum temperature. Increase in irrigated area also important factor to lead the productivity of barley, potatoes, and cotton crops.

Table 3 -Regression results for impact of different factor on various crops with Driscoll-Kraay standard errors model

Variable	Barley	Sugarcane	Potatoes	Cotton
No. of Observation	240	390	390	360
No. of Groups	8	13	13	12
F-Value	60.71*	262.77*	90.94*	126.78*
R-squared	0.7821	0.5441	0.3813	0.4288
IA	0.0373362	-0.0416909	0.0370261	0.1425529*
TF	0.1174811*	0.081517*	0.154175	0.1822216*
AL	0.0487923**	-0.1257564*	-0.0248255	0.0602017
TT	0.0104204	-0.1092452*	-0.104405**	-0.1290043*
PS	0.1011199*	0.0258532	-0.0098854	-0.1151975*
FA	-0.1800224*	0.0238193	-0.0764277*	-0.2787205*
LR	0.0053756	0.2907052*	0.1797079*	0.2416903*
FHP	0.0019455	0.1204568*	0.1048024*	0.1443817**
AARF	-0.0581638**	-0.1064073**	0.0060348	0.0618751
AAMAXT	-0.767329***	-1.620821*	0.4911615	-1.539945**
AAMINT	-0.2189489	1.020454*	-0.4758949**	2.065035**
Con. Term	1.154381***	3.842093*	1.199881	-0.29994

Source -*Estimated by Authors; and *, ** and *** indicates the 1%, 5% and 10% significance level of regression coefficient for respective variables in the table*

1% rise in irrigated area for cotton crops than it may lead the productivity of this crop by 0.14%. Fertilizer also another factor to increase the productivity of barley, sugarcane, potatoes, and cotton; it has positive and statistically significance impact on these crops; and productivity of these may rise by 0.12%, 0.08%, 0.15%, and 0.18% respectively. Use of agriculture labour, tractors and pumpset also has a positive and negative impact of these crops. Increase area of forest is not a beneficial for barley, potatoes, and cotton crops. Here literacy rate and farm harvest are the crucial factor to increase the productivity of barley, sugarcane, potatoes, and cotton crops.

Table 4 -Regression results for impact of different factor on various crops with Driscoll-Kraay standard errors model

Variable	Groundnut	Sesamum	Linseed	Soyabeans
No. of Observation	360	390	300	90
No. of Groups	12	13	10	3
F-Value	55.60*	148.26*	69.55*	43.62*
R-squared	0.1928	0.4598	0.4142	0.3220
IA	0.0218522	0.0183914	0.0788102***	-0.2553091*
TF	0.0271069	0.1717619**	-0.0889485	0.0668923
AL	-0.0182489	-0.0741317**	0.1756394**	0.0297998
TT	-0.0947396**	-0.1148709**	0.0570584	0.0767545
PS	0.0090967	-0.1014543**	-0.2564433*	-0.189086*
FA	-0.0259163	-0.1854527*	-0.173508*	0.8258356*
LR	0.0967159***	0.2873567*	0.2009721**	1.259613***
FHP	0.1916712*	0.2587821*	0.1951049	-0.0247732
AARF	0.0159407	0.2481689*	-0.0050405	-0.2462659*
AAMAXT	-0.3180023	-2.332888*	3.779256*	6.430912
AAMINT	-0.2826171	0.7107594	-1.64148*	-0.4681562
Con. Term	0.7025546	1.967681*	-4.275654*	-13.25003**

Source -*Estimated by Authors; and *, ** and *** indicates the 1%, 5% and 10% significance level of regression coefficient for respective variables in the table*

Table 4 shows that rise in rainfall has negative and statistically significant impact on soyabeans productivity and it may go down by around 0.25% with 1% increment in rainfall. Increase in level of maximum temperature negative affect the sesamum productivity; and if maximum temperature rise up to 1% than it may reduce to sesamum productivity by 2.33%. Rising maximum temperature has a positive and statistically significant impact on linseed. Linseed productivity may go down by 1.64% due to 1% increment in minimum temperature. Here 1% increase in irrigated area for linseed may lead its productivity by 0.08%. Fertilizers could be another indicator to improve the sesamum productivity and it may lead on the average by 0.17% with 1% more use of fertilizer. Agricultural labour, tractor and pumpset also have a positive and negative impact with various crops. According to empirical results shows that increasing forest area is not good for groundnut, sesamum, and linseed crop because it has a negative impact on these crops. Increasing participation of literate population in cultivation of groundnut, sesamum, linseed, and soyabeans has a positive and statistically significant impact on the productivity of these crops; and their productivity may lead by 0.10%, 0.29%, 0.20%, and 1.26% respectively with increase of 1% literate population for cultivation of these crops. Farm harvest price could be another crucial factor to lead the productivity of groundnut and sesamum since productivity of these crops may lead by 0.19% and 0.26% respectively due to 1% rise in farm harvest prices for these crops.

5.0. Conclusion, Discussion, and Policy Implication

This study analysis the impacts of climate sensitivity on food grain and non-food grain crops in India with panel data. Based on empirical results several conclusion can be drawn such as any increment in maximum temperature have a negative and statistically significant impacts on productivity of rice, maize, bajra, jowar (sorghum), barley, sugarcane, cotton, and sesamum (Kalra *et al.*, 2008; Geethalakshmi *et al.*, 2011; Kumar *et al.*, 2011b; Kaul and Ram, 2009; Kumar and Parikh, 2001; Gupta *et al.*, 2012; Srivastava and Rai, 2012; Hundal and Prabhjyot-Kaur, 2007; and Kapur *et al.*, 2009). While, linseed productivity has positive and significant relationship with rising maximum temperature; and it means that only one crop may get benefit due to rising maximum temperature. Arhar, gram, wheat, maize, potatoes, and linseed also negatively affected due to any variation in minimum temperature (Kumar and Parikh, 2001; Ranuzzi and Srivastava, 2012; and Hundal and Prabhjyot-Kaur, 2007). Sorghum, sugarcane and cotton productivity positively affects by increase in minimum temperature. Any increment in rainfall has a negative impact on rice, barley, ragi and maize productivity; and rising rainfall positively affects to arhar, gram, wheat, bajra and sorghum productivity (Kaul and Ram, 2009; and Gupta *et al.*, 2012).

In brief: wheat, barley, sorghum, arhar and maize food grain crops negatively affected due to climate sensitivity; and these all are the major food grain crops of Indian. In case of non-food grain crops like sugarcane, cotton, sesamum, linseed, and potatoes also negatively affected due climate change and its sensitivity. Hence, this study provide the evidence that climate sensitivity adversely affects the food grain and non-food grain (cash crop) crops productivity and thus it may be serious threaten for food security and other sector of the economy that are based on agriculture related activities like sugar industry, cotton industry and others related sector in India. Effects of climatic factors on various crops are not similar and it means that there is need to apply various policies for each crop to well growth of respective crops (Ninan and Bedmatta, 2012). Based on empirical findings this study suggests several policies to mitigate the adverse effect of climate sensitivity and to increase the per unit land productivity. More irrigation facility may be an important factor to mitigate the adverse effect of climate sensitivity for rice, arhar, wheat, bajra, sorghum, cotton, and linseed crop (Kar and Kar, 2008); and it may be better idea to improve the productivity of these crops. In case of rice, arhar, gram, wheat, maize, sorghum, ragi, barley, sugarcane, and cotton productivity may be lead with more utilization fertilizers for these crops but it may not be beneficial in long term; and it may not be proper solution since abundant use of fertilizers on cultivated land may reduce the land productivity, soil quality, and environmental degradation (Wallace, 1997; Chandrashekar, 2010; and SriSubramaniam and Sairavi, 2009).

Arhar, gram, wheat, and linseed productivity may be lead with increasing of agricultural labour for these crops. In case of mechanization i.e. increase in number of tractors has a positive and statistically significant impact on arhar and gram. Productivity of barley may rise with increasing in pumpset. Increase in forest area has negatively affects the productivity of mostly food grain and non-food grain crops; it means that there may be reason that increases in forest area and it may lead decline in cultivated land due to this productivity may go down. It is very interesting that literacy rate is a very important factor to improve the productivity of mostly non-food grain crops (cash crops) compared to food grain crops and there could be one reason that literate farmers are going to shift with non-food grain (cash crops) cultivation to get the more financial benefits compared to food grain crops. Farm harvest price of each crops are very crucial variables to increase the productivity of mostly crops and there may be reason that farmer give the preference to those crops which may provide the more financial benefits; and it may increase the decision of farmers to select an appropriate crop for cultivation.

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Appendix A-Regression results for food grain crops

Table 1- Regression results for rice crop with Driscoll-Kraay standard errors model

No. of Observation		390	*R-squared*		0.7411	
No. of States		13	*F-value*		2418.42	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.138967***	0.068122	2.04	0.064	-0.00946	0.28739
TF	0.157368*	0.029488	5.34	0.000	0.09312	0.22162
AL	-0.177525*	0.038696	-4.59	0.001	-0.26184	-0.09321
TT	-0.007702	0.03005	-0.26	0.802	-0.07318	0.05777
PS	0.0430818	0.036350	1.19	0.259	-0.03612	0.12228
FA	-0.162879*	0.053477	-3.05	0.010	-0.27939	-0.04636
LR	0.0609228	0.046205	1.32	0.212	-0.03975	0.16159
FHP	0.11793**	0.048958	2.41	0.033	0.01126	0.22460
AARF	-0.062544	0.040934	-1.53	0.152	-0.15173	0.02664
AAMAXT	-2.63979*	0.818566	-3.22	0.007	-4.42329	-0.85629
AAMINT	0.0455405	0.461836	0.10	0.923	-0.960714	1.05179
Intercept	4.594237*	0.954531	4.81	0.000	2.51449	6.67398

Source -*Estimated by Authors*

Table 2-Regression results for Arhar crop with Driscoll-Kraay standard errors model

No. of Observation		390	*R-squared*		0.4694	
No. of States		13	*F-value*		88.67	
No. of Obs./ States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.0592594*	0.013145	4.51	0.000	0.03237	0.08614
TF	0.0766149***	0.0445189	1.72	0.096	-0.01444	0.16767
AL	0.1524533*	0.0304407	5.01	0.000	0.09020	0.21471
TT	0.0546441***	0.0286383	1.91	0.066	-0.00393	0.11322
PS	-0.1560596*	0.037735	-4.14	0.000	-0.23324	-0.07888
FA	-0.1959318*	0.0350722	-5.59	0.000	-0.26766	-0.12420
LR	0.114658**	0.0473978	2.42	0.022	0.01771	0.21160
FHP	-0.0719933	0.0464417	-1.55	0.132	-0.16698	0.02299
AARF	0.1718052*	0.0532294	3.23	0.003	0.06294	0.28067
AAMAXT	0.0549597	0.0511889	1.07	0.292	-0.04973	0.15965
AAMINT	-0.7777738**	0.3412565	-2.28	0.030	-1.47572	-0.07983
Intercept	0.2804212	0.4758298	0.59	0.560	-0.69276	1.25360

Source -*Estimated by Authors*

Table 3- Regression results for gram crop with Driscoll-Kraay standard errors model

No. of Observation		390	*R-squared*		0.3758	
No. of States		13	*F-Value*		148.27	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*Z*	*P > |z|*	*95% Confidence Interval*	
IA	-0.0394102*	0.0119973	-3.28	0.003	-0.06395	-0.01487
TF	0.0874326***	0.0497984	1.76	0.090	-0.01442	0.18928
AL	0.1019586*	0.0233115	4.37	0.000	0.05428	0.14964
TT	0.0501294*	0.0153908	3.26	0.003	0.01865	0.08161
PS	-.0890603*	0.0135104	-6.59	0.000	-0.11669	-0.06143
FA	-0.0290008*	0.0099046	-2.93	0.007	-0.04926	-0.00874
LR	-0.0857079*	0.0240233	-3.57	0.001	-0.13484	-0.03657
FHP	0.0753251*	0.0243366	3.10	0.004	0.025551	0.12510
AARF	0.0157571	0.0122986	1.28	0.210	-0.00940	0.04091
AAMAXT	-0.1446674	0.2123613	-0.68	0.501	-0.57900	0.28966
AAMINT	-0.2181449**	0.0874378	-2.49	0.019	-0.39697	-0.03931
Intercept	-0.2025993	0.3076508	-0.66	0.515	-0.83182	0.42662

Source -*Estimated by Authors*

Table 4- Regression results for wheat crop with Driscoll-Kraay standard errors model

No. of Observation		360	*R-squared*		0.8654	
No. of States		12	*F-value*		988.00	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*Z*	*P > |z|*	*95% Confidence Interval*	
IA	0.206481*	0.0436951	4.73	0.000	0.11711	0.29584
TF	0.1784687*	0.0426504	4.18	0.000	0.09124	0.26570
AL	0.0490914*	0.0210147	2.34	0.027	0.00611	0.09207
TT	-0.0159599	0.0172236	-0.93	0.362	-0.05119	0.01927
PS	-0.3016264*	0.0250683	-12.03	0.000	-0.35290	-0.25036
FA	-0.1213848*	0.0178535	-6.80	0.000	-0.15790	-0.08487
LR	0.0869473*	0.0281314	3.09	0.004	0.02941	0.14448
FHP	0.2518352*	0.0225872	11.15	0.000	0.20564	0.29803
AARF	0.0174774	0.0128887	1.36	0.186	-0.00888	0.04384
AAMAXT	2.717306	0.5074972	5.35	0.000	1.67936	3.75525
AAMINT	-1.730916*	0.2716718	-6.37	0.000	-2.28655	-1.17528
Intercept	-1.851947*	0.4346581	-4.26	0.000	-2.74092	-0.96297

Source -*Estimated by Authors*

Table 5- Regression results for maize crop with Driscoll-Kraay standard errors model

No. of Observation		390	*R-squared*		0.5257	
No. of States		13	*F-Value*		369.40	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*Z*	*P > |z|*	*95% Confidence Interval*	
IA	-0.030496	0.0196704	-1.55	0.132	-0.07073	0.00973
TF	0.4396549*	0.0594778	7.39	0.000	0.31801	0.56130
AL	-0.3548917*	0.0501822	-7.07	0.000	-0.45753	-0.25226
TT	-0.0379894	0.0307021	-1.24	0.226	-0.10078	0.02480
PS	-0.0046028	0.0297046	-0.15	0.878	-0.06536	0.05615
FA	0.1125156*	0.0181873	6.19	0.000	0.075319	0.14971
LR	-0.201911*	0.0565668	-3.57	0.001	-0.31760	-0.08622
FHP	0.3842181*	0.0400673	9.59	0.000	0.30227	0.46616
AARF	-0.1656763*	0.0355722	-4.66	0.000	-0.23843	-0.09292
AAMAXT	-2.734031*	0.6257312	-4.37	0.000	-4.01380	-1.45427
AAMINT	-0.3209142	0.6777304	-0.47	0.639	-1.70703	1.06520
Intercept	5.756559*	0.7232683	7.96	0.000	4.27731	7.23581

Source -*Estimated by Authors*

Table 6 -Regression results for bajra crop with Driscoll-Kraay standard errors model

No. of Observation		390	*R-squared*		0.4148	
No. of States		13	*F-Value*		77.49	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.2326374*	0.0261966	8.88	0.000	0.17906	0.28622
TF	-0.0366419	0.0577958	-0.63	0.531	-0.15485	0.08156
AL	-0.0953908*	0.0334281	-2.85	0.008	-0.16376	-0.02702
TT	0.0100231	0.0402272	0.25	0.805	-0.07225	0.09230
PS	0.0082368	0.0195297	0.42	0.676	-0.03171	0.04818
FA	-0.0272639	0.0177016	-1.54	0.134	-0.06347	0.00894
LR	-0.02843	0.0267766	-1.06	0.297	-0.08319	0.02633
FHP	0.2689615*	0.055847	4.82	0.000	0.15474	0.38318
AARF	0.1410577*	0.067507	2.09	0.046	0.00299	0.27913
AAMAXT	-0.17002***	0.5899427	-0.29	0.075	-1.37659	1.03655
AAMINT	-0.1565812	0.3676491	-0.43	0.673	-0.90851	0.59535
Intercept	-0.4802868	0.6296734	-0.76	0.452	-1.76811	0.80754

Source -*Estimated by Authors*

Table 7-Regression results for Jowar (Sorghum) crop with Driscoll-Kraay standard errors model

No. of Observation		360	*R-squared*		0.5346	
No. of States		12	*F-value*		235.82	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.040406**	0.0152033	2.66	0.013	0.00931	0.07150
TF	0.07268***	0.0404073	1.80	0.082	-0.00996	0.15533
AL	-0.07125***	0.0396871	-1.80	0.083	-0.15242	0.00992
TT	-0.0102297	0.0301409	-0.34	0.737	-0.07187	0.05142
PS	0.129355**	0.0473249	2.73	0.011	0.03256	0.22614
FA	0.2119613*	0.0262075	8.09	0.000	0.15836	0.26556
LR	-0.3899554*	0.0442574	-8.81	0.000	-0.48047	-0.29944
FHP	0.1259395*	0.0411028	3.06	0.005	0.04187	0.21000
AARF	0.159045**	0.0601684	2.64	0.013	0.03599	0.28210
AAMAXT	-0.92749***	0.6156351	-1.51	0.063	-2.18660	0.33163
AAMINT	0.759374**	0.3093329	2.45	0.020	0.12672	1.39203
Intercept	-1.094372	0.9070423	-1.21	0.237	-2.94948	0.76074

Source -*Estimated by Authors*

Table 8- Regression results for ragi crop with Driscoll-Kraay standard errors model

No. of Observation		270	*R-squared*		0.7866	
No. of States		9	*F-value*		786.78	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*Z*	*P > |z|*	*95% Confidence Interval*	
IA	-0.02705**	0.0121208	-2.23	0.034	-0.05183	-0.00226
TF	0.4474094*	0.0465391	9.61	0.000	0.35222	0.54259
AL	-.00072763	0.0258639	-0.28	0.780	-0.06017	0.04562
TT	-0.085340*	0.030848	-2.77	0.010	-0.14843	-0.02224
PS	-0.0005272	0.025179	-0.02	0.983	-0.05202	0.05097
FA	-0.252833*	0.0651961	-3.88	0.001	-0.38617	-0.11949
LR	0.0541629	0.0440707	1.23	0.229	-0.03597	0.14430
FHP	-0.0280944	0.0419852	-0.67	0.509	-0.11396	0.05778
AARF	-0.0835979	0.0849185	-0.98	0.333	-0.25727	0.09008
AAMAXT	-0.8214893	0.6669696	-1.23	0.228	-2.18559	0.54262
AAMINT	0.5838598	0.5758221	1.01	0.319	-0.59383	1.76155
Intercept	1.049845	0.6625732	1.58	0.124	-0.30523	2.40496

Source -*Estimated by Authors*

Table 9- Regression results for barley crop with Driscoll-Kraay standard errors model

No. of Observation		240	*R-squared*		0.7821	
No. of States		8	*F-value*		60.71	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.0373362	0.0375605	0.99	0.328	-0.03948	0.11416
TF	0.1174811*	0.0390973	3.00	0.005	0.03752	0.19744
AL	0.0487923**	0.0186585	2.62	0.014	0.01063	0.08695
TT	0.0104204	0.0077486	1.34	0.189	-0.00543	0.02627
PS	0.1011199*	0.0260917	3.88	0.001	0.04776	0.15448
FA	-0.1800224*	0.0276527	-6.51	0.000	-0.23658	-0.12347
LR	0.0053756	0.0273987	0.20	0.846	-0.05066	0.06141
FHP	0.0019455	0.0376715	0.05	0.959	-0.07510	0.07899
AARF	-0.058164**	0.0235834	-2.47	0.020	-0.10640	-0.00993
AAMAXT	-0.76733***	0.6046091	-1.27	0.074	-2.00390	0.46924
AAMINT	-0.2189489	0.1564612	-1.40	0.172	-0.53895	0.10105
Intercept	1.154381***	0.6759865	1.71	0.098	-0.22817	2.53693

Source -*Estimated by Authors*

Appendix B-Regression results for non-food grain crops

Table 10- Regression results for sugarcane crop with Driscoll-Kraay standard errors model

No. of Observation		390	*R-squared*		0.5441	
No. of States		13	*F-value*		262.77	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	-0.0416909	0.025632	-1.63	0.115	-0.09411	0.01073
TF	0.081517*	0.0356784	2.28	0.030	0.00855	0.15449
AL	-0.1257564*	0.0262176	-4.80	0.000	-0.17938	-0.07214
TT	-0.1092452*	0.0284703	-3.84	0.001	-0.16747	-0.05102
PS	0.0258532	0.0159276	1.62	0.115	-0.00672	0.05843
FA	0.0238193	0.023417	1.02	0.317	-0.02407	0.07171
LR	0 .2907052*	0.0537077	5.41	0.000	0.18086	0.40055
FHP	0.1204568*	0.0357353	3.37	0.002	0.04737	0.19354
AARF	-0.106407**	0.042762	-2.49	0.019	-0.19387	-0.01895
AAMAXT	-1.620821*	0.5760802	-2.81	0.009	-2.79904	-0.44260
AAMINT	1.020454*	0.4344123	2.35	0.026	0.13198	1.90893
Intercept	3.842093*	0.4670358	8.23	0.000	2.88690	4.79729

Source -*Estimated by Authors*

Table 11- Regression results for potatoes crop with Driscoll-Kraay standard errors model

No. of Observation		390	*R-squared*		0.3813	
No. of States		13	*F-value*		90.94	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.0370261	0.1186376	0.31	0.757	-0.20562	0.27967
TF	0.154175	0.1232394	1.25	0.221	-0.09788	0.40623
AL	-0.0248255	0.0331489	-0.75	0.460	-0.09262	0.04297
TT	-0.104405**	0.0422106	-2.47	0.019	-0.19074	-0.01807
PS	-0.0098854	0.023478	-0.42	0.677	-0.05790	0.03813
FA	-0.0764277*	0.0158792	-4.81	0.000	-0.10890	-0.04395
LR	0.1797079*	0.0648681	2.77	0.010	0.04704	0.31238
FHP	0.1048024*	0.0282109	3.71	0.001	0.04710	0.16250
AARF	0.0060348	0.0156122	0.39	0.702	-0.02590	0.03797
AAMAXT	0.4911615	0.8391117	0.59	0.563	-1.22502	2.20734
AAMINT	-0.475895**	0.2907503	-1.64	0.012	-1.07055	0.11876
Intercept	1.199881	0.7868864	1.52	0.138	-0.40948	2.80924

Source -*Estimated by Authors*

Table 12- Regression results for cotton crop with Driscoll-Kraay standard errors model

No. of Observation		360	*R-squared*		0.4288	
No. of States		12	*F-value*		126.78	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.1425529*	0.0319997	4.45	0.000	0.07711	0.20800
TF	0.1822216*	0.0501753	3.63	0.001	0.07960	0.28484
AL	0.0602017	0.0705416	0.85	0.400	-0.08407	0.20448
TT	-0.1290043*	0.0458809	-2.81	0.009	-0.22284	-0.03517
PS	-0.1151975*	0.0506634	-2.27	0.031	-0.21882	-0.01158
FA	-0.2787205*	0.051164	-5.45	0.000	-0.38336	-0.17408
LR	0.2416903*	0.0550391	4.39	0.000	0.12912	0.35426
FHP	0.1443817**	0.0650426	2.22	0.034	0.01135	0.27741
AARF	0.0618751	0.068733	0.90	0.375	-0.07870	0.20245
AAMAXT	-1.539945**	0.9943919	-1.55	0.032	-3.57371	0.49381
AAMINT	2.065035**	0.8862831	2.33	0.027	0.25238	3.87769
Intercept	-.29994	1.225973	-0.24	0.808	-2.80734	2.20746

Source -*Estimated by Authors*

Table 13- Regression results for groundnut crop with Driscoll-Kraay standard errors model

No. of Observation		360	*R-squared*		0.1928	
No. of States		12	*F-value*		55.60	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.0218522	0.0164781	1.33	0.195	-0.01185	0.05555
TF	0.0271069	0.0798503	0.34	0.737	-0.13621	0.19042
AL	-0.0182489	0.0366292	-0.50	0.622	-0.09316	0.05667
TT	-0.094740**	0.0384931	-2.46	0.020	-0.17347	-0.01601
PS	0.0090967	0.0310582	0.29	0.772	-0.05442	0.07262
FA	-0.0259163	0.0327855	-0.79	0.436	-0.09297	0.04114
LR	0.096716***	0.049034	1.97	0.058	-0.00357	0.19700
FHP	0.1916712*	0.0372836	5.14	0.000	0.11542	0.26792
AARF	0.0159407	0.0298441	0.53	0.597	-0.04510	0.07698
AAMAXT	-0.3180023	0.3464092	-0.92	0.366	-1.02649	0.39048
AAMINT	-0.2826171	0.2369912	-1.19	0.243	-0.76732	0.20208
Intercept	0.7025546	0.4709308	1.49	0.147	-0.26061	1.66572

Source -*Estimated by Authors*

Table 14- Regression results for sesamum crop with Driscoll-Kraay standard errors model

No. of Observation		390	*R-squared*		0.4598	
No. of States		13	*F-value*		148.26	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.0183914	0.0150889	1.22	0.233	-0.01247	0.04925
TF	0.1717619**	0.0676098	2.54	0.017	0.03348	0.31004
AL	-0.074132**	0.0347991	-2.13	0.042	-0.14530	-0.00296
TT	-0.114871**	0.0423935	-2.71	0.011	-0.20156	-0.02817
PS	-0.101454**	0.0387524	-2.62	0.014	-0.18072	-0.02220
FA	-0.1854527*	0.0364064	-5.09	0.000	-0.25991	-0.11100
LR	0.2873567*	0.0923061	3.11	0.004	0.09857	0.476140
FHP	0.2587821*	0.0535329	4.83	0.000	0.14930	0.36827
AARF	0.2481689*	0.0648608	3.83	0.001	0.11551	0.38082
AAMAXT	-2.332888*	0.6805483	-3.43	0.002	-3.72477	-0.94101
AAMINT	0.7107594	0.86408	0.82	0.417	-1.05648	2.47801
Intercept	1.967681*	0.7309543	2.69	0.012	0.47271	3.46261

Source -*Estimated by Authors*

Table 15- Regression results for linseed crop with Driscoll-Kraay standard errors model

No. of Observation		300	*R-squared*		0.4142	
No. of States		10	*F-value*		69.55	
No. of Obs./States		30	*Prob > chi2*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	0.078810***	0.0431958	1.82	0.078	-0.00953	0.16716
TF	-0.0889485	0.1008531	-0.88	0.385	-0.29521	0.11732
AL	0.1756394**	0.0666443	2.64	0.013	0.03933	0.31194
TT	0.0570584	0.0630239	0.91	0.373	-0.07184	0.18596
PS	-0.2564433*	0.0509993	-5.03	0.000	-0.36075	-0.15214
FA	-0.173508*	0.0436117	-3.98	0.000	-0.26270	-0.08431
LR	0.2009721**	0.0952744	2.11	0.044	0.00611	0.39583
FHP	0.1951049	0.0435533	4.48	0.000	0.10609	0.28418
AARF	-.0050405	0.0224328	-0.22	0.824	-0.05092	0.04084
AAMAXT	3.779256*	0.7978699	4.74	0.000	2.14743	5.41108
AAMINT	-1.64148*	0.3720489	-4.41	0.000	-2.40241	-0.88055
Intercept	-4.275654*	0.9448337	-4.53	0.000	-6.20806	-2.34325

Source -*Estimated by Authors*

Table 16- Regression results for soybeans crop with Driscoll-Kraay standard errors model

No. of Observation		90	*R-squared*		0.3220	
No. of States		3	*F-value*		43.62	
No. of Obs./States		30	*Prob > F*		0.0000	
Variable	*Reg. Coefficient*	*Panel Corr. Std. Errors*	*z*	*P > |z|*	*95% Confidence Interval*	
IA	-0.2553091*	0.0561162	-4.55	0.000	-0.37008	-0.14054
TF	0.0668923	0.0581595	1.15	0.259	-0.05206	0.185849
AL	0.0297998	0.0873357	0.34	0.735	-0.14882	0.20842
TT	0.0767545	0.0884415	0.87	0.393	-0.10413	0.25764
PS	-0.189086*	0.0675718	-2.80	0.009	-0.32729	-0.05089
FA	0.825836*	0.2497227	3.31	0.003	0.31510	1.33658
LR	1.259613***	0.7000055	1.80	0.082	-0.17206	2.69129
FHP	-0.0247732	0.1885735	-0.13	0.896	-0.41045	0.36090
AARF	-0.2462659*	0.0862053	-2.86	0.008	-0.42258	-0.06996
AAMAXT	6.430912	4.848943	1.33	0.195	-3.48629	16.34811
AAMINT	-0.4681562	2.538114	-0.18	0.855	-5.65918	4.72287
Intercept	-13.25003**	5.604349	-2.36	0.025	-24.71221	-1.78785

Source -*Estimated by Authors*

Table 17 -Expected effects of climatic factors on various crops due to 1% variation in climatic variables

Variable	*AARF*	*AAMAXT*	*AAMINT*
Rice	NS	-2.64%	NS
Arhar	+0.17%	NS	-0.78%
Gram	NS	NS	-0.22%
Wheat	NS	NS	-1.73%
Maize	-0.17%	-2.73%	NS
Bajra	+0.14%	-017%	NS
Sorghum (Jowar)	+0.16%	-0.93%	+0.76%
Ragi	NS	NS	NS
Barley	-0.60	-0.77%	NS
Sugarcane	-0.11	-1.62%	+1.02%
Potatoes	NS	NS	-0.48%
Cotton	NS	-1.54%	+2.07%
Groundnut	NS	NS	NS
Sesamum	+0.25	-2.33%	NS
Linseed	NS	+3.78%	-1.64%
Soyabeans	-0.25%	NS	NS

Source -*Estimated by Authors; and NS- indicates that regression coefficient was not significant for respective crop*