Impact of climate change on agricultural productivity and food security in India: A State level analysis

Sanjeev Kumar* and Sanjay Kumar Upadhyay

Department of Economics,
University of Lucknow, Lucknow-226 007, Uttar Pradesh, India.
Received: 22-09-2018 Accepted: 06-02-2019 DOI: 10.18805/IJARe.A-5134

ABSTRACT

This paper has analysed the emerging dimensions of food security and trends of crop productivity by using secondary data from 1980-81 to 2014-15 at State level of India and has also identified the impact of climatic and non-climatic variables on food security and crop productivity. The study revealed that the growth rate of foodgrains and non-foodgrains productivity was found positive except for some crops of non-foodgrains at state level with some fluctuations. In case of food security and its component, the result showed that there were wide variations across the states during the study period. The panel data regression results also highlighted that the non-climatic factors had positive and significant impact on food security except urbanization while climatic factors viz., maximum temperature had negative and significant impact and minimum temperature and rainfall had insignificant impact on food security. Furthermore, the impact of climatic and non-climatic factors had a mixed effect on crop productivity. The paper suggested that there was need to change the policy in term of building sustainable climate resilient technology, enhancing the agricultural infrastructure and optimizing use of inputs for boosting up the crop productivity and increasing public-private partnerships for sustainable development to solve the problems of food and nutrition at state level.

Key words: Climatic change, Crop productivity, Food security.

JEL Classification: Q15, Q18, Q54

INTRODUCTION

Climate change is a critical issue in the context of Indian economy. More than 60 per cent of agricultural land depends on monsoon. Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in the view of high population depending on agriculture and excessive pressure on natural resources. Climatic variables are influencing the growth of agriculture sector as well as food security in different States of the country. The fluctuations in the predictability of weather and climate are making farm operation more difficult in the country. Change in the climatic factors are causing drying of rivers, loss in biodiversity, declining of water resource, falling of ground water table, decreasing agricultural productivity, and influencing the socio-economic conditions of the human society. On the other hand, the high rainfall situations are also causing declining agricultural land, agricultural productivity, and affecting in human health affecting labour productivity in agriculture, loss of biodiversity, and socio-economic conditions of the human society. The warming trend in India over the past 100 years (1901 to 2007) was observed to be 0.5°C with accelerated warming of 0.2°C every ten years since 1970 (Kumar, 2009). The production of major crops of wheat, rice, sugarcane, cotton and oilseeds increased due to adoption of high-tech agricultural practices (Panwar and Dimri, 2018).

Climate change has an economic impact on agriculture as well, including changes in crop productivity, profitability and value of output from agriculture. The magnitude and geographical distribution of such climate-induced changes may affect our ability to expand the food production as required to feed the populace. Climate change could thus have far-reaching effects on the patterns of trade among nations, development and food security (Goswami and Chatterjee, 2010). Farming experience and access to credit are the vital factors determining adaptation of climatic variability and improve agricultural productivity (Chukwukere et al. 2011). Declining agricultural productivity is associated with the climatic variability. There is a need to focus on research and technologies which increase crop and livestock productivity (Kaur and Kaur, 2017). It is clear that climate change negatively affect the all three dimensions of food security i.e. food availability, stability, and accessibility (Khan and Hasan, 2017). Climatic variations such as occurrences of drought have high level of impact on the yield of rain fed crops. If the temperatures rises 28°C to 32°C results in significant decrease wheat productivity by 20 percent or more (Kumar and Priyanka, 2017). The annual
rainfall had significant effect on rice productivity and temperature was significant for maize and groundnut crops (Chakraborty and Hazari, 2017).

The variability in agricultural development arises due to vast regional diversities in agro-climatic environment, resource endowment, and growth of the population among various regions of the country. The regional disparities in agricultural productivity arises due to differential resource endowment in terms of soil fertility, land pattern, average annual rainfall, irrigation, varying levels of investment in rural infrastructure, technological innovations and climatic variability different regions/ states of the country (Raman and Kumari, 2012). The trends of food insecurity is high in poor states (Panday, 2015). The diversity and regional disparity has widened over the years and significantly across the economy at State level. Therefore, it is very important to think over disparity in agricultural productivity, climate change and food security across different States. The regional disparities in agricultural productivity arises due to differential resource endowment in terms of soil fertility, land pattern, average annual rainfall, irrigation, varying levels of investment in rural infrastructure, technological innovations and climatic variability different regions/ states of the country (Raman and Kumari, 2012). The trends of food insecurity is high in poor states (Panday, 2015). The diversity and regional disparity has widened over the years and significantly across the economy at State level. Therefore, it is very important to think over disparity in agricultural productivity, climate change and food security across different States. Therefore, it is very important to think over disparity in agricultural productivity, climate change and food security across different States.

The main objectives of the present paper are (i) to analyse the emerging trends of productivity and dimensions of food security at State level, (ii) to determine the impact of climatic and non-climatic variables on food security and crop productivity at State level; and (iii) to suggest the policy implications to enhance the level of food security as well as crop productivity in India at State level.

MATERIALS AND METHODS

Climate change and food security are important aspects for socio-economic development at State level. To calculate the Food Security Index (FSI) and its components index, viz., Food Availability Index (FAI), Index of Food Stability (IFS) and Index of Food Accessibility (IFA), the technique of Z-score has been used [http://www.foodsecurityindex.eiu.com/]. If the parameters/indicators are favorable for food security and its components, the following formulae has been used to estimate the Z-score (As used by Shakeel et al., 2012, and Rukhsana, 2011) for various indicators of food security and its components;

\[ CI_i = \frac{(x_i - \text{Min}(x))}{\text{Max}(x) - \text{Min}(x)} \]

Where CI is composite Z-score (Z-index); \text{Min}(x) and \text{Max}(x) are lowest and highest value in each indicators/parameters during the study period for food security or its components. If the parameters are unfavorable for food security and its components the following formulae has been used to estimates the Z-score;

\[ CI_i = \frac{(x_i - \text{Max}(x))}{\text{Max}(x) - \text{Min}(x)} \]

With the help of composite Z-score (CI), we have calculated Food Availability Index (FAI), Index of Food Stability (IFS) and Index of Food Accessibility (IFA) with their respective indicators/parameters in the following manners;

\[ \text{FAI or IFS or IFA} = \frac{\sum CI_i}{n} \]

Finally, Food Security Index (FSI) is based on the simple average of food availability, food stability and food accessibility Z-score and it was calculated by;

\[ \text{FSI} = \frac{\text{FAI} + \text{IFS} + \text{IFA}}{n = 3} \]

Where FSI is Food Security Index, \( CI_i \) is the Composite Z-value of the components of food security, i.e., food availability, food stability and food accessibility and n is the number of components of food security. The indicators of food security and its components can be explained with the help of Fig 1.

The impact of climatic variables is worldwide in term of influencing agricultural productivity, bio-diversity and food security at State level. Climatic variables i.e. rainfall, minimum and maximum and temperature have been directly related to agriculture sector and food security of the nation. The impact of climatic factors and non-climatic factors on major foodgrain crops productivity, as well as...
non-foodgrain crops productivity and food security index, has been estimated by following panel data multiple regression equations during the study period 1980-81 to 2014-15.

\[
\text{CSP}_{it} = \beta_0 + \beta_1 (\text{RAIN})_t + \beta_2 (\text{MINT})_t + \beta_3 (\text{MAXT})_t + \beta_4 (\text{FERC})_t + \beta_5 (\text{GIA/NSA})_t + \beta_6 (\text{FAGSA})_t + \beta_7 (\text{CI})_t + \beta_8 (\text{RL})_t + \beta_9 (\text{PD})_t + \beta_{10} (\text{LR})_t + \beta_{11} (UR)_t + \text{Ui}
\]

Whereas: CSP is Crop Specific / Crop Sector Productivity; \( i = \text{State}, \ t = \text{time} \), RAIN, MINT and MAXT are average annual rainfall, average annual minimum temperature and average annual maximum temperature respectively. FERC, GIA/NSA, CI, FAGSA, RL, PD, LR, and UR are per hectare consumption of fertilizers, ratio of gross irrigated area to net sown area, cropping intensity, ratio of forest area to gross sown area, road length per thousand population, population density, literacy rate, and urbanization respectively. \( \beta_0 \) is constant coefficient term, \( \beta_1 \) to \( \beta_{11} \) are regression coefficient for respective independent variables and Ui is stochastic error term. To remove the problem of multicollinearity, all variables such as dependent and independent variables has been transformed.

The present research paper is based on secondary data such as Indian Metrological Department (IMD), Department of Food and Public Distribution System, Economic Survey, National Accounts Statistics prepared by the Central Statistical Organization (CSO), Ministry of Statistics and Program Implementation, Government of India, Agricultural Statistics at a Glance prepared by Directorate of Economics and Statistics, Ministry of Agriculture, Handbook of Statistics of Indian Economy Prepared by Department of Agriculture and Cooperation Network (DACNET).

TRENDS OF FOODGRAIN AND NON-FOODGRAIN CROPS PRODUCTIVITY

The performance of agricultural productivity in the country depends on its constituent States. But the features in term of land holdings, irrigation inputs, soil nutrients, financial services, climatic variability and access to modern technology are diverse in the different States of India. As results, a variety of crops are grown in the States of the country. It is found that the production of foodgrain was 198.40 million tonnes in 2004-05 and increased to 265.04 million tonnes in 2014-15. The deficient rainfall during pre-monsoon rains and post-monsoon rains affected the production of both kharif and rabi crops. The share of foodgrain production at the State level presents a very different picture across the States. The high-level production of foodgrain is very important for national food security. The top ten foodgrain producing States in India during 2014-15 are shown in Fig 2. It is observed that due to the various climatic regions, there are sharp disparities in foodgrain production among the States during 2014-15.

Productivity plays an important role in increasing foodgrain production at State and national level. At State level, there is widespread regional variations in crop productivity of foodgrain. Table 1 shows the State level Compound Annual Growth Rate (CAGR) of foodgrain productivity/yield during 1980-81 to 2014-15 and its sub periods. The study period are also divided in three sub phases, i.e., first phase from 1980-81 to 1989-90 (mature green revolution), second phase from 1990-91 to 1999-00 (early economic reforms) and third phase from 2000-01 to 2014-15 (economic reforms). It is found that the CAGR of foodgrain productivity
productivity was highest in Rajasthan followed by Andhra Pradesh, Gujarat, Haryana, Karnataka, West Bengal, Madhya Pradesh and Bihar during the study period. On the other hand, the other States such as Kerala, Assam, Maharashtra, Uttar Pradesh, Himachal Pradesh, Orissa, Tamil Nadu and Punjab have the foodgrain productivity growth rate lower than the national average. The growth rate of foodgrain was positive in all the States. Gujarat remained negative during the mature green revolution period. Overall, from the above analysis, the results reveal that productivity of foodgrain grew at a positive rate but fluctuating trends noticed across the States and study periods.

The State wise foodgrain productivity levels are presented with the help of Fig 3 during the study period. The State level growth trends of foodgrain productivity during the study period are divided into three categories, namely, high foodgrain productivity States (CAGR >2.50), moderate foodgrain productivity States (CAGR: 1.90 to 2.50) and low foodgrain productivity States (CAGR <1.89). The Fig shows that there are very sharp variations in the foodgrain productivity levels across the States in India during the study period.

Non-Foodgrain Crops: The trends of CAGR of major non-foodgrain crops productivity, i.e., sugarcane, oilseeds and cotton at States level are presented in Table 2. The results reveal that sugarcane grew at positive rate in all the States except Andhra Pradesh, Himachal Pradesh, Kerala and Maharashtra during mature green revolution period. In case

| State           | 1980-81 to 1989-90 | 1990-91 to 1999-00 | 2000-01 to 2014-15 | 1980-81 to 2014-15 |
|-----------------|--------------------|--------------------|--------------------|--------------------|
| Andhra Pradesh  | 1.73               | 3.73               | 2.29               | 2.70               |
| Assam           | 0.49               | 1.11               | 2.65               | 1.81               |
| Bihar           | 3.06               | 3.56               | 2.29               | 2.14               |
| Gujarat         | -1.87              | 4.37               | 4.73               | 2.69               |
| Haryana         | 4.84               | 2.09               | 1.60               | 2.63               |
| Himachal Pradesh| 0.63               | 1.36               | 1.22               | 1.34               |
| Karnataka       | 0.34               | 3.69               | 2.76               | 2.40               |
| Kerala          | 0.85               | -1.52              | 2.09               | 1.64               |
| Madhya Pradesh  | 1.67               | 2.74               | 3.90               | 2.28               |
| Maharashtra     | 0.61               | 2.29               | 2.64               | 1.58               |
| Orissa          | 1.14               | 0.93               | 3.42               | 1.98               |
| Punjab          | 2.90               | 1.48               | 0.73               | 1.44               |
| Rajasthan       | 0.99               | 4.70               | 3.13               | 2.86               |
| Tamil Nadu      | 2.64               | 1.86               | 2.53               | 1.81               |
| Uttar Pradesh   | 3.19               | 2.76               | 1.08               | 1.90               |
| West Bengal     | 5.01               | 2.38               | 1.17               | 2.37               |
| All India       | 2.97               | 2.18               | 2.11               | 2.06               |

Source: Directorate of Economics and Statistics, Department of Agriculture, Co-operation and Farmer’s Welfare, Ministry of Agriculture and Farmer’s Welfare, Government of India.

The State wise foodgrain productivity levels are presented with the help of Fig 3 during the study period.
of early economic reforms period (1990-91 to 1999-00), sugarcane has shown positive trend among all the States except Bihar, Gujarat and Rajasthan. On the other hand, sugarcane grew at a positive rate in major States rather than Gujarat during 2000-01 to 2014-15. Regarding entire study period, i.e., from 1980-81 to 2014-15, sugarcane grew at positive rate in Andhra Pradesh, Bihar, Haryana, Himachal Pradesh, Karnataka Kerala, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal, while in Assam, Gujarat, Maharashtra, and Orissa it was found negative and insignificant in the same period of the study. At National level, sugarcane grew at 1.21 per cent per annum in mature green revolution period, decreased to 1.05 per cent in early economic reform period, 0.69 per cent in economic reform period and become 0.56 per cent per annum during the study period.

With respect to the oilseeds productivity, the CAGR showed positive trend in most of the selected States of the study except during the study period. At National level, the growth rate of oilseeds was 2.01 per cent during the same period. It is also found that oilseeds grew at mixed rate and fluctuated during mature green revolution period, early economic reform period and economic reform period. The performance of oilseeds productivity sharply declined during 1990-91 to 1999-2000 as compared to 1980-81 to 1989-1990 in all selected States except Himachal Pradesh, Karnataka, Kerala and Maharashtra. Considering cotton productivity, the CAGR was 3.46 per cent per annum during the study period at National level. At State level, it increased in case of selected States except Bihar and Kerala during the study period. The growth rate of cotton productivity shows that there are sharp variations at inter States-level as well as sub-period level of study. In Karnataka, Madhya Pradesh, Maharashtra, Orissa and Tamil Nadu, positive growth rate of cotton productivity noticed during the study period as well as in all its sub-periods. From the above analysis, it is observed that the growth rate of non-foodgrain crops i.e. sugarcane, oilseeds and cotton fluctuated with mixed trends at States level during the study period and in all its sub-phases. However, widespread variations in terms of growth rate of non-foodgrain crops are the major concern. At present, non-foodgrain is also very important for food and nutrition security at State level and National level. So, policy makers should emphasize on these crops to sustain growth rate of non-foodgrain productivity.

### STATE LEVEL TRENDS OF FOOD SECURITY AND ITS COMPONENTS INDEX

Food security requires that all people at all times have both physical and economic access to basic food. Recently, food security has become the great challenge in the major States of the country due to the variations in agricultural condition across them. Food availability is one dimension of the food security which means having enough food for the entire population at all times and to sustain human life. The trends of Food Availability Index (FAI), Index of Food Stability (IFS), Index of Food Accessibility (IFA) and Food Security Index (FSI) at States level are presented in Table 3 during 1980-81 and 2014-15. It is found that States like Punjab and Haryana occupied the top rank whereas Kerala had lowest rank in term of FAI during the economic reform period and economic reform period. The CAGR was 3.46 per cent per annum during the study period. The growth rate of cotton productivity shows that there are sharp variations at inter States-level as well as sub-period level of study. In Karnataka, Madhya Pradesh, Maharashtra, Orissa and Tamil Nadu, positive growth rate of cotton productivity noticed during the study period as well as in all its sub-periods. From the above analysis, it is observed that the growth rate of non-foodgrain crops i.e. sugarcane, oilseeds and cotton fluctuated with mixed trends at States level during the study period and in all its sub-phases. However, widespread variations in terms of growth rate of non-foodgrain crops are the major concern. At present, non-foodgrain is also very important for food and nutrition security at State level and National level. So, policy makers should emphasize on these crops to sustain growth rate of non-foodgrain productivity.

### Table 2: Trends of productivity (Yield) of major non-foodgrain crops at states level in India.

| State                | 1980-81 to 1989-90 | 1990-91 to 1999-00 | 2000-01 to 2014-15 | 1980-81 to 2014-15 |
|----------------------|--------------------|--------------------|--------------------|--------------------|
| Sugar cane | Oil seeds | Sugar cane | Oil seeds | Sugar cane | Oil seeds | Sugar cane | Oil seeds |
| Andhra Pradesh | -1.6 | 2.77 | -5.1 | 0.91 | -2.32 | -2.33 | 0.03 | -0.08 | 4.87 | 0.28 | 0.17 | 2.17 |
| Assam     | 1.16 | 0.01 | -0.21 | 0.12 | -1.08 | 0.65 | 0 | 1.72 | -1.55 | -0.54 | 0.56 | 0.56 |
| Bihar     | 4.55 | 2.88 | 2.53 | -0.93 | 2.4 | 2.53 | 1.77 | 2.54 | -0.36 | 1.02 | 2.75 | -0.34 |
| Gujarat   | 3.88 | -0.81 | -1.68 | -3.04 | 4.38 | -4.09 | -0.15 | 5.54 | 11.05 | -0.09 | 2.81 | 4.36 |
| Haryana   | 2.33 | 6.26 | 1.12 | 0.41 | -0.31 | -3.35 | 2.16 | 1.83 | 6.2 | 1.78 | 2.34 | 2.22 |
| Himachal Pradesh | -6.35 | -3.74 | -9.51 | 12.48 | 8.2 | -0.64 | 0.67 | -0.79 | 1.81 | 2.26 | 2.65 | 2.76 |
| Karnataka | 0.34 | 0.57 | 12.25 | 2.27 | 1.11 | 0.99 | 0.57 | 1.64 | 8.12 | 0.34 | 0.24 | 3.44 |
| Kerela    | -1.74 | -1.26 | 0.35 | 3.68 | 3.36 | 0.41 | 1.34 | 4.97 | -1.25 | 1.57 | 2.36 | -0.66 |
| Madhya Pradesh | 3.3 | 5.51 | 3.64 | 3.26 | 3.05 | 5.9 | 1.77 | 2.86 | 14.4 | 1.11 | 2.77 | 5.54 |
| Maharashtra | -1.4 | 0.75 | 3.2 | 0.9 | 5.13 | 3.76 | 1.03 | 1.34 | 7.78 | -0.51 | 2.52 | 4.63 |
| Orissa    | 0.81 | 1.38 | 4.48 | -0.94 | -5.42 | 6.96 | 1.41 | 4.26 | 6.14 | -0.08 | -0.77 | 3.76 |
| Punjab    | 0.65 | 2.97 | 9 | 0.12 | -0.34 | -9.35 | 1.4 | 2.57 | 8.33 | 0.29 | 1.38 | 2.27 |
| Rajasthan | 0.98 | 7.01 | 4.84 | -0.78 | 2.27 | -2.92 | 3.99 | 2.52 | 9.79 | 1.66 | 2.89 | 2.08 |
| Tamil Nadu | 1.33 | 2.33 | 5.85 | 0.48 | 1.06 | 0.04 | 0.51 | 3.78 | 7.69 | 0.14 | 2.82 | 1.87 |
| Uttar Pradesh | 1.81 | 4.4 | 3.44 | 0.77 | -0.41 | -10.99 | 0.51 | -0.37 | 0.32 | 0.70 | 1.83 | 0.32 |
| West Bengal | 2.28 | 7.5 | 4.43 | 3 | -0.53 | -2.83 | 3.45 | 2.08 | -2.39 | 1.69 | 2.07 | 1.44 |
| All India | 1.21 | 2.95 | 4.1 | 1.05 | 2.01 | -0.4 | 0.69 | 2.62 | 7.54 | 0.56 | 2.01 | 3.46 |

Source: Directorate of Economics and Statistics, Department of Agriculture, Co-operation and Farmer’s Welfare, Ministry of Agriculture and Farmer’s Welfare, Government of India.
study period. Food Stability Index of all States has increased from 0.157 in 1980-81 to 0.242 in 2014-15. In 2014-15, Punjab ranked first in IFIS followed by Haryana, West Bengal and Andhra Pradesh, lowest being Rajasthan. Access to adequate food for all people at all times is defined as ‘food security (World Bank, 1986). The value of IFA of all States together increased marginally from 0.399 in 1980-81 to 0.424 in 2014-15. On the other hand, Kerala had the highest rank in term of IFA whereas Bihar occupied the lowest rank during the study period.

The category values are defined in the given map Fig 4. The State wise level of food security Z-score (Z-value/100) is divided into three broad categories, i.e. high, moderate and low level of food security in 2014-15. Punjab, Haryana and Madhya Pradesh are under the high-level food security states. On the other hand, Uttar Pradesh, Bihar, Orissa, Gujarart, Maharashtra, and Himachal Pradesh fall into low level of food security States. There are sharp disparities of food security across the States. It can be noticed that there are fluctuations and widespread variations in FSI across the

Table 3: Trends of food security index and its components of selected Indian states.

| States            | Food Availability Index | Food Stability Index | Food Accessibility Index | Food Security Index |
|-------------------|-------------------------|----------------------|--------------------------|---------------------|
|                   | 1980-81 Z-value         | 2014-15 Z-value      | 1980-81 Z-value          | 2014-15 Z-value     |
| Andhra Pradesh    | 0.398(7)                | 0.295(11)            | 0.354(4)                 | 0.383(7)            |
| Assam             | 0.296(10)               | 0.387(6)             | 0.137(11)                | 0.351(11)           |
| Bihar             | 0.238(13)               | 0.285(13)            | 0.251(7)                 | 0.262(16)           |
| Gujarat           | 0.404(5)                | 0.356(9)             | -0.020(15)               | 0.121(13)           |
| Haryana           | 0.490(3)                | 0.618(3)             | 0.472(2)                 | 0.328(14)           |
| Himachal Pradesh  | 0.341(9)                | 0.288(12)            | 0.169(10)                | 0.374(9)            |
| Karnataka         | 0.282(12)               | 0.423(5)             | 0.127(12)                | 0.444(5)            |
| Kerala            | 0.086(16)               | 0.064(16)            | 0.221(4)                 | 0.252(6)            |
| Madhya Pradesh    | 0.427(4)                | 0.643(2)             | 0.245(8)                 | 0.337(12)           |
| Maharashtra       | 0.511(2)                | 0.365(7)             | -0.018(14)               | 0.071(15)           |
| Orissa            | 0.358(8)                | 0.356(8)             | 0.111(14)                | 0.444(4)            |
| Punjab            | 0.731(1)                | 0.808(1)             | 0.617(1)                 | 0.364(10)           |
| Rajasthan         | 0.404(6)                | 0.611(4)             | -0.131(16)               | 0.043(16)           |
| Tamil Nadu        | 0.101(15)               | 0.244(14)            | 0.220(5)                 | 0.228(9)            |
| Uttar Pradesh     | 0.284(11)               | 0.236(15)            | 0.271(3)                 | 0.283(5)            |
| West Bengal       | 0.181(14)               | 0.298(10)            | 0.203(7)                 | 0.385(3)            |
| All States        | 0.346                   | 0.392                | 0.157                    | 0.242               |

Source: Estimated by Authors Calculations, parentheses shows the Ranks of States.

Source: Estimated by Authors Calculations

Fig 4: State Wise Food Security Levels in India in 2014-15.
States due to socio-economic and climatic factors. The aspects of food security and its dimensions are also analysed by (Shakeel et al., 2012). In this context, the government should raise farmer’s incomes through best utilisation of inputs, better farm practices, climatic adaptability seeds, rural entrepreneurship and infrastructure development, and new technology in different region of the States in the country.

**PANEL DATA REGRESSION RESULTS**

The panel data regression results are divided into two following sections;

**Impact of climatic and non-climatic variables on agricultural productivity of foodgrain crops:**

The regression results of foodgrain productivity and its component crops during the study period, i.e. 1980-81 to 2014-15 are presented in Table 4. The regression results highlights the factors like minimum temperature, rainfall, per hectare consumption of fertilizer, gross irrigated area, cropping intensity, road length, and literacy rate had positive and significant impact on cereals productivity whereas population density had positive but insignificant impact on cereals productivity during the study period. On the other hand, productivity of cereals has been negatively affected by maximum temperature and area under forest. In case of pulses productivity, the variables like maximum temperature, rainfall, per hectare consumption of fertilizer, cropping intensity, forest area, population density and literacy rate had positive and significant impact on productivity of pulses, whereas road length had positive but insignificant impact on productivity of pulses. On the other hand, minimum temperature had negative and statistically significant impact on productivity of pulses, whereas gross irrigated area had negative but insignificant impact on productivity of pulses. The explanation power of the model in case of pulses productivity is around 46 per cent during the study period. The State level panel data regression result regarding foodgrain productivity indicate that the factors such as per hectare consumption of fertilizers, gross irrigated area, cropping intensity, road length, population density, literacy rate, annual rainfall, and minimum temperature had positive and statistically significant impact on the foodgrain productivity during the study period. The value of R-square is very high, i.e. 81.26.

It means that the model describes more than 81 per cent variation in foodgrain productivity by the variation in climatic and non-climatic factors during the study period. In other words, the impact of climatic and non-climatic factors on foodgrain productivity was highly significant during the study period. Overall, it can be concluded that climatic and non-climatic factors affected the crops wise productivity across major States during the study period. The magnitude of F-value indicates that the given model is a good fit for foodgrain productivity and VIF value confirms that there is absence of multi-co-linearity in the regression model.

**Productivity of non-foodgrain crops:** The performance of non-foodgrain crops is directly related to climatic and non-climatic variables at State level. The results of panel data

| Table 4: Panel data regression results of productivity of foodgrain and its component crops. |
|---|
| **Independent Variables** | **Dependent Variables** |
| **Crops** | **Cereals** | **Pulses** | **Foodgrain** |
| Coefficient | t-value | P-value | Coefficient | t-value | P-value | Coefficient | t-value | P-value |
| **Climatic Variables** | | | | | | | | |
| RAIN | 0.090 | 3.090 | 0.002 | 0.088 | 2.180 | 0.030 | 0.080 | 2.740 | 0.006 |
| MINT | 0.496 | 2.930 | 0.004 | -1.262 | -5.370 | 0.000 | 0.338 | 1.990 | 0.047 |
| MAXT | -1.092 | -3.900 | 0.000 | 2.675 | 6.890 | 0.000 | -1.301 | -4.630 | 0.000 |
| **Non Climatic Variables** | | | | | | | | |
| Per Hectare Consumption of Fertilizer | 0.246 | 12.490 | 0.000 | 0.058 | 2.140 | 0.033 | 0.231 | 11.680 | 0.000 |
| Gross Irrigated Area /NSA | 0.240 | 10.700 | 0.000 | -0.026 | -0.830 | 0.408 | 0.200 | 8.900 | 0.000 |
| Cropping Intensity | 0.620 | 5.630 | 0.000 | 0.638 | 4.180 | 0.000 | 0.841 | 7.620 | 0.000 |
| Forrest Area to GSA | -0.040 | -2.870 | 0.004 | 0.040 | 2.050 | 0.041 | -0.046 | -3.320 | 0.001 |
| Road Length | 0.144 | 4.940 | 0.000 | 0.025 | 0.610 | 0.540 | 0.137 | 4.670 | 0.000 |
| Population Density | 0.013 | 0.440 | 0.659 | 0.320 | 8.030 | 0.000 | 0.088 | 3.040 | 0.002 |
| Literacy Rate | 0.228 | 4.340 | 0.000 | 0.146 | 2.010 | 0.045 | 0.242 | 4.590 | 0.000 |
| Constant | 3.038 | 2.580 | 0.010 | -5.615 | -3.440 | 0.001 | 2.837 | 2.400 | 0.017 |
| **R-Squared** | 0.7921 | | | 0.4593 | | | 0.8128 | | |
| **Adj. R-Squared** | 0.7883 | | | 0.4495 | | | 0.8128 | | |
| **F (10,549)** | 209.19 | | | 238.40 | | | | |
| **Prob > F** | =0.0000 | | | =0.0000 | | | | |
| **VIF = 3.88** | | | | | | | | |

Source: Author’s Calculation
multiple regression equation in case of non-foodgrain crop productivity is presented in Table 5. The result highlights that the factors like per hectare consumption of fertilizers, road length, literacy rate, rainfall, and minimum temperature had positive and statistically significant impact on sugarcane productivity during the study period. On the other hand, maximum temperature had negative but insignificant impact; whereas cropping intensity and area under forest had negative and significant impact on the sugarcane productivity during the study period. The value of R-square is 0.7657; which means that more than 76 per cent variation in sugarcane productivity is explained by the variation in climatic and non-climatic factors during the study period.

In case of oilseeds productivity, the factors such as gross irrigated area, literacy rate, minimum temperature, and maximum temperature had positive and statistically significant impact during the study period. Oilseeds productivity was positively affected by per hectare of consumption of fertilizers but not significant during the same period. It is also negatively affected by rainfall, road length, and population density. On the other hand, cropping intensity had negative and significant impact on oilseeds productivity during the study period. However, around 59 per cent variation in oilseeds productivity is explained by the climatic and non-climatic factors during the study period. The value of R-square is 0.7614; which means that more than 76 per cent variation in oilseeds productivity is explained by the variation in climatic and non-climatic factors during the study period.

Table 5: Regression results of non-foodgrain crops productivity.

| Independent Variables | Sugarcane | Oilses | Cotton |
|-----------------------|-----------|--------|--------|
|                       | Coefficient | t-value | P-Value | Coefficient | t-value | P-Value | Coefficient | t-value | P-value |
| Climatic Variables    |            |        |         |            |        |         |            |        |         |
| RAIN                  | 0.118      | 3.610  | 0.000   | -0.055     | -1.390 | 0.164   | 0.026      | 0.430   | 0.669   |
| MINT                  | 2.560      | 13.370 | 0.000   | 0.673      | 2.910  | 0.004   | 0.983      | 2.740   | 0.006   |
| MAXT                  | -0.338     | -1.070 | 0.287   | 0.904      | 2.360  | 0.019   | -1.017     | -1.720  | 0.086   |
| Non Climatic Variables|            |        |         |            |        |         |            |        |         |
| Per Hectare Consumption of fertilizers | 0.064 | 2.860 | 0.004 | 0.002 | 0.080 | 0.936 | 0.192 | 4.590 | 0.000 |
| Gross Irrigated Area /NSA | 0.131 | 5.150 | 0.000 | 0.236 | 7.670 | 0.000 | 0.459 | 9.670 | 0.000 |
| Cropping Intensity    | -0.868     | -6.980 | 0.000   | -0.488     | -3.240 | 0.001   | 0.076      | 0.330   | 0.745   |
| Forrest Area to GSA   | -0.166     | -10.540| 0.000   | -0.103     | -5.420 | 0.000   | -0.036     | -1.230  | 0.219   |
| Road Length           | 0.084      | 2.550  | 0.011   | -0.003     | -0.080 | 0.939   | 0.051      | 0.830   | 0.409   |
| Population Density    | -0.055     | -1.700 | 0.089   | -0.043     | -1.080 | 0.280   | -0.329     | -5.410  | 0.000   |
| Literacy Rate         | 0.222      | 3.740  | 0.000   | 0.570      | 7.930  | 0.000   | 0.582      | 5.240   | 0.000   |
| Constant              | 6.996      | 5.250  | 0.000   | 1.629      | 1.010  | 0.313   | 2.556      | 1.030   | 0.306   |

R-Squared = 0.7657  Adj. R-Squared = 0.5902  F (10, 549) = 4.590  Prob > F = 0.000  VIF = 560  Mean = 3.88

Source: Author’s Calculations
any increment in rainfall had negative but insignificant impact on FSI during the study period. The value of R-square is 0.6012, which denotes that more than 60 per cent variation in FSI is explained by the climatic and non-climatic factors during the study period. On the other hand, the value of F-statistics implies that the model is good fit for regression result. Similarly, VIF value i.e. 4.17 reveals that there is absence of multicollinearity in regression model. From the above analysis, it is clear that the impact of the climatic variables and non-climatic variables on food security index are either positive or negative across the selected major sixteen States during the study period.

CONCLUSION

The growth of foodgrain productivity was positive during 1980-81 to 2014-15 in all the States but there were sharp variations during the sub-period analysis at State level in India. On the other hand, the growth rate of non-foodgrain crops was fluctuated with mixed trends at States level during the study period as well as in all the sub-phases. The panel data regression results shows that the all climatic and non-climatic variables have positive impact on foodgrain productivity except maximum temperature and forest area during the study period. But climatic and non-climatic variables have positive impact on non-food grain productivity except maximum temperature, forest area and population density during the study period.

There are widespread variations in terms of having food security and its components among all the States due to the diversified climatic and development condition of the States. Punjab and Haryana occupied first and second position whereas Bihar the lowest position in Food Security Indices. The panel data regression results also reveal that the factors like cropping intensity, road length, and gross irrigated area, forest area, per hectare consumption of fertilizer and literacy rate had positive impact on food security, whereas urbanization had negative and statistically significant impact on food security index in selected different States during the study period. The impact of maximum temperature on FSI has been found negative and significant. It indicates the serious implication of food security across the selected major sixteen States during the study period. Government should be emphasized to enhance the crop productivity because crop productivity is directly linked with food security, rural livelihood as well as rural poverty eradication. There is need to make appropriate strategies at State level to mitigate the climatic factors, appropriate use of inputs, enhance rural infrastructure and suitable technology to be extended to the farmers to boost crop productivity and ensure the food security at State level.

ACKNOWLEDGEMENT

The authors are thankful to ICSSR, New Delhi for financial support.

REFERENCES

Chakraborty, Bhargabi and Hazari, Sujoy (2017). Impact of climate change on yields of major agricultural crops in Tripura. Indian Journal of Agricultural Research. 51 (4): 399-401.

Chukwukere, P. Okezie1, Umeh Udochim, Chidimma, R. Okezie and Amaladudin Sulaiman1 (2011). Climate variability and change: perceptions and adaptations in subsistence agriculture. Indian Journal of Agricultural Research. 45 (4): pp. 275 - 282.
Goswami, P.K., and Chatterjee B. (2010). Linkage between rural poverty and agricultural productivity across the districts of Uttar Pradesh in India. *Journal of Development and Agricultural Economics*, **2**(2): 26-040.

Kaur, H, and Kaur, S (2017). Climate change impact on agriculture and food security in India. *Journal of Business Thought*, **7**(2).

Khan, A.A, and Hasan, A (2017). Climate Change: Concern for Food Security in India. *IOSR Journal of Humanities and Social Science (IOSR-JHSS)*, **22**(10): 52-57.

Kumar, K. (2009). Impact of climate change on India’s monsoon climate and development of high resolution climate change scenarios for India. Presented at MoEF, New Delhi on October 14, 2009. (accessed Jan. 2012)

Kumar, S, and Priyanka (2017). Impacts of Climate Change on Agriculture Productivity: A case study of Haryana. *International Journal of Academic Research and Development*, **2**(5): 252-257.

Panday, A (2015). Food security in India and states: Key challenges and policy option. *Journal of Agricultural Economics and Rural Development*, **2**(1): 012-021, May 2015.

Panwar, Savita and Dimri, A. K (2018). Trend analysis of production and productivity of major crops and its sustainability: A case study of Haryana. *Indian Journal of Agriculture Research*, **52**(5): 571-575.

Raman, Rakesh and Kumari, Reena (2012). Regional disparity in agricultural development: a district level analysis for Uttar Pradesh. *Journal of Regional Development and Planning*, **1**(2).

Rukhsana (2009). Dimension of food security in a selected State- Uttar Pradesh. *Journal of Agricultural Extension and Rural Development*, **3**(2), pp. 29-41, February 2011.

Shakeel, A. *et al* (2012). A Regional Analysis of Food Security in Bundelkhand Region. *Journal of Geography and Regional Planning*, **5**(9): 252-262.

World Bank (1986). Poverty and hunger: issues and options for food security in the developing countries, Washington DC.