Assessing The Impact of Climatic And Socio-Economic Factors On Food Security In India And Thailand: An Empirical Analysis

Dr. Ajay Kumar Singh[1] Dr. Bhim Jyoti[2]

Department of Humanities and Social Sciences, DIT University, Dehradun, Uttarakhand-248009 (India).

Department of Seed Science and Technology, V.C.S.G., UUHF, College of Forestry, Ranichauri, Tehri Garhwal.

a.k.seeku@gmail.com, kumar.ajay_3@yahoo.com, bhimjyoti2210@gmail.com

Abstract

This study investigates the food security of 13 Indian states during 1985-2009 and 56 provinces of Thailand during 2008-2011. For above-mentioned investigation, state-wise food security index (FSI) for India, and province-wise FSI for Thailand are created using three key components of food security (i.e., food availability, food stability, and food accessibility). Thereupon, it assesses the influence of climatic and non-climatic factors on constructed FSI using rosbust linear regression models. FSI is generated using state-wise and provinces-wise panel data for India and Thailand, respectively. 26 key determinants of food security for India and 18 key determinants of food security for Thailand are compiled to create FSI for both the economies. For this, Composite Z-score technique is used. Empirical results based on Driscoll-Kraay standard errors regression model imply that climatic factors have a negative influence on FSI in both the countries. Poverty and food security have a causal relationship and vice-versa in India. Government expenditure on infrastructure development and agricultural R&D; irrigated area; applications of green fertilizer in cultivation; protection of natural resources and participation of literate persons in agricultural sector would be effective to reduce negative consequences of climatic factors on agricultural production activities and food security in India and Thailand.

Keywords: Agricultural production; Climatic and non-climatic factors, Climate change; Food security index, India and Thailand; Composite Z-score technique; Regression models.

1. Background

Earlier studies have estimated the climate change impact on agricultural productivity in different regions of the world. Most studies claimed that food security will be in alarming position due to climate change in different regions of developing and developed countries (Kumar and Sharma, 2013; Kumar et al., 2014; Murali and Afifi, 2014; Kumar et al., 2015a; Kumar et al., 2015b; Kumar et al., 2015c; Singh et al., 2017a; Kumar et al., 2017; Kumar et al., 2018; Singh and Sharma, 2018; Attavanich, 2018; Sitthisuntikul et al., 2018; Singh and Shram, 2018a; Singh et al., 2019b; Arcanjo, 2019; Singh and Jyoti, 2019). Thailand and India are the larger agrarian economy among the Asian countries. Despite that, food insecurity, hunger, undernourished, and malnourished are serious problems in the both countries.

In wide perspective, India is an agricultural intensive country, despite that, there are 360 million populations are undernourished (Ahmad et al., 2011; Kumar and Sharma, 2013). India is a home of largest number of hunger population, including food insecure population in at global level. There are several reasons such as income poverty, food poverty, distributional problem, and regional disparities which are responsible for food insecurity in India (Warr, 2014; Kumar et al., 2017). Furthermore, it is observed that climate change brings a serious threat for agricultural sector and to maintain food security of rural and urban dwellers in India (Kumar and Sharma, 2013; Arcanjo, 2019). Zhai and Zhuang (2009) is observed that agricultural production may go down by 24% by 2080 due to climate change in India. Exsting studies are also observed that productivity of food-grain and non-food-grain crops are expected to be declined due to climate change in India (Kumar and Sharma, 2013a; Kumar and Sharma, 2013; Kumar et al., 2014; Kumar et al., 2015a; Kumar et al., 2016; Kumar et al., 2015b; Singh et al., 2016; Singh, 2018; Singh and Jyoti, 2019). Thus, food security of people would be in a serious position due to climate change and its variability in India in the near future.

Thailand is largley agricultural intensive economy. Agriculture plays a sgnficant role to feed Thi people and to provide job security in Thailand (Attavanich, 2018). Thailand is also a food surplus country at macro level, and it is known as the 'rice bowl of east.' Despite that, food accessibility at the household level remains a problem, particularly in remote areas of Thailand (Isvilanonda and Bunyasiri, 2009). Fluctuation in food price, loss of agricultural production due to climate change, increasing production cost, applications of low technology in cultivation, and labour migration from rural to urban area, high population growth and overwelming industrlization are primarily responsible for undernourishment and food insecurity in Thailand (Isvilanonda and Bunyasiri, 2009). While, incidence of climate change is seen in term of drouhgt, rising temperature, variability in rainfall, decreasing agricultural productivity and health diseases in Thailand (Marks, 2011; Waibel et al., 2018). Therefore, agricultural sector is highly sensetive due to climate change in Thailanl (Attavanich, 2018). Maize is the main stable food-grain crop of Thailand, while demand for maize is expected to be increased due to rapid populaton growth in Thailand (Ekasingh et al., 2014). Also, it is expected that climate change might be useful to for certain crops, while it will have negative impact on rice and cassava production in Thailand. In abovementioned context, several studies claimed that productvity of food-grain crops like rice, maize, cassava and other are expected to be declined due to climate change in Thailand (Felkner et al., 2009; Kawasaki and Herath, 2011; Waibel et al., 2018). Hence, food security of rural and urban dwellers in Thailand will be in serious position due to climate change and natural disaster (Suttinon et al., 2010; Marks, 2011; Waibel et al., 2018; Attavanich, 2018).

2. Research Gap, Research Questions and Objectives of the Study

Past few years studies are given signifiicant focus on estimating the impact of climate change on agricultural productivity in different regions of the world. These studies have indicated that climate change would be caused to increase food insecurity especially in developing countries like India and Thailand (Marks, 2011; Kumar and Sharma, 2013; Kumar and Sharma, 2013a; Kumar et al., 2014; Kumar et al., 2015a; Singh et al., 2017a; Kumar et al., 2017; Singh, 2018; Singh and Shram, 2018a; Abdullah et al., 2019; Singh et al., 2019b). However, in developing economies, limited research caryout to estimate the impact of climatic factors on overall food security. Overall food security includes most variables of the food security that is known as food security index (FSI) (Rukhsana, 2011; Demeke et al., 2011; 1Shakeel et al., 2012;Ye et al., 2013; Kumar and Sharma, 2013; Kumar et al., 2015a; Kumar et al., 2017; Sharma and Singh, 2017; Singh, 2018; Singh and Sharma, 2018). Overall food security is a indicator that covers most of variables which are associated with food security.

Furthermore, several studies have provided empirical evidence that climate change have a negative impact on agriculture productivity and food security at world-wide. Few studies investigated the economic impact of climate change on agricultural productivity of two to three crops as a proxy for food security. However, assessment of climate change impact on overall food security is a very important question for scientific research community and existing researchers. Food security varies at various stages, such as indivdual level, household level, and national level (Abdullah et al., 2019). Food security varies at global to national level, national to household level, and household to indvidual level due to multiple and complex assocation of it with its determinants (Abdullah et al., 2019). For this, existing researchers, international development organization, and research academia could not provide the universally accepted measurement of food security. Furthermore, this is also very crucial that food security is not a function of food-grain crops productivity only. There are many socio-economic avtivities, infrastructure development, physical factors and socio-economic characteristic of farmers and others factors which have significant association with food security including production of commercial crops, income of the people, education level, level of employment, decline in cultivated area, higher population growth, rapid urbanization, government expenditure on agricultural and rural development, cattle and others (Kumar and Sharma, 2013; Warr, 2014; Singh and Sharma, 2018; Abdullah et al., 2019). Hence, it is very interesting to assess the climate change impact on FSI. Due to above research gaps, the main purpose of this study is:

- To generate state-wise food security index (FSI) for India and province-wise food security index (FSI) for Thailand using key components of food security.
- To assess the impact of climatic and non-climatic factors (i.e. socio-economic indicators) on constructed FSI for India and Thailand.

3. Data Source and Description

For India, useful data on agricultural, socio-economic and climatic factors are collected from various sources like Ministry of Agriculture (GoI), Planning Commission (GoI), National Sample Survey Organization (NSSO), Reserves Bank of India (RBI), Centre for Monitoring Indian Economy (CMIE), Census (GoI), Census of Agriculture (GoI), State Departments of Agriculture for selected states (falling in specific agro-ecological zones, and the Central Statistical Organization (CSO). Monthly rainfall and temperature related data is collected from the respective Meteorological stations in India. Climate change related other variables are taken from Indian Meteorological Department (IMD) (GoI), and National Remote Sensing Agency (NRSA), Hyderabad.

Thirteen larger agrarian states of India are considered to create the state-wise FSI, while data is considered during 1985-2009. Following states of India are included in this study: Bihar, Orissa, Uttar Pradesh, Punjab, Haryana, Gujarat, Madhya Pradesh, West Bengal, Maharashtra, Rajasthan, Andhra Pradesh, Tamil Nadu, and Karnataka. Total 26 determinats of food secuirty are segregated in three categories, such as food availability, food stability, and food accessibility. Following indicators are used to create state-wise FSI in India:

Food Availability:

(1) Number of livestock/1000 population (in Number)

(2) Per capita food-grain availability/year (in Kg.).

(3) Per capita calorie availability/day (in Calories).

(4) Number of agricultural labour/hectare cultivated land (in Number).

(5) Per capita consumption expenditure/month (in Rs.).

(6) Government expenditure (revenue+capital) on agricultural and allied sector, rural development, and irrigation and flood control/per hectare cultivated land (in Rs.).

Stability of Food:

(1) Food-grain yield/heactare (in Kg./Ha.).

(2) Applications of fertilizer/hectare cultivated land (in Kg./Ha.).

(3) Percentage of gross irrigated area to net sown area (in %).

(4) Cropping intensity (in %).

(5) Ratio of literate population to gross sown area (in Number).

(6) Percentage of forest area to gross sown area (in %).

(7) Storage capacity/1000 population (in Quintal).

Accessibility of Food:

(1) Percentage of main worker to the total population (in %).

(2) Literacy rate (in %).

(3) Road length/1000 population(in Km.).

(4) Railway road length/per 1000 population (in Km.).

(5) Per capita national domestic product (in Rs.).

(6). Poverty (in %).

(7) Urbanization (in %).

(8) Gender ratio (in Number).

(9) Population density (in Number).

(10) Percentage of rural population to total population (in %).

(11) Credit Deposits Ratio (in Number).

(12) Infant Mortality Rate (in Number).

(13) Rural population/hectare arable land (in Number).

For Thailand, it compiles data on agricultural, socio-economic and climatic factros during 2008-2011 for selected fifty six provinces. These provinces cover more than 80% arable land incduding around 80 agricultural workers and households of Thailand. Most data is taken from the Center for Agricultural Information, and Office of Agricultural Economic and Social Survey of Household Labor, Agriculture Crop (Thai Government). Annual maximum, minimum, and mean temperature and annual rainfall are taken from the Office of Meteorological Department (Thai Government). Furthermore, agriculture, socio-economic and climatic factors related information are taken from different sources published by varous ministries of Kingdom of Thailand such as statistical year book, population survey, environment statistics, househod socio-economic survey, population, and housing survey, labour force suvey, agricultural census, socio-economic survey of farmers of agricultural ministry, and meteorological department. 56 provinces are considered to create provinces-wise FSI of Thailand. Following provinces of Thailand are included in this study: Chiang Rai, Kamphaeng Phet, Sukhothai, Phitsanulok, Phichit, Nakhon Sawan, Phetchabun, Phu, Udon Thani, Nong Khai, Sakon Nakhon, Nakhon Phanom, Mukdahan, Yasothon, Amnat Charoen, Ubon Ratchathani, Si Sa Ket, Surin, Buri Ram, Maha Sarakham, Roi Et, Kalasin, Khon Kaen, Chaiyaphum, Nakhon Ratchasima, Saraburi, Lop Buri, Sing Buri, Chai Nat, Suphan Buri, Ang Thong, Ayutthaya, Nonthaburi, Pathum Thani, Nakhon Nayok, Chachoengsao, Sa Kaeo, Chanthaburi, Trat, Rayong, Chon Buri, Nakhon Pathom, Samut Songkhram, Prachuap Khiri Khan, Chumphon, Surat Thani, Phangnga, Krabi, Trang, Nakhon Si Thammarat, Phatthalung, Songkhla, Satun, Pattani, Yala, and Narathiwat.

Following variables is used to create province-wise FSI of Thailand-

Availability of Food (AVAF): 1) Cattles per household (in Numbers) (CPAH), (2) Government grant/Rai (in Baht) (GGPUL), (3) Agricultural worker/Rai (in Numbers) (AWPUL), (4) Per capita food-grain availability under agriculture household (Kg/person) (PCFGA), (5) Per capita expenditure on food material under agriculture household (Baht/person) (PCEFM), (6) Per capita non-agricultural cash expenditure on other goods under agriculture household (Baht/person) (PCNACE), and (7) Cost of mechanization/Rai (Baht/Rai) (CMPUL)

Stability of Food (STAF): (1) Food-grain production/Rai (Kg/Rai) (FGPPUL), (2) Utilization of chemical fertilizer/Rai (Kg/Rai) (UCFPUL), (3) Ratio of irrigated area with arable land (Number) (RIWAL), (4) Trained agriculture worker/Rai (Number/Rai) (TAWPUL), and (5) Agricultural workers are member of agricultural institutions/Rai (Number/Rai) (AWMAIPUL)

Accessibility of Food (ACCF): (1) Agricultural population by sex (in %) (participation of male and female population) (FAW and MAW), (14) Debt amount/Rai (Baht/Rai) (DAPUL), (15) Loan amount/Rai (Baht/Rai) (LAUPUL), (16) Per capital income of agricultural household (Baht/Person/Year) (PCI), 17) Value of production/Rai (Baht/Rai) (VPPUL) and (18) Per capita arable land under agricultural household (Rai/Person) (PCAL).

4. Creation of Food Security Index (FSI)

To estimate climate change impact on agricultural and others sectors of the economy is multi-dimensional and complex issues (Kumar and Sharma, 2013; Kumar et al., 2015c; Kumar et al., 2016; Singh et al., 2017a; Kumar et al., 2017; Singh and Sharma, 2018). Agrcultural is key source of food security, thus food security of a country or rgion is affected due to variation in agricultural productivity and production (Kumar et al., 2014; Kumar et al., 2015a; Kumar et al., 2017; Singh and Issac, 2018; Singh and Sharma, 2018). It is stated that agriculture is a sole component of food security, thus food security is significantly associated with climate chnage (Ye et al., 2013; Kumar and Sharma, 2013; Sharma and Singh, 2016; Abdullah et al., 2019). Also, food security is sgnificanlty associated with socio-economic, geographical and other activities of an economy (Singh et al., 2016; Singh et al., 2017a; Kumar et al., 2017; Singh and Sharma, 2018; Abdullah et al., 2019). Thus measurment of food security is a complex and multidimensional concept at househod to national level and national level to global level.

Existing researchers such as Adenegan et al. (2004); Rukhsana (2011); Demeke et al. (2011); Shakeel et al. (2012); Ye et al. (2013); Sharma and Singh (2016); Singh et al. (2017a); Kumar et al. (2017); Singh and Sharma (2018) are given priority on FSI estimation as a representative of food security at various levels in different economies. Smith (1973) is used Compostie Z-score technique to create FSI. Thereafter that similar method is used by Rukhsana (2011); Shakeel et al. (2012) to creae FSI in Uttar Pradesh (India). Composite Z-score method is based on descriptive analysis. FSI includes all components of the food security like food availability, food accessibility, food stability and food utilization (Richardson, 2010; Sharma and Singh, 2016; Singh et al., 2017a; Kumar et al., 2017; Singh and Sharma, 2018; Abdullah et al., 2019; Singh et al., 2019a; Ashraf and Singh, 2019). However, food utilization component of food security is not included in the present study due to unavailability of food utilization related information for India and Thailand. Hence, FSI is generated through Composite Z-score methods, while it includes only three key components of food security i.e. food availability, food stability and food accessibility (Richardson, 2010; Sharma and Singh, 2016; Singh et al., 2017a; Kumar et al., 2017; Singh and Sharma, 2018). Composite Z-score method quantify the departure of individual observations that is expressed in a comparable and relatve form (Kumar et al., 2015c; Sharma and Singh, 2016; Singh et al., 2017a; Kumar et al., 2017; Singh and Issac, 2018; Singh and Sharma, 2018; Singh et al., 2019a; Ashraf and Singh, 2019).

5. Empirical Analysis

5.1. Theoretical Foundation of Econometric Model for FSI and Associated Factors

Many studies have attempted to assess the influence of socio-economic and other factors on constructed FSI and other indexes in different countries (Adenegan et al., 2004; Demeke et al., 2011; Ye et al., 2013; Kumar and Sharma, 2013; Kumar et al., 2015c; Sharma and Singh, 2016; Singh et al., 2017a; Kumar et al., 2017; Singh and Sharma, 2018). Faridi and Wadood (2010); Ye et al. (2013) is used FSI as dependent variable, and it is regressed with different socio-economic variables in Bangladesh and China, respectively. Demeke et al. (2011) is investigated the influence of rainfall and socio-economic factors on constructed FSI in Ethiopia. Ye et al. (2013) is also assessed the effect of climatic factors on generated FSI in China.

Singh et al. (2017a) are also assessed the impact of socio-economic factors on estimated global FSI in selected 31 economies. Kumar et al. (2017) is also investigated the influence of climatic factors on created FSI in India.

Singh and Issac (2018) are also considred estimated sustainable livelihood security index as dependent variable, and it is regressed with climatic and non-climatic factors in Gujarat state of India. Singh (2018) is also assessed the association of global FSI with climatic and non-climatic factors in selected economies using linear and non-linear regression models. Recenlty Singh et al. (2019a) is created environmental sustainability index for selcted Asian economies. Thereupon, this index is considred as dependent and independent variables for futher empirical investigations for various purpose by the authors. Ashraf and Singh (2019) is also generated entrepreneurship creative development index, thereafter it is used a dependent variable to assess its association with economic development in selected economies.

As several studies have considerd estimated index as dependent variables to assess its association with socio-economic and other factors. Therefore, this study is also used estimated FSI as dependent variables to assess its assocation with clmatic and non-climatic variables in India and Thailand. In the present study, linear, non-linear, and log-linear regression models are considered to assess the influence of climatic and socio-economic factors on estimated FSI. For this investigation, it assumes that constructed FSI is a function of climatic and socio-economic factors of a particular state in India and province in Thailand. For this study, the proposed model is adopted from Demeke et al. (2011); Singh et al. (2017a); Kumar et al. (2017). Empirically, the proposed model is expressed as:

$$(\text{fsi})_{st} = \text{£}_0 + \theta_t\,(\text{Year}) + \theta_i \sum_{i=1}^{n} (\text{CF})_{st} + \text{¥}_i \sum_{i=1}^{n} (\text{SEF})_{st} + (u)_{st} \qquad (1)$$

Here, fsi is generated FSI for cross-sectional states and provinecs in india and Thailand respectively and t time period. CF is vector of climatic factors and SEF is a vector of socio-economic factors of respective states of India and provinces of Thailand. £_0, is constant term; θ_i, and ¥_i are the vector of estimated regression coefficients of associated variables; θ_t is the regression coefficient of time trend factor that is used to capture the influence of technological change (e.g., seed quality, adoption of new technology in cultivation, govt. expenditure on agricultural R&D, climate change adaptation techniques, farmers experience and other) on FSI; and $(u)_{st}$ is error term in the equation (1).

5.2. The process to Select an Appropriate Model

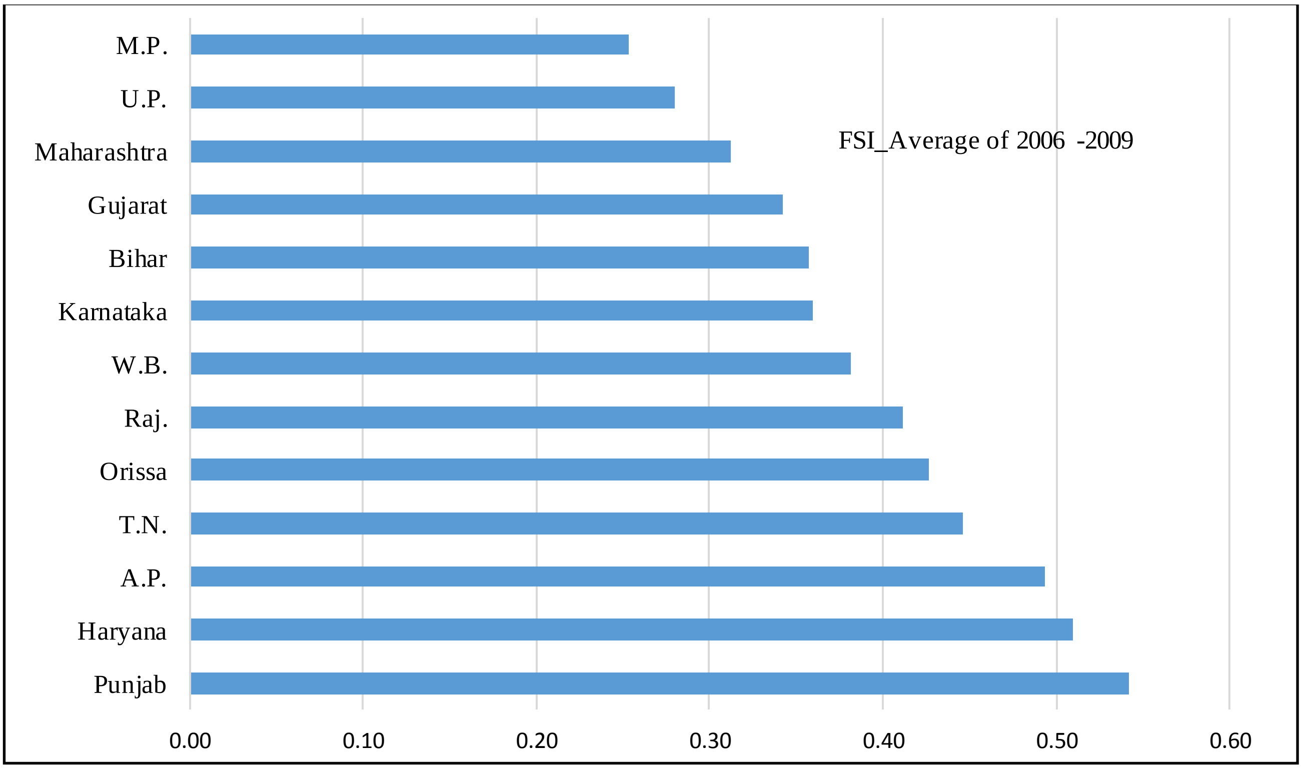
As this study includes state-wise and province-wise panel data for India and Thailand resepectively. Since Indian states do have significant diversity in socio-economic, climatic, and natural resources related factors and agricultural production activities. Thailand also have significant diversity in socio-economic, climatic and natural resources across provinces. Thus, it is obvious that there might be high possibity of existance of cross-sectional dependency, serial-correlation, auto-correlation, and heteroskedastity in state-wise and province-wise panel data for India and Thailand resepectively. Earlier researchers claimed that linear regression correlated panels corrected standard errors (PCSEs) model and Driscoll-Kraay standard errors regression models are useful to reduce the impact of cross-sectional dependency, serial-correlation, auto-correlation and heteroskedastity in estimation of regression coefficients of explanatory variables (Kumar and Sharma, 2013; Kumar et al., 2015a; Kumar et al., 2015b; Kumar et al., 2015c; Kumar et al., 2016; Singh et al., 2016; Sharma and Singh, 2016; Kumar et al., 2018; Singh and Jyoti, 2019). Thus, in this study regreression coefficients of explanatory variables are estimated using aforementioned models.

6. Empirical Results

6.1. Discussion and Explanation on Estimated FSI for India

The mean value of estimated FSI during 2006 - 2009 for 13 Indian states are presented in Figure: 1. Refer to Table: A1 in Appendix: A for detail of estimated FSI of Indian states during 1985 – 2009. As estimated values of FSI lies between 0.54 to 0.25 for undertaken states of India. Thus, it infers that there is a high diversity in food security across Indian states. There are many reasons which are causing to increase high diversity in food security across Indian states. As Punjab has a highest value of estimated FSI, thus Punjab has a better position in food security as compared to other states of India. Haryana has a 2nd position in food security among the 13 states of India. Punjab and Haryana have a better position in most of factors like number of livestock, per capita food-grain availability, per capita calorie availability per day, per capita consumption expenditure, food-grain yield, applications of fertilizer, cropping intensity, literate population, appropriate infrastructure, and per capita national domestic product. Therefore, Punjab and Haryana have a better position in food security, while other states like Madhya Pradesh and Uttar Pradesh have a poorest position in food security than other 11 states of India. There are many reasons which are creating barriers and obstacles to maintain food security in Madhya Pradesh and Uttar Pradesh. Madhya Pradesh and Uttar Pradesh have a lower per capita food-grain availability, per capita calorie availabiility, per capita consumption expenditure, government expenditure, food-grain yield, literacy rate, inappropriate infrastructure and per capita national domestic product in as compared to other undertaken states of India. Furthermore, there is existance of extreme poverty and greater dependency of population on agrcultural sectors with lower job opportunities in non-agricultural sectors. Therefore, Madhya Pradesh and Uttar Pradesh have a poor position in food security among the other states of India. Thus, both the states are essential to sustain food security through maintaing the conistency in aforesaid factors. Furthermore, extreme poverty, high infant mortality rate, and urbanization are also creating barriers to attain food security in Madhya Pradesh and Uttar Pradesh. Other states like Maharashtra, Gujarat, Bihar, Karnataka and West Bengal also have a relative better position in food security than Uttar Pradesh and Madhya Pradesh. While, Rajasthan, Orissa, Tamil Nadu, and Andhra Pradesh have a capability to maintian food security of their rural and urban dwellers. As these states have a effective policies towards food distribution system under Public Distribution System, thus these states are able to have a good position in food security.

Figure 1: Distribution of Indian states based on estimated values of FSI during 2006-2009

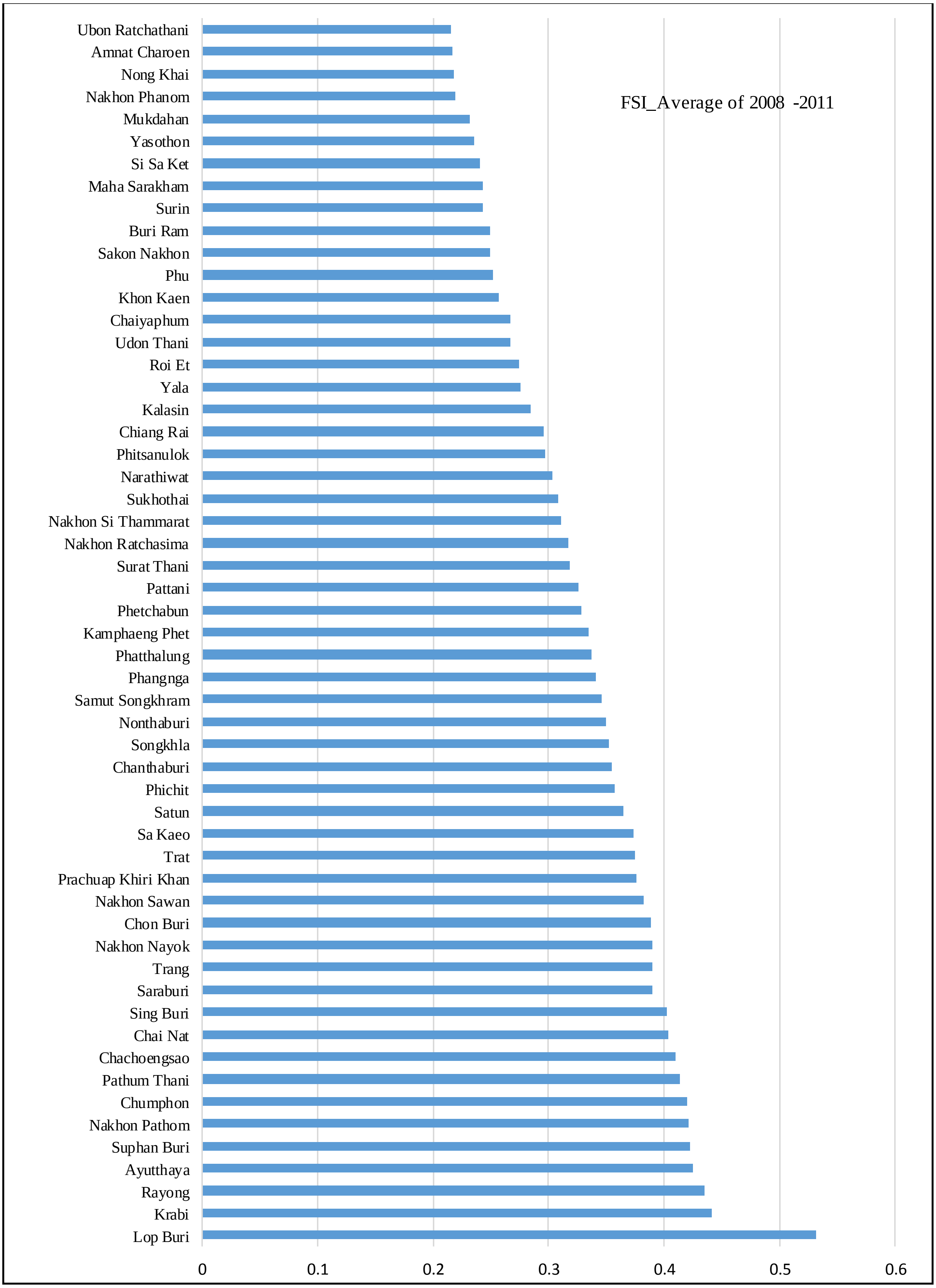


Source: Author's estimation.

6.2. Discussion and Explanation on Estimated FSI for Thailand

Variation in food security across provinces of Thailand are measured in term of food security index (FSI). Here, FSI is a relative index that estimate the variation in food security across provinces.

Figure 2: Distribution of Thai provinces based on estimated values of FSI



Source: Author's estimation.

The mean values of FSI during 2008 – 2011 are given in Figure: 2. Refer to Table: A2 in Appendix: A for detail of estimated FSI of Thai provinces during 2008 – 2011. As the mean values of FSI lies between 0.2151 - 0.5317 during 2008 - 2011, thus it indicates that there is an existence of high and significant diversity in food security across Thai provinces. This diversity in food security is exist due to variability in main components of food security i.e. food availability, food stability, and food accessibility. Results also show that Lop Buri is observed most food secure province among the undertaken Thai provinces. Thus, Thai policy maker desires to adopt similar agriculture policies and other policies that is exist in this province to improve the food security in remaining provinces. Furthermore, estimated values of FSI infer that most of provinces of Thailand have poor position in food security. Thus, it is a very great concern for Thai government and policy makers to maintain food security of rural and urban dwellers in Thailand. Since, estimated FSI is the integrated components of number of cattle per household, government grant on per Rai, agricultural worker/Rai, per capita food-grain availability under agriculture household, per capita expenditure on food material under agriculture household, per capita non-agricultural cash expenditure on other goods under agriculture household, cost of mechanization/Rai, food-grain production/Rai, utilization of chemical fertilizer/Rai, ratio of irrigated area with arable land, and trained agriculture worker/Rai, agricultural workers/Rai. So, Thai government needs to give more focus on above-mentioned factors to increase food security in Thailand. In addition to above factors, agricultural population by sex, debt amount/Rai, loan amount/Rai, per capital income under agricultural household, value of production/Rai, and per capita arable land under agricultural household are also observed significant contributor for food security.

6.3. Discussion and Explanation on Association of FSI with Its Components

Empirical findings based on Driscoll-Kraay standard errors regression model for FSI and its components show that all components of food security are crucial determinants to improve the food security in India and Thailand (Table: 1). Estimates indicates that FSI and its components are inter-related and highly correlated to each other (Dev and Sharma, 2010; Kumar et al, 2015c; Kumar et al., 2017; Sharma and Singh, 2017; Singh et al., 2017a; Singh, 2018; Singh and Sharma, 2018).

Table 1: Association of FSI with its components with linear regression, using correlated panels corrected standard errors (PCSEs) model for India and Thailand

Variable/Country	India	Thailad
No. of Observations	325	224
No. of States/Provinces	13	56
R-squared	1.0000	0.9828
Wald Chi^2	2.66e+16	4732.19
Prob > Chi^2	0.0000	0.0000
Food Availibility Index	0.23077*	0.4103795*
Food Stability Index	0.26923*	0.2870213*
Food Accessibility index	0.5*	0.2706736*
Contant Term	4.52e-09	0.015896*

Source: Author's estimation. * indicates the 1% significance level of regression coefficient for respective variables.

Food availability index, food stability index, and accessibility index have a positive and statistically significant (p<000) association with FSI. Thus, results clearly indicates that all components of food security play a crucial role to increase food security of a nation (Kumar et al, 2015c; Kumar et al., 2017; Sharma and Singh, 2017; Singh et al., 2017a; Singh, 2018; Singh and Sharma, 2018). Availability of food depends upon key component of agricultural activities, thus a nation needs to give more priority on agricultural activities to sustain food security (Ye et al., 2013; Kumar et al., 2015b,c; Singh et al., 2017a; Kumar et al., 2017; Sharma and Singh, 2018; Singh and Sharma, 2018; Singh 2018).

6.4. Discussion on Empirical Findings

Regression results which assesses the influence of climatic and socio-economic variables on estmated FSI for India and Thailand are given in Table: 2. Results show that maximum and minimum temperature have a negative and statistically significant impact on FSI. It means that rising temperature would cause to reduce food security of India and Thailand. While rainfall has a positive and statistically significant impact on FSI in Thailand. Estimates indicate that ranfall is a very important natural resource to meet the water requirement for irrigation in agricultural crop produciton and rainfall is also useful to maitian the groundwater availabilty. Therefore, rainfall show positive impact on FSI in both the economies. Cattle and livestock, increment in government expenditure and more application of fertilizer on arable land; and increase in irrigated area for cultivation are also found important factors to maintain food security in both countries. It is evident that above-mentioned factors are crucial determinants of food security. Thus, these factors have a positive impact on food security in India and Thailand.

Since, inorganic fertilizer have a positive impact on land productivity in short-term, while it have a negative implicatons on land productivity, soil quality and natural resources in long-term. In addition to above, extensive applications of inorganic fertilizer in agriculture may be caused to increase GHGs emissions in atmospher, further it would increase the more possibilities for climate chnage in near future. Thus, it is suggested that the farmers must be avoided extensive applicatons of inorganic fertilizer in agricultural production activities. It is essential for farmers to give signficant focus on utilization of green and organic fertilizer in crop cultivation (Sitthisuntikul et al., 2018). Green and organic fertilizer would be useful to improve land productivity, soil quality, and actual nutritional contents in the produced food. Subsequently, applications of green and organic fertilizer would be useful to enhance food production and food security as well (Sitthisuntikul et al., 2018). Irrigated area have a higher yielding capacity as compared to non-irrigated land in crop production, thus irrigated area shows positive impact on FSI. Therefore, it is suggsted that both the economies need to provide additional irrigation facilties to farmers to maintain agrilcultural production and food security.

Training for agrcultural workers play a signifcant role to increase the production efficiency of workers, thus trained agricultrual worker have a positive association with FSI. Hence, it is proposed that there must be a training progrmme for farmers at regular basis. Literate person have capablity to choose a rational crop for cultivation, and right timing for sowing and irrigation in cultivation. Also, literate farmers have better knowledge to use a exact quantity of fertilizer for a specific crops (Kumar et al., 2015a). Thus, contribution of literate person in cultvation would be useful to maintian crop productivity. Results of this study also indicate that literate population have a positive influence on FSI. Abdullah et al. (2019) is also observed that education play an effective role to increase food security at individual level in Pakistan.

In Thailand, food-grain production, per capita food-grain availability, per capita food-grain expenditure, value of agrcultural production/Rai, and participation of female worker have a positive and statisticall significant impact on FSI. As above factors are crucial determinant of agricultural production and food security. Thus, it shows that food security of Thailand would be improved as increase in aforementioned factors.

Table 2: Regression results for different variables on FSI with linear regression, correlated panels corrected standard errors (PCSEs) model in India and Thailand

Thailand		India	
Variables	Reg. Coe.	Variables	Reg. Coe.
No. of observations	224	No. of observations	323
No. of provinces	56	No. of states	13
R-squared	0.9002	R-squared	0.8419
Wald Chi^2	497385.29	Wald Chi^2	7751.96
Prob > Chi^2	0.0000	Prob > Chi^2	0.0000
Cattles/agricultural households (in Number)	0.0227058*	Number of livestock/Ha.	0.0000389*
Government support (Baht/Rai)	0.0000229	Government expenditure (Rupees/ Ha.)	0.4841313**
Utilization of carbon fetilizer (Kg./Rai)	0.0000603*	Use of fertilizer (kg/Ha.)	0.0000436
Ratio of irrigated area with arable land	0.0537023*	Ratio of irrigated area with gross sown area	0.0018328*
No. of trained agricultural worker/Rai	0.0296323	Literate populations/Ha.	3.65e-06*
Food-grain production (Kg./Rai)	0.0000147*	Croping intensity	0.0013366*
Per capita food-grain availability (in Kg.)	1.10e-06*	Ratio of road length with gross sowan area	0.0007693***
Per capita food-grain expenditure (in Baht)	6.84e-06*	Number of tractor/Ha.	0.0003471
No. of agicultural workers /Rai	-0.0046111	Poverty (% of Population)	-0.0021261*
Female agricultural worker (in %)	0.0040701*	Urbanization rate (in %)	-0.001471*
Value of agrcultural production/Rai (in Baht)	1.94e-06*	Population density (in Number)	-0.0002985*
Annual maximum temperature (in ^{0}C)	-0.00435**	Annual maximum Temperature (in ^{0}C)	-0.003259***
Annual minimum temperature (in ^{0}C)	-0.00317***	Annual inimum Temperature (in ^{0}C)	-0.0047075*
Annual rainfall (in mm)	0.0000189*	Annual rainfall (in mm)	1.17e-08
Constant Coefficient	0.0698563	Constant Term	0.3940859*

Source: Author's estimation. *, ** and *** indicate the 1%, 5% and 10% significance level of regression coefficient for respective variables.

Regression coefficients of croping intensity, ratio of road length with gross sown area, and number of tractor/hectare land with FSI are found positive and statistcally significnat in India. Thus, estimates give an evident that these factors would be useful to maintain food securty in India. Since, ratio of road length with gross sown area is considerd as a proxy for infrastructural development to assess its impact on food security.

Estimate indicate that creation of appropriate infrastructural development would be useful to improve food security in India. In India, FSI is negatively associated with poverty, rapid urbanization, and population density. Thus, estimates show that food insecurity would be increased as increase in these factors in India. Poor people have a low economic capacity to buy the food product from market, thus food security is negatively associated poverty. It infers that food security of people would lead to decline as increase in poverty. Earlier studies are also found negative implcations of poverty on food security (Kumar and Sharma, 2013; Warr, 2014; Kumar et al., 2015c; Kumar et al., 2017; Singh et al., 2017a; Sharma and Singh, 2017; Singh, 2018; Singh and Shamra, 2018). Urbanization and population density are also show negative influence on FSI. It can be justfed that arable land udder food-grain crops is expected to be declined as increase in urbanization and population density (Scanlan, 2001; Kumar and Sharma, 2013; Kumar et al., 2015c; Kumar et al., 2017; Singh et al., 2017a; Sharma and Singh, 2017; Singh, 2018; Singh and Shamra, 2018).

7. Conclusions and Policy Suggestions

7.1. Statistical Inferences

The main aim of this study is to create state-wise food security index (FSI) for India and province-wise FSI for Thailand. For aforementioned investigation, it uses Compsite Z-score method, while three components of food security (i.e. food availability, food accessibility and food stability) are considred. State-wise FSI of India is an integration of 26 factors and province-wise FSI of Thailand is the combination of 18 factors of food security. Thereupon, it estmate the influence of climatic and non-climatic factors on estimated FSI for India and Thailand using linear and non-linear regression models. For this, it used state-wise panel data during 1985-2009 for India and province-wise panel data during 2008-2011 for Thailand. Estimated provinces-wise FSI for Thailand, demonstrate that there is a presence in significant diversity in food security across provinces of Thailand. This variation in food security is exist due to variability in all components of food security i.e. food availability, food stability and food accessibility. Similar to Thailand, Indian states also have a significant variation in food security due to high variability in agricultural related factors, geographical location, socio-economic characteristics of farmers, and climate change.

Empirical results of the present study gives an indication that all components of food security i.e. food availability, food accessibility, and food stability are positively associated with each other (Kumar and Sharma, 2013). Thus, it is suggested that policymakers are desirable to give significant priority to all components of food security. As agricultural activities are the key determinants of food security, thus national policy maker of India and Thailand must be given significant attention towards agricultural production related factors to maintain sustainable food security (Kumar and Sharma, 2013; Kumar et al., 2017).

Resutls also clearly indicate that FSI is negativley associated with maximuam and minium temperature. It implies that cliamtic factors have a negative impact on food security. Further, results show that quality and nutritional contents of food would hamper due to rising maximuam and minium temperature during crop growth period in India and Thailand. So, it is suggested that both the economies needs to give significant priority to reduce the climate change impact on agricultural crop production to ensure food securty.

FSI is positivley associated with number of livestock, government expenditure on agriculture sector, applications of fertilizer, irrigated area, contrbution of literate populaton in agriculture, trained agrcultural workers, food-grain production, per capita avalabilty of food-grain producion, human resource and value of agricultural production. These are the crucial determinants of agrcultural production system. Thus, it is proposed that agrcultural production activities are crucial to sustain food security (Kumar and Sharma, 2013; Warr, 2014). Further, poverty, urbanization and population densitity have a negative and statistically significant influence on FSI. It imply that food security would be declined as increase in poverty, urbanization, and population density. Hence, India and Thaland are needed to adopt a conducive policy to reduce the negative implications of poverty, urbanization and population density on food security. Infrastructure development is a crucial driver to improve food security in several ways such as creation of jobs for current worker and maintianing the apprpriate communication of rural dwellers with markets in urban area. Thus, it is proposed that India and Thailand require to create an appropriate Infrastructure to imporve food security.

This study also provides several effective policy suggestions to mitigate the adverse effect of climate change on agricutlure sector and to improve food security of India and Thailand. Better irrigation facilities, fertilizer (applications of organic and green fertilizer) and government expenditure on agricultural and allied sector would be imperative to improve food security. Furthermore, Indian government needs to give more preference for poverty eradication programme to ensure the food security of rural and urban dwellers. Poverty and food security has a cause and effect relationship with each other and vice versa. Poverty has a negative impact on food security, thus it is a prime cause to increase food insecurity. Poverty and other socio-economic variables like farm mechanization has done greater harm than benefit for rural households by effectively reducing the agricultural labour employment opportunities for unskilled landless labourers. Food insecurity and poverty are also casued to increase higher incidence of infant mortality in India. Swaminathan (1998) is also reported that poverty and food insecuity is mian caused for infant mortality in India.

7.2. Effective and Practical Policy Suggestions

The study identified different areas in which there may be poossibilities to take immediate action to mitigate the adverse effect of climate change on agricultural production actvities and to sustain food security for India and Thailand, and other developing economies-

Applcations of Modern Technologies in Agricultural Sector: Modern varieties and high yield varieties of seed, new method of cultivation, changing planting time, selection of genotype, crop diversification, mixed or dual cropping system, cropping intensity, and sustainable land management practices can be used as a moden technolgies in agrcultural sector (Kumar and Sharma, 2013; Kumar et al., 2015a; Kumar et al., 2015b; Kumar et al., 2015c; Kumar et al., 2016; Kumar et al., 2017; Sharma and Singh 2017; Singh et al., 2017a; Singh, 2018; Singh and Jyoti, 2019). It would be useful to enhance sustainable food security in India and Thailand.

Initiations of Applications of Green Fertilizer: Production of food-grain and non-food-grain crops would increase as applications of fertilizer in short-term (Kumar and Sharma, 2013; Kumar and Sharma, 2013a; Kumar et al., 2014; Kumar et al., 2015b; Sharma and Singh 2017; Singh, 2018). However, it would be caused to decrease land productivity and soil fertility in long-term (Kumar et al., 2014). Applications of fertilizer in cultivation would increase the more quanity of GHGs emssion in atmosphere (Kumar and Sharma, 2013a). Thus, it may be caused to increase additional probabilities for climate change in near future. Also, environmental resources and groundwater quality would detrioriate due to extensive applications of fertilizer in farming (Kumar and Sharma, 2013; Kumar et al., 2015b; Kumar et al., 2015c; Kumar et al., 2017). Subsequently, applications of fertilizer may be caused to increase severe health issues in humnity. Thus, it is essential to avoid or to reduce the applications of fertilizer in agricultural sector. Furthermore, farming commnity may use green fertlizer in crop production to in increase agricultural production and to maintian food security. Green fertilizer would be useful to maintian the quanity of available natural resources and hauman helath in long-term.

Infrastructure Development and Facilities: Infrastructure development like transport facility, market accessibility, and proper road connectivity between rural to urban areas are essential to sustaina food security in various ways (Kumar et al., 2015a; Kumar et al., 2017; Sharma and Singh 2017; Singh, 2018). Proper transport faclities would be useful for rural farmers to visit in city market. Thereby, farmers can buy the agricultural related material from the market in cities. Thus, appropriate infrastructure development would be helpful to increase production of food-grain and non-food-grain crops (Kumar and Sharma, 2013; Warr, 2014; Kumar et al., 2015a; Kumar et al., 2015c; Singh et al., 2017a). Resulting, it would be beneficial to improve food security.

Land and Farm Management Policy: Initiations of proper land and farm management practices are essential to increase soil fertility and quality. Subsequently, it would enhance production of food-grain and non-food-grain production. Hence, it is required to adopt a effective and conducive land and farm management policies to increase agricultural production and food security in India and Thailand.

Water Management Policies: Agricultural production is a fruit of land and water, and it cannot produce without land and water (Richardson, 2010; Kumar et al., 2014; Kumar et al., 2015b; Singh, 2018). Hence, water is a blood for agricultural production system. Thus, it is suggested that India and Thailand needs to adopt sustainable water managment policies to meet the water requiremnt for irrigation in cultivation. Sustaianble water managment practices can be used as water harvesting and conservation, efficient use of water through micro-irrigation techniques like sprinkler and drip irrigation (Kumar and Sharma, 2013; Murali and Afifi, 2014; Kumar et al., 2016; Kumar et al., 2017; Sharma and Singh 2017). Hence, irrigation facilties would be effective to sustain agricultural production and food security in India and Thailand (Kumar and Sharma, 2013a; Kumar et al., 2015c; Singh et al., 2017a).

Management of Ecosystem Services and Natural Resources: To sustain the common property of natural resources (e.g., water, forestry, soil, air, land, etc.) are the essential determinants of agricultural production and food security (Richardson, 2010; Kumar et al., 2015b; Kumar et al., 2017). In contrary, existig ecosystem services are being hampring due to rapid urbanization, population growth, extenstive applications of fertilizer in cultvation, overwelming industrilization and commercialization of cash crops in most developing economies (Kumar and Sharma, 2013; Kumar et al., 2016; Kumar et al., 2017). Thus, there must be an effective polies to control rapid urbanizaton and populaton growth which would be useful to sustian the productivity of available ecosystem services and natural resources in India and Thailand (Richardson, 2010; Kumar et al., 2017). Subsequently, it would be beneficial to sustain the food security of India and Thailand in near future (Sharma and Singh 2017).

Natural Disaster Management Policy: The occurances of natural disasters like drought, floods, hailstroms, heavy wind, and natural calamities have incresed after 1970s. Therefore, agricultural production and food security are negativley influenced due to occurances of natural disasters. Hence, there must be provision to disseminte climate change and natural disasters related information to farmers on time. For this, it is proposed that government needs to increase public expenditure on telecommunication to do above excercise in farming intensive areas in India and Thailand. There may be proper natural disaster managment policy to reduce the negative implications of it on agriculture sector and food security in India and Thailand.

Financial Management Policy: Financial facilties play a effective role for farmer to meet their credit requirement in emergency. Most of farmers do receive remuneration for their services during harvesintg time of crops. Thus, farmers do have financial lacuna in remaing time except harvesting time. Appropriate availability of credit for farmers would be useful to maintian their farming activities (Kumar et al., 2017). Thus, there must be proper financial management policies for farmers to improve their agricultural production and food security. Furthermore, government needs to take actio like crop specific insurance policies to recover cultivation cost of farmers who lost agricultural production due to climate change (Abdullah et al., 2019). Government also take an effectivie actions to create job possibilities for rural dwellers in non-agricultural sector (Richardson, 2010; Murali and Afifi, 2014; Singh et al., 2017a; Abdullah et al., 2019). It would be helpful for farmer and landless labours to increase their economic capacity to buy food product from the market, thus food security of rural dwellers would be improved as increase in jobs oppourtunities in rural areas.

Training and Institutional Management Policies: Provision of short-term training to farmers would be useful for them to increase their understanding towards negative consequences of climate change in agricultural production activities (Kumar and Sharma, 2013; Kumar et al., 2015a; Kumar et al., 2015b; Sharma and Singh 2017; Singh, 2018). Also, agricultural extension offices, NGOs and local stakeholders need to take an action to provide a practical and viable solutions to mitigate the negative consequences of climate chnage in agricultural prodction activities. These also can convey the massage of climate change related information and susggestions to faremrs. Thereby, they can avoid the negative impact of climate change in crop farming (Kumar et al., 2015a).

Agricultural R&D: Agricultural research and development (R&D) is a crucial practice of researchers and scientists to discover new varietis of seed and heat tolerance crops (Kumar et al., 2015a; Kumar et al., 2016; Singh, 2018). Productivity of heat tolerace crops would be ineffective due to presence of climate change.

Furthermore, agricultural scientists and researchers should do collaboration with local farmers, inputs suppliers, traders and consumers to understand the exsting consequcnes of climate change in farming. Thereby, scientists can do more research to search a solution of existing problmes to reduce the impact of climate change in agricultural production. Government also needs to increase R&D expendture in agricultural sector to increase the consciousness of young scientists and researchers to take a innovative R&D project in agricultural sector (Warr, 2014; Kumar et al., 2015b; Kumar et al., 2016; Kumar et al., 2017; Sharma and Singh 2017; Singh, 2018).

Additional Measures: Most food-grain production is being damage due to lack of proper storage facility in public Godwans in India. Thus, there must be appropriate storage capacity in public Godwans to store the food-grain production in India (Sharma and Singh 2017). It would be helpful to increase food security in India. Food security is in alarming position due to incidence of high poverty, high fluctuation in prices of food-grain product, and unfair food distribution policy in most developng economies like India, Bangladesh and Thailand (Richardson, 2010; Kumar and Sharma, 2013a; Akter and Basher, 2014; Warr, 2014; Kumar et al., 2015c; Kumar et al., 2017; Sharma and Singh 2017; Singh et al., 2017a). Abdullah et al. (2019) is also reported negative impact of inflation on food security in Pakistan. Thus, Indian government needs to take an effective action for poverty eradication and to control food-prices. It would be beneficial to maintain sustainable food security in India and Thailand.

7.3. Future Research Direction

Since the present study is given focus only on macro level components in food security estimation and to assess the influence of climatic and non-climatic factors on it in India and Thailand. For this, it includes 13 Indian states and 56 Thai provinces, while Indian states and Thai provinces do have significant diversity in socio-economic factors, geographical factors, physical indicators, government policy factors, political activities, climate change related calamities, available natural resources and other indicators which are esential to boost agricultural production system. Thus, empirical findings of this study must be validated through micro level survey of farming community to reach a effective policy proposal. Hence, it is authentic research gap for exsting researchers and research academia to undertake furture research on aforemenioned proposal. Existing researchers and national development agencies can give more focus on those indicators which are creating high diversity in food security across Indian states and Thai provinces in futher research.

Acknowledgements: The paper is an output of a scholarship from the Food Security Center, University of Hohenheim, Stuttgart (Germany) which is part of the DAAD (German Academic Exchange Service) program "exceed" and is supported by DAAD and the German Federal Ministry for Economic Cooperation and Development (BMZ), and in cooperation with AIT, Bangkok (Thailand) as a host institute and IIT Indore (M.P.) India as a co-funding organization. The article is one of significant part of doctoral research of first author entitled '**Effect of Climatic Factors on Agricultural Productivity and Food Security in India: An Econometric Analysis**.' The author is grateful to MHRD (GoI) for providing scholarship to pursuing PhD at School of Humanities and Social Sciences, IIT Indore.

References

1. Abdullah, Zhou D., Shah T., Ali S., Ahmad W., Din I.U. and Ilyas A. (2019). Factors affecting household food security in rural northern hinterland. Journal of the Saudi Society of Agricultural Sciences, 18(2):201-210.
2. Adenegan K.O., Oladele O.I. and Ekpo M.N. (2004). Impact of agricultural export on food security in Nigeria. Food, Agriculture & Environment, 2(1):107-112.
3. Ahmad J., Alam, D. and Haseen S. (2011). Impact of climate change on agriculture and food security in India. International Journal of Agricultural Environmental and Bio-technology, 4 (2):129-137.
4. Akter S. and Basher S.A. (2014). The impact of food price and income stocks on household food security and economic well-being: Evidence from rural Bangladesh. Global Environmental Change, 25(1):150-162.
5. Attavanich W. (2018). How is climate change affecting Thailand's agriculture? A literature review with policy update. MPRA Paper No. 90255. https://mpra.ub.uni-muenchen.de/90255/.

6. Ashraf S.N. and Singh A.K. (2019). Does entrepreneurship ecosystem have a long-term relationship with economic Growth in selected economies? A statistical investigation. In Misra S., Shukla S. and Batthini G. (Eds.). Proceedings of the 13th Biennial Conference on Entrepreneurship Organized by EDII Ahmedabad during Feb 20-22, 2019, 1(1):176-187. New Delhi: Bookwell Publishing House.. http://library.ediindia.ac.in:8181/xmlui/handle/123456789/7903.
7. Arcanjo M. (2019). Climate change and the public health dilemma in India. A Climate Institue Publication, New York, Washington DC. http://climate.org/wp-content/uploads/2019/06/Climate-Change-and-the-Public-Health-Dilemma-in-India.pdf.
8. Demeke A.B., Keil A. and Zeller M. (2011). Using Panel Data to Estimate the Effect of Rainfall Shock on Smallholders Food Security and Vulnerability in Rural Ethiopia. Climate Change, 108:185-206.
9. Ekasingh B., P. Gypmantasiri, K. Thong-ngam and P. Grudloyma (2004). Maize in Thailand: Production System, Constraints, and Research Priorities. Mexico, D.F., CIMMYT.
10. Faridi R., Wadood S.N. (2010). An econometric assessment of household food security in Bangladesh. The Bangladesh Development Studies, 33(3), 97-111.
11. Felkner J., Tazhibayeva K. and Townsend R. (2009). Impact of climate change on rice production in Thailand. American Economic Review, 99(2):205-210.
12. Dev S.M., and Sharma A.N. (2010). Food security in India: Performance, challenges and policies. Oxfam India Working Paper Series 08, New Delhi.
13. Isvilanonda S. and Bunyasiri I. (2009). Food Security in Thailand: Status, Rural Poor Vulnerability, and Some Policy Options. ARE Working Paper, 2552/1.
14. Kumar A. and Sharma P. (2013). Impact of climate variation on agricultural productivity and food security in rural India. Economics Discussion Papers, No. 2013-43, Kiel Institute for the World Economy. http://www.economics-ejournal.org/economics/discussionpapers/2013-43.
15. Kumar, A., and Sharma P. (2013a). Climate sensitivity and agriculture productivity in India: A crop-wise analysis. Proceedings of the 7th Biennial Conference 2013 of the Indian Society for Ecological Economics (INSEE) on 'Global Change, Ecosystems, Sustainability', Organized at Tezpur University, Tezpur (Assam), [December 05-08, 2013]. Indian Society for Ecological Economics, New Delhi. http://ecoinsee.org/conference/conf_papers/conf_paper_49.pdf.
16. Kumar A., Ahmad M.M. and Sharma P. (2015c). Carbon emission and global food security: A cross country analysis. PENCIL Publication of Agricultural Sciences, 2(1):7-24.
17. Kumar A., Ahmad M.M., and Sharma P. (2017). Influence of climatic and non-climatic factors on sustainable food security in India: A statistical investigation. International Journal Sustainable Agricultural Management and Informatics, 3(1):1-30.
18. Kumar A., Sharma P. and Ambrammal S.K. (2014). Climatic effects on food grain productivity in India: A crop wise analysis. Journal of Studies and Dynamics and Change, 1(1):38-48.
19. Kumar A., Sharma P. and Ambrammal S.K. (2015b). Climatic effects on sugarcane productivity in India: A stochastic production function application. International Journal Economics and Business Research, 10(2):179-203.
20. Kumar, A., Sharma, P., and Joshi S. (2015a). Effect of climatc factors on agricultural productivity in India: A state-wise panel data analysis. International Journal of Basic and Life Sciences, 3(1):48-67.
21. Kumar, A., Sharma P., and Joshi S. (2016). Assessing the impact of climate change on land productivity in Indian crop agriculture: An evidence from panel data analysis. Journal of Agricultural Science and Technology, 18(1):1-13.
22. Kawasaki J. and Herath S. (2011). Impact assessment of climate change on rice production in Khon Kaen province, Thailand. Journal of ISSAAS, 17 (2):14-28.
23. Marks D. (2011). Climate change and Thailand: Impact and response. Contemporary Southeast Asia, 33(2):229-58.

24. Murali, J., and Afifi, T. (2014). Rainfall variability, food security, and human mobility in the Janjgir-Champa district of Chhattisgarh state, India. Climate and Development, 6(1):28-37, DOI:10.1080/17565529.2013.867248.
25. Richardson R.B. (2010). Ecosystem services and food security: Economic perspectives on environmental sustanability. Sustainability, 2(2):3520-3548.
26. Rukhsana (2011). Dimension of Food Security in a Selected State-Uttar Pradesh. Journal of Agricultural Extension and Rural Development, 3(2):29-41.
27. Scanlan S. J. (2001). Food availability and access in lesser-industrialized societies: a test and interpretation of Neo-Malthusian and technoecological theories. Sociological Forum, 16(2), 231-262.
28. Shakeel A., Jamal A. and Zaidy N. (2012). A Regional Analysis of Food Security in Bundelkhand Region (Uttar Pradesh, India). Journal of Geography and Regional Planning, 5(9):252-262.
29. Sharma, P., and Singh A.K. (2017). Association of state-wise food security index with climatic factors in India: Evidence from state-wse panel data. Journal lof Global Agrculture and Ecology, 6(3):196-205.
30. Singh A.K. (2018). Influence of climatic and non-climatic factors on global food security index: A cross country-wise analysis. Socialsci Journal, 1(1):22-35.
31. Singh A.K. and Issac J. (2018). Impact of clmatic and non-climatic factors on sustainable livelihood securty in Gujarat state of India: A statistical exploration. Agriculture and Food Sciences Research, 5(1):30-46.
32. Singh A.K. and Shamra P. (2018). Implications of climatic and non-climatic variables on food security in Developing economies: A conceptual review. MOJ Food Process Technol, 6(1):1-13.
33. Singh A.K. and Shamra P. (2018a). Measuring the productivity of food-grain crops in different climate change scenarios in India: An evidence from time series investigation. Climate Change, 4(16):661-673.
34. Singh A.K., Ahmad M.M. and Sharma P. (2017a). Implications of socioeconomic factors on food security in selected economies: An empirical assessment. Journal of Global Economics, Management and Business Research, 8(2):103-115.
35. Singh A.K., Issac J. and Narayanan K.G.S. (2019a). Measurment of environmental sustainability index and its association with socio-economic indicators in selected Asian economies: An empirical investigation. International Journal Environment and Sustainable Development, 18(1):57-100.
36. Singh A.K., Narayanan K.G.S. Sharma P. (2019b). Measurement of technical efficiency of clmatic and non-climatic factors in sugarcane farming in Indian states: Use of stochastic frontier production function approach. Climate Change, 5(29):150-166.
37. Singh A.K. and Jyoti B. (2019). Measuring the climate variablity impact on cash crops farming in India: An empirical investigation. Agriculture and Food Sciences Research, 6(2):155-165.
38. Singh A.K., Sharma P. and Singh D.S. (2016). Measuring the influence of weather variables on productivity of food-grain crops in India: An application of Just & Pope's pruduction technique. ABBS Management Business and Entrepreneurship Review, 7(2):29-46.
39. Sitthisuntikul K., Yossuck P. and Limnirankul B. (2018). How does organic agriculture contribute to food security of small land holders?: A case study in the North of Thailand. Cogent Food & Agriculture, 4(1):1-12.
40. Smith D.M. (1973). The Geography of Social Well Being in United States. New York, Amol Heinman, (78).
41. Suttinon P., Bhatti A. M.and Nasu S. (2010). Impact of Climate Change on Rice Water Demand and Food Security: Case of Thailand and Vietnam. Journal of Agricultural Science and Technology, 4(6):63-70.
42. Swaminathan M.S. (1998). Population, environment and food security. Journal of the Indian Society of Agricultural Statistics, 51(2-3):99-112.
43. Waibel H., Pahlisch T.H., and Völker M. (2018). Farmers' Perceptions of and Adaptations to Climate Change in Southeast Asia: The Case Study from Thailand and Vietnam. In: Lipper L., McCarthy N., Zilberman D., Asfaw S., Branca G. (eds) Climate Smart Agriculture. Natural Resource Management and Policy, Vol 52. Springer, Cham.
44. Warr P. (2014). Food insecurity and its determinants. Australian Journal of Agricultural and Resource Economics, 58(1):519-537.
45. Zhai, F. and Zhuang, J. (2009). Agriculture impact of climate change: A general equilibrium analysis with special reference to Southeast Asia. ADBI Working Paper Series, 131.
46. Ye L., Xiong W., Li Z., Yang P., Wu W., Yang G., Fu Y., Zou J., Chen Z., Ranst E.V, Tang H. (2013) Climate change impact on China food security in 2050, Agron. Sustain. Dev., 33, 363–374.

pendix A: Estimated Food Security Index (FSI) for India and Thailand

Table A1: Estimated FSI for Indian States during 1985-2009

Year/States	A.P.	Bihar	Gujarat	Haryana	Karnataka	M.P.	Maharashtra	Orissa	Punjab	Raj.	T.N.	U.P.	W.B.
1985	0.328	0.430	0.291	0.501	0.316	0.338	0.255	0.379	0.539	0.424	0.349	0.275	0.307
1986	0.354	0.430	0.255	0.502	0.313	0.337	0.269	0.409	0.540	0.423	0.356	0.298	0.328
1987	0.366	0.430	0.311	0.476	0.308	0.318	0.282	0.411	0.536	0.415	0.371	0.287	0.337
1988	0.371	0.439	0.284	0.494	0.304	0.318	0.256	0.381	0.551	0.393	0.377	0.295	0.337
1989	0.358	0.438	0.291	0.508	0.304	0.319	0.260	0.382	0.543	0.411	0.368	0.286	0.318
1990	0.359	0.442	0.298	0.498	0.311	0.362	0.266	0.391	0.555	0.385	0.401	0.301	0.338
1991	0.356	0.445	0.293	0.500	0.310	0.351	0.263	0.377	0.552	0.385	0.394	0.302	0.327
1992	0.361	0.416	0.288	0.498	0.320	0.338	0.269	0.374	0.556	0.395	0.402	0.304	0.322
1993	0.371	0.431	0.307	0.506	0.318	0.336	0.289	0.385	0.574	0.403	0.399	0.301	0.340
1994	0.371	0.421	0.297	0.506	0.307	0.322	0.288	0.367	0.571	0.382	0.391	0.289	0.323
1995	0.390	0.386	0.334	0.496	0.322	0.317	0.287	0.375	0.557	0.417	0.396	0.293	0.344
1996	0.409	0.372	0.334	0.511	0.339	0.327	0.316	0.391	0.570	0.421	0.420	0.311	0.370
1997	0.392	0.348	0.355	0.501	0.340	0.304	0.316	0.373	0.553	0.438	0.437	0.306	0.347
1998	0.395	0.357	0.339	0.500	0.332	0.308	0.302	0.377	0.559	0.432	0.441	0.310	0.381
1999	0.427	0.359	0.349	0.478	0.355	0.291	0.308	0.379	0.520	0.440	0.442	0.295	0.391
2000	0.416	0.357	0.318	0.515	0.358	0.272	0.295	0.381	0.562	0.439	0.434	0.300	0.412
2001	0.430	0.324	0.318	0.532	0.346	0.252	0.296	0.379	0.565	0.440	0.425	0.301	0.408
2002	0.419	0.336	0.315	0.524	0.336	0.272	0.292	0.379	0.571	0.424	0.399	0.296	0.402
2003	0.441	0.350	0.327	0.528	0.333	0.276	0.296	0.386	0.555	0.420	0.405	0.307	0.394
2004	0.451	0.315	0.326	0.515	0.340	0.261	0.282	0.391	0.549	0.455	0.429	0.290	0.395
2005	0.483	0.338	0.325	0.497	0.364	0.257	0.291	0.399	0.543	0.407	0.451	0.289	0.393
2006	0.479	0.348	0.335	0.498	0.347	0.250	0.299	0.396	0.544	0.407	0.441	0.283	0.382
2007	0.491	0.361	0.348	0.501	0.357	0.253	0.310	0.418	0.548	0.416	0.438	0.281	0.381
2008	0.496	0.353	0.342	0.499	0.359	0.249	0.313	0.438	0.547	0.410	0.444	0.277	0.374
2009	0.510	0.366	0.345	0.540	0.376	0.261	0.327	0.452	0.529	0.414	0.462	0.280	0.391

Source: Author's estimation.

Table A2: Estimated FSI for Thai Provinces during 2008-2011

Provinces/Years	2008	2009	2010	2011
Chiang Rai	0.338	0.280	0.295	0.269
Kamphaeng Phet	0.333	0.381	0.303	0.322
Sukhothai	0.294	0.361	0.291	0.287
Phitsanulok	0.313	0.338	0.282	0.255
Phichit	0.386	0.369	0.351	0.323
Nakhon Sawan	0.365	0.422	0.358	0.384
Phetchabun	0.306	0.359	0.316	0.333
Phu	0.256	0.272	0.244	0.238
Udon Thani	0.247	0.261	0.265	0.293
Nong Khai	0.182	0.233	0.220	0.238
Sakon Nakhon	0.238	0.275	0.220	0.266
Nakhon Phanom	0.238	0.250	0.199	0.192
Mukdahan	0.272	0.282	0.188	0.184
Yasothon	0.246	0.269	0.209	0.219
Amnat Charoen	0.228	0.248	0.188	0.205
Ubon Ratchathani	0.207	0.235	0.203	0.217
Si Sa Ket	0.228	0.282	0.236	0.218
Surin	0.213	0.248	0.235	0.278
Buri Ram	0.233	0.268	0.240	0.256
Maha Sarakham	0.237	0.304	0.212	0.217
Roi Et	0.354	0.283	0.209	0.250
Kalasin	0.324	0.333	0.245	0.236
Khon Kaen	0.255	0.300	0.218	0.253
Chaiyaphum	0.255	0.295	0.246	0.270
Nakhon Ratchasima	0.328	0.351	0.264	0.328
Saraburi	0.440	0.396	0.342	0.384
Lop Buri	0.505	0.571	0.540	0.511
Sing Buri	0.425	0.406	0.350	0.431
Chai Nat	0.406	0.455	0.382	0.370
Suphan Buri	0.416	0.475	0.415	0.383
Ang Thong	0.383	0.417	0.316	0.376

Ayutthaya	0.429	0.457	0.409	0.405
Nonthaburi	0.348	0.339	0.343	0.371
Pathum Thani	0.369	0.442	0.420	0.426
Nakhon Nayok	0.306	0.494	0.457	0.302
Chachoengsao	0.414	0.500	0.329	0.398
Sa Kaeo	0.369	0.381	0.350	0.396
Chanthaburi	0.330	0.345	0.373	0.371
Trat	0.362	0.396	0.328	0.416
Rayong	0.371	0.478	0.449	0.444
Chon Buri	0.377	0.427	0.355	0.396
Nakhon Pathom	0.399	0.501	0.366	0.420
Samut Songkhram	0.381	0.372	0.289	0.343
Prachuap Khiri Khan	0.380	0.357	0.404	0.363
Chumphon	0.404	0.432	0.405	0.442
Surat Thani	0.314	0.336	0.309	0.314
Phangnga	0.259	0.354	0.387	0.366
Krabi	0.485	0.398	0.452	0.433
Trang	0.281	0.456	0.397	0.428
Nakhon Si Thammarat	0.313	0.358	0.285	0.289
Phatthalung	0.358	0.358	0.307	0.328
Songkhla	0.344	0.375	0.311	0.379
Satun	0.344	0.358	0.324	0.432
Pattani	0.337	0.306	0.330	0.329
Yala	0.284	0.235	0.282	0.300
Narathiwat	0.265	0.337	0.329	0.285

Source: Author's estimation.