

# Implications of Climatic and Non-climatic Variables on Food Security in Developing Economies: A Conceptual Review

## Abstract

The present study explores the relationship between food security, socioeconomic factors and climatic variables in context of developing economies based on existing studies. It suggests several scientific techniques to measure the food security at individual/state/region/country level. Reasonable and viable methods are also given, which can be used to assess the influence of climatic and non-climatic variables on estimated food security index (FSI). It primarily deals with various issues to measuring food security, and provides detail description of socio-economic and policy factors which have significant association with food security especially in developing economies. It emphasized that FSI is best estimator to identify the food security at individual/state/region/country level. It provides several policy suggestions for agriculture sustainability and to maintain food security in developing countries. It also facilitates several policy directions to mitigate the adverse effect of climate change in agriculture production activities and to achieve sustainable food security in developing economies.

**Keywords:** Climatic and socio-economic variables; Food security; FSI; India; Developing countries

## Research Article

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**Abbreviations:** FSI: Food Security Index; FAO: Food and Agriculture Organization; FSMI: Food Security Multidimensional Index; FSVIMSA: Food Security and Vulnerability Information and Mapping System Analysis; LES: Linear Expenditure System; AIDS: Almost Ideal Demand System; CGEM: Computational And General Equilibrium Model; GDP: Gross Domestic Product

## Introduction

Numerous of studies estimate the influence of climatic factors on food-grain crops as a proxy for integrated food security in different regions of India, conclude that climate change has a significant and negative impact on food security in India [1-3]. Few studies used agricultural productivity of food-grain and commercial crops to assess the climatic change impact on agricultural productivity using district-wise and state-wise panel data in India [2,4-7]. These studies also predicted that climate change would bring serious threat for food security especially for developing countries [1-3,8]. Since, food security is not a function of food-grain crops only and some other socio-economic and government policy factors also may affect the food security. Therefore, study based on food-grain crops may be unable to identify the actual situation of food security. Earlier studies did not empirically measure the influence of climatic factors on overall food security. Overall food security covers all the components of food security that is consider as food security index (FSI) [5,9-11]. FSI is an integrated index that includes a wide range of factors which are significantly associated with food security [5,9-11].

Furthermore, there is debate ongoing among the researchers in different field of studies (e.g., economics, sociology, health and biological sciences), national policy makers, development thinkers, international development organization and global policy maker that what must be proper solution to estimate the influence of climatic indicators, socio-economic variables, government policy factors and geographical factors on overall food security at individual level to households level, and country level to global level [9-12]. But anyone could not develop a concrete and rational scientific method to solve aforementioned problem. The question, therefore, to estimate the influence of climatic parameters and geographical location on FSI is still a greater challenge for existing researchers. For above-mentioned perspectives, few studies argued that scientific research communities need to develop an appropriate econometric model which would be useful to investigate the complex association of climatic factors with FSI. To account aforesaid drawback of earlier studies, the present study attempts to answer the following research questions:

- What could be reasonable technique to estimate the food security of a region?
- Which socio-economic and climatic factors are significantly associated with FSI?
- How climate variability do affects FSI?
- How it is possible to mitigate the adverse effect of climatic factors and socio-economic variables on agricultural production activities and food security?

With regards to aforementioned research question, the main purpose of the present paper is to assess the food security influencing factors in developing countries based on existing literature. This study facilitates suitable techniques to measure food security at individual level to household level, household to county level, and country level to global level. Also, it suggests scientific tools to examine the influence of climatic variables on FSI. Several policy suggestions are also given to maintain sustainable food security in developing economies.

### **Food Security and its Components**

The concept of food security emerged in the conference of United Nations Food and Agriculture Organization (FAO), World Food Conference in 1974. That time food availability was considered as a key component of food security [12]. In 2009, FAO defined food security as 'Food security exists when all people in the society at all times have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [13]'. At present food security is analyzed with four major components i.e. food availability, food accessibility, food utilization and food stability [5,9-12,14,15]. Food availability refers physical presence of food either through domestic food-grains production from agriculture in a region or import from food surplus area [5,9-12,15] or through export and import from food surplus areas. It increase as increase in technology inventory levels, local and international trade, and commercial imports or food aid [12]. Food accessibility focuses on the ability of people to obtain food, either through their own production and purchase or transfer [5,9-13]. This is related with economic ability of peoples to afford food according to their need. Food stability is a situation in which food is regularly and periodically available in the domestic/local market, therefore it has an ability to respond food in emergencies like war, crisis, natural disaster and etc. [5,9-11,13]. Food utilization refers the nutritional value of food, the interaction of physiological condition and food safety [13]. This component is linked with nutritional value of food that includes quality, safety and actual nutritional contents, and provides nutritional security to peoples.

### **Climate Change and Component of Food Security**

Extensive literature have been shown that climate change has negative and significant impact on all components of food security (i.e., food availability, accessibility, stability and utilization) [5,9-12,16,17]. As significant variability in climatic factors have a negative impact on country's ability to feed its population [5,9-12,18], thus, food security is associated with climate change. Food availability is adversely affected due to climate change through its impact on agricultural productivity [19,20]. Climate change unfavorably affects all inputs factors (e.g., soil fertility, water availability and quality, air quality, biodiversity, and other natural resource) of agricultural production system [3,8,21]. Subsequently, economic growth, income distribution and food demand have a tendency to be declined due to variability in climatic factors [17,19]. Decline in food production due to climate change may be caused to decrease food accessibility power of people. Also, real income of population decrease as hike in food prices in local market. Hence, food becomes unaffordable

for a large community of society [21]. Subsequently, climate change has a negative impact on food accessibility [20,22]. In addition, climate change could cause to decline farmer's incomes, employment opportunities, purchasing power of the poor people [2,3,8,17,23]. Moreover, climate change would lead to decrease food supply in local and global market, thereby food stability also decline. Thus, food stability declines as decrease in food production in an economy [17]. Climate change reduce the real nutrient contents of food, therefore it may cause to create several health problems for human [17]. Hence, climate change has a negative implications on food utilization. Food quality and actual nutrient contents of food also decrease due to climate change, which would be pushed to farmers and general population in greater safety risk and malnutrition [21]. Increasing temperature and changing rainfall pattern (e.g., change in rainfall pattern, drought, flood and warmer or cooler temperature lead to change length of growing and harvesting season of crops) are caused to decrease crop growth, yield and soil fertility which would create crop pests and news diseases [9-12,17,20,21].

### **Food Security and Economic Development**

Food is something that provides energy to function and keeps us alive and it is most essential part of our daily life [9-12,24]. 'Food is of high importance in matters of human well-being and economic productivity and it has been described as an important aspect in any consideration of the sustainability of the wealth of a nation' [25]. Food security is crucial factor for long-term sustainable growth and development [9-12,15]. It directly and indirectly associated with national prosperity and human well-being. Food security of a person is likely to have high productivity and energetic participation in economic growth [15]. It increases the working efficiency and productivity of peoples, and create horizontal pathway for economic development [26]. However, economic development and economic growth are essential to increase per capita income but development is unable to reduce food insecurity [27]. Hence, food security of population must be an issue of great importance of a country. It also must be great concern for all governments as food security build foundations for economic development, political stability and sustainable development [28].

### **Brief Overview of Food Security at Global Level**

Feeding to growing population is one of the most critical challenges for policy makers at global level [9-12]. There is a sufficient global food supply to feed the world's population. Despite that nearly 925 million people were undernourished in 2010, which accounts roughly 14% of the world's population [29]. Low income countries have highest number of malnourished children under age of five due to food unavailability and low economic capacity of people to acquire food [9-12,15]. Asia has largest number of undernourished population and it is the most food insecure region. Whereas Sub-Saharan African countries are second most food insecure region with 239 million undernourished populations. At present more than 870 million peoples do have unsecure resource for food at worldwide. Around one billion populations live their life in chronic hunger worldwide [30]. About 1.2 billion populations suffer from deficiency of

calories and protein; similar population suffer from obesity (excess fats and salts, deficiency of vitamins and minerals), and 2 to 3.5 million population have micronutrient deficiency at global level [31]. Also, somewhere one child dies in every six seconds [31], around eight million populations which counts around 50% world's children die every year due to hunger-related causes world-wide [28]. Hunger and malnutrition situation kill more people every year than serious diseases like AIDS, malaria and tuberculosis in the world [31]. Ultimately, malnutrition leads to increase disease and devastating the lives of hungry poor people especially in developing economies.

### Food Security Affecting Factors

Food security is broad and complex phenomenon, varies across households, regions and countries [9-11]. Food security of a nation significantly gets affected due to variation in agricultural production. Agriculture is a crucial factor to sustain food security as it can at least feed the population even in adverse economy [32,33]. Nevertheless, in the era of globalization, food security may not be defined by agricultural production only since food security is a multidimensional, multi-processing and multiple interacting component of an economy [19,30]. There are several factors that play a significant role to sustain food security at individual/households/national/global level. Food security is significantly associated with age, sex, occupation, employment, vegetarian and non-vegetarian diet, poverty, per capita income, income inequalities, demand of food-grains, rapid population growth, fluctuation in food-grains and oil prices, poor market accessibility, low irrigation facilities, application of fertilizer, credit accessibility, cost of cultivation, application of traditional technologies in cultivation, literacy of farmers, declining land productivity and soil quality, decline in arable land due to urbanization and industrialization, diminishing ground water availability due to over exploitation of water, geographical location, government policies, government expenditure on agriculture and rural development, public spending on R&D, natural resource management and environmental protection policies, trade policies, and climate change [1,2,5,6,8-11,27,32-45]. As high income inequalities increase people's involvement in illegal activities outside the market which contribute political and social instability. Income inequality, therefore, is a major driver for food insecurity in society [9,46]. Consequently, food-price inflation has a high tendency to be increased [46].

Food insecurity is consequence of poverty and low accessibility of population to acquire food according to their need. Poverty is significant cause for food insecurity [9-11,15,47], it is the prime cause of hunger and at the same time hunger is the cause of poverty and under nutrition. Figure 1 shows the poverty situation for different economies of the world. India and Nigeria count largest number of undernourished person due to high and chronic poverty. It also makes the comparison of India's food security as compared to China, El-Salvador, Hungary, Mexico, Morocco, Paraguay, Thailand, Ukraine and Nigeria. India is in alarming position in food insecurity due to chronic poverty as compared to other larger agrarian economies like China, Brazil and Thailand [5,9,40,48].

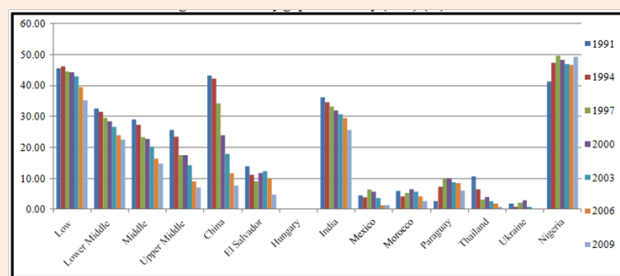


Figure 1: Poverty gap at \$2 a day (PPP) (%)

Source: World Bank Statistics (2013).

Increasing food prices is also another cause for food insecurity, hunger and poverty in most developing countries like India, Bangladesh, Pakistan and Thailand [5,9-11,22,38]. In developing countries a large portion of poor people spend a large share of their income on food and any price hike has negative impact on their food consumption level. However, most developing countries are in food insecurity trap due to lower cereal productivity and per capita availability of cereal [11,48]. Hence, agriculture is considered as a best estimator for food security as it reduces malnutrition level, hunger and poverty for small scale farmers who undertake cultivation at subsistence and marginal level [9,48]. High variability in food price is caused to decrease ability of poor people to move out from poverty and food insecurity would be in serious position due to high poverty. Adenegan KO et al. [49], observed that instability in food prices is a potential problem for food insecurity in Nigeria. Faridi R et al. [37], witnessed that food price is one of the most significant factors for reducing household's food security in Bangladesh. Figure 2, indicates the consumer price inflation rate of various economies. The average inflation rate is higher in developing countries than developed economies during 1996-2009. Therefore, developing economies like India and Nigeria are in food insecurity trap [48].

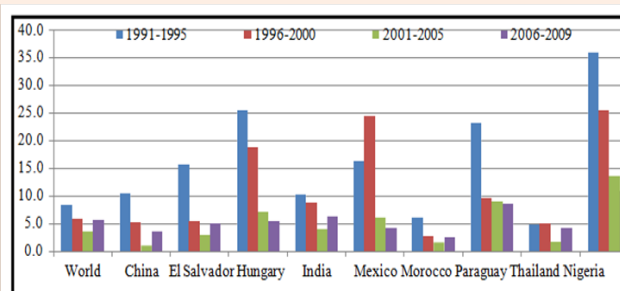


Figure 2: Inflation, consumer prices annual (in %)

Source: World Bank Statistics (2013).

Excessive demand of food-grain products due to rapid population growth is caused to increase food insecurity in developing economies like India, Nigeria, China, Indonesia, Bangladesh, Pakistan [9-11,26,33,48]. Rapid population growth has also created food crisis at global level [50]. Figure 3, provides

the scenario of population growth of different income group countries. Nigeria, India and Paraguay have a high population growth, therefore these all countries are most food insecure countries as compared to those economies which have lower population growth [11,48].

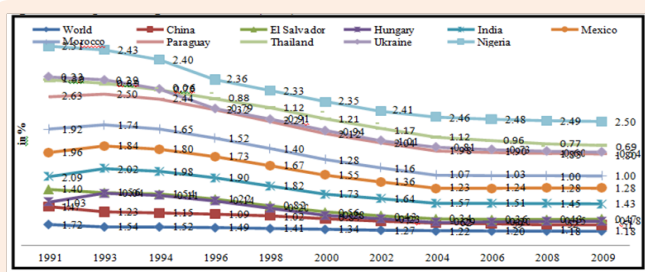


Figure 3: Population growth annual (in %)

Source: World Bank Statistics (2013).

Additionally, rapid urbanization has a negative implication on food security [9-11,26]. Urbanization is creating another form of acute hunger in most of developing regions like India and China [28,48]. Fertile arable land is using for non-agricultural purpose (i.e., building, roads, houses construction and factories) due to rapid urbanization and industrialization. Thereby food-grain area and food-grain production has decreased at global level [9,50,51]. Also, it has been evident that global area under pulses has decreased from 5 million hectare in 1968 to 3.9 million hectare in 2007. Consequently, consumption of pulses in terms of kcal/capita/day is also declined due to urbanization and industrialization during 1968-2007 [22]. Figure 4 specifies the urbanization rate for different countries. Brazil, El-Salvador, Ghana, Hungry, Indonesia, Nigeria, Paraguay, Ukraine and Uganda have a higher urbanization. So, urbanization has brought negative implications on food security in these economies.

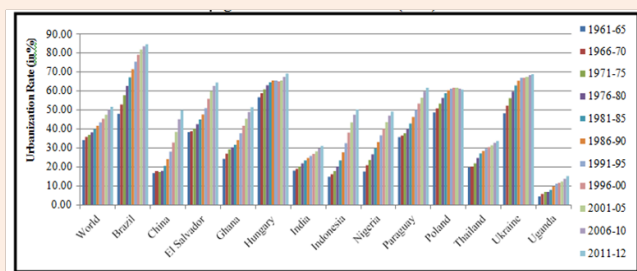


Figure 4: Urbanization rate (in %).

Source: World Bank Statistics (2013).

Moreover, it has seemed that urbanization has a negative impact on predominantly poor farming communities in Ghana [52]. Around 1.5 million hectare land (mostly agriculture) has decreased due to high urban growth rate in India during 1955-1985 [51]. In India, per capita arable land has declined from 0.48 hectare in 1950 to 0.15 hectare in 2000 due to rapid urbanization and industrialization [53]. Per capita arable land is expected to decline by 0.08 hectare by 2020 [53]. Joshi L [20], also claimed that

food and nutritional security of population is in serious position due to extensive utilization of groundwater, industrialization and urbanization in Maharashtra (India). Over urbanization brought several problems like environmental degradation, pollution (land, air, noise, water and visual), unemployment, poverty, slums, high traffic congestion, social crime and food insecurity in Nigeria [54]. However, one group of researcher claimed that urbanization creates new employment opportunities, increases income of population and generate physical assets which would be useful to increases economic capacity of people to acquire food [9,11,48]. Thus, urbanization would be useful to increase economic development for those countries which have higher ability to maintain the pace of urbanization [48].

### Measurement of Food Security

There are more than 450 parameters and 200 definitions which describes the food security in existing literature [12]. As food security has a multiple-interacting, multi-dimensional and multi-complex association of with its determinants [19,30], therefore, food security measurement is very difficult, complex, typical and controversial [5,9,10]. It can be measured at global, national and household/individual level [55-62]. Precisely, food security at global level does not guarantee that food availability at national level, and at national level does not necessary that food is available at household/individual level [47]. There is existence a hierarchical structure in food security at individual-household, households-community, community-region, region-country and country-global level [55]. Food security can be estimated through three major approaches: First approach includes all components of food security (i.e., food availability, accessibility, stability and utilization) [9-11,48]. The approach is known as food security and vulnerability information and mapping system analysis (FSVIMSA) [56] or food security multidimensional index (FSMI) technique. Second approach is based on computational and general equilibrium model (CGEM) [56]. Third approach is an econometric estimation that depends upon consumer demand by linear expenditure system (LES) and almost ideal demand system (AIDS) [56]. This approach estimates elasticity, nutrition related measures and welfare indicators at household level. Aforesaid approaches may be applied at micro and macro level to assess the food security.

Figure 5 shows the details of several methods to evaluate the food security at different levels. It infers that food security can be estimated through absolute and relative level, while different techniques like FIVIMS dimension, multidimensional index, GFSI, RFSI, SWFSI, GHI, SHI, per capita food-grain availability, per capita calories intake availability, per capita food expenditure, per capita depth of food-deficit, etc. may be used to estimate the food security at global/national/sub-national/household/individual level in an economy [56].

Food security can be estimated by per capita calorie intake availability method, food expenditure method, food-grain availability method, food-deficit method, dietary food energy supply technique, food energy deficiency and diet quality method at individual level [35,40,43,44,55,63-76]. Food inequality across individuals and households can be measured by headcount ratio, Simpson and Shannon index methods. Household's food



security can be estimated by anthropometrics methods based on subjective information observed by researchers at the time of field survey. Total food-grain production may be considered as a sole component to observe the food security at national level [38,40,58,77-80]. Existing studies used several methods to estimate the food security at individual to national level, like [26], mentioned that per capita dietary energy supply is best estimator to measure the food security. Adenegan KO et al. [49], used food-deficit in per capita calories availability to ascertain the food security in Nigeria. Shakeel A et al. [27], argued that food production availability reveals the food security of a region in specific time period, while food availability is a functionally linked with domestic agricultural production or through imports from surplus areas. However, food security is not only function of food availability and stability but depends upon food accessibility also [5,10,24]. Food stability and food accessibility would improve as increase in food availability [27]. It infers that all components of food security would be automatically adjusted as increase in food production [5,9,10,48]. Hence, food security is significantly associated with food availability, accessibility and stability [9-11,27]. Although food accessibility and food stability are independently related to each other [5,10,11,48]. Few researchers emphasized that food security index (FSI) is a best estimator to assess the state of food security of a region [5,9-11,33,35,37,48,49,55,64,66-68,81].

estimated values of FSI for regions/states/nations. Highest value of FSI for a region reveals a higher food security of this region as compared to others. FSI can be generated for two to more than two individuals in a village/region to get insightful idea of food inequalities across households. Hence, FSI works as a powerful policy tool to take an essential action to maintain sustainable food security in a region [5,9-11,48,81,84].

### Association of FSI with Socio-economic Factors

Exiting researchers used three techniques to estimate FSI, first group of researchers used a single parametric method; second groups of studies generate FSI using calorie intake method, per capita food-deficit method, and food expenditure method; and third group of analyses create FSI using food security and vulnerability information and mapping system method. Scanlan SJ [26], used per capita dietary energy supply (in calories) as proxy for food security in across economies. This study showed that population pressure and over-urbanization has negative implication on food security, while food security would be improved as increase in application of fertilizer, technologies, land use intensification, economic growth, infrastructural development and internationalization of food markets. Most researchers have evaluated household's food security status based on secondary and primary data in developing countries (*i.e.*, Nigeria, India, Malaysia, Bali, Cameroon, Iran, Ethiopia, Kenya, Mexico, Ghana, Zambia, Pakistan, Bangladesh, ESA countries). Adenegan KO et al. [49], estimated the influence of various factors on constructed FSI using food-deficit in per capita calorie availability method in Nigeria. It implies that there is needed to increase domestic food production to ensure food security, while import and export earning, and variability in staple food prices were the potential factors for food insecurity. One group of researchers created FSI using calories intake methods and applied logistic regression model to identify the FSI influencing factors in developing economies [39,40,43,44,55,64,68,69-71,73,74,76,85-89].

In Nigeria Babatunde RO et al. [64], observed that total annual income, household size, educational level of household's head and food production quantity are the significant determinants of household's food security. Ibrahim H et al. [66], also focus that there is desirable to increase production of food-grain crops to reduce food insecurity in Nigeria. Omotesho OA et al. [55], recognized that farm size of households, gross farm and non-farm income, and household size were the most significant determinants of household's food security in Nigeria. Omotesho OA et al. [25], concluded that household's food security is significantly associated with health facilities, household size, farm size and food expenditure in Nigeria. Orewa SI et al. [67], found that salary earners and farm families were more food secure than non-salary and non-farm families in Nigeria. Ajao KO et al. [68], mentioned that households with large family size and poor child care practices were likely to have malnourished children in Nigeria. Ahmed FF et al. [36], discover that income and employment level, physical assets and credit accessibility have positive influence on food security in Nigeria. Aidoo R et al. [87], detected that household size, farm size, off-farm income, credit access and marital status were the important factors to increase household's food security in Ghana.

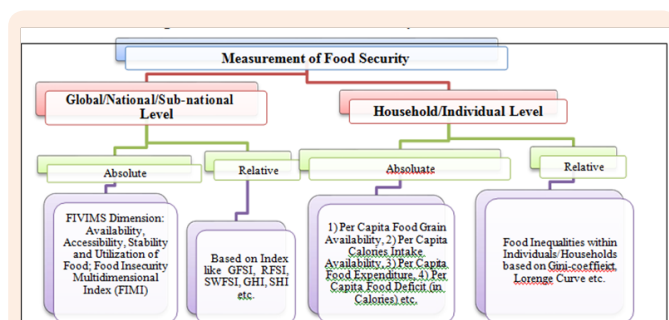


Figure 5: Assessment of food security at different levels.

Source: Adopted from [56] and based on earlier studies.

### Importance of Food Security Index (FSI)

Food security index (FSI) is a simple number that covers most variables of food security (*i.e.*, food availability, accessibility, stability and utilization) [5,9-11]. Though, an exact, specific or scientific definition of FSI is not available in the existing literature. The index can be generated using various methods (e.g., composite Z-score, principle component analysis, binary-dimensional, and head count ratio method) [82]. Several researcher estimates FSI as multi-dimensional and multi-complex parameter that includes a large number of data sets [5, 9-11,48]. Few researchers have preferred to FSI based on one crucial parameter of food security (*i.e.*, per capita calories availability, per capita food expenditure, depth of food- deficit, diversity in food availability) [25,26,35,49,55,63-67,69-71,73,74,83]. FSI provides the awareness to policy makers or economic agents for a specific place to take initiative for policy purposes or target intervention toward food security [5,9-11]. There can be given ranks based on

Beyene F et al. [85], claimed that experience in farming activities, off-farm and non-farm incomes, land and livestock holding, fertilizer application, soil and water conservation practices have the positive and significant impact on household's food security in Ethiopia. Tefera T et al. [74], reported that age of household head, level of education, household size, size of cultivated land, use of improved seed, contact with development agents, size of credit received, size of livestock owned and off-farm income per adult were appeared crucial factors for households food security in Ethiopia. Nyaga EK et al. [90], described that increasing cash crop area was helpful to increase the economic capacity and food security of households in Kenya. Wambua BN et al. [91], revealed that marketing system, land ownership, farming practices, poor food storage, household's income, water availability, expenditure, traditional cultural values and ecosystem services were found important determinants of food security in Kenya. Tantu AT et al. [44], perceived that sex of household head, age of household head, family size, marital status, occupation, monthly income, food expenditure, house ownership and credit access were found significant indicators for food security in Ethiopia. Tambi MD et al. [80], observed that contribution of women in agricultural have a positive impact on food security, while mother's education, family size, farm size were the significant indicators for food security in Cameroon.

Arene CJ et al. [35], witnessed that poverty, employment creation, income of the household, income generation, re-use of waste water were significant factors for food security in Nigeria. Ifeoma JI et al. [73], stated that that educational level, household size, sex of household, access to credit facilities were the crucial factors for food security in Nigeria. Ogundari K [45], observed that household size and income were the significant factors for food security in Nigeria. Gebre GG [69], witnessed that household size, household head age, household head education, asset possession, access to credit service and access to employment were the important factors influencing food security in Ethiopia. Gholami A et al. [92], noticed that car ownership, chronic disease in household and household income have significant association with food security in Iran. Magaña Lemus D et al. [88], found that younger, less- educated heads, headed by single, widowed or divorced women, rural and lower income households were more food insecure in Mexico. Cordero Ahiman OV et al. [89], point out that income, consumed seed stock, maize production, casual employment, household size, education, access to water facilities, electricity, energy for cooking, land ownership, consumed seed stock, situation of poverty were critical factors which are affecting food security in Mexico.

Zakari S et al. [40], quantified that drought, high food prices, poverty, soil infertility, disease and insects were the negatively associated with food security in Niger. Harris Fry H et al. [75], concluded that wealth and land ownership were the crucial factor to reduce the food insecurity in Bangladesh. Zou J et al. [93], found that China's food security is negatively impacted due to redistribution of land resources, rising international food prices, declining water resources, growth in food demand. It also highlighted that there is required to provide financial support to agriculture, land protection mechanism and improve utilization of grain to sustain food security in China. Farzana FD et al. [43],

observed that education level, occupation, household income, women education, household size were the key indicators for food security in Bangladesh. Suharyanto et al. [39], provide empirical evidence that housewife's education, income and food reserves have positive impact on food security, while family size and price of price have a negative impact on food security in Bali.

Erokhin V et al. [79], found that there was significant causality between dependent variables and explanatory variables, while food prices, population and CO<sub>2</sub> emissions were not significant factors to define food security in Malaysia. Applanaidu SD et al. [58], concluded that biodiesel production, exchange rate and government expenditure on rural development variables were the crucial factors to food security in Malaysia. Iram U et al. [83], provide evidence that household's income, mother's age have a significant impact on average calorie intake in Pakistan. Sultana A et al. [86], claimed that household's residence place, dependency ratio, education level were the significant factors for food security, whereas household's food security does not have significant association with social capital and employment level in Pakistan. Khan REA et al. [77], noticed that food availability has positive association with food-grain production, while food accessibility was positively associated with literacy rate; and female literacy, sage drinking water, number of hospitals were also useful to sustain food security in Pakistan. Bashir MK et al. [70], observed that monthly income and education level of household have positive impact on food security, while age of household's head and family size were negatively associated with food security in Pakistan. Bashir MK et al. [71], demonstrated that household's monthly income and education level were positively associated with food security, while food security negatively related with household head's age and family size in Pakistan. Karmakar S [46], observed that severity of food insecurity do not depends on chronic poverty but it depend upon income inequalities in West Bengal (India).

Babatunde RO et al. [65], recognized that female-headed households were more food insecure than male-head households, while vulnerability of food insecurity increase for male-headed households as household's size increase but it could decrease as the value of crop output, food expenditure, farm size and labours hours increase in Nigeria. Few studies calculated FSI using food expenditure method and applied a logistic regression model to assess the influence of socio- economic variables on FSI. Based on aforementioned estimation. Arene CJ et al. [35], presented that income and age of household's head have positive and significant impact on food security in Nigeria. In Bangladesh Faridi R et al. [37], determines that food security is highly sensitive with variation in rice prices. Another group of researchers applied food security and vulnerability information and mapping system method to measure the food security. Yu B et al. [33], used principal component analysis to measure the food security of 175 developing countries and demonstrated that high food price was the key reason for food insecurity in most African countries.

Few studies applied composite Z-score method to create FSI using three components of food security, i.e., food availability, food stability and food accessibility [5,9-11,24,48]. Rukhsana [24], mentioned that there is high variation in all components of food security across districts in Uttar Pradesh (India).

Shakeel A et al. [27], revealed that food security measurement is very critical and it varies across districts (India). [94], showed that food availability has declined due to higher urbanization in Uttar Pradesh (India). Rukhsana [24], Sajjad H et al. [84] also explained that food production and food security has decreased due to higher industrialization, urbanization, commercialization and technological innovation in agriculture, thereby farmers are getting incentive to grow cash crops for quick financial benefit in Uttar Pradesh (India). Hashmi SNI et al. [94], found that northern part is more food insecure than eastern part of Uttar Pradesh (India) due to low food production, lack of storage facility and high illiteracy rate. Kumar A et al. [5], also observed that high inequalities in food security due to climate change and variability in socio-economic structure across Indian states. Sidhu RS et al. [95], reported that consumption expenditure was positively associated with income level of household, whereas low income households were in more food insecure trap than high income households in Punjab (India). Sajjad H et al. [84], observed that there existence a high food inequality across blocks, and per capita food-grain output has declined due to less irrigation facilities and climate change in Vaishali district of Bihar (India). Kumar A et al. [9], estimated the state-wise FSI in India and observed that there was existence of variability in food security across Indian states due to variability in socio-economic characteristic and environmental factors.

### Association of Climatic Factors with FSI

It has been proved that very few researcher investigated the impact of climatic factors on constructed FSI using econometric modeling [5,10,38,48,81,82,96,97,99]. The first study has included climatic factors as a part of their analysis for empirical investigation undertaken by [82]. It demonstrated that household food security is significantly getting influenced due to changing rainfall pattern and variability in Ethiopia. Ye L et al. [81], observed that FSI would be dropped from +24% in 2009 to -4.5% and +10.2% under A2 and B2 scenarios respectively by 2030 in China. While, FSI is predicted to be increased by +7.1% and +20.0% under A2 and B2 scenarios respectively by 2050, but FSI will improve as decrease in Chinese population. Belloumi M [38], assessed that GDP per capita, inflation, population growth and land under cereal production were crucial factors to define food security, while rainfall were show positive impact and temperature show negative impact on food security. In ESA countries, unstable rainfall and temperature have adverse impact on food production, malnutrition and mortality rates. Wineman A [96], observed that seasonal rainfall and temperature show significant impact on household's food security in Zambia. Badolo F et al. [97], found that food supply is negatively impacted due to rainfall variability, while impact was high in rain-fed agricultural or agriculture intensive economies which are depend upon rainfall. Per capita GDP show a positive impact and population size show negative impact on food supply in 71 across economies. Ismail M [99], detected that without adaptation actions, the climate change is significant cause to reduce food sustainability in Malaysia. Kumar A et al. [5], estimated state-wise FSI in India, thereafter it used estimated index as dependent variable, and regress it with climatic and non-climatic factors. Kumar A et al. [48], appraised the influence of CO<sub>2</sub> emission as proxy for climatic

factors and socioeconomic variables on estimated global food security index (GFSI) in selected cross economies. It proved that CO<sub>2</sub> emission was negatively associated with global food security, and highlighted that the world's economies are essential to develop appropriate scientific techniques to abatement of GHGs. Sharma P et al. [10], observed that climatic factors and geographical location have statistically significant association with food security in Indian states.

### Conclusion and Policy Guidelines

This study provided an extensive literature review on food security affecting factors in developing economies. It argued that FSI is a better estimator to identify ground information on food security at individual/region/country level [5,9-11,82]. FSI can be estimated using composite Z-score method, principle component analysis and binary-dimensional technique [5,9-11,24,33,43,48,49,71,72,82,84,90,93]. At individual/household level, FSI can be created based on per capita food-grain availability, per capita calories intake availability, per capita food expenditure and per capita food-deficit method [25,36,46,55,63-71,73,74,83,85-87]. Calories intake method is most significant technique to estimate the food security at individual level [47]. Food security is significantly associated with food availability, stability, accessibility and utilization [5,9-11,14,15,24,48]. Family size, age of household's head, cultivated area, food production, inefficient food-grain market, rising food prices and credit accessibility have a significant impact on food security [33,37,39,44,65,68,71,87,92]. Education level and people's income, drinking water availability, livestock rearing, farm size, irrigation facilities and fertilizer, land intensification, soil and water conservation practices, infrastructure development, gross farm and non-farm income, health facilities, access to credit and employment opportunities have positive influence on food security in most developing economies [1,23,36,41,44,65,68,71,74,80,84,85,86,87].

Based on extensive literature review a large number of factors are recognized which are significantly associated with food security in developing economies and given as: percentage of gross irrigated area to net sown area, households having drinking water, primary health care, access to credit service, access to employment, access to media, access to nearest market, access to water facilities, age dependency, age of family's head, age of housewife, age of mother, agricultural density, agricultural labour force, agricultural land, agricultural mechanism, annual gross farm income for household, annual non-farm income, asset possession and food aid, availability of food stocks, education of household's head, basic amenities, caloric availability of food-grain, capital input, carbon concentration, carbon cycle, temperature, caste system, casual employment, cereals and oilseeds production, chemical fertilizer uses, child care, chronic disease in household, climate damage, CO<sub>2</sub> emission, social conflicts, seed stock, consumption expenditure, credit facilities, crop rotation, cropland area, cropping intensity, cultural background/ethnicity, daily wage, decision making, democratic institutions, dietary diversity, diseases and insects, distance from city and main road, drought, economic growth, education level of household head, education of mother, electricity, employment



status, energy for cooking, ethnicity, fair price shop, family type, farm income, farm inputs, farm size, farming experience, father present in the house, fertility rate, fish price, flooding, grain yield, food consumption expenditure, food energy deficit, food export earning, food import, food price shock variability, food stock, food-grain area, food-grain availability, foreign workers, education of housewife, freedom for women to access the market by herself, fruit and oilseed, per capita gross domestic product (GDP), gender of household head, grain trade decency, health conditions of households members, health facilities, health status of the mother, high dependency ratio, hospitals, house ownership, household annual income, household demographics, household food reserves, household head participation in social organization, household head with farming as major occupation, household size, household tastes and preferences, household wealth, household with electricity, households location, households that only home produced food consumed, immunization rate, income inequality, income sources, inflation, infrastructural development, insect and pest infestation, involvement in decision-making relating to daily household expenditures, knowledge of malnutrition prevention, labour market participation, lack of employment opportunity, land ownership, land rented out, land size, land under cereal production, land intensity, length of road, livestock asset, livestock per population, marital status of household head, marital status of mother, market structure, mean annual temperature, member of professional association and cooperative society, milk production, mother's age, mother's education, number of contact with development agents, number of earners in household, number of under-five children, number of women of reproductive age in the household, occupation of head of household, occupation of mother, occupation of primary earner, off-farm income activity, off-farm income per adult equivalent, off-farm/non-farm income, over urbanization, ownership of land, per capita grain gap, per capita income, per capita value of agricultural production, population growth, population pressure, population size, poverty, precipitation, price of cooking oil, price of instant noodles, price of rice, price of vegetables, prices of inputs, primary school enrolment/1000 population, production of eggs or milk and vegetable/fruits, production of fish, production of poultry meat, production of pulses, productive assets, proportion of household member by age, quality of food from own production, rainfall fluctuation, rainfall variability, rainfall variation, ratio of agricultural labours to total workers, ratio of grain sown area to gross crop sown area, ratio of scheduled castes and scheduled tribe to total population, ration shop, real effective exchange rate, real per capita income, religion, remittance, residential infrastructure, rural connectivity, rural-urban disparity index, salary wage employment, self-employed, sex of household head, size of credit received, skilled off-farm workers, social capital, soil and water conservation, soil infertility, storage capacity, technology development, transfer network, types of assets, urbanization rate, use of improved seed, use of vegetable gardens, variety of crops planted, variety of food groups consumed, participation of women in agriculture, crime, and working status of family members in various economic activities [24,26,27,34-40,43-46,49,55,57,60,61,63-66,68-71,73-75,77,78,80-90,92-99]. Hence, it can be concluded that food security is complex phenomenon and significantly gets affected by wide number of socio-economic and

government policy factors. However, the effects of various factors on food security are varied across regions/economies. Poverty and income inequality are also caused to increase food insecurity in developing economies [9,15,46]. Rapid population growth, overwhelming industrialization and urbanization are also created several problems to sustain food security [9,10,20,22,26,28,50-54,94].

The study provides a confirmation that climatic variability has a significant and negative association with food security in Ethiopia [82], and China [81], India [5,10,11], developing economies [48]. However, the present study could not find more literature which estimates the impact of climatic factors on FSI in developing economies. So, it would be incompetent to say that climatic factors have negative association with constructed FSI in developing economies. Hence, the present study emphasized that there is required to generate FSI using a reasonable technique in developing economies. Thereupon, constructed FSI must be used as dependent variable to assess the influence of climatic and non-climatic factors on FSI using advanced econometric models. It would be useful to empirically assess the reasonable effects of climatic and non-climatic variables on FSI in developing economies.

Several policy recommendations can be given to sustain food security in developing economies. The study strongly argued that larger agrarian economies must be self-dependent in food-grain production. Food security would be improved as increase in agricultural production and agriculture is a straight forward solution to achieve sustainable food security [33,48]. Thus, there is essential to adopt modern technology in agriculture to increase food productivity. While, agricultural productivity would improve as increasing irrigation facilities, high yields varieties of seed, improving soil quality using bio-fertilizer, government expenditure on infrastructural development and agriculture and rural development, public spending on agricultural R&D, market accessibility, crop insurance policies [1,6,23,41]. In addition, effective rural and urban development schemes for poverty eradication and to reduce income inequalities, appropriate credit facilities to farmers, policies to regulate food prices, proper storage facilities for food products, fair food distribution policy, livestock rearing occupations, and to create more employment opportunities in non-agricultural sector, accessibility of safe drinking water, primary health and education facilities, and healthy environment would be key components to sustain food security.

Poverty and high food price have a negative implication on food consumption in developing countries, where the poor typically spend a large share of their income on food. Therefore, governments need to provide a bundle of public goods to support progressive steps to increase household's food security [47]. As agriculture is a significant product of ecosystem services of land and water, while per capita arable land and cereal land has declined due to rapid urbanization, industrialization and population growth [53]. Subsequently, ground water availability is also declined [51]. As high population growth has two negative implications in economy: first, food demand will increase due to rising population, additional demand of food-grain products



would cause to increase food price; and second, unemployed population would also increase. Rising food prices may be caused to decrease food accessibility capacity of population, which would turn in more food insecurity. So, there is essential to implement effective policies to reduce the negative consequences of rapid urbanization (e.g., to control labour migration from rural to urban area) and population growth (e.g., family planning) which would be appropriate to sustain the common property of natural resource (i.e., water and cultivated land) [26,48,50]. It would be useful to reduce income inequalities and improve socio-economic condition of peoples, and to maintain sustainable food security [26,50,52,54].

Also, irrigated area has a greater yield advantages than rain-fed/non-irrigated area [1,5,9,10,23,41,84]. Therefore, policy makers essential to increase investments in irrigation facilities that would improve the water efficiency to increase agricultural productivity [1,41,85]. Irrigation facilities would improve as application of water harvesting and water conservation policies [85], efficient use of water through micro-irrigation techniques (sprinkler and drip irrigation). Suggested quantity of fertilizer must be applied in cultivation to increase food production, otherwise excessive utilization of fertilizer would be caused to decrease land productivity, soil fertility, environmental quality, groundwater quality and pure water for irrigation [1,2,22,23,50]. Climate change also brought serious crisis for food insecurity and hunger at global level [42]. The situation would be more alarming if climate change happened in near future because even without climate change the World would be required 70% more food to feed nine billion populations by 2050 [17]. While, global growth of agricultural productivity for staple crops (rice and wheat) has declined and it is expected to go down by 1.5% by 2030. Further, it is expected to decline by 0.9% by 2050 compared to 2.3% per year since 1961 [22]. For example, India would be most vulnerable country due to climate change as compared to other agrarian economies like Brazil and China [2,41,42]. The current population of India is 1.23 billion that is projected to be increased by 1.53 billion by 2030 (if the population growth rate continue at 1.58% annual) [51]. So, there would be a great challenge to produce additional 345 million tonnes (70% more) of food production by 2050 from 141 million hectare land. Thus, in India, food demand will be double by 2050 due to high population growth and it may increase the competition for already scarce natural resources (land, water, capital, labour) [18], while India becomes the largest ground water based food growing country in the world [51]. Accordingly, extra pressure to increase agricultural production would require more groundwater which already diminished in India. Government agents, international development organizations and policy makers are necessary to increase public investments in agricultural sector to feed present and growing population of the world. Public expenditure on agricultural R&D would be important to select a reasonable adaption techniques to mitigate the adverse effects of climate change [23,41,42]. Short-term training to farmers about climate change would help to farmers to select an appropriate food-grain crops for cultivation, which are less climate sensitive [41]. More public spending on telecommunication to provide the climate change related information to farmers on time would be quite

beneficial to take precautionary actions in cultivation and to avoid loss of agricultural production [41]. Agriculture extension offices and district rural development agencies can play a significant role to convey climate change related information (cyclone, floods, and droughts) to farmers. Infrastructural development (i.e., transport facilities and road construction) would be alternative technique to increase good communication of rural farmers with markets in urban area [41]. This would be helpful to improve agricultural productivity and food security in long term as farmers would be in a position to buy modern varieties of seeds and advance technology for cultivation from the market [41]. Collaborative association among local farmers, inputs suppliers, traders, consumers, agriculturist scientists, researchers, stakeholders and policy maker would be useful to take an effective decision to choose an appropriate adaptation technique to mitigate the negative consequence of climate change in large agrarian economies [41].

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### Conflict of Interest

Authors declare that they have no conflict of interest.

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