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Panel Quantile Approach towards Exigent Determinants of Food Security in the Selected Developing Countries

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ABSTRACT

This paper presents the comprehensive measurement of food security index by incorporating all of its dimensions for a panel of 50 developing countries. The study also empirically examines the exigent determinants of the overall food security index across developing countries by categorizing them into two distinct income groups from 2007 to 2020. The study used Panel Quantile Regression to capture and analyze the heterogeneous effects across different quantiles of the distribution. The findings reveal that urbanization, food prices, and unemployment negatively affect food security, whereas the effect of unemployment is obscure as the country's income rises. Findings also indicate that carbon emissions may pose a significant threat to food security in newly industrialized countries. Furthermore, the findings also illustrate that GDP per capita, literacy rate, arable land, credit to agriculture, and institutional quality are significant contributors to food security. Hence, there should be a significant emphasis on improving the quality of institutions to strengthen the positive determinants of food security and mitigate their adverse effects.

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1. Introduction

One of the Sustainable Development Goals (SDG) set by the U.N. General Assembly (2015) includes accomplishing food security, finishing hunger, endorsing sustainable agriculture, and improving nutrition by the end of 2030. Regrettably, developing countries are not expecting to achieve zero hunger by the end of 2030 (FAO, IFAD, UNICEF, WFP, & WHO, 2020). Almost 60 million hunger people in the world increased from 2014 to 2020, and if the recent trend continues, the number of people affected by hunger will exceed 840 million by the end of 2030 (Awad, 2023). The accomplishment of food security continuously entails the availability of food in appropriate quantities, sufficient income or resources to buy adequate food items, sufficient quality of food, and nutritional requirements (Bahiru, Senapathy, & Bojago, 2023).

Food is viewed as a universal good that should always be accessible to everyone. Every person has the right to enjoy quality food and a quality lifestyle and none can be excluded from it. Over time, it has consistently been a top policy concern for numerous governments and nations (Asim, 2018). The biggest issue that society faces today on a worldwide basis is obtaining adequate meals to maintain an active and healthy lifestyle whereas those who have been unable to provide their masses enough food, irrespective of their status as king, dictator, or parliamentarian, have often fallen (Fraser & Rimas, 2011). Despite significant progress in the agricultural sector and knowledgeable economic development in recent decades, the problem of food shortages still exists in many economies of the world (Asim & Akbar, 2019). After some years of decline, global hunger is currently on the rise (FAO, IFAD, UNICEF, WFP, & WHO, 2018; Molotoks, Smith, & Dawson, 2021).

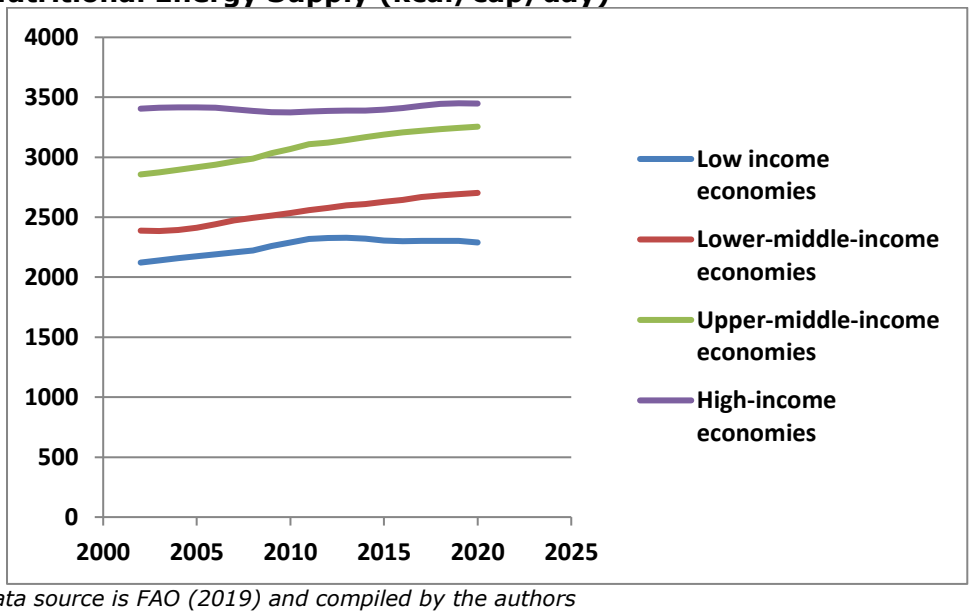
Since food is considered the first and most important basic need for the well-being and survival of human life, therefore "*the humans' right to food is recognized in the various instruments under the international law and regulations*" (Lyu, 2021). It suggests that no one has the right to be denied access to enough food consistently. Consequently, policymakers and researchers have been engaged in analyzing the pressing issue of food insecurity around the world in recent years because it has many detrimental socioeconomic effects that undermine people's growth and well-being not only in developing countries but also in many newly industrialized economies as well (Asim, 2018; FAO et al., 2018).

Most undernourished individuals reside in low-income countries, mostly in the poorest countries of the world (such as Africa and some parts of Asia), where food inaccessibility is the main cause of food insecurity (FAO et al., 2018, 2020). Recent UN forecasts for 2050 show that the world population is projected to grow up to 9.7 billion and the majority of this growth in the population is predicted to take place in developing economies (UN, 2019). One of the major issues the globe will face in the upcoming years is providing food security and sufficient nutrition for the rapidly growing population (IPCC, 2007; Molotoks et al., 2021). According to FAO projections, food production will need to be doubled from current levels to provide sufficient food to the forecasted 9.7 billion population by 2050 (Rijsberman, 2012).

Figure 1 depicts that the nutritional energy supply measured in kilo calories per capita per day is rising but the rate of this increase is slow as compared to the growth of population and hence the growth of food production is slower. The per capita nutritional energy supply of high-income countries is still higher than that of low and lower-middle-income countries, despite numerous advancements and improvements in agriculture production. This is also due to the higher population growth rate in developing countries as compared to developed countries (Hall, Dawson, Macdiarmid, Matthews, & Smith, 2017).

It is vital to comprehend the notion of food security to identify the various factors contributing to the deteriorating extent of food security in underdeveloped economies. As demonstrated by Frenken (2009), Food security exists "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life".

Figure 1: Nutritional Energy Supply (kcal/cap/day)



Source: The data source is FAO (2019) and compiled by the authors

Therefore, looking at this way, food security refers to the situation of having sufficient food not only for a few days but also for the rest of the years. Previous studies have used individual variables to measure the concept of food security (Qingshi, Awan, & Ashraf, 2020). In the present study, the concept of food security is measured by calculating its four pillars, *i.e.,* availability, accessibility, stability, and utilization of food (FAO, 2001). Therefore, the study adopts a more comprehensive viewpoint and concentrates on the general state of food security among people living in developing nations by covering all dimensions of food security.

Historically, developing nations have been the main ones to deal with the phenomenon of declining food security, as millions of people there suffer from severe undernourishment as a result of food insecurity (Fusco, Coluccia, & De Leo, 2020).

Many developing economies have undergone institutional and governance system changes in recent years, which have an impact on agricultural activities. Despite these changes, these economies have made significant strides towards increasing domestic food production (Lioubimtseva, 2019). However, food security remains inadequate in the developing world and is jeopardized by many factors, including changing climate conditions, greenhouse gas (GHG) emissions, and an aging population (Fusco et al., 2020). Ensuring food security for the growing population is a key challenge that the world may have to face in the coming years (Molotoks et al., 2021; Rasul, 2021).

Besides all of the factors mentioned above, some socioeconomic, demographic, and institutional aspects may also affect food security through its different dimensions, *i.e.,* arable land (Murphy, 2008), prices (Campbell et al., 2016), income (Tadasse, Algieri, Kalkuhl, & Von Braun, 2016), population (Hanjra & Qureshi, 2010), unemployment (Etana & Tolossa, 2017), literacy rate, etc. Moreover, one of the most critical factors for food insecurity in any country is some institutional quality indicators (Abdullah, Awan, & Ashraf, 2020; Mehta & Jha, 2012) that affect food security through different dimensions.

The problem of food insecurity is important to analyze as it has serious consequences for human development, economic development, health, individual productivity, and learning capabilities (Upton, Cissé, & Barrett, 2016). Therefore, FAO (2014) has emphasized the need to put the issue of food insecurity at the top priority of political, economic, and global research planning and also stressed formulating better policies to enhance the food security and nutritional requirements of the growing population.

The majority of studies that estimated the extent of food security in various nations and areas are done so at the micro level, whereas some macro-level studies are qualitative or focus on a single aspect of the factors that stimulate food security. These studies highlight the causes and solutions for food security and make important contributions to the literature. However, because of the limited data analyses used, these studies' scope is also constrained, which means they might not be very useful for developing macroeconomic policies. Therefore, the present study enhances the existing literature by incorporating various dimensions of food security into the assessment, thereby contributing to a more comprehensive understanding of this critical issue. A comprehensive measurement of food security will encompass its multiple dimensions, offering a representation of both the current status and the extent of food security over the study period.

Moreover, the study will investigate the exigent determinants of food security in selected developing economies by using Panel Quantile Regression (PQR). Moreover, the study will apply this approach to two distinct groups of developing countries: one comprising low and lower-middle-income nations, and the other consisting of upper-middle-income countries. This purpose is to elucidate the extent of food security within each group and explore how its determinants manifest across different income brackets. Ultimately, the PQR methodology proves instrumental in capturing and analyzing heterogeneous effects across various quantiles of the distribution. This approach is especially valuable when handling data in which effects may not remain constant throughout the entire distribution.

By applying a thorough, multifaceted approach, this endeavor not only fills the current gap in the literature on the subject being discussed but also makes a numerous addition to the pursuit of food security in the targeted economies. The study's conclusions will be a valuable source of reference for representatives to plan sensible policy measures to enhance the chosen countries' level of food security. The remaining study is comprised of 4 sections, the next section represents a framework to access the preceding theories and review of literature. Section 3 covers the model, variables description, and econometric methodology. In section 4, empirical findings and discussions are portrayed. The last section presented the conclusion and policy implications.

2. Theoretical Background and Review of Literature

Several aspects of food security that have been presented over time are based on the following theories and have been confirmed by past studies. According to the basic principles of economics, population has a major impact on food availability. Malthus (1798) is considered a pioneer in developing a theoretical framework and initiated the debate on the issue of food shortages for the increasing population of the world. Accordingly, food insecurity is a long-term issue as food scarcity is caused by the presence of more people in comparison to food production. Several studies have concluded that the population growth rates determine the rate at which food supplies grow (Schneider et al., 2011). According to and Tian, Bryksa, and Yada (2016), food demand grows more when there is an increase in the population and hence comes up with insufficient food availability for feeding the entire population. According to the well-recognized relationships between Population and food, yet, there is no methodical econometric investigation of how rapid growth in urban population affects food insecurity (Szabo, 2016).

Over time, Malthusian theory has been revitalized into the Neo Malthusian theory by adding the arable land to the population size which is considered pivotal to food security. Cultivable land is crucial for maintaining food production, security, and availability for the expanding population, as highlighted by Schneider et al. (2011), Negash and Swinnen (2013), and Li, Li, Tan, Wang, and Xin (2018). Their findings demonstrate that food crops increase significantly with more available land and hence have a dynamic role in addressing the problems of food security. In a nutshell, Malthus and Neo Malthusian theories indicate that a growing population and arable land have an essential part in fulfilling dietary needs.

The Food Availability Decline (FAD) model is the next one to take a look at. According to this theory, the main cause of food insecurity is the decrease in food availability, which might mean there won't be enough food to feed the expanding population. Moreover, the availability of credit in the agricultural sector is crucial for the adoption of modern agricultural techniques (Fitchett, 1992). The main emphasis of this theory is on the failure of the supply side which is considered as a source of this issue. This theory shows that credit to the agricultural sector determines the level of food supply as it assists farmers in boosting their productivity in the agricultural sector. Hanjra and Qureshi (2010), Hussain and Thapa (2012), Iftikhar and Mahmood (2017), and Asghar and Salman (2018) indicate that credit availability enables farmers to improve farm productivity. Therefore, we can say that a well-developed system of agricultural credit acts as an incentive to the farmers and is necessary to raise food production.

FAD also advocates that another hurdle to the food supply issue is environmental degradation. Poor quality of the environment threatens the capacity of individuals and countries to continue the production of enough food while environmental resources are deteriorating. Climatic change is a major risk to food and nutritional security and minimizing this risk for food security is one of the critical issues of this era (Campbell et al., 2016). Empirically, Dawson, Perryman, and Osborne (2016), Hall et al. (2017), Rasul and Sharma (2016), and Szabo (2016), examine the effects of environmental quality on food production. All of these studies indicate that the degradation of the environment is significantly threatening the production of food due to the changing pattern of rainfall, water availability, biodiversity, and depletion of natural resources. It will worsen the crop yields as well as the ability to feed the increasing number of people.

The estimates depict the severe impacts of its usage in the form of stunting in children can increase by the year 2050 as compared to the future with no climatic changes (Lloyd, Kovats, & Chalabi, 2011). The continuous upswing in the average temperature of the earth has threatened millions of persons around the world with a higher risk of floods, hunger, water, and food shortages (Sarr, 2012). However, developing economies have been emphasizing increasing their usage of energy for more rapid production of commodities (Hang & Yuan-Sheng, 2011). It is a fact that climatic variations affect every component of food security over time (Noiret, 2016; Vermeulen, Campbell, & Ingram, 2012).

The third theory is the Food Entitlement Decline (FED), which submits that food scarcities are triggered by the absence of privileges, showing that some individuals cannot access sufficient food (Devereux, 1993). This theory is concerned with access to food demand-side aspects of food security. Similarly, Tadasse et al. (2016) contend that the capability of consumers to get food is exaggerated by their income. The level of affordability of households increases with

income and vice versa. Therefore, higher income is crucial to reducing food insecurity as well as undernourishment for a healthy and active way of living. In the same way, food prices also have a key role to play in deteriorating or improving the food security situation. Zhou and Wan (2017) and Chavas (2017) are of the view that the purchasing power of households deteriorates with the increasing food prices and hence it worsens their status of food security. In this framework, the buying capacity of households in developing economies is constrained by food prices.

Some studies represent the varied effects of education on food security (Mutisya, Ngware, Kabiru, & Kandala, 2016). Nord, Coleman-Jensen, and Gregory (2014) also represent that a fall in the unemployment rate would indicate a decline in the prevalence of food insecurity. Furthermore, the literacy rate significantly plays an important role in improving food security through food availability as well as food utilization. Accordingly, farmer's literacy rate is a major component of food security (Iftikhar, Amir, Khadim, & Bilal, 2015). According to Etana and Tolossa (2017), the incidence of food insecurity is found to be higher among households with a person without a job. Food insecurity is affected by unemployment through the mechanism of education and economic factors. A lack of education lowers employment opportunities and causes food insecurity (Etana & Tolossa, 2017).

Besides all the factors discussed above, institutional aspects of any economy have a central role in improving the food security situation of that economy. In this context, Devereux (1993) and Rocha (2007) found that the failure of the market is another cause of food insecurity issues, particularly if food is categorized as a public good rather than being treated as a private good. Food is the basic need for human survival and hence food security is considered a public good, that can be relished by all individuals simultaneously, and no one can be stopped to take it. However, high and rising prices of foodstuff show that this behavior in the real world does not exist, rather food is classified as a private good. Rocha (2007) focuses on the governance to produce public goods with the intention of social efficiency.

Mehta and Jha (2012) explore the impact of corruption (a component of governance) on food security. Accordingly, an increase in corruption seems to disturb the food security situation in countries with meager governance. Anik, Manjunatha, and Bauer (2013) are among the few studies available in this framework, that have proposed that governance quality can significantly influence food production. Institution and Governance may be defined differently but for the sake of simplicity, we are assuming these two terms as identical. In the same context, Abdullah et al. (2020) found that corruption and poor quality of institutions deteriorate the food security position of developing as well as developed countries whereas democratic accountability, government stability, and the role of law and order have a significant and positive influence on the food supply.

Previous studies used one or two individual variables to represent the concept of food security, however, our inference from the past studies mentioned above is that food security is a multidimensional phenomenon that cannot be represented by one or two variables. Therefore, the present study has adopted a more comprehensive approach in measuring the concept of food security by covering all of its dimensions. The concept of food security can be affected by variations in different variables ranging from climate change, population growth, and rapid urbanization, and many socioeconomic, demographic, and institutional factors.

All of the above studies have a great contribution to the existing literature by analyzing the food security situation for different nations and examining the impact of some of these variables on food security. However, very limited literature has been found at the macro level that has explored the combined impact of all these factors on food security by using a comprehensive approach. Hence, this study will fill this gap in the literature. Moreover, other elements of governance such as government stability, quality of bureaucracy, democratic accountability, corruption, and law and order situation as highlighted by Abdullah et al. (2020) will be used by calculating an institutional quality index based on different components of governance and then examining its effect on food security situation for the panel of developing countries.

3. Model and Methodology

According to the Malthusian as well as neo-Malthusian theory, the human population tends to grow geometrically, while food and agricultural production grow arithmetically. It means that the increase in population is much quicker than the increase in food production, which may lead to food shortages (Malthus, 1798). According to Szabo (2016), and Tian et al. (2016), food scarcities arise when there is excessive population concerning the amount of food available, and hence the food security situation becomes worsened. In addition, the neo-Malthusian model proposes that limited land resources are a significant cause of the insufficiency of per capita food supply. Consequently, the following is a statement of the food security function:

$$FS = f(POP, AL) \qquad \text{(i)}$$

Here, AL represents arable land, POP stands for population, and food security is represented by FS. Furthermore, the FAD advocates that the primary cause of food insecurity is declining food availability which may lead to insufficient food to silage the rising population (Devereux, 1988; (Devereux, 1993). This theory shows that credit to the agricultural sector and environmental damages affect the level of the food supply through their impact on the farmers' productivity in the agricultural sector. Therefore, based on the previous studies, food availability may be affected by the credit to the agricultural sector (Asghar & Salman, 2018; Hanjra & Qureshi, 2010; Hussain & Thapa, 2012; Iftikhar & Mahmood, 2017) and environmental quality (Campbell et al., 2016). Henceforth, equation (i) can be re-written as follows:

$$FS = f(POP, AL, CA, EQ) \qquad \text{(ii)}$$

Here CA stands for credit to the agricultural sector and EQ represents environmental quality. Consequently, the above model is extended with the incorporation of FED theory, which is concerned with food access or can be taken as a demand side aspect of food security. Hence, by combining the available literature (Campbell et al., 2016; Fitchett, 1992; Pingali, 2007), food security is measured by compiling all of its dimensions (represented below in figure 1) is affected by different variables such as gross domestic product (GDP), food price level (FP), unemployment (UNE), and literacy rate (LR). Finally, an index of institutional quality (IQ) is incorporated into the model to investigate the effect of governance on food security. Hence, the final augmented model is:

$$FS = f\ (POP,\ AL,\ CA,\ EQ,\ GDP,\ FP,\ UNE,\ LR,\ IQ) \qquad (iii)$$

Accordingly, the econometric model is specified as follows:

$$FS_{i,t} = \alpha_1 + \beta_1 POP_{i,t} + \beta_2 AL_{i,t} + \beta_3 CA_{i,t} + \beta_4 EQ_{i,t} + \beta_5 GDP_{i,t} + \beta_6 FP_{i,t} + \beta_7 UNE_{i,t} + \beta_8 LR_{i,t} + \beta_9 IQ_{i,t} + \mu_{i,t} \quad (iv)$$

Where *β's* represents the coefficients of the model that are to be estimated; *i* denotes the country, *t* represents time, *ln* represents natural logarithm, and *μ* refers to the stochastic error term which is incorporated to capture the effect of those factors that may affect the food security but are not included in this model. Moreover, we have employed the natural logarithm of GDP, FP, and IQ to normalize the data. We can simplify the model in equation *(iv)* as follows:

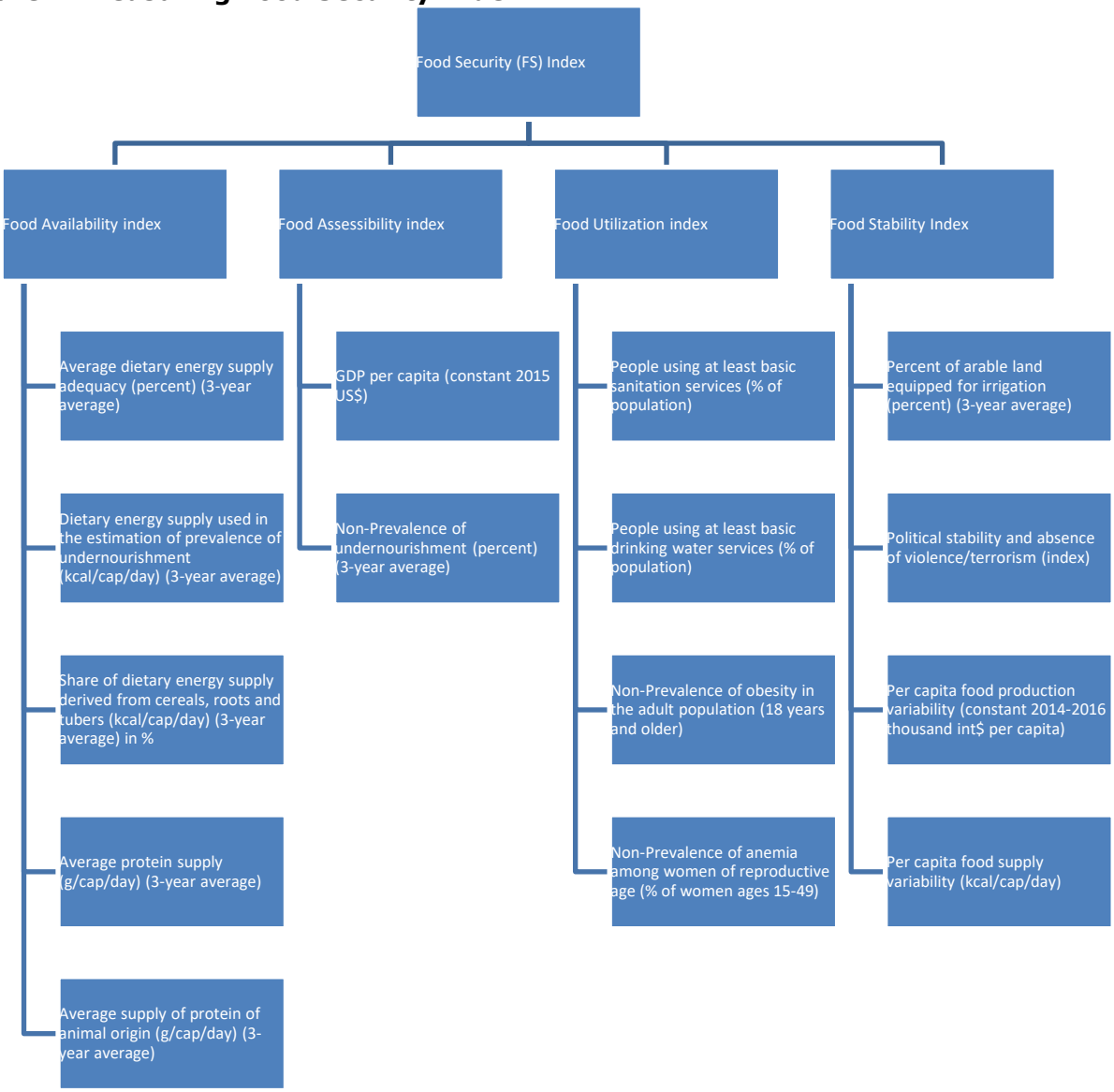
$$FS_{i,t} = \alpha_1 + \beta X_{i,t} + \mu_{i,t} \quad (v)$$

Here, the $X_{i,t}$ is a vector of independent variables that is thought to be essential in explaining food security. Furthermore, the study used a cumulative method to measure and understand the concept of food security. The Present study incorporated all four dimensions of food security to measure a comprehensive food security index that encompasses all facets of the concept. These dimensions include food stability, utilization, accessibility, and availability. The final index was created by the study by averaging these four dimensions.

Furthermore, each dimension's index is a composite derived from a distinct set of elements, encompassing the comprehensive details specific to that dimension. For example, the food accessibility index consists of two elements, whereas the food availability index has five. Additionally, both the food utilization and food stability indices consist of four elements each. The comprehensive depiction of the food security index accompanied by variables' description is illustrated in the following figure 2. To formulate the comprehensive food security index and

develop a model for empirically estimating the underlying determinants of food security, this study utilizes a panel dataset spanning from 2007 to 2020, encompassing 50 selected developing countries.

Figure 2: Measuring Food Security Index



Source: Collected from FAO and compiled by the authors

Nevertheless, these countries have been categorized into two groups. Group 1 comprises of 28 low-income and lower-middle-income countries, as classified by the World Bank, hereafter referred to as Benin, Bolivia, Burkina Faso, Cabo Verde, Cambodia, Cote d'Ivoire, Egypt, Arab Rep., Gambia, Ghana, India, Indonesia, Kyrgyz Republic, Lesotho, Mali, Morocco, Nepal, Nigeria, Pakistan, Philippines, Rwanda, Senegal, Sri Lanka, Tajikistan, Tanzania, Timor-Leste, Togo, Tunisia, and Ukraine. Group 2 comprises 22 upper-middle-income countries, as classified by the World Bank, hereafter referred to as Albania, Argentina, Armenia, Azerbaijan, Belarus, Belize, Brazil, Bulgaria, Costa Rica, Dominican Republic, Ecuador, Georgia, Guatemala, Iran Islamic Republic, Jordan, Kazakhstan, Malaysia, Mexico, Peru, Russian Federation, Serbia, and Thailand. The countries are selected based on the availability of data on the variables included in the study. The data for the variables mentioned in the previous section will be taken from World Development Indicators (WDI, 2020), World Governance Indicators (WGI, 2020), and the Food and Agriculture Organization (FAO). The description of variables included in equation *(iv)* is given in Table 1.

The area of food security has often observed diverse peaks or fat tails in the data, especially in developing countries. The majority of the body of current research examines the

conditional mean regression-based panel data model. Nevertheless, it is common to overlook the variation in how exigent determinants affect food security. Conspicuously, panel data models would produce biased estimations if this heterogeneity was ignored (Cheng, Ren, Dong, Dong, & Wang, 2021). Hence, this study used the PQR to elevate this difficulty. This estimation method allows us to go beyond simply describing the average and instead characterize the whole conditional distribution of a response variable in terms of a set of explanatory variables. Additionally, because it can handle a variety of distributions, we can do away with the need for the normalcy assumption and address long-standing issues within a more grounded framework (Davino, Furno, & Vistocco, 2013).

Table 1: Description of Variables

Variable	Variable Proxy	Data Source
Food Security (FS)	The food security index is calculated by the authors with the amalgamation of four dimensions as illustrated in Figure 1.	FAO
Population (POP)	Urban population (% of total population)	WDI
Arable Land (AL)	Arable land (hectares per person)	WDI
Credit to Agriculture (CA)	Credit to the agricultural sector as % of total credit	FAO
Environmental Quality (EQ)	CO2 emissions (metric tons per capita)	WDI
GDP per capita (GDP)	Natural logarithm of GDP per capita (constant 2010 US$)	WDI
Food Price (FP)	Natural logarithm of consumer prices index (annual %)	FAO
Unemployment (UNE)	Unemployment, total (% of total labor force) (modeled ILO estimate)	WDI
Literacy Rate (LR)	School enrollment, primary (% gross)	WDI
Institutional Quality (IQ)	Natural logarithm of institutional quality index which is the amalgamation of four Indicators, *i.e.* Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence/Terrorism, Rule of Law, and Regulatory Quality	WGI

Quantile regression is a set of estimations for diverse restrictive quantile functions that extend the traditional least-squares estimation of the conditional mean (R. Koenker & Bassett Jr, 1978). Even though the conditional mean and conditional median are the only estimates that traditional OLS regression can provide, which are found at the circulation's center and can only provide a partial portrayal of a conditional distribution quantile regression has the primary advantage over OLS in that it can analyze the entire distribution (Mosteller & Tukey, 1977). Moreover, compared to OLS, quantile regression is more forgiving because of its relative insensitivity to outliers and distributions with heavy tails (Lv & Xu, 2017). Therefore, the research makes use of PQR to estimate the exigent determinants of food security for developing countries. Thus, the equation *(iv)* takes the form of the PQR model, which can be represented as under:

$$Q_{lnFS_{i,t}}(\tau_k \setminus \alpha_i, x_{i,t}) = \alpha_1 + \beta_{1\tau}POP_{i,t} + \beta_{2\tau}AL_{i,t} + \beta_{3\tau}CA_{i,t} + \beta_{4\tau}EQ_{i,t} + \beta_{5\tau}lnGDP_{i,t} + \beta_{6\tau}lnFP_{i,t} + \beta_{7\tau}UNE_{i,t} + \beta_{8\tau}LR_{i,t} + \beta_{9\tau}lnIQ_{i,t} + \beta_{10\tau}\mu_{i,t} \qquad (vi)$$

The country and year are indicated by the subscripts *i* and *t*, respectively, whereas α_i represents the unobservable individual effect. Additionally, the coefficients for the τ-th quantile of the conditional distribution can be estimated by using following equation as proposed by (R. Koenker & Bassett Jr, 1978).

$$\hat{\beta}(\tau) = \arg\min \sum_{i=1}^{n} \rho_\tau(y_i = x_i^T \beta) \qquad (vii)$$

Where $\rho_\tau(u) = u(\tau - I(u < 0)), I(u < 0) = \begin{Bmatrix} 1, u < 0 \\ 0, u \geq 0 \end{Bmatrix}$

$$\left(\hat{\beta}(\tau_k,\lambda),\quad \{\alpha_i(\lambda)\}_{i=1}^{N}s\right) = \arg\min \sum_{k=1}^{K}\sum_{t=1}^{T}\sum_{n=1}^{N} w_k\,\rho_{tk}\left(y_{it}-\alpha_i-x_{it}^{T}\beta(\tau_k)\right)+\ \lambda\ \sum_{i=1}^{N}|\alpha_i| \qquad (viii)$$

In Equation *(vii)*, it becomes evident that quantile regression operates as a weighted regression, assigning diverse weights τ and 1−τ to positive and negative residuals, respectively. Nevertheless, it does not consider α_i, denoting unobserved country heterogeneity. Given the limited annual observations in this study, present study has adopted the estimation approach introduced by Roger Koenker (2004). This method incorporates the unobservable individual effect α_i as one of the regression parameters, and the parameters are estimated in the subsequent equation:

Where w_k is the weight of the k-th quantile and we assign equal weights ($w_k = 1/k$) in this paper by following Alexander et al. (2011). Individual effect is captured by the tuning parameter (λ) (Roger Koenker, 2004) and λ = 1 has been chosen in accordance with Damette and Delacote (2012).

4. Empirical Results and Discussion

Tables 2 and 3 represent the descriptive analysis of the dependent and explanatory variables for a sample of 28 and 22 countries, respectively. Based on the estimates, group 1 of developing countries has a mean food security score of 0.347. The maximum FS is just 0.548, whereas the lowest value of FS is observed at 0.259.

Table 2: Descriptive Analysis (Group 1)

Variable	Obs.	Mean	Std. dev.	Min	Max
FS	392	0.347	0.059	0.259	0.548
POP	392	41.499	15.699	15.781	70.123
AL	392	0.206	0.144	0.029	0.746
CA	392	6.235	6.418	0.097	55.294
EQ	392	1.009	1.085	0.059	6.711
GDP	392	1776.6	1063.5	449.8	4228.1
FP	392	5.446	6.606	-3.233	59.220
UNE	392	6.481	5.166	0.140	29.623
LR	392	105.241	16.677	67.669	149.957
IQ	392	-0.532	0.394	-1.352	0.484

Source: Estimated by the authors

For Group 2, the mean value of FS has been estimated at 0.45, which is notably superior to that of Group 1. However, there has been no significant improvement observed in the minimum and maximum values of FS, which stand at 0.33 and 0.59, respectively. The following tables present additional statistics for observation and comparison.

Table 3: Descriptive Analysis (Group 2)

Variable	Obs.	Mean	Std. dev.	Min	Max
FS	308	0.45	0.05	0.33	0.59
POP	308	104.37	8.68	75.40	132.06
AL	308	0.32	0.38	0.02	1.85
CA	308	5.13	3.83	0.58	24.16
EQ	308	4.28	3.22	0.80	15.34
GDP	308	6725	2713	2884	14200
FP	308	-0.22	0.38	-1.30	0.66
UNE	308	8.27	5.19	0.25	24.00
LR	308	67.71	13.44	39.95	92.11
IQ	308	6.22	5.33	-1.66	29.51

Source: Estimated by the authors

Table 4 and Table 5 depict the findings of the VIF test, serving to assess the existence of Multicollinearity within the developing countries of Group 1 and Group 2, respectively. The estimates demonstrated the lack of Multicollinearity in all the explanatory variables within both groups of countries. The study also used Pesaran CD test, Hetero-test and autocorrelation test to estimate the existence of cross-sectional dependence, heterogeneity and serial correlation, respectively. The estimates of are portrayed in table 6 and table 7 for both group of countries.

The estimates indicate that there is no cross-section dependence in either group. However, both groups exhibit heterogeneity and serial correlation. As a result, the study continues with our empirical analysis, which considers heterogeneity in both the distribution and the individual, using the PQR method.

Table 4: Multicollinearity Test (Group 1)

Variables	VIF Test	Tolerance Test
POP	2.450	0.408
AL	2.450	0.408
CA	1.170	0.852
EQ	3.110	0.321
GDP	3.110	0.322
FP	1.030	0.972
UNE	1.120	0.889
LR	1.420	0.705
IQ	1.280	0.780

Source: Estimated by the authors

Table 5: Multicollinearity Test (Group 2)

Variables	VIF Test	Tolerance Test
POP	1.580	0.633
AL	3.050	0.328
CA	1.490	0.670
EQ	2.810	0.357
GDP	3.980	0.251
FP	1.880	0.532
UNE	1.430	0.698
LR	1.960	0.510
IQ	1.100	0.909

Source: Estimated by the authors

H_0: VIF < 10 (no Multicollinearity in the dataset)
H_1: VIF > 10 (Multicollinearity in the dataset)

Table 6: Pre-Models Diagnostics (Group 1)

Tests	
Pesaran CD	0.214
Hetero-test	1298.34***
Autocorrelation	207.326***

Source: Estimated by the authors

Table 7: Pre-Models Diagnostics (Group 2)

Tests	
Pesaran CD	0.903
Hetero-test	1766.66***
Autocorrelation	128.862***

*Source: Estimated by the authors, ***, **, * shows significance level at 1%, 5% and10% respectively, Null hypothesis: No cross-section dependence, no heterogeneity and no serial correlation exist*

Table 8 and table 9 represents the estimates of PQR for group 1 and 2, respectively. In the regression process, we opt for nine quantiles to provide a comprehensive overview across various quantiles. The findings demonstrate that there is a distinct heterogeneity in the effect of exigent determinants on food security index. Later on in the empirical investigation, we will go over each variable's impact individually for both groups of countries. Findings demonstrate that urbanization has a significant and detrimental impact on the food security of both groups. This suggests that the degree of food security decreases with the increase in population. Though, the effect of urban population on food security are heterogeneous across different quantile.

Specifically, in group 1, the extent of negative affect of urban population on food security continuously changed throughout the different quantile. Furthermore, its negative impact rise from 10th to 20th quantile (0.469 to 0.667), but fall in the 30th quantile (0.384). After that, at high quantiles, the adverse effects essentially continued to increase. The swift urbanization witnessed in developing countries results in a diminished agricultural workforce and fewer resources allocated to the agricultural sector. Consequently, this causes heightened level of food insecurity in these developing nations.

The PQR estimates of arable land reveal a significant direct impact on food security in both groups. Nevertheless, the influence of arable land exhibits notable heterogeneity across various quantiles within Group 1, in contrast to Group 2 where it appears to be relatively less volatile. The average coefficient indicates that arable land has increased impact on food security in group 1 than in group 2. This implies that low-income countries have a higher potential to enhance food security by utilizing arable land. Arable land demonstrates a prominent role in the production and provision of food. Through implementing contemporary farming techniques, it helps farmers to grow a wide variety of food crops, increasing total yield. The capacity to grow various crops contributes significantly to a stable and diversified food supply. This result can be confirmed by Negash and Swinnen (2013).

Table 8: Panel Quantile Regression (Group 1)

Ind. Var.	τ = 10th	τ = 20th	τ = 30th	τ = 40th	τ = 50th	τ = 60th	τ = 70th	τ = 80th	τ = 90th
POP	-0.182***	-0.317***	-0.148***	-0.192***	-0.155***	-0.259***	-0.432***	-0.168***	-0.147***
AL	0.579	0.178***	0.849***	0.828***	0.717***	0.778***	0.138***	0.627***	0.792***
CA	0.400***	0.529***	0.444***	0.479***	0.495***	0.563***	0.553***	0.436***	0.492***
EQ	0.396	0.184	0.168	0.224	0.256	0.193	0.220	0.193	0.249
GDP	0.349	0.410***	0.364***	0.386***	0.367***	0.342***	0.360***	0.468***	0.366***
FP	0.173	-0.361***	-0.511	-0.326***	-0.430***	-0.823***	-0.396***	-0.276***	-0.270***
UNE	-0.285***	-0.323***	-0.241***	-0.281***	-0.313***	-0.351***	-0.276***	-0.295***	-0.286***
LR	0.137	0.166***	0.341***	0.213***	0.355***	0.392***	0.333***	0.294***	0.353***
IQ	0.177	0.762***	0.160***	0.142***	0.973***	0.871***	0.883***	0.533***	0.143***

Source: Estimated by the authors, ***, **, * shows significance level at 1%, 5% and10% respectively

Table 9: Panel Quantile Regression (Group 2)

Ind. Var.	τ = 10th	τ = 20th	τ = 30th	τ = 40th	τ = 50th	τ = 60th	τ = 70th	τ = 80th	τ = 90th
POP	-0.469***	-0.667***	-0.384***	-0.497***	-0.475***	-0.526***	-0.543***	-0.554***	-0.582***
AL	0.260***	0.372***	0.224***	0.297***	0.284***	0.212***	0.242***	0.233***	0.233***
CA	0.390***	0.134***	0.720***	0.656***	0.467***	0.758***	0.723***	0.579***	0.755***
EQ	0.929	-0.782	-0.428**	-0.397**	-0.198***	-0.653***	-0.188**	0.345	0.315
GDP	0.130***	0.119***	0.128***	0.132***	0.126***	0.129***	0.131***	0.131***	0.132***
FP	-0.649***	0.325***	-0.470***	-0.335***	-0.719***	-0.517***	-0.569***	-0.524***	-0.491***
UNE	0.442***	0.367	0.395	0.399	-0.350	0.368	0.377	0.383***	0.377
LR	0.662	0.759***	0.654***	0.648***	0.600***	0.747***	0.698***	0.679***	0.665***
IQ	0.725***	0.517***	0.753***	0.833***	0.816***	0.838***	0.893***	0.832***	0.892***

Source: Estimated by the authors, ***, **, * shows significance level at 1%, 5% and10% respectively

The findings also reveal that that credit to agricultural sector is directly and significantly contributing towards food security in both groups. The PQR estimates indicate that the impact of agricultural credit on food security varies across different quantiles in both groups. Typically, there appears to be a growing effect on food security as the quantiles increase. This implies that credit availability may help the farmers in farm productivity and production which in turn will improve the food availability (Hussain & Thapa, 2012).

Furthermore, group 2's food security appears to be negatively and significantly affected by the PQR estimates of environmental quality, whereas group 1's food security appears to be unaffected by this variable. This implies that CO_2 emission is not correlated with food security in low and lower-middle income countries, because these nations have less industrialized, less technologically advanced, and more agriculturally based and the effect of CO_2 on food security is overshadowed by other exigent determinants in these countries. However, the effect of CO_2 emission becomes significant as income level of countries rises. Due to their ongoing rapid industrialization, these nations are poised to experience a surge in greenhouse gas emissions, potentially contributing to a detrimental global temperature increase. This escalation in carbon emissions could have adverse effects on food production, leading to a potential deterioration in both the quality and quantity of crops (Rasul & Sharma, 2016).

The findings also illustrate a significant improvement in food security condition due to increase in GDP per capita in both groups. The PQR estimates of GDP per capita appear heterogeneous across different quantiles but little volatile as compared to other determinants in both groups. Nevertheless, there is a notable contrast in the average coefficient of GDP per capita between group 1 and group 2. This implies that countries with lower income levels exhibit a larger influence of GDP per capita on food security, suggesting a heightened sensitivity to economic factors in these regions. Thus, GDP per capita may increase the food security both from food availability as well as its accessibility (Hanjra & Qureshi, 2010).

Moreover, the estimate of food price lacks significance in the 10th and 30th quantiles of group 1, but becomes both significant and negative in the remaining quantiles, exhibiting heterogeneous effects. Additionally, in group 2, the estimate of food price is also significant and negative, with heterogeneous effects observed across various quantiles. Furthermore, the average coefficient of food price is more sensitive to food security in group 2 than group 1. The adverse effect of food prices on food security illustrates that a rise in the cost of food items results in reduced access to food resources.

In group 1, the estimated unemployment coefficient is significant and negative, with varying effects across quantiles, whereas it is significant in 10^{th} and 80^{th} quantile only with positive sign in group 2. This suggests that the effect of unemployment on food security becomes overshadowed as countries income level rises. Unemployment results to a loss of income for individual or household and ultimately limits the access to sufficient and nutritious diet, affecting their overall food security. Moreover, the PQR estimate of the literacy rate is positive and significant in both groups, and exhibiting diverse effects across different quantiles. Although, the average coefficient of the literacy rate is more responsive to food security in group 2 than in group 1. This suggests that the influence of the literacy rate on food security increases as the income level of countries rises. The improvement in education enables individuals or households to enhance their income sources, subsequently leading to improved access to food resources.

Finally, the PQR estimates reveal that food security situation is significantly improved with the increase in institutional quality. Nevertheless, the influence of institutional quality exhibits notable heterogeneity across various quantiles within Group 1, in contrast to Group 2 where it appears to be relatively less volatile. This implies that institutional quality may exert a more consistent influence on food security in settings where the income level of countries is higher. Enhancing the quality of institutions can foster stability, predictability, and accountability within a country, thereby creating an environment conducive to agricultural production and supply. This, in turn, mitigates uncertainties that could otherwise have negative effects on food security. This result can also be verified from (Qingshi et al., 2020).

5. Conclusion and Policy Implications

The study focuses on the comprehensive measurement of food security by incorporating its multiple dimensions and estimated the exigent determinants of food security for two distinct groups of developing countries. The study employs PQR analysis to mitigate potential biases in the results and to gain deeper insights into the impacts. The empirical findings illustrate the heterogeneous impacts of explanatory variables on food security across different quantiles. The main conclusion of the study can be summarized as follows: (1) Urbanization and rise in food prices directly reduces food security in both groups of developing countries; (2) unemployment negatively affects food security in Group 1, whereas its significance is inconsequential in the 7th quantile out of 9 in Group 2, which means that the effect of unemployment obliterates with the increase in the country's income; (3) CO_2 emissions is insignificant in Group 1, whereas rise in CO_2 emission significantly condenses food security in Group 2; (4) Arable land, credit to the agriculture sector, GDP per capita, literacy rate, and institutional quality contribute to the enhancement of food security in both groups.

The study suggests the following policy recommendations based on the above empirical findings and discussions: (1) Implementing checks and balances on urbanization and monitoring food prices are essential measures to bolster food security; (2) The government should adopt policies aimed at expanding arable land and facilitating easy credit access to the agriculture sector. These measures are crucial to promoting agricultural production and availability; (3) Exerting control over urbanization and promoting the expansion of arable land can contribute to the reduction of carbon emissions, thereby mitigating its adverse effects on food security; (4) Emphasizing

education and fostering employment opportunities can lead to an increase in GDP per capita, thereby playing a pivotal role in alleviating the extent of food insecurity; (5) Prioritizing the enhancement of institutional quality is crucial, as robust institutions can establish an environment conducive to agricultural production and supply. By promoting stability, predictability, and accountability within a country, such efforts can effectively mitigate uncertainties that might otherwise adversely impact food security.

References

Abdullah, Q., Wang, Awan, M. A., & Ashraf, J. (2020). The Impact of Political Risk and Institutions on Food Security. *Current Research in Nutrition & Food Science, 8*(3).

Anik, A. R., Manjunatha, A., & Bauer, S. (2013). Impact of farm level corruption on the food security of households in Bangladesh. *Food Security, 5*, 565-574.

Asghar, N., & Salman, A. (2018). Impact of agriculture credit on food production and food security in Pakistan. *Pakistan Journal of Commerce and Social Sciences (PJCSS), 12*(3), 851-864.

Asim, H. (2018). Food Security Analysis in Pakistan: A Multi-Indicator Approach. *Kashmir Economic Review, 27*(1).

Asim, H., & Akbar, M. (2019). Sectoral growth linkages of agricultural sector: Implications for food security in Pakistan. *Agricultural Economics/Zemedelska Ekonomika, 65*(6).

Awad, A. (2023). The determinants of food insecurity among developing countries: Are there any differences? *Scientific African, 19*, e01512. doi:https://doi.org/10.1016/j.sciaf.2022.e01512

Bahiru, A., Senapathy, M., & Bojago, E. (2023). Status of household food security, its determinants, and coping strategies in the Humbo district, Southern Ethiopia. *Journal of Agriculture and Food Research, 11*, 100461. doi:https://doi.org/10.1016/j.jafr.2022.100461

Campbell, B. M., Vermeulen, S. J., Aggarwal, P. K., Corner-Dolloff, C., Girvetz, E., Loboguerrero, A. M., . . . Thornton, P. K. (2016). Reducing risks to food security from climate change. *Global Food Security, 11*, 34-43. doi:https://doi.org/10.1016/j.gfs.2016.06.002

Chavas, J.-P. (2017). On food security and the economic valuation of food. *Food policy, 69*, 58-67.

Cheng, C., Ren, X., Dong, K., Dong, X., & Wang, Z. (2021). How does technological innovation mitigate CO2 emissions in OECD countries? Heterogeneous analysis using panel quantile regression. *Journal of Environmental Management, 280*, 111818.

Damette, O., & Delacote, P. (2012). On the economic factors of deforestation: what can we learn from quantile analysis? *Economic Modelling, 29*(6), 2427-2434.

Davino, C., Furno, M., & Vistocco, D. (2013). *Quantile regression: theory and applications* (Vol. 988): John Wiley & Sons.

Dawson, T. P., Perryman, A. H., & Osborne, T. M. (2016). Modelling impacts of climate change on global food security. *Climatic Change, 134*, 429-440. doi:https://doi.org/10.1007/s10584-014-1277-y

Devereux, S. (1993). Theories of famine, harvester wheat sheaf. *New York*.

Etana, D., & Tolossa, D. (2017). Unemployment and food insecurity in urban Ethiopia. *African Development Review, 29*(1), 56-68.

FAO. (2001). *The State of Food Insecurity in the World 2001*. Rome, Italy: Food and Agriculture Organization of the United Nation.

FAO. (2014). *The State of Food Insecurity in the World 2014*: Food and Agriculture Organization, Rome.

FAO, IFAD, UNICEF, WFP, & WHO. (2018). *The state of food security and nutrition in the world 2018: building climate resilience for food security and nutrition*: Food & Agriculture Org.

FAO, IFAD, UNICEF, WFP, & WHO. (2020). *The state of food security and nutrition in the world 2020: transforming food systems for affordable healthy diets*: Food & Agriculture Org.

Fitchett, D. A. (1992). Informal finance in low-income countries.

Fraser, E. D., & Rimas, A. (2011). *Empires of food: Feast, famine and the rise and fall of civilizations*: Random House.

Frenken, K. (2009). Irrigation in the Middle East region in figures AQUASTAT Survey-2008. *Water Reports*(34).

Fusco, G., Coluccia, B., & De Leo, F. (2020). Effect of trade openness on food security in the EU: A dynamic panel analysis. *International Journal of Environmental Research and Public Health, 17*(12), 4311. doi:https://doi.org/10.3390/ijerph17124311
Hall, C., Dawson, T., Macdiarmid, J., Matthews, R., & Smith, P. (2017). The impact of population growth and climate change on food security in Africa: looking ahead to 2050. *International Journal of Agricultural Sustainability, 15*(2), 124-135. doi:https://doi.org/10.1080/14735903.2017.1293929
Hang, G., & Yuan-Sheng, J. (2011). The relationship between CO2 emissions, economic scale, technology, income and population in China. *Procedia Environmental Sciences, 11*, 1183-1188.
Hanjra, M. A., & Qureshi, M. E. (2010). Global water crisis and future food security in an era of climate change. *Food policy, 35*(5), 365-377. doi:https://doi.org/10.1016/j.foodpol.2010.05.006
Hussain, A., & Thapa, G. B. (2012). Smallholders' access to agricultural credit in Pakistan. *Food Security, 4*, 73-85. doi:https://doi.org/10.1007/s12571-012-0167-2
Iftikhar, S., Amir, H., Khadim, Z., & Bilal, K. (2015). Farmer's Literacy Rate as Key Driver in Food Production and Food Security: An Empirical Appraisal from Punjab, Pakistan. *European online journal of Natural and Social Sciences, 4*(4), 683.
Iftikhar, S., & Mahmood, H. Z. (2017). Ranking and relationship of agricultural credit with food security: A district level analysis. *Cogent Food & Agriculture, 3*(1), 1333242.
IPCC. (2007). Climate change- a synthesis report of the IPCC. Technical Report, Intergovernmental Panel on Climate Change.
Koenker, R. (2004). Quantile regression for longitudinal data. *Journal of multivariate analysis, 91*(1), 74-89.
Koenker, R., & Bassett Jr, G. (1978). Regression quantiles. *Econometrica: journal of the Econometric Society*, 33-50.
Li, Y., Li, X., Tan, M., Wang, X., & Xin, L. (2018). The impact of cultivated land spatial shift on food crop production in China, 1990–2010. *Land degradation & development, 29*(6), 1652-1659.
Lioubimtseva, E. (2019). Food security factors and trends in Central Asia.
Lloyd, S. J., Kovats, R. S., & Chalabi, Z. (2011). Climate change, crop yields, and undernutrition: development of a model to quantify the impact of climate scenarios on child undernutrition. *Environmental health perspectives, 119*(12), 1817-1823.
Lv, Z., & Xu, T. (2017). A panel data quantile regression analysis of the impact of corruption on tourism. *Current Issues in Tourism, 20*(6), 603-616.
Malthus, T. (1798). An essay on the principle of population. Printed for J. Johnson. *St. Paul's church-yard, London*, 1-126.
Mehta, A., & Jha, S. (2012). Corruption, food subsidies, and opacity: Evidence from the Philippines. *Economics Letters, 117*(3), 708-711.
Molotoks, A., Smith, P., & Dawson, T. P. (2021). Impacts of land use, population, and climate change on global food security. *Food and Energy Security, 10*(1), e261. doi:https://doi.org/10.1002/fes3.261
Mosteller, F., & Tukey, J. W. (1977). Data analysis and regression. A second course in statistics. *Addison-Wesley series in behavioral science: quantitative methods*.
Murphy, S. (2008). Globalization and corporate concentration in the food and agriculture sector. *Development, 51*(4), 527-533. doi:https://doi.org/10.1057/dev.2008.57
Mutisya, M., Ngware, M. W., Kabiru, C. W., & Kandala, N.-b. (2016). The effect of education on household food security in two informal urban settlements in Kenya: a longitudinal analysis. *Food Security, 8*, 743-756.
Negash, M., & Swinnen, J. F. (2013). Biofuels and food security: Micro-evidence from Ethiopia. *Energy Policy, 61*, 963-976. doi:https://doi.org/10.1016/j.enpol.2013.06.031
Noiret, B. (2016). Food security in a changing climate: a plea for ambitious action and inclusive development. In: Springer.
Nord, M., Coleman-Jensen, A., & Gregory, C. (2014). Prevalence of US food insecurity is related to changes in unemployment, inflation, and the price of food.
Pingali, P. (2007). Westernization of Asian diets and the transformation of food systems: Implications for research and policy. *Food policy, 32*(3), 281-298.
Qingshi, W., Awan, M. A., & Ashraf, J. (2020). The Impact of Political Risk and Institutions on Food Security. *Current Research in Nutrition & Food Science, 8*(3).
Rasul, G. (2021). Twin challenges of COVID-19 pandemic and climate change for agriculture and food security in South Asia. *Environmental Challenges, 2*, 100027.

Rasul, G., & Sharma, B. (2016). The nexus approach to water–energy–food security: an option for adaptation to climate change. *Climate policy, 16*(6), 682-702.
Rijsberman, F. (2012). CGIAR: A Global Research Partnership for a Food Secure Future.
Rocha, C. (2007). Food insecurity as market failure: a contribution from economics. *Journal of Hunger & Environmental Nutrition, 1*(4), 5-22.
Sarr, B. (2012). Present and future climate change in the semi-arid region of West Africa: a crucial input for practical adaptation in agriculture. *Atmospheric Science Letters, 13*(2), 108-112.
Schneider, U. A., Havlík, P., Schmid, E., Valin, H., Mosnier, A., Obersteiner, M., . . . Sauer, T. (2011). Impacts of population growth, economic development, and technical change on global food production and consumption. *Agricultural Systems, 104*(2), 204-215. doi:https://doi.org/10.1016/j.agsy.2010.11.003
Szabo, S. (2016). Urbanisation and food insecurity risks: Assessing the role of human development. *Oxford Development Studies, 44*(1), 28-48. doi:https://doi.org/10.1080/13600818.2015.1067292
Tadasse, G., Algieri, B., Kalkuhl, M., & Von Braun, J. (2016). Drivers and triggers of international food price spikes and volatility. *Food price volatility and its implications for food security and policy*, 59-82.
Tian, J., Bryksa, B. C., & Yada, R. Y. (2016). Feeding the world into the future–food and nutrition security: the role of food science and technology. *Frontiers in life science, 9*(3), 155-166.
Upton, J. B., Cissé, J. D., & Barrett, C. B. (2016). Food security as resilience: reconciling definition and measurement. *Agricultural economics, 47*(S1), 135-147.
Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. (2012). Climate change and food systems. *Annual review of environment and resources, 37*, 195-222.
Zhou, Z.-y., & Wan, G. (2017). *Food insecurity in Asia: Why institutions matter*: Asian Development Bank Institute.