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FOOD SECURITY IN DEVELOPING COUNTRIES: ROLE OF AGRICULTURAL EXPORTS, INCOME INEQUALITY AND ECONOMIC GROWTH

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ABSTRACT

Food security is considered as a basic right of human beings as it is also clear from the Agenda of Sustainable Development Goals (SDGs). Target 2.1 of SDG focuses on eliminating hunger and food insecurity and target 2.2 is related to the ending of all forms of malnutrition. The present study highlights the role of agricultural exports, income inequality, and economic growth in food security of 89 developing countries by using panel data from the years 1990 to 2020. Employing the Method of Moments Quantile Regression (MMQR), it analyses four dimensions of food security: availability, access, stability and utilization. Key findings include a negative impact of agricultural exports and income inequality on food security in case of developing countries. The results reveal a positive and highly significant impact of economic growth on food security. The study recommends interventions to reduce reliance on agricultural exports and policies to reduce income inequality and for achieving sustainable economic growth.

Keywords: Food security; Agricultural exports; Income inequality; Economic growth; Method of moments; Quantile regression.
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INTRODUCTION

Since the post-1945 period, the concept of food security has been established by various international organizations. The most commonly acceptable definition of food security was officially institutionalized by the World Food Summit in 1996. The definitions and pillars of food security, further polished in 2009, indicated the ongoing historical development of policymakers' concerns. Before the world food crisis of 1973-74, official declarations used to define food security just around the food supplies' "availability" and "stability" on national and worldwide markets. Afterward, as the food prices decreased during the structural adjustment period of the 1980s, the concern shifted to the distributional issues within the countries, therefore, the policymakers added the "access to food" among vulnerable groups. In the recent era, due to more attention to the health during 1990s and 2000s "utilization of safe and nutritious food" got a focus. This official terminology is historical in nature, with each element and pillar of the definition suggesting the central concerns of the particular time period.

In spite of great advances in science and technology, an increase in food production in developing countries as well as ease in transportation of food and globalization, the challenge of food insecurity remains a major development concern. Presently, food security is a prevailing issue of humankind that needs to be addressed properly. Food security is a multidimensional topic that covers a lot of aspects, such as inequality, poverty, consumption habits, prices, unemployment, agricultural trade, nutrition, gender, etc. The causes of food security vary considerably among individuals, social groups, and areas. Food security is the base upon which a prosperous society is built, as it ensures that a country's population has a sufficient and nourishing food supply.

A resilient agricultural sector has an important role in achieving this goal. Also, agricultural exports can significantly contribute to a nation's economic growth by enhancing revenue, creating employment opportunities, and generating foreign exchange reserves. Van and Maertens (2016) and Van et al. (2018) concluded positive relationship existed between horticultural exports and FS. Moeover, Poaster (2012) concluded Chile's export boom has a strong influence on improving FS. However, there must be a balance between meeting domestic food requirements and exporting agricultural products. Overdependence on exports can sometimes compromise food security by reducing the availability of food crops domestically. Various studies highlight the potential negative effect of ARM on FS (Drèze & Sen, 1989; Watts & Bohle, 1993; Devereux & Guenthe, 2009; FAO, 2015).

Income inequality is a vital concern of the contemporary world. Income inequality creates vulnerability as well as uncertainty (World Bank, 2019). A considerable number of empirical studies have found negative impact of income inequality on food security of developing economies (Heerink & Folmer, 1994; Carolan, 2012; Elmes & Derry, 2013; Grzelak, 2017; Debebe & Zekarias, 2020; Holleman & Conti, 2020; Long et al., 2020; Wu et al., 2020; Hossain et al., 2020; Chegini et al., 2021). Preceding studies indicated inequality as a destroying force for an economy's capacity to keep its masses' food secure. However, the variations in the stages and models of economic development result in great differences in the levels of income inequality and FS.

During past two decades, comparatively high GDP growth is caused by economic development in low and middle-income economies. For instance, since 2000, more than 30 low-income countries (LICs) have moved to the ranks of middle-income countries (MICs), just due to rise in per capita GNI (World Bank, 2020). Achieving a balance between these variables is a difficult task, but it is essential for ensuring the prosperity and well-being of populations in developing nations. Several authors found that FS increase as a result of increase in GDPPC (Smith & Haddad, 2002; Haddad et al., 2003; Maisonet-Guzman, 2011; Asche et al., 2015; Holleman & Conti, 2020). This definition of food security by Food and Agriculture Organization (FAO, 2009) outlines four primary pillars of food security including physical availability of food, economic and physical access to food, food utilization and stability of the other three dimensions over time.

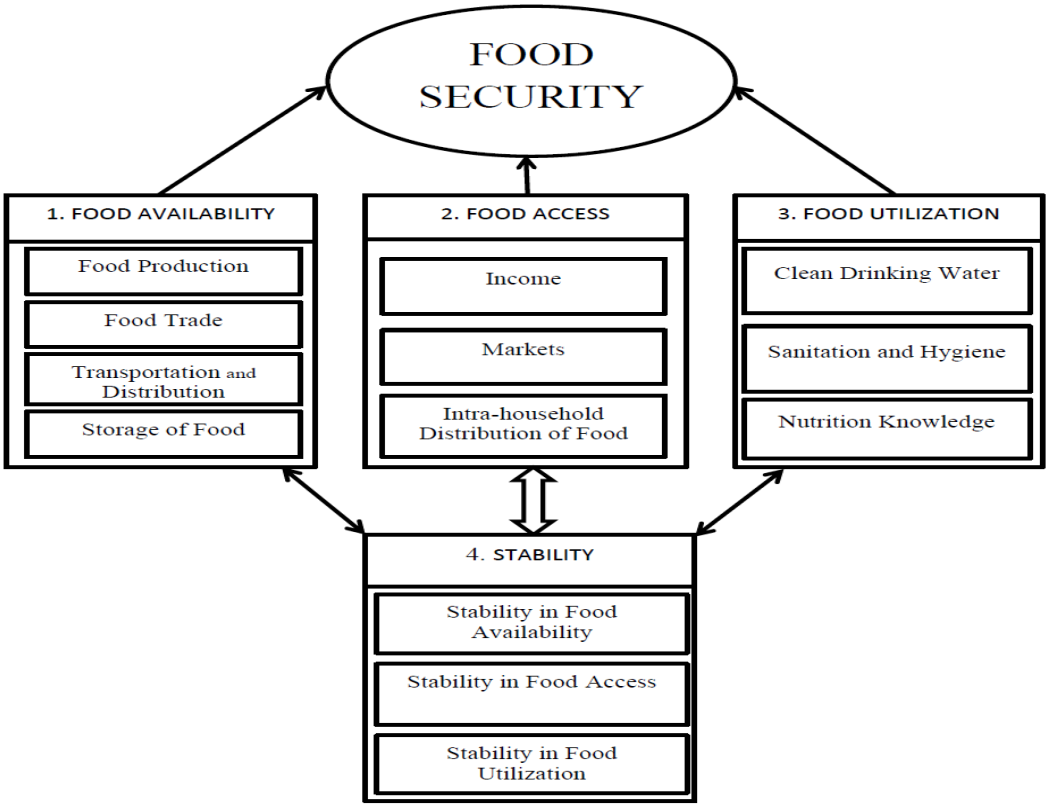

Figure 1. The four pillars of food security; Source: Author's own elaboration.

REVIEW OF LITERATURE

Studies on Food Security and Agricultural Exports

Food security persists as a pressing global challenge. In the pursuit of this goal, the connection of agricultural exports and food security has garnered significant attention from researchers, policymakers and international organizations. As the global landscape continues to evolve with changing economic, social and environmental factors, grasping the complex connection between agricultural trade and food security becomes increasingly crucial. There exist a lot of studies that pose a negative impact of agricultural exports on food security. Gacitua and Bello (1991) and Patnaik (1996) showed a negative impact of agricultural exports on food security in 15 Latin American countries and India respectively, as it is empirically found that per capita food availability declined through agricultural exports. Béné (2008) utilized the FAO fisheries statistic system (FSHSTAT) data for forty-seven sub-Saharan African countries and revealed that fish exports hampered the food security of Africa. The results of research conducted by Austin et al. (2012) were aligned with the dependency perspective of the relationship between agricultural exports and hunger. Otero et al. (2013) compared five growing economies India, Brazil, Turkey, Mexico and China with two agricultural-products exporting powerhouses, the United States and Canada on the bases of the concepts of food security and trade. The empirical findings showed that trade liberalization had only benefited the countries that were competitive in the export market and the food dependency was strong on basic foods in case of developing economies whereas developed economies were more dependent on luxury foods. The study also revealed that such uneven and combined dependency has augmented the risk of food security in developing countries because the more they become dependent on food exports and imports the more they import world food prices which affects their working class adversely who spend a large share of their budget on food items. The study of Bjornlund et al. (2022) claimed the agricultural exports often came at the expense of domestic food production which led to a decline in per capita food availability.

There are also some studies that concluded a positive association between agricultural exports and food security. Such as, using the empirical data of FAOSTAT, Fortucci (2002) explained some selected salient features of cotton related to its economic significance concerning developing countries as cotton export increased food security of these economies. Poaster (2012) revealed that huge exports by Chile improved food security as sustainable employment opportunities got created in the agri sector. Van and Maertens (2016) suggested a positive relationship between horticultural exports at macro-economic level having positive impact on the country's balance of trade rather than reducing food availability in domestic market. Furthermore, horticultural exports have contributed to improved food access through rising incomes and the purchasing power of the growers. A study by Van et al., (2017) indicated a positive impact of horticultural export sector wage employment on household income, particularly for poor households. Again in Van et al. (2108) examined the association between horticultural exports and food security. The results indicated that horticultural exports increased the volume of imports and did not pose a threat to domestic food availability.

Studies on Food Security and Income Inequality

Food security and income inequality both are critical topics that have garnered significant attention in the fields of economics and public policy. Assuring access to safe, sufficient and nutritious food for all individuals is a fundamental human right, but in reality food insecurity continues to persist in developing as well as in developed countries. Numerous studies have explored the complex interplay between food security and income inequality, aiming to understand how these factors are interconnected and how they impact the well-being of individuals and societies.

Smith & Haddad (2000) examined 58 developing countries having extreme levels of food insecurity. The results are in the line with the notion that the most prevalent reason of food insecurity in developing countries is poverty. For the case of low income mother-headed families for four Provinces of Canada, McIntyre et al. (2002) examined the occurrence and predictors regarding hunger and food insecurity. The study concluded that 96.5% of low income mother- headed families remained food insecure over the last year.

Acknowledging child malnutrition as a nutritional aspect of food security, Larrea and Kawachi (2005) measured the connection between economic inequality and child malnutrition for Ecuador. The results showed adverse effects of economic inequality on child nutrition. For the sake of examining the relationship between state income inequality and double burden of over nutrition and undernutrition for 26 Indian states Subramanian et al. (2007) conducted a study based on 77,220 married women between the ages 15-49 years. The researchers found that the double burden of undernutrition and over nutrition is more likely to be occurred in high inequality states. Carolan (2012) concluded that inequality has destroying effects on the capacity of a country to keep its population food secure. Considering the experiences of the OECD countries Grzelak (2017) evaluated the association between income inequality and food security. The study attributed the issue of food insecurity to the low level of income. Loopstra et al., (2019) examined that among the low income households how vulnerability has changed. The results indicated that unemployment, disability and low income all are related with extreme food insecurity. Debebe and Zekarias (2020) identified and measured the determinants as well as analyzed the consequences of poverty and income inequality on food insecurity status of a sample of 227 households' head in Sawla town of southern Ethiopia. The researchers concluded that income inequality has worsened food insecurity status. For 75 low and middle income nations, Holleman and Conti (2020) assessed the macroeconomic consequences of income inequality and growth on food insecurity. The results showed that individual food insecurity declines as a result of increase in GDP. Haini et al. (2023) examined that whether the adverse effects of income inequality on food security can be weakened through unemployment. By employing GMM the authors found that in case of developing nations the negative effects of income inequality further exacerbate due to increased unemployment.

Studies on Food Security and Economic Growth

A considerable number of studies have conducted world-wide on the topic of economic growth and food security. The link between food security and economic growth has long captivated the attention of researchers as well as policymakers. Tweeten (1999) argued that both transitory and chronic food insecurity were primarily attributed to poverty and should have been addressed through economic development. By scrutinizing 63 developing nations over the course of 1970-1990 through panel data analysis, Smith and Haddad (2002) identified a positive relationship between income growth and child nutritional status. The empirical findings indicated a positive association of income growth with child nutritional status. Haddad et al. (2003) indicated that sustained income growth exhibited comparable rates of reduction in child malnutrition, both across countries and within households. In a study conducted by Brady et al. (2007), empirical findings suggest a robust positive impact of gross domestic product on average caloric consumption, male life expectancy and female life expectancy concluding that economic growth results in boosting these three well-being measures in LDCs. The study of Wong (2009) concluded that a dynamic interaction between agri-biotechnology development and agri-food supply chains is vital to induce income, wealth and stability, especially to ensure food security. Kavallari et al. (2014) assessed the possible results of speeded growth in emerging as well as developed nations and exhibited that faster economic growth has higher effects on food security and agricultural commodity markets which have benefited the farmers but at the same time has negative influence on consumers especially the net food importing countries. Suryanto et al. (2023) explored how economic growth, climate change and population growth affect Indonesia's food security. The researchers suggested that the government should increase social protection to stabilize development and to minimize the effect of economic crises on food security.

We also found some studies in the literature which posed no or negative impact pf economic growth on the state of food security. Subramanyam et al. (2011) measured the link between economic growth and child undernutrition. The results provided limited support to the widely accepted notion of relationship between economic growth and the risk of child undernutrition for India. Derived from previous research and data, Desta (2017) tried to understand and discover the link between food availability and economic growth. By reviewing previous studies, author asserted that in Ethiopia there is no link between food insecurity and low economic

growth; rather, it was affected directly by an excess in money supply, inflationary pressure, population growth, and budgetary deficits.

METHODOLOGY

The primary focus of this study is to investigate how agricultural exports, income inequality and economic growth impact the four key dimensions of food security: availability, access, stability, and utilization.

Model-1: Baseline Model based on Food Availability

$$Q_{APS_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} ARM_{it} + \eta_{2,\tau} GI_{it} + \eta_{3,\tau} HLIS_{it} + \eta_{4,\tau} GDPPC_{it} + \mu_{\tau,it}$$

Model-2: Baseline Model based on Food Access

$$Q_{PUN_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} ARM_{it} + \eta_{2,\tau} GI_{it} + \eta_{3,\tau} HLIS_{it} + \eta_{4,\tau} GDPPC_{it} + \mu_{\tau,it}$$

Mo del-3: Baseline Model based on Food Stability

$$Q_{PFPV_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} ARM_{it} + \eta_{2,\tau} GI_{it} + \eta_{3,\tau} HLIS_{it} + \eta_{4,\tau} GDPPC_{it} + \mu_{\tau,it}$$

Model-4: Baseline Model based on Food Utilization

$$Q_{IDW_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} ARM_{it} + \eta_{2,\tau} GI_{it} + \eta_{3,\tau} HLIS_{it} + \eta_{4,\tau} GDPPC_{it} + \mu_{\tau,it}$$

where τ show quantiles such as 10th, 25th, 50th, 75th and 90th

i = 1, ……. N is for cross sections, and t for the time period starting from t = 1, ….. T.

Where:

APS = Average protein supply (g/cap/day, 3-year averaged)

PUN = Prevalence of undernourishment (%, Yearly estimates)

PFPV = Per capita food production variability (Constant 2014-2016 thousand international $ per capita)

IDW = People using at least improved drinking water services (% of population)

ARM = Agricultural raw material exports (% of merchandise exports)

GI = Gini index (Annual %)

HLIS= Income share ratio held by highest (20%) to lowest 20% (Annual %)

GDPPC=GDP per capita growth (Annual %)

For the sake of empirical analysis in this study, data has been sourced from two distinct repositories; firstly, the comprehensive source of Food Security Indicators (FSI) and the second repository is the extensive World Development Indicators (WDI) database. The data for 89 developing countries has extracted with precision, based on the availability of required data within both sources. The time span for this study comprises the years 1990 to 2020. Moreover, Method of Moments Quantile Regression (MMQR) technique has been used to examine the effect of agricultural exports, income inequality and economic growth on the food security of developing countries.

RESULTS AND DISCUSSIONS

Descriptive statistics of key variables

Descriptive analysis is used to present the qualitative description as well as to summarize the characteristics of the data. APS demonstrates a mean of 64.46, is skewed to the right, suggesting that a significant proportion of observations lie below the mean. PUN displays a mean of 19.77, the distribution is right-skewed. PFPV exhibits a mean of 10.44 and is highly right-skewed. IDW have a mean of 75.09. The left-skewed distribution implies that the majority of observations are concentrated towards higher levels

of improved drinking water services. ARM ranges from -5.25 to 98.95, with a mean of 6.91. The distribution is right-skewed. The GI demonstrates a mean of 42.48 and the distribution is approximately symmetrical. Income Share Ratio Held by Highest to Lowest 20 % (HLIS) ranges from 0.60 to 68.78, with a mean of 9.90. The positively skewed distribution suggests that a majority of observations lie on the lower end of the HLIS spectrum. GDPPC displays a mean of 2.04, ranging from -64.99 to 53.97. The negatively skewed distribution suggests a concentration of observations towards higher values of GDP per capita growth.

Table 1. Descriptive statistics of key variables of FS models (1990-2020).

Variables	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	JB	Probability
APS	64.46	118.10	30.00	13.88	0.64	3.25	175.24	0.00
PUN	19.77	80.80	-45.20	14.14	0.65	4.18	314.80	0.00
PFPV	10.44	107.40	-6.10	10.93	3.70	23.79	49806.9	0.00
IDW	75.09	107.10	1.60	19.03	-0.75	2.94	233.08	0.00
ARM	6.91	98.95	-5.25	12.59	3.25	14.51	17875.4	0.00
GI	42.48	84.41	-11.93	9.48	-0.15	4.74	318.70	0.00
HLIS	9.90	68.78	0.60	6.19	2.41	13.57	13780.3	0.00
GDPPC	2.04	53.97	-64.99	5.67	-0.93	24.66	54315	0.00

Source: Authors' computations.

Cross-Sectional Dependence and Slope Homogeneity Tests

This section depicts the results of cross-sectional dependence and slope homogeneity tests. Table 2 is showing the results of Pesaran's cross sectional dependence (CD) test.

Table 2. Pesaran's Cross sectional Dependence (CD)Test.

Variable	CD-test	p-value
APS	195.1040	0.0000
PUN	101.3140	0.0000
PFPV	-1.0920	0.2750
IDW	163.2440	0.0000
ARM	38.9990	0.0000
GI	22.4950	0.0000
HLIS	23.8500	0.0000
GDPPC	57.4530	0.0000

Source: Authors' computations.

From Table 2, it can be observed that apart from PFPV (per capita food production variability), all the other quantitative variables exhibit cross-sectional dependence across countries. Table 3, presents the results of the homogeneity/heterogeneity test for all four models of FS.

Table 3. Slope Homogeneity test.

Models	DV	(Pesaran and Yamagata, 2008)		(Blomquist and Westerlund, 2013)	
		Delta Test	P-Value	HAC Robust Adjusted Delta Test	P-Value
Baseline FS Models	APS	52.4310	0.0000	-7.2380	0.0000
	PUN	46.8810	0.0000	-6.1120	0.0000
	PFPV	23.2760	0.0000	-5.5480	0.0000
	IDW	54.3300	0.0000	-7.6790	0.0000

The slope homogeneity indicates that in case of both tests of homogeneity, the null hypothesis has been rejected and evidence of heterogeneous slopes prevails.

Unit Root Tests

Now, we are discussing the results of Im-Pesaran-Shin (CSDIPS) unit root test by keeping in mind our CD related data. So, we have applied the second generation of unit root test that consider the CD properties of data. The results of Im-Pesaran-Shin (CSDIPS) unit root test are presented in the Table 4.

Table 4. Second generation panel unit root test results.

Cross-Section Dependence based Im-Pesaran-Shin (CSDIPS) Unit Root Test						
Variables	Without Trend			With Trend		
	Lags	Zt Statistics	P-Value	Lags	Zt Statistics	P-Value
APS	0	-7.3920	0.0000	0	-3.3610	0.0000
PUN	0	1.5410	0.9380	1	-16.1310	0.0000
PFPV	0	-4.5260	0.0000	0	-5.9170	0.0000
IDW	0	3.8820	1.0000	0	-0.9460	0.1072
ARM	0	-6.9180	0.0000	0	-3.495	0.0000
GI	0	-5.9380	0.0000	0	-4.7610	0.0000
HLIS	0	-6.5850	0.0000	0	-3.1020	0.0010
GDPPC	0	-17.3310	0.0000	1	-5.7600	0.0000

Source: Authors' computations.

The results of the panel unit root test have applied on two equations i.e. without trend and with trend. The results of the unit root test have shown that except one variable i.e. IDW (improved drinking water services), all the other variables are stationary.

4.4 Panel Cointegration Analysis

In order to ascertain the existence of a non-spurious long-run relationship between the variables continuing with our research, the study has performed three cointegration tests namely; Kao test, Pedroni test and Westerlund test. Results show that overall a long-run relationship exists so the null hypothesis of no cointegration has been rejected.

Table 5. Cointegration tests results.

Model	DV	Kao Test			Pedroni Test		Westerlund Test				
		Dickey-Fuller test	Augmented Dickey-Fuller test	Modified Dickey-Fuller test	Phillips-Perron test	Modified Phillips-Perron test	Augmented Dickey-Fuller test	Gt	Ga	Pt	Pa
Baseline Food Security Models	APS	3.9809 (0.000)	4.8540 (0.0000)	4.7177 (0.0000)	-0.9901 (0.1611)	6.8267 (0.0000)	-0.0112 (0.4955)	-1.033 (0.1000)	-2.597 (0.2518)	-5.352 (0.0010)	-1.170 (0.0001)
	PUN	2.6513 (0.0040)	3.9333 (0.0000)	4.6606 (0.0000)	1.0627 (0.1440)	7.9823 (0.0000)	1.2284 (0.1108)	-1.753 (0.0000)	-4.709 (0.0371)	-13.076 (0.0000)	-2.616 (0.0471)
	PFPV	-1.8631 (0.0312)	-2.7475 (0.0030)	-1.6892 (0.0456)	-3.0042 (0.0013)	5.2091 (0.0000)	-5.1754 (0.0000)	-2.550 (0.0000)	-8.728 (0.0371)	-19.463 (0.0000)	-6.170 (0.0471)
	IDW	3.8857 (0.0001)	3.9605 (0.0000)	2.9769 (0.0015)	-0.3443 (0.3653)	6.3400 (0.0000)	-1.7388 (0.0410)	-0.903 (0.0001)	-2.372 (0.0054)	-8.579 (0.1754)	-1.913 (0.2981)

Note: The values in the parenthesis are p-values; Source: Authors' computations.

Method of Moments-Quantile Regression Results of Food Security

In this section, the study has employed Method of Moments-Quantile Regression (MMQR). The results for all estimated twelve models have presented in this section. The results for each model have presented in a separate table and discussed respectively. This section explains the results of MMQR for developing countries through five quantiles, i.e. 10th, 25th, 50th, 75th and 90th. The results of baseline models of FS are depicted and discussed in this section, taking into consideration four dimensions of FS namely availability, access, stability and utilization, accordingly. Table 6 shows the results for MMQR for the

baseline model of FS by considering APS as the proxy variable for the "availability" dimension of FS and has been used as the dependent variable.

Table 6. MM-QR results of baseline model based on food availability.

DV= APS (APS)							
Variables	Location	Scale	Q 0.10	Q 0.25	Q 0.50	Q 0.75	Q 0.90
ARM	-0.226***	-0.0767***	-0.115***	-0.155***	-0.216***	-0.294***	-0.357***
	(0.0178)	(0.0107)	(0.0188)	(0.0169)	(0.0174)	(0.0231)	(0.0299)
GI	-0.383***	-0.151***	-0.163***	-0.242***	-0.362***	-0.515***	-0.639***
	(0.0572)	(0.0344)	(0.0602)	(0.0541)	(0.0558)	(0.0741)	(0.0960)
HLIS	-0.218***	-0.0783***	-0.106***	-0.146**	-0.208***	-0.287**	-0.351***
	(0.0174)	(0.0104)	(0.0181)	(0.0164)	(0.0170)	(0.0225)	(0.0291)
GDPPC	0.0145***	0.00494***	0.00605*	0.0109***	0.0150***	0.0189***	0.0217***
	(0.00177)	(0.00124)	(0.00331)	(0.00233)	(0.00173)	(0.00162)	(0.00189)
Constant	82.91***	18.82***	55.60***	65.41***	80.36***	99.40***	114.9***
	(1.889)	(1.135)	(2.020)	(1.812)	(1.882)	(2.464)	(3.216)
Observations	2,759	2,759	2,759	2,759	2,759	2,759	2,759

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; Source: Authors' computations.

As we can observe from Table 6, there is a statistically significant and negative (at 1% level of significance) relationship between food availability dimension of Food Security (FS) by using APS as proxy variable and Agricultural Exports (ARM). The negative sign of the coefficient of ARM means that an increase in ARM decreases the APS. Our results are in line with the dependency argument of FS which emphasizes the harmful effects of ARM on the FS of developing countries. According to this argument, all productive resources along with agricultural land shift from domestic use to external markets. Usually, food products (fruits, vegetables, meat, fish and dairy products), oil seeds (soybeans and sunflower seeds), cotton, tea, coffee, cocoa and sugar are included in the ARM by the developing countries. With a heavy reliance on agricultural exports by developing countries can affect their APS in two ways. Firstly, food items that are exported from developing countries are important source of protein. These exports lead to decrease in the protein-rich food for the local populations, in turn, the availability of food decreases. As a result of increase in ARM, the protein supply decreases domestically, which leads to decrease the availability of food and consequently, FS of developing countries declines. Secondly, by prioritizing the production of cash crops (such as cotton and oil seeds) over staple crops for the sake of exports, the supply of protein-rich food for domestic consumption decreases. This lead to lower food availability and as a result FS decreases. Many of the previous studies have highlighted the potential negative impact of ARM on FS, as due to higher incentives for export-oriented agriculture decreased local food availability (Drèze & Sen, 1989; Watts & Bohle, 1993; Devereux & Guenthe, 2009; FAO, 2015). The results of present study are also in agreement with other found in literature (Braun & Kennedy, 1986; Gacitua & Bello, 1991; Wimberley & Bello, 1992; Jenkins & Scalan, 2001; Abdullateef & Ijaiya, 2010; Austin et al., 2012; Ivanic & Martin, 2014) with three arguments. Firstly, the negative relationship of FS and agricultural trade is the result of the competition for the production of food crop and cash crops. Secondly, it is determined that the adverse impact of agricultural exports on local food consumption is due to changes in the pattern of production encouraged through the export endorsement strategies. Thirdly, it is pointed out that food production for the sake of exports raises reliance on food imports and concluded that as a result deprived individuals turn highly exposed to fluctuations of prices in international markets for food. Some studies contradict the results of present study.[1]

Similar to the ARM, Table 6 shows that the relationship between FS and GI is negative and statistically significant for all the quantiles. This indicates as the value of GI (used to measure income inequality) increases, it decreases the APS. The well-known economists like Perotti (1996), Barro (1999) and Tanninen (1999) provided evidence that inequality has negative effects on growth i.e. income inequality retards it in

[1]Van and Maertens (2016) and Van et al. (2018) empirically found positive relationship between horticultural exports and FS. Moeover, Poaster (2012) concluded Chile's export boom has a strong influence on improving FS.

less developed countries. A reduction in such growth leads to decrease the economy's overall incomes, individuals as well as governments not have enough incomes to invest in agriculture sector and it leads to decrease in overall agricultural productivity. Moreover, economic slowdowns can impact farmers' access to credit and necessary inputs for agriculture, such as seeds, fertilizers, and machinery. Reduced access to credit can limit farmers' ability to invest in production and expansion of protein-rich foods, while limited availability of inputs can affect the quality and quantity of production. This can result in reduced supply of protein-rich foods in the market. Ultimately, agricultural production decrease due to decrease in the agricultural productivity and thus supply of protein rich food (APS) also decreases leading to decline the availability of food. As a result of decrease in food availability, the FS of developing countries decreases. This finding is supported by previous studies on income inequality and FS, including protein supply (Heerink & Folmer, 1994; Wu et al., 2020; Hossain et al., 2020), which have shown that lower-income individuals are more likely to experience nutrient deficiencies, including protein deficiency. Economic downturns can negatively impact the availability of protein-rich foods in developing countries, resulting in reduced APS. This highlights the importance of addressing income inequality and promoting economic growth to improve protein availability and overall FS in developing countries. Our results for the relationship of FS and first variable for income inequality are in line with a lot of empirical studies (Carolan, 2012; Elmes & Derry, 2013; Grzelak, 2017; Debebe & Zekarias, 2020; Holleman & Conti, 2020; Long et al., 2020; Chegini et al., 2021). The prior research concluded that inequality has destroying effects on the country's capacity to keep its people food secure and there is a great variation in the levels of income inequality and FS due to the dissimilarities in the level of economic development and the method of economy's working. In short, the studies attributed the food insecurity issue to the low level of income and these problems are intensive in case of less developed countries and in the poorer ranks of society in developed countries as well. According to the recent studies, income inequality worsened the food insecurity status of households as well as economic growth of the country. And economic growth by itself is insufficient to decrease food insecurity without addressing the problem of income inequality.

Our MMQR results, relating to the relationship between FS and the second variable related to income inequality i.e. income share ratio held by highest to lowest 20% are also negative throughout and statistically significant for the all quantiles. It means that as this ratio rises it reduces the APS. An increase in income inequality means that share of the poor segments of population in income has decreased. As the number of individuals with low-income increases, the demand for the protein-rich food decreases because low income individuals may not have purchasing power to afford such food. Consequently, food producers will consider it unprofitable to invest in the production and supply of such foods. We may conclude from this phenomenon that reduction in the APS deteriorates FS of developing countries. Likewise, income inequality can also results in reduced investment in agricultural sector, which leads to reduce FS by decreasing availability of food through a decrease in the APS. A lot of previous studies have shown a clear link between low incomes of households and greater risk of food insecurity (Abdulkadyrova et al., 2016; Loopstra et al., 2019; Pybus et al., 2021).

Concerning the MMRQ results for the last variable of the baseline model i.e. GDPPC, a positive and statistically significant relationship with APS found in the study for all the quantiles. The results show that APS increases with greater GDPPC. As a result of increased GDPPC, the purchasing power of population also increases which results in increased demand for a wider variety of food (including protein-rich food) such as meat, seafood, dairy, eggs etc. An increase in demand for such food items may lead to a corresponding increase in their prices. Due to the higher price signals, the producers will find it more profitable to allocate resources in the production of such foods, which leads to increase the supply of food rich in protein. When APS increases it will results in improved FS status of developing countries. As well as, increase in the agricultural productivity due to increased investment in this sector, increases the supply of food for the people of developing countries. Such increases in APS will definitely increase the FS status of developing countries. The results are in line with some other existing studies (Nelson et al., 2018; Hossain et al., 2020).

The studies have demonstrated that rise in per capita GDP growth is positively related with APS. Increase in FS due to increase in GDPPC is also consistent with many empirical studies (Smith & Haddad, 2002; Haddad et al., 2003; Maisonet-Guzman, 2011; Asche et al., 2015; Holleman & Conti, 2020). Our results also verify that alongwith GDPPC the distribution of income also matters as it has significant effect on FS. The results of the present study also validate the theory "that an appropriate composition of growth is indispensable to alleviate hunger" (OECD, 2013).

For baseline model of FS by considering second dimension of FS i.e. "access", we have used PUN as the proxy variable. The results of MMQR by taking PUN as the dependent variable are shown in the Table 7.

Table 7. MM-QR results of baseline model based on food access.

DV= Prevalence of Undernourishment (PUN)							
Variables	Location	Scale	Q 0.10	Q 0.25	Q 0.50	Q 0.75	Q 0.90
ARM	0.195***	0.0782***	0.102***	0.118***	0.172***	0.256***	0.329***
	(0.0294)	(0.0196)	(0.0244)	(0.0237)	(0.0265)	(0.0402)	(0.0561)
GI	0.184***	0.0829***	0.0839**	0.101***	0.159***	0.248***	0.325***
	(0.0453)	(0.0302)	(0.0377)	(0.0367)	(0.0407)	(0.0620)	(0.0864)
HLIS	0.00309	-0.103**	0.127**	0.105*	0.0340	-0.0766	-0.173
	(0.0702)	(0.0468)	(0.0585)	(0.0568)	(0.0630)	(0.0961)	(0.134)
GDPPC	-0.291***	-0.136***	-0.0954***	-0.165***	-0.273***	-0.410***	-0.521***
	(0.0314)	(0.0187)	(0.0328)	(0.0297)	(0.0308)	(0.0407)	(0.0526)
Constant	9.176***	8.186***	-0.660	1.071	6.717***	15.50***	23.16***
	(1.419)	(0.947)	(1.182)	(1.149)	(1.289)	(1.947)	(2.716)
Observations	2,759	2,759	2,759	2,759	2,759	2,759	2,759

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; Source: Authors' computations.

The results of MMQR have shown a positive and significant (at 1% level of significance) impact of ARM on the "access" of FS by taking PUN as proxy variable. It shows that increase in agricultural exports leads to increase the prevalence of undernourishment. With the increase in agricultural exports the domestic food availability is compromised. Such food shortage for the domestic population food prices in the country will increase as well as the domestic population will leave with less food options. As a consequence of high prices and fewer availability of food stuff, it may become difficult for people especially poor to afford enough quantity of healthy and nutritious food by leaving them undernourished. An increase in PUN can cause a vicious cycle of poverty through poor health leading to decreased productivity and then ultimately to low incomes. Low incomes make it difficult for people to access adequate quantity of healthy and nutritious food. The entire scenario will result in decreased FS. The results of our study complement those obtained by (Sumner, 2000; Shandra et al., 2009a; Shandra et al., 2009b; Austin, 2010a; Austin, 2010b; Tiongco & Francisco, 2011; Austin et al., 2012; Mejia, 2022; Mejia, 2023). These studies contributed to the literature by establishing that exports in the primary sector from developing countries results in extreme harmful consequences on their undernourishment. Coming to second independent variable GI, of the model under discussion, the results are statistically significant throughout the quantiles as well as exhibits positive effect on prevalence of undernourishment. The results regarding the GI and PUN exhibited that increase in income inequality results in a rise in undernourishment. High inequality in income expresses that a minor proportion of population withholds a major share of income leaving the majority of population poor, this makes difficult for the poor to meet their nutritional needs. Undernourishment arises as a result of shortage of appropriate access to nutritious and healthy food leads to malnutrition and consequently to weakened immune system and poor health. As a result of decrease in productivity, due to poor health the result will be low incomes/poverty. The access of people to the healthy and nutritious food is due to their low purchasing power, such decrease in the access of food deteriorates the FS status of developing countries. Our study seconds results of two other studies done by Subramanian et al., (2007) and Grzelak (2017). Both of the studies have stated a positive impact of income inequality on the risk of malnutrition.

Regarding the relationship of HLIS (income share ratio held by highest to lowest 20%) and PUN the study shows the positive and statistically significant relationship for lower quantiles i.e. 10th and 25th. It means that higher income inequality is connected with higher degrees of undernourishment. The results implicate that the wealthiest can easily afford the adequate amount of nutritious or high quality food while the poor individuals of developing countries usually fail to afford such food which increases undernourishment. As such inequality in accessing nutritious and healthy food results in low productivity and then ultimately low incomes and poor individuals fail to break the poverty trap. Due to low incomes, the people's access to food restricts because of low purchasing power and as a result the food security of developing countries decline.

Regarding the variable used to measure economic growth i.e. GDPPC in this study the results are significant for all quantiles. Here, the results are statistically significant for all quantiles and as far as the relationship between GDPPC and PUN is concerned it is negative throughout quantiles. It indicates that increase in GDPPC decreases prevalence of undernourishment. As the GDPPC increases, individuals tend to have higher incomes and purchasing power, leading to increased access to nutritious food. With more access to healthy and nutritious the PUN decreases. When PUN decreases, the overall health and productivity of individuals increase through better nutrition. By increase in productivity of individuals through improving health, they are more likely to participate in economic activities which, can translate into higher incomes as individuals are able to work more efficiently and effectively. Such increased incomes mean more purchasing power and more access of food which in turn, increases FS in case of developing countries. This finding regarding the increase in improved household diets as a result of increase in incomes is in agreement with the results of previous studies (Lee & Brown, 1989; Thiele & Weiss, 2003; Annim & Frempong, 2018). Our result of negative impact of GDPPC on PUN is consistent with the findings of (O'Connell & Smith, 2016; Soriano & Garrido, 2016). The studies concluded that income growth assists turnarounds in the PUN of developing countries initially through increased income and then investment in public services like education, health and improved access to drinking water. As well as, Jaworska (2018) concluded that economic growth led to structural changes that improved food accessibility.

To estimate the results of MMQR for the third dimension of FS i.e. "stability" we have used PFPV (Per capita food production variability) as proxy variable. The results of MMQR by considering PFPV as dependent variable are exhibited in the Table 8.

Table 8. MM-QR results of baseline model based on food stability.

DV= Per-Capita Food Production Variability (PFPV)							
Variables	Location	Scale	Q 0.10	Q 0.25	Q 0.50	Q 0.75	Q 0.90
ARM	-0.0449***	-0.0667***	0.0303***	0.0152**	-0.0129	-0.0660***	-0.155***
	(0.0136)	(0.0144)	(0.00737)	(0.00625)	(0.00813)	(0.0177)	(0.0371)
GI	-0.0491	-0.0764	0.0370	0.0197	-0.0124	-0.0732	-0.176
	(0.0460)	(0.0488)	(0.0252)	(0.0212)	(0.0274)	(0.0601)	(0.124)
HLIS	-0.0541	-0.0529	0.00542	-0.00653	-0.0288	-0.0709	-0.142
	(0.0584)	(0.0619)	(0.0321)	(0.0270)	(0.0348)	(0.0764)	(0.157)
GDPPC	-0.0358***	0.00315	-0.0413***	-0.0382***	-0.0356***	-0.0331***	-0.0313***
	(0.00309)	(0.00217)	(0.00579)	(0.00405)	(0.00301)	(0.00282)	(0.00330)
Constant	14.46***	12.10***	0.825	3.560***	8.655***	18.29***	34.51***
	(1.546)	(1.640)	(0.823)	(0.704)	(0.928)	(2.011)	(4.302)
Observations	2,759	2,759	2,759	2,759	2,759	2,759	2,759

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; Source: Authors' computations.

From the table, MMQR estimates display that the effect of Agricultural exports measured through ARM on PFPV is significant across the quantiles except the middle most quantile i.e. 50th with the positive relationship for the 10th and 25th quantiles while a negative impact on 75th and 90th quantiles. The positive results establish that when developing countries give precedence to the agricultural exports, they may shift resources from the production of food for local consumption, resulting in food shortages and higher prices. This may lead to increase the PFPV by making it more difficult for the poor or vulnerable

domestic populations to access adequate amounts of food. According to FAO (2006), household or population must ensure access to sufficient quantity of food at all times. Furthermore, such access should not be at risk as a result of any shock e.g. an economic or climatic crisis, as well as cyclical challenges. But in such situation, created by the exports of agricultural products by the developing countries, the stability of food is compromised because in this case people especially poor will deprive from the continuous access of food. To sum up, we can conclude that increase in ARM results in a rise in PFPV, which in turn decreases food stability and finally the state of FS is decreased in case of developing countries. While the negative impact of ARM on PFPV (as the case of 75th and 90th quantiles) implies that through agricultural exports developing countries can increase their access to diversified income sources. Such increased income sources as well as greater access to the foreign exchange from agricultural exports can lead to increased investments in agricultural sector which can help in reducing variability in the production of agriculture. As PFPV decreases it results in increased food stability and ultimately food security of developing nations can be increased.

Our results of MMQR regarding both variables of income inequality i.e. GI and HLIS are insignificant throughout the quantiles. It can be interpreted from the results that income inequality has no effect on the PFPV (Per capita food production variability) as a lot of studies have shown that income inequality is related with the consumption side.2

Concerning the GDPPC, the results have shown negative and statistically significant effect of GGPPC on PFPV. The results show that an increase in GDPPC results in a decline in PFPV used as the "stability" dimension of FS. As the GDPPC of developing countries increases, these countries become able to invest more in agricultural sector, infrastructure and transportation systems, in response the food production and distribution improves. Moreover, increase in incomes instigates people to shift their dietary patterns by demanding greater quantities as well as healthy and nutritious food. This encourages producers to produce a wider range of crops which helps in coping with the variations in production of food due to any sudden economic, social, climatic, and political shock and ensures FS by guaranteeing all the time access to food. Our results are in accordance with the results of Ogunlesi et al. (2018) who imply that increase in GDP per-capita positively contribute to the food stability in developing countries.

Now, coming to the fourth dimension of FS i.e. "utilization", we have used IDW (People using improved basic drinking water) as a proxy for FS. The effects of independent variables of our baseline model of FS on IDW are shown in the Table 9.

Table 9. MM-QR Results of baseline model based on food utilization.

DV= People Using Improved Drinking Water (IDW)							
Variables	Location	Scale	Q 0.10	Q 0.25	Q 0.50	Q 0.75	Q 0.90
ARM	-0.353***	0.0310	-0.410***	-0.376***	-0.341***	-0.323***	-0.315***
	(0.0334)	(0.0242)	(0.0721)	(0.0482)	(0.0274)	(0.0230)	(0.0237)
GI	-0.414***	0.0837*	-0.566***	-0.476***	-0.382***	-0.333***	-0.310***
	(0.0618)	(0.0448)	(0.134)	(0.0893)	(0.0508)	(0.0426)	(0.0439)
HLIS	-0.558***	-0.193***	-0.910***	-0.703***	-0.485***	-0.374***	-0.320***
	(0.0892)	(0.0647)	(0.193)	(0.129)	(0.0735)	(0.0615)	(0.0632)
GDPPC	0.0191***	-0.00400**	0.0260***	0.0221***	0.0187***	0.0156***	0.0133***
	(0.00290)	(0.00203)	(0.00542)	(0.00380)	(0.00282)	(0.00265)	(0.00309)
Constant	91.23***	13.15***	67.22***	81.35***	96.25***	103.8***	107.5***
	(1.984)	(1.438)	(4.312)	(2.896)	(1.655)	(1.370)	(1.402)
Observations	2,759	2,759	2,759	2,759	2,759	2,759	2,759

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; Source: Authors' computations.

[2] Lei et al. (2021) stated "food consumption projections indicate that reducing income inequality in rural society can improve the living standard of low-income people in terms of nutrient intakes". Moreover, Charles and Lundy (2013) found clear and consistent effects of inequality on household spending.

Starting with the result of ARM on FS, the results of MMQR have shown a significantly negative impact throughout the quantiles. It implies that increase in ARM leaves the population with limited access to IDW. Thus, the study establishes that, an increase in agricultural production for the sake of exports, leads to water pollution, resulting due to the agricultural activities such as the use of fertilizers and pesticides, leave the people with unsafe drinking water. Furthermore, agriculture as a water intensive industry, consumes higher quantity of water while producing agricultural crops for export purpose. Such production strains the water resources and as a result the access to safe drinking water for the local consumption decreases. The utilization dimension is concerned with the nutritional quality, safety and sanitation aspects of food consumption, in case of decreased access to safe drinking water, the utilization of food decreases automatically. Ultimately, decreased access of people to safe drinking water worsens the FS of developing countries. The results of our study match the findings of Rudra (2011). The results provide the negative impact of agricultural exports on potable water (safe drinking water) in developing countries.

Same as ARM, impact of GI on "utilization" dimension of FS is negative and significant for all quantiles. It reflects that rise in income inequality exerts a negative impact on the peoples' access to improved drinking water. In view of the study findings, we argue that as income inequality increases a small proportion of population holds a large share of income, leaving the majority of population poor, this makes difficult for the poor to pay for the improved drinking water due to lack of financial resources. Accordingly, the study establishes, decreased access of people to improved drinking water reduces the utilization of food and therefore, the FS status of developing countries deteriorates. Like our results, another study claims that income inequality exerts negative effects on access to safe drinking water (Sassi, 2012; Rudra, 2011).

There is a negative and significant impact of HLIS on FS for all quantiles. Income share ratio is negatively linked to the food utilization variable i.e. IDW. This relationship is not only according to what we had predicted, but significant as well. Therefore, it seems that increase in income inequality is associated with reductions in peoples' access to improved drinking water within developing countries. Increase in HLIS means the share of income of the poor segments has decreased. This suggests the improved drinking water is utilized by people lie in the upper portion by leaving those who lie in the bottom portion of the income distribution. The results second the findings of some previous research by considering quintiles (Hong et al., 2006; Yang et al., 2013). The results of previous studies indicated, the effects of inequality which resulted in deficiency of access to safe drinking water showed great disparity between the wealthiest quintile and the poorest quintile in low and middle-income countries.

Concerning the impact of GDPPC on Food Utilization our study has shown positive and significant results. It depicts that the increase in GDPPC of developing countries is associated with the utilization of food through peoples' access to improved drinking water. Results of our study establish, that as the economies of developing countries grow, they invest more resources for the provision of safe drinking water through investment in infrastructure as well as awareness campaigns, leading to increased access to improved drinking water. As the utilization of food increases through the increased number of people using improved drinking water, it improves the FS of developing countries. Our results are in line with the result, that economic growth is conducive to food utilization through an increased number of people using improved drinking water (Soriano & Garrido, 2016). The authors found that economic growth decreases undernourishment through investment in education, health, and improved access to drinking water.

CONCLUSIONS AND RECOMMENDATIONS

In this study, the impact of agricultural exports, income inequality and economic growth has been estimated on the food security of developing countries by using data from the years 1990 to 2020 for 89 countries. The study employed the Method of Moments Quantile Regression (MMQR) technique to estimate the results. The results revealed that the effect of agricultural exports on food availability is adverse, as it diminishes the local supply of protein-rich food items, thereby posing a challenge to ensuring adequate nutrition. Moreover, income inequality

exacerbates this predicament, while economic growth plays a constructive role in enhancing "food availability" by bolstering purchasing power and encouraging investments in the agricultural sector.

The analysis reveals that both agricultural exports and income inequality contribute to a rise in the PUN, underscoring their detrimental impact on access to essential and nutritious food sources. Conversely, economic growth serves to mitigate undernourishment by elevating income levels and increasing the purchasing capacity of individuals. The presence of agricultural exports tends to introduce instability to food security, potentially resulting in heightened PFPV. Furthermore, income inequality serves as a factor that adversely affects the food security of developing countries by exacerbating disparity in resource access. Conversely, economic growth acts as a stabilizing force by promoting enhanced agricultural investments and fostering a more diversified production base which can help developing countries to ensure food security. The provision of IDW emerges as a critical component for ensuring effective food utilization, given its direct impact on the health and nutritional well-being of the population. In conclusion, agricultural exports, income inequality, and economic growth emerge as pivotal determinants shaping the landscape of food security in developing nations.

The findings of this research will be of interest to researchers and policymakers working to address food security and enhance economic growth from the perspective of agricultural exports, income inequality, and economic growth. Addressing agricultural exports and dependency is critical for the attainment of sustainable food security and economic growth of developing countries by reducing their reliance solely on primary agricultural exports. Governments of these countries should prioritize efforts to reduce income inequality through policies such as progressive taxation, social safety nets (in form of cash transfers or food subsidies to the vulnerable population) and inclusive economic growth strategies through the creation of new job opportunities, education and awareness, financial inclusion, especially for rural population as well as investment in rural infrastructure. Developing countries excessively reliant on agricultural exports should emphasize on economic diversification. By expanding into other sectors such as manufacturing and services, these countries can reduce their vulnerability to unfavourable terms of trade and price volatility. Diversification can stimulate economic growth, create employment opportunities and eventually enhance overall food security.

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