World Economy Brief

March 28, 2023 | Vol. 13 No. 11 | ISSN 2233-9140

Implications of Climate Change Impacts on Food Security Threats in Africa and the Middle East

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I. Introduction

As a result of the food crisis that occurred between 2007 and 2008, food supplies were disrupted, prices spiked, and export restrictions were imposed on food-exporting countries, which contributed to food insecurity, especially in African and Middle Eastern countries (Gilbert 2010). As a result of this event, the global society was taught a lesson about food security and countries began to expand cooperation. In spite of this, climate change and the Russian invasion have caused another food crisis in Africa and the Middle East. The two regions account for six out of the top ten countries with the highest food inflation rates. A number of recent studies have also investigated the impact of weather shocks on short-term and substantial food insecurity in developing countries. Between 2014 and 2021, the proportion of Africans experiencing food insecurity increased from 47.9% to 63.2%. This is particularly true in countries that are highly dependent on wheat and corn imports (e.g., Egypt, Tunisia, Lebanon, etc.). In addition, climate change is one of the exogenous factors that cannot be controlled and has an impact on food production systems. Due to these factors, food price shocks caused by climate change may affect food availability, accessibility, and utilization.

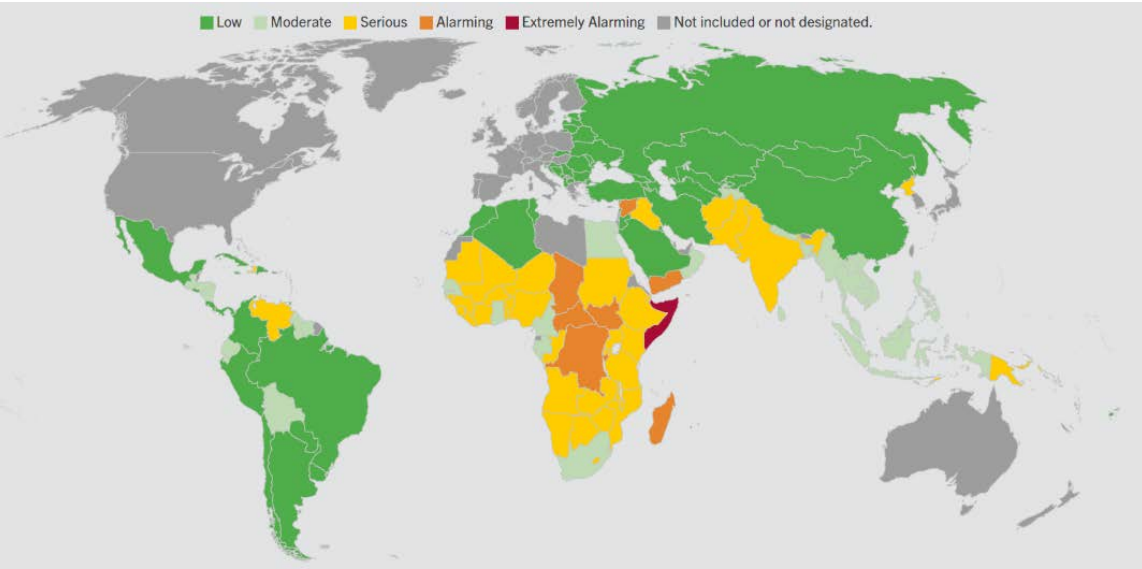
In this study, we focus on the climate shock impacts on food prices in Africa and Middle East. More specifically, we examine whether climate shocks have an impact on food price shocks in these regions. We focus particularly on the drought effects in Africa and the Middle East, where most farmers rely on rain rather than irrigation for their livelihoods. One of the most pertinent previous literatures is Raleigh et al. (2015). According to Raleigh and colleagues, drought is the most significant factor influencing food price increases in Africa due to climate change. Letta et al. (2022) find that climate change or weather shocks induce market prices in India, and one of the reasons is that weather shock signals sellers' expectations of higher prices. Due to this reason, food suppliers have an incentive to increase their food stocks to ensure a secure supply, and this results in an increase in market food prices. Food trade and reserves accumulated by the government play a central role in reducing the volatility of food prices, as argued by Kalkuhl et al. (2016). The geographical boundary of our study is restricted to Africa and the Middle East.

II. Impact of Weather Shocks on Food Security

1. Food Security Situation in Africa and Middle East

The concept of food security is defined as *"…when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life."* (FAO 2001). As part of the Sustainable Development Goals (SDGs), food security is also mentioned as a second agenda item. The Global Hunger Index in 2021 indicates that most countries in sub-Saharan Africa are experiencing "serious" levels of hunger. Furthermore, GHI indicates an "alarming" situation in several African and Middle Eastern countries, which indicates that such countries require international or national intervention to alleviate food insecurity. In accordance with EIU, food security index and GDP are correlated, and vulnerable countries are more likely to suffer from food insecurity (EIU 2021).

Figure 1. Global Hunger Index Situation (2021)



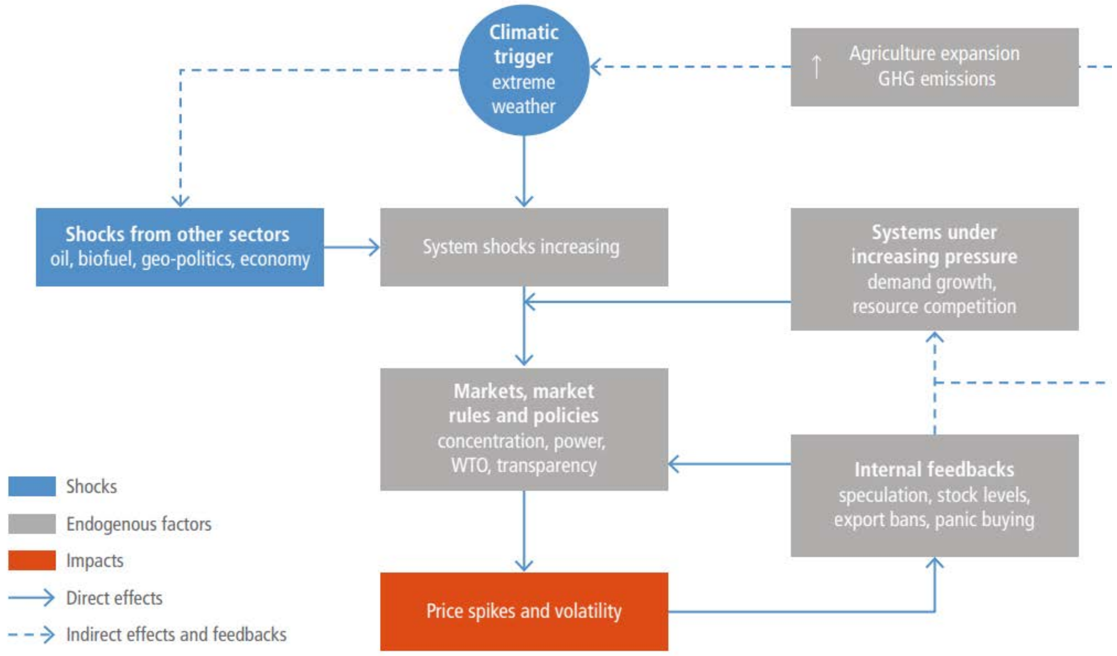
Source: Global Hunger Index Webpage.

These days, climate change is one of the most important factors contributing to food insecurity in Africa and the Middle East. As defined by the FAO (2022), it includes food access and livelihood, agricultural production and consumption, and environmental factors. Climate shocks can have a negative impact on the agricultural value chain, food prices, the depletion of land and water resources, and the disruption of the environment. These factors are again correlated to poverty, inequality, and food insufficiency. As a result, FAO examines the relationship between climate change and food security within the framework of the food system, from production to consumption.

2. Weather Shocks on Food Prices

Food production and distribution are disrupted by weather shocks. If the demand for food remains stable, then it may be possible for countries experiencing weather shocks to restrict their food exports in order to protect their domestic consumers. Food-importing countries with poor food storage systems may experience short-term shortages of food, and food price volatility or price spikes may decrease consumer demand for food, resulting in higher food insecurity rates. Figure 2 shows the sequential flow of the relationship between climate shocks and food prices.

Figure 2. Relation of Climate Shocks to Food Price Spikes



Source: IPCC (2019).

We use market prices provided by the World Food Program (WFP). WFP publishes monthly food prices in 98 countries. Out of 47 African and Middle Eastern countries, we used the

WFP market price data for 32 countries by building a panel data set for the period 2000–2020. We include major staple crops in the region, such as maize, imported rice, millet and sorghum, as well as wheat flour. We contribute to this study by analyzing the impact of climate shocks on food prices using multiple countries. In contrast to previous studies that employed the MGARCH or Vector Error Correction Model, time-series analysis cannot be performed in a multi-country setting. According to previous studies, Hill and Fuje (2020) and Letta et al. (2022) used a fixed effect panel model for the region and year, and we follow Letta et al. 's model for the region and year. The dependent variable $\boldsymbol{P_t^{ij}}$ in Equation (1) is the monthly price of market $\boldsymbol{i}$ in country $\boldsymbol{j}$. Vector of independent variable $\boldsymbol{V_t^{ij} = SPEI_t^{ij} + SPEI_{plant}^{ij} + Flood_t^{ij} + p_t^{fert}}$, where SPEI is the standardized Precipitation-Evapotranspiration Index that indicates drought index. If SPEI is located between -1 and 0, it indicates light drought while an SPEI value less than -1 means severe drought. $\boldsymbol{Flood_t^{ij}}$ and $\boldsymbol{p_t^{fert}}$ are the flood event dummy and fertilizer prices in month $\boldsymbol{t}$.

$$\boldsymbol{P_t^{ij} = \beta_0 + \beta_1 V_t^{ij} + \beta_2 P_t^w + \alpha_j + \alpha_t + u_t^{ij}}$$

Tables 1 and 2 show the results of the drought effect on maize, millet, and sorghum. We find that corn prices increase by 4.9% if the average SPEI for the previous 12 months is less than -1 or if there is a severe drought. The results of this study are similar to those reported by Letta et al. (2022) in the Indian case. Accordingly, severe droughts relative to the reference year have an adverse effect on the price of maize. However, results for SPEI less than 0 were not significant at all. The most prominent factor contributing to the increase in maize prices is floods. It is estimated that the maize price would increase by 5.1% if the flood occurred and would also be significant at the 1% level. A number of price variables, such as international oil and fertilizer prices, or international maize prices, have no economic significance, so that international price transmissions are not related to domestic prices in Africa and the Middle East. When it comes to the monthly average SPEI, drought does not affect price changes to a significant extent. Due to the long cultivation season, it takes several months for drought to negatively impact crop production and market prices. Therefore, the short-term drought index does not show economically significant price effects as it does in Table 1.

Table 1. Effects of Droughts Shocks on Maize Price

	(1)	(2)	(3)	(4)	(5)	(6)
	12 months average SPEI			Monthly average SPEI		
-1<SPEI<0	0.022			-0.008***		
	(0.016)			(0.002)		
SPEI<-1	0.049**			-0.021***		
	(0.019)			(0.004)		
SPEI		-0.033			0.008***	
		(0.022)			(0.001)	
SPEI<0			0.022			-0.012***
			(0.016)			(0.003)
Mean SPEI for planting season	0.004	0.005	0.004	-0.002	-0.002	-0.001
	(0.009)	(0.009)	(0.009)	(0.006)	(0.006)	(0.006)
Flood dummy	0.051***	0.051***	0.052***	0.047***	0.047***	0.048***
	(0.015)	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)
Int'l oil price	-0.002***	0.007	-0.002***	-0.002**	-0.001*	-0.001*
	(0.001)	(0.005)	(0.001)	(0.001)	(0.001)	(0.001)
Int'l corn price	0.006*	-0.000	0.006*	0.006**	0.006**	0.005**
	(0.003)	(0.000)	(0.003)	(0.003)	(0.003)	(0.003)
Int'l fertilizer price	-0.002	-0.003	-0.002	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Constant	-0.114*	0.856*	-0.115*	-0.141**	-0.147***	-0.119**
	(0.059)	(0.445)	(0.059)	(0.056)	(0.056)	(0.055)
# of obs.	12,984	12,984	12,984	12,984	12,984	12,984
R^2	0.047	0.045	0.047	0.047	0.047	0.047
# of markets	84	84	84	84	84	84

Note: ***<0.01 **<0.05 *<0.1.

As shown in Table 2, SPEI has no effect on millet and sorghum prices at all. Despite the fact that the results show that millet and sorghum prices increase by 1.4% if the average SPEI for the past 12 months is located between 0 and -1, this is not statistically significant. Furthermore, floods and price fluctuations do not affect the price changes of millet and sorghum. Compared to other crops such as maize and rice, millet and sorghum do not suffer from exogenous price fluctuations, thus allowing their price to be less volatile than other crops such as maize and rice. Due to the fact that millet and sorghum are major staple crops, farmers who are faced with weather shocks may be able to mitigate the effects of those shocks by growing these crops. According to Hadebe et al. (2017), millet and sorghum have a comparative advantage in countries with a semi-arid or arid climate. Additionally, millet and sorghum have been proven to be more resistant to drought and low precipitation regions than other crops. Thus, increasing crop land for sorghum and millet could contribute to better food security in low-income countries in Africa and the Middle East.

Table 2. Effects of Droughts Shocks on Millet and Sorghum Price

	(1)	(2)	(3)	(4)	(5)	(6)
	12 months average SPEI			Monthly average SPEI		
-1<SPEI<0	0.014			0.005		
	(0.021)			(0.007)		
SPEI<-1	0.051			-0.014**		
	(0.037)			(0.006)		
SPEI		-0.033			-0.001	
		(0.033)			(0.004)	
SPEI<0			0.014			-0.001
			(0.021)			(0.005)
Mean SPEI for planting season	0.003	0.005	0.002	-0.000	0.001	0.001
	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
Flood dummy	-0.001	0.001	-0.001	-0.003	-0.001	-0.001
	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
Int'l oil price	0.003*	0.002	0.003**	0.003**	0.003**	0.003**
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Int'l corn price	0.011	0.006**	0.011	0.011	0.012	0.012
	(0.010)	(0.002)	(0.010)	(0.010)	(0.010)	(0.010)
Int'l fertilizer price	-0.001	0.000	-0.001	-0.001	-0.001	-0.001
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Constant	-0.210	-0.060	-0.221	-0.223	-0.239*	-0.235*
	(0.144)	(0.197)	(0.140)	(0.137)	(0.137)	(0.136)
# of obs.	10,399	10,399	10,399	10,399	10,399	10,399
R^2	0.039	0.038	0.039	0.039	0.039	0.039
# of markets	66	66	66	66	66	66

Note: ***<0.01 **<0.05 *<0.1.

III. Policy Implications

Based on the results, we suggest four policy implications. First, production support, such as early warning surveillance and targeted financial assistance, is becoming increasingly important. In 60 countries, international organizations such as the World Bank and the World Meteorological Organization (WMO) have launched early warning systems to improve forecasting. Consequently, West and Central African countries benefited from this program. The Korean government has experience in agricultural cooperation with African and Middle Eastern countries under the ODA scheme. The Korean government may be able to expand its agricultural cooperation through the use of the early warning system. A further area of cooperation could be in the area of low-carbon agricultural practices. In both the agricultural and manufacturing sectors, low-carbon technologies are essential. No tillage practices and agroforestry are examples of practices that can be applied to Africa and the Middle East. The development of heat-resistant crops and the use of smart farms can also be examples of ways to extend cooperation to overcome climate change impacts.

Secondly, cooperation in the area of water resources is also important. Considering that over 90% of farmers in low-income countries in Africa and the Middle East depend on rainfall, expanding irrigation systems could be one of the sectors that could be expanded. As an example, the Korean government has implemented irrigation projects in Ghana and Ethiopia. Cooperation between Korea and the Middle East could also be considered in light of the water scarcity in the Middle East.

Third, support for vulnerable groups is also important. We will discuss the previous two policy implications from the perspective of production. FAO and other international organizations recognize the importance of considering food security from the standpoint of the food system. The Korean government provided 50,000 tons of rice as food aid to six countries. As the food reserve system in Africa and the Middle East, with the exception of high-income countries, is weak, food stocks are insufficient to meet the needs of countries in the event of climate shocks. As a result, major donor countries and international organizations provide food aid to countries suffering from weather shocks and severe droughts. As an example, food aid is provided to East African countries such as Kenya and Ethiopia. In the event of gradual climate change, a greater number of people may experience food insecurity or food deficiency in the region, and that is the reason that a support scheme for the vulnerable group is imperative.

Finally, we suggest that not only bilateral but also multilateral cooperation with international research institutions or non-governmental organizations is required. As a result of food insecurity and climate change, international cooperation may become more important. For the purpose of collaborating with partner countries for R&D, the Rural Development Agency has established KOPIA branches in several countries. It would be possible to extend this cooperation to research institutions such as CGIAR for the development of new varieties of crops and livestock.

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