World Economy Brief

June 9, 2022 | Vol. 12 No.22 | ISSN 2233-9140

Climate Change Impacts on Agriculture and Conflicts in Sub-Saharan Africa

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I. Introduction

The sixth assessment report (2021) by the Intergovernmental Panel on Climate Change (IPCC) warns that the global temperature has increased by more than 1°C during the 21st century alone compared to the pre-industrialization period (1850-1900). The report also warns that mankind will lose the ability to predict weather if global responses to climate change are hindered. Particularly in sub-Saharan African countries, problems such as food insecurity, water scarcity, etc. arise because of weather shocks and climate change. Chronic declines in agricultural productivity and water resources have already begun to occur, and conflict has increased as common resources become scarce.

Agricultural activities in sub-Saharan Africa are the main generators of income and food security, and in many countries in this region, over 50% of the people are engaged in agriculture. However, higher temperatures and lower precipitation are leading to a decline in agricultural productivity, and farmers are more likely to experience agricultural failure because of a lack of climate adaptation technologies. Schlenker and Lobell (2010) predicted that climate change would induce a decline in the productivity of major crops, such as maize, millet, sorghum, and groundnuts, in Africa. Decreases in agricultural productivity could lead to increased agricultural prices and a food security crisis, especially for vulnerable groups, if government-level food supply is lacking. Bellemare (2015) found that soaring agricultural prices caused instability, indicating that response measures to climate change in sub-Saharan Africa are related to peace in the region, a benefit beyond agricultural productivity. In this study, we demonstrate the effect of climate change on agricultural productivity and conflict in sub-Saharan Africa.

II. Climate Change Impacts on Agricultural Productivity

1. Empirical Model and Data

Following Lobell, Schlenker, and Costa-Roberts (2011), we use a year- and country-fixed effects model to investigate the climate effects on farm yield between 1983 through 2016. We only include the rainy season for the analysis to avoid the results being misled. Variable y_{it} in the left-handed side of equation (1) is the log of national-level yield for maize, rice, millet, and sorghum in country i for year t. Climate-related variables are included in a vector $\chi'_{it} = (T_{it}, T_{it}^2, P_{it}, P_{it}^2)$ where T_{it} and P_{it} stand for temperature and precipitation. We also use country fixed effects α_i and time trend t to control the unobserved heterogeneity.

$$y_{it} = \chi'_{it}\beta + t + t^2 + \alpha_i + \epsilon_{it} \quad (1)$$

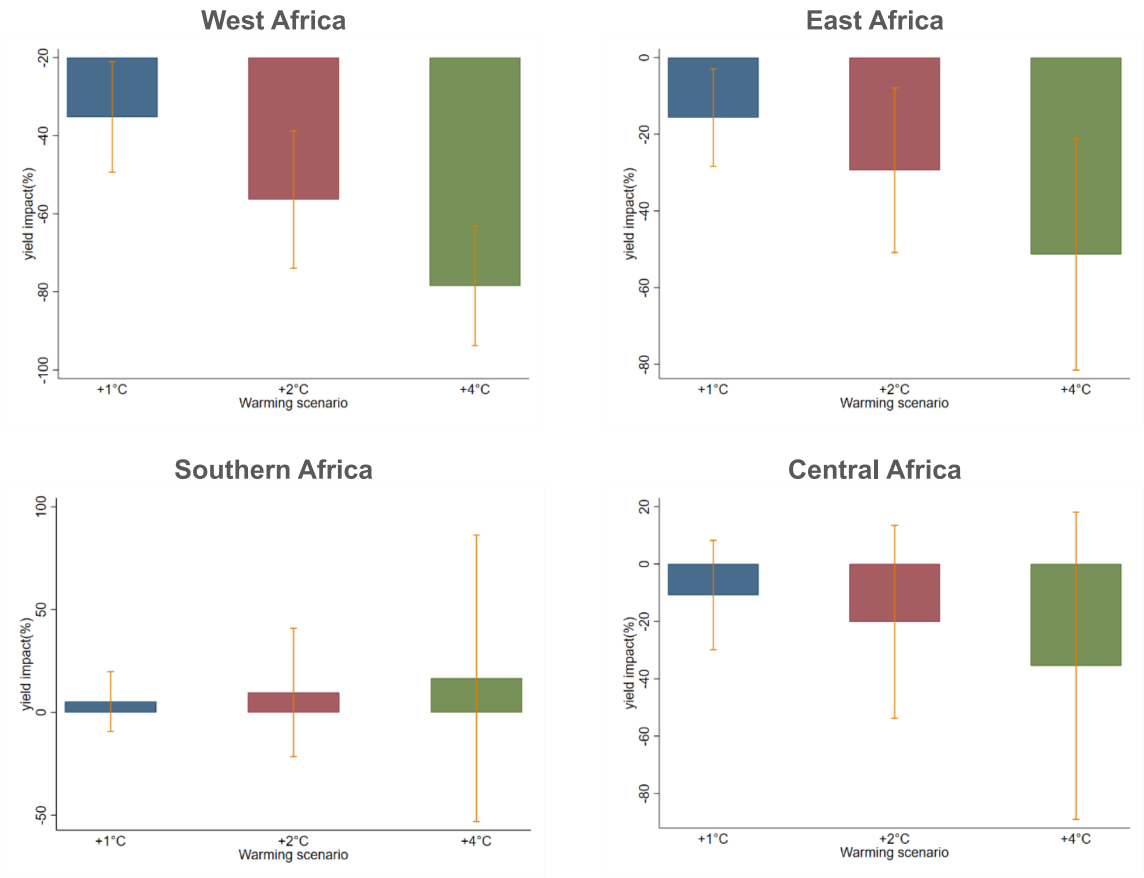
Another way of analyzing weather impacts on agricultural productivity is to use growing degree days (GDD) instead of average temperature. For example, Tack et al. (2015) used GDD to predict wheat yield in the US. We follow Schlenker and Lobell (2010) for GDD intervals as 0-10°C, 10-30°C and above 30°C for two reasons. First, unlike Tack et al. (2015), we use national-level yield data because of a lack of grid- and regional-level data. Second, since we cover 43 sub-Saharan African countries, it is difficult to identify GDD by using a piecewise-linear function of temperatures at the national level. After the analysis using GDD variables, we predicted national-level yield for different scenarios of temperature increases from 1°C through 4°C. We divide SSA into four regions for the warming scenario. The USDA PSD (Production, Supply, and Distribution) database was used for the analysis of weather effects on yield of four major crops grown in sub-Saharan African countries: maize, rice, sorghum, and millet.

2. Results

Prediction results in Figure 1 show that temperature effects on maize yield are higher in West and East Africa relative to Southern and Central African countries. As the average temperature increases by 4°C, this will decrease maize yield by around 80% in West Africa, whereas more than half the maize yield will be disrupted in East Africa. Several countries in West and East Africa consume maize as a staple food, and our results indicate that maize-producing countries are vulnerable to global warming. However, increases in average temperature benefit Southern African countries in terms of maize production.

It is also predicted that temperature increases in each region will negatively affect sorghum and millet yield while rice yield conversely increases in Eastern and Central African countries. As the average temperature increases in African countries, the possibility of staple crops being substituted with other crops might also increase (Rippke et al. 2016).

Figure 1. Prediction of Maize Yield by Warming Scenario



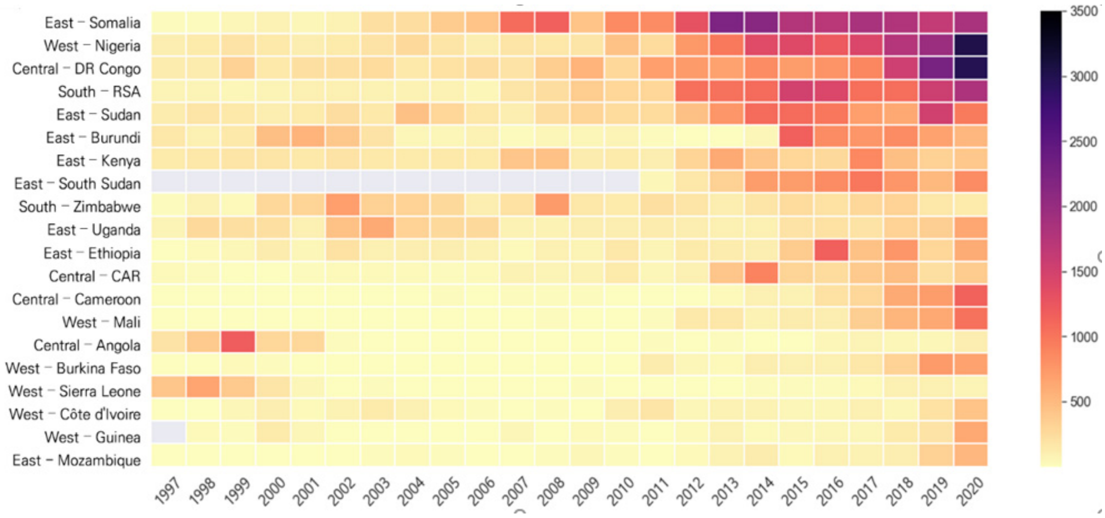
III. Climate Change Impacts on Conflict

1. Conflict Trend

Conflict in sub-Saharan Africa has increased over the last decade. For example, conflict cases reported in the ACLED database, including riots, demonstrations, battles, and civilian attacks, have significantly increased in Somalia, DR Congo, Nigeria, and South Sudan (Figure 2). However, unlike other regions where there was a high proportion of battles and civilian attacks, over 70% of the conflicts in Southern Africa were riots and demonstrations. Western African countries also experienced a higher proportion of demonstrations relative to Eastern and Central African countries.

In this study, we focus on the relationship between weather shock and conflict cases using ACLED data from 1997 to 2020. At this point, there are few conflict cases directly related to climate change in African countries. However, some cases in Nigeria and South Sudan show that drought influences the occurrence of conflict between farmers and pastoralists. In particular, conflicts between farmers and pastoralists reported in Nigeria have rapidly increased since 2013. Similarly, decreases in rainfall in the Darfur region in Sudan also generated conflict between farmers and pastoralists. As a result, this conflict led to the independence of South Sudan from Sudan. The World Bank warns that nonvoluntary climate migrants could reach 70 million in West and East Africa as the water in Lake Chad and Lake Victoria begin to deplete. This means that climate-related conflict could be triggered with a mass migration.

Figure 2. Conflict Trends in Top 20 SSA Countries



Source: ACLED

2 Empirical Model

We use a region- and year-fixed effect model to analyze the weather shock effects on regional conflict. Equation (2) does not include socioeconomic or cultural variables other than a weather variable. As Burke, Hsiang, and Miguel (2015) argue, including socioeconomic factors could generate an endogeneity problem by reverse causality issues. For this reason, we only include region- and year-fixed effects to control other socioeconomic backgrounds that influence conflict in region i in country j. The data used in this analysis covers from 1997 to 2016. We also use maximum temperature and standardized precipitation score to substitute annual precipitation as a robustness check.

$$conflict_{it} = \beta \times climate_{ijt} + \phi_{ij} + \psi_t + \epsilon_{ijt} \quad (2)$$

3. Results

We find that annual temperature increases are related to all types of conflicts we identified in sub-Saharan Africa. First, the relationship between temperature change and demonstrations is U-shaped, which means that the demonstrations increase after a certain point of temperature. Likewise, riots also increase once the annual temperature exceeds 27.5°C. This result indicates that demonstrations and riots are deeply related to the economic activity of residents. Continuous temperature increases could deteriorate productivity, as well as decreases in opportunity costs. For this reason, residents might have higher motivation to express their discontent with the government. Furthermore, temperature increases in the neighboring region might stimulate the influx of internal migrants, and this could heighten tension between natives and migrants. Bohra-Mishra et al. (2014), using the Indonesian case, show that internal migration starts to increase as the average temperature exceeds 25°C. Even if heterogeneity among countries exists, our results also show that the disruption of economic activities from increasing average temperatures stimulates riots and protests in sub-Saharan Africa as the average temperature exceeds 22-27°C. Unlike riots and demonstrations, the propensity of battles and civilian attacks decreases as the temperature increases past a certain point. Our results differ from the results of Burke et al. (2009) because of the empirical strategy of using non-linear form.

Second, climate conditions in the previous year are also significantly related to the probability of riots and demonstrations. By including both the current and previous year's weather variables, we find that the magnitude of the weather effects on riots and demonstrations is similar. As Burke, Hsiang, and Miguel (2015) explain, weather effects on the economy do not appear immediately, but the effect appears rather lagged. For example, a weather shock at a specific time does not imply a sudden disruption of agricultural productivity. Farmers realize the size of economic loss after they harvest from the field, and this means that temperature increases for a specific year could affect the next year’s yield. This pattern can be shown also in the migration pattern. Migrants do not decide to move to another region or country immediately after they experience extreme weather. Also, residents do not express their anger right after an inflow of immigrants, but rather as they realize economic loss. For this reason, it is important to consider lagged weather variables to control the effects coming from previous years.

Third, the evidence of our regression shows that the effects of maximum temperature change in the frequency of conflict do not exceed the effects of average temperature changes. In general, the effects of maximum temperature changes are related to the yield, and previous studies also included those variables for the analysis of agricultural productivity. However, this does not mean that the increases in maximum temperature also stimulate more conflicts.

Last, we find no evidence for the relationship between changes in precipitation and conflict. For example, increases in precipitation are not significant with all types of conflicts in sub-Saharan Africa. Our results are similar to McGuirk and Nunn (2020), who use grid-level data to find that precipitation itself does not have a significant effect on the changes in conflict. In our study, the economic significance of the precipitation is small enough even if it is statistically significant. Some may be concerned that the volatility of rainfall is more related to the frequency of conflict rather than annual rainfall. For this reason, we also include the Z-score after normalizing rainfall of 1997-2016 with the reference year from 1900 to 1950. After normalized precipitation, we include the Z-score instead of the annual precipitation variable, and we find little evidence that precipitation is related to the probability of conflict.

Table 1. Climate Change Effects on Probability of Demonstration in SSA

	Protests				Riots			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Average Temperature	0.044***		0.043***		0.055***		0.055***	
	(0.005)		(0.005)		(0.005)		(0.005)	
Average Temperature^2	-0.001***		-0.001***		-0.001***		-0.001***	
	(0.000)		(0.000)		(0.000)		(0.000)	
Lagged Average Temperature	0.047***		0.048***		0.041***		0.041***	
	(0.005)		(0.005)		(0.005)		(0.005)	
Lagged Average Temperature^2	-0.001***		-0.001***		-0.001***		-0.001***	
	(0.000)		(0.000)		(0.000)		(0.000)	
Average Maximum Temperature		0.011***		0.011***		0.006***		0.006***
		(0.002)		(0.002)		(0.002)		(0.002)
Average Maximum Temperature^2		-0.000***		-0.000***		-0.000*		-0.000*
		(0.000)		(0.000)		(0.000)		(0.000)
Lagged Average Maximum Temperature		0.013***		0.013***		0.012***		0.012***
		(0.002)		(0.002)		(0.002)		(0.002)
Lagged Average Maximum Temperature^2		-0.000***		-0.000***		-0.000***		-0.000***
		(0.000)		(0.000)		(0.000)		(0.000)
Annual Precipitation (100mm)	-0.001***	-0.001***			-0.002***	-0.002***		
	(0.000)	(0.000)			(0.000)	(0.000)		
Annual Precipitation^2 (100mm)	0.000	0.000			0.000**	0.000***		
	(0.000)	(0.000)			(0.000)	(0.000)		
Lagged Annual Precipitation (100mm)	-0.002***	-0.002***			-0.001***	-0.001***		
	(0.000)	(0.000)			(0.000)	(0.000)		
Lagged Annual Precipitation^2 (100mm)	0.000***	0.000***			0.000	0.000***		
	(0.000)	(0.000)			(0.000)	(0.000)		
Annual Precipitation z-score			-0.001***	-0.001***			-0.001***	-0.001***
			(0.000)	(0.000)			(0.000)	(0.000)
Lagged Annual Precipitation z-score			-0.001***	-0.001***			-0.001***	-0.001***
			(0.000)	(0.000)			(0.000)	(0.000)
No. of Grids	470,635	470,635	470,635	470,635	470,635	470,635	470,635	470,635
Regions Experiencing Conflict	23,881	23,881	23,881	23,881	23,881	23,881	23,881	23,881

Note: Standard errors are clustered at the region level. *** p<0.01 ** p<0.05 * p<0.1

Table 2. Climate Change Effects on Probability of Violative Conflict in SSA

	Protests				Riots			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Average Temperature	-0.048***		-0.047***		-0.022***		-0.021***	
	(0.004)		(0.004)		(0.005)		(0.005)	
Average temperature^2	0.001***		0.001***		0.000***		0.000***	
	(0.000)		(0.000)		(0.000)		(0.000)	
Lagged Average Temperature	-0.034***		-0.033***		-0.018***		-0.016***	
	(0.004)		(0.004)		(0.005)		(0.005)	
Lagged Average Temperature^2	0.001***		0.001***		0.000***		0.000***	
	(0.000)		(0.000)		(0.000)		(0.000)	
Average Maximum Temperature		-0.003		-0.003		0.011***		0.011***
		(0.002)		(0.002)		(0.002)		(0.002)
Average Maximum Temperature^2		0.000		0.000		-0.000***		-0.000***
		(0.000)		(0.000)		(0.000)		(0.000)
Lagged Average Maximum Temperature		0.005**		0.006***		-0.004		-0.003
		(0.002)		(0.002)		(0.002)		(0.002)
Lagged Average Maximum Temperature^2		-0.000***		-0.000***		0.000		0.000
		(0.000)		(0.000)		(0.000)		(0.000)
Annual Precipitation (100mm)	-0.001***	-0.001***			-0.000	-0.000		
	(0.000)	(0.000)			(0.000)	(0.000)		
Annual Precipitation^2 (100mm)	0.000***	0.000***			-0.000	-0.000		
	(0.000)	(0.000)			(0.000)	(0.000)		
Lagged Annual Precipitation (100mm)	-0.001***	-0.001***			-0.001**	-0.001***		
	(0.000)	(0.000)			(0.000)	(0.000)		
Lagged Annual Precipitation^2 (100mm)	0.000***	0.000***			0.000***	0.000***		
	(0.000)	(0.000)			(0.000)	(0.000)		
Annual Precipitation z-score			-0.000***	-0.000***			-0.000	-0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Lagged Annual Precipitation z-score			-0.000	-0.000			0.000*	0.000
			(0.000)	(0.000)			(0.000)	(0.000)
No. of Grids	470,635	470,635	470,635	470,635	470,635	470,635	470,635	470,635
Regions Experiencing Conflict	23,881	23,881	23,881	23,881	23,881	23,881	23,881	23,881

Note: Standard errors are clustered at the region level. *** p<0.01 ** p<0.05 * p<0.1

From the analysis, we find evidence that temperature changes are more affecting the number of conflicts, and it is important to provide a risk-coping strategy against the temperature increases rather than precipitation changes.

IV. Policy Implications and Conclusion

In this paper, we find that climate change influences both agricultural productivity and conflict negatively in sub-Saharan Africa. For this reason, the IPCC (2019) refers to the importance of adaptation strategy in the agricultural sector coping with climate change. Rather than mitigation, adaptation strategy is more relevant and effective for the agricultural sector and small-scale farmers in sub-Saharan Africa.

As an adaptation strategy, we suggest policy implications that the Korean government could focus on. First, the importance of index insurance is increasing. Previous studies such as Carter et al. (2018) or Jensen and Barrett (2017) stress the importance of index insurance in SSA as a risk-coping strategy. Adoption of index insurance is cheaper than a regular insurance plan, and small-scale farmers consider it a form of social safety net. While there is also criticism that index insurance only covers specific weather shocks such as droughts, floods, or cyclones, it also has the advantage of being predetermined (e.g. rainfall threshold), meaning farmers do not need to prove their loss. For this reason, even if some limitations exist, the Korean government could consider index insurance for ODA projects.

Second, the water-energy-food (WEF) nexus is increasing its focus on solutions to climate change. For example, the water, energy, and food sectors are interconnected with each other and carbon emission from one sector could affect another sector (Rasul and Sharma 2016). For this reason, the SADC has also adopted the WEF nexus framework to battle with climate change and water depletion problems.

Third, there could be more cooperation on the supply chain and genetic improvement for sub-Saharan Africa. Demands for heat-resistant seeds are increasing in SSA, especially for staple crops such as maize, sorghum, and millet. There are several institutions such as the Africa Rice Center, CIMMYT, and DTMA (Drought Tolerant Maize for Africa) that the Korean government could cooperate with. Korea's Rural Development Agency (RDA) also has a high capacity to cooperate with the SSA region in terms of genetic improvement. For this reason, cooperation between the RDA and CGIAR could increase technical cooperation with African countries to improve seed varieties and productivity.

The Korean government has announced its ODA strategy to support green transition in developing countries, which includes strategies for climate change, energy transition, etc. The importance of green ODA is increasing in both Korea and African countries responding to climate change adaptation measures. For this reason, it is necessary to target African countries to adapt to the effects of weather shocks on agriculture, food prices, and conflict.

This study is limited in terms of the conflict path related to weather shock. It is difficult to identify the path of conflict arising from climate change. The origin of conflict in SSA comes from ethnic, religious, and economic factors, whereas climate change is but one reason. However, conflict between pastoralists and farmers or among pastoralists is increasing in several countries such as Nigeria or East Africa, and further research will be needed to identify country-specific climate-related conflicts.

Notwithstanding these limitations, this study finds that climate change is affecting the probability of conflict in SSA. This indicates that international cooperation in response to the climate crisis and agricultural production could improve peace and security in SSA.

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