How does climate exacerbate root causes of conflict in Sudan? An econometric analysis

1. Objective and research questions

As the concerns about climate change intensifies, the idea that climate change might influence peace and security at different level continue to grow providing mixed findings (Bernauer *et al.*, 2012). In this research we examine the relationship between climate anomalies (both rainfall and temperature) and conflict events that are largely at community level, measured by whether or not inhabitant of a community feel unsafe, fear crime or fear theft. Using a representative data from Sudan, we answer the following research question:

I. Do extreme climatic events and variability exacerbate households' food insecurity?
II. Does food insecurity, as exacerbated by climate impacts, affect the likelihood and intensity of conflict?

Specifically, we argue that climate anomalies exacerbate conflict by adversely affecting household food security.

2. Methods and data

The analysis in this study is based on rich representative household data from Sudan which is administered by the Afrobarometer a pan-African institution conducting public attitude surveys repeated on a regular cycle (Afrobarometer, 2019). We use the pooled data of 2 rounds; round 2 collected in 2015 and round 3 collected 2018. The survey collects data on democracy, governance, the economy, household characteristics and security within the community. This household level data was merged with climate data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) which contains information on maximum and minimum temperature and rainfall.

Food security used in this study was capture by the question how often a member of the household went without food, this is a dummy variable taking the value 0 if they never went without food and 1 otherwise. The conflict variables were derived from the security section of the questionnaire, three variables are used there are whether the household (a) feel unsafe, (b) fear crime (c) fear theft. We calculated both temperature and rainfall anomalies by taking into account the lagged values 12 months before the month of the survey. To calculate the climate anomalies, we applied the formula by Maystadt and Ecker (2014).

For the econometrics analysis, we conduct analysis in two steps. First, we test whether climate change through the rainfall and temperature anomalies on food security. We employ a probit model to unravel this relationship controlling for household characteristics including year and district fixed effects given that we use a pooled data for two rounds. In the second step we test using a probit model whether food insecurity (gone without food) exacerbate conflict (feel unsafe, fear crime, and fear theft) controlling for household characteristics including year and district fixed effects. For brevity, we only present the results of the variables of interest.

3. Results

Tables 1 and 2 presents the descriptive statistics of the variables used in the empirical models. The choice of the variables is guided by economic theory and previous literature.

Table 1. Food insecurity, climate anomalies and conflict

Food security		**Full sample**				
Variable	**Variable description**	**Obs**	**Mean**	**SD**	**Min**	**Max**
Gone without food	Gone without food (1=skipped; 0 otherwise)	1309	0.322	0.467	0	1
Climate anomalies						
Rain anomalies	Rain anomalies 12 months before the survey month	1312	0.161	0.184	-0.132	0.692
Temperature anomalies	Temperature anomalies 12 months before the survey month	1312	-0.120	0.217	-0.392	0.514
Rain positive extreme 12 months	Positive rain anomalies taking into account quantiles 4 and 5 (1=Yes: 0= No)	1312	0.250	0.433	0	1
Temperature positive extreme 12 months	Positive temperature anomalies taking into account quantiles 4 and 5 (1=Yes: 0= No)	1312	0.079	0.270	0	1
Conflict						
Feeling unsafe	Felt unsafe to walking in the neighborhood (1=Yes: 0= No)	1311	0.267	0.443	0	1
Fear crime	Feared crime (1=Yes: 0= No)	1310	0.190	0.393	0	1
Fear theft	Feared theft (1=Yes: 0= No)	1312	0.438	0.496	0	1

Table 2. Household characteristics

Variable	**Variable description**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Age	Age of the household head	1311	34.375	12.521	18	88
Gender	Gender of the household head (1=Male; 0=Female)	1312	0.502	0.500	0	1
Education	Education of respondent (0=No education; 1=Primary; 2=Secondary; 3=Secondary; 4=Post-secondary)	1308	2.121	0.970	0	3
Remittances	Received remittances (1=Yes: 0= no)	1302	0.286	0.452	0	1
Agric. occup	Agriculture is the main occupation (1=Yes: 0= no)	1312	0.097	0.296	0	1
Group mem.	Member of community association (1=Yes: 0= no)	1312	0.223	0.416	0	1
Electricity	Connected to electricity (1=Yes: 0= no)	1308	0.806	0.396	0	1
Own television	Own television (1=Yes: 0= no)	1307	0.810	0.392	0	1
Source of water	Source of water (0=outside the compound; 1= Within)	1303	0.797	0.402	0	1
Urban-rural	Residence (0=Rural; 1=Urban)	1312	0.457	0.498	0	1

To unravel the relationships between climate anomalies and food security; climate anomalies and conflict and food security and conflict, we first conduct a series of simple correlation analysis assuming linear relationships. Table 3 presents the correlation results.

Table 3. Correlation between climate anomalies, food insecurity and conflict

	Rain anomalies 12 months	Temperature anomalies 12 months	Rain positive extreme 12 months	Temperature positive extreme 12 months	gone without food	Feeling unsafe	Fear crime	Fear theft
Rain anomalies 12 months	1							
Temperature anomalies 12 months	0.116	1						
Rain positive extreme 12 months	0.810	0.046	1					
Temperature positive extreme 12 months	0.013	0.526	0.143	1				
gone without food	0.203	0.093	0.165	0.015	1			
Feeling unsafe	-0.012	0.089	-0.052	0.009	0.175	1		
Fear crime	0.052	0.021	-0.019	0.031	0.159	0.460	1	
Fear theft	-0.035	0.080	-0.050	0.014	0.175	0.309	0.297	1

Overall, the results indicate a positive correlation between food insecurity (going without food) and both rainfall and temperature anomalies before the survey month. The results of correlations between food insecurity (going without food) and conflict (feeling unsafe, fear crime, and fear theft) are positive suggesting that increasing food insecurity increases the conflict occurrence. Relating to rainfall anomalies in the previous 12 months, the correlation with feeling unsafe and fear of theft is negative but show positive correlation with fear crime. Suggesting that increasing rainfall anomalies in the previous 12 months reduces the chance that the households will feel unsafe and fear theft but increase the chance thst they will fear crime. On the other hand, correlations between temperature anomalies in the previous 12 months with feeling unsafe, fear crime and fear theft is generally positive. This suggests that increase in temperature anomalies in the previous 12 months increase the probability that household will feel unsafe, fear crime, and fear theft.

In sum, there seems to be an indication that generally climate anomalies increase food insecurity which in turn increases conflict occurrence. However, a conclusion based on correlation analysis only may be misleading particularly because the correlations performed does not take into account the complexity of the relationships, rather it assumes linear relationship which may not necessary be the case. Further, the correlation values are small with mixed findings particularly between for rainfall anomalies and conflict variables. There is nee therefore to model this through econometrics controlling for household level covariates.

In the next section, we provide the econometric estimation results controlling for the household level covariates.

I. Do extreme climatic events and variability exacerbate households' food insecurity?

Table 4 presents the results of the probit estimation for the influence of climate anomalies on food insecurity.

Table 4. Probit models of the influence of climate anomalies in food insecurity

	(1) Gone without food – using the anomalies		(2) Gone without food – using the extreme positive anomalies	
Variables	**dy/dx**	**Robust SE**	**dy/dx**	**Robust SE**
anom_tmax_12	0.152**	0.196		
anom_rain_12	0.482***	0.236		
temp_positive_extreme12			0.047	0.102
rain_positive_extreme12			0.159***	0.063
Controls	YES		YES	
Year FE	YES		YES	
District FE	YES		YES	
Observations	1,272		1,272	

Robust standard errors in parentheses

*** p<0.01, p<0.05, * p<0.1

The results in Table 4 show that overall, past temperature and rainfall anomalies have positive association with food insecurity. Everything else held constant, increase in climate anomalies by 1 unit increase the probability that households will go without food by 15.2 percentage points. This suggest that increase in temperature anomalies imply that food production is adversely affected and this has implications food security. This is consistent with previous studies found that increase in temperature relative to normal reduce economic opportunities for the rural dwellers, reduce crop production and thus amplify food insecurity (Raleigh *et al.*, 2015). Similarly, increase in rainfall anomalies by 1 unit is associated with 48.2 percentage points increase in the probability that household will go without food. This suggest that increase in rainfall relative to normal has adversely effects on food production and hence food security. However, to understand what level of rainfall anomaly cause increase in food insecurity, we exploit the rainfall anomaly data and calculate the extreme positive rainfall anomaly. We estimate model 2 using the positive extremes. The results indicate that indeed extreme positive rainfall anomalies is associated with increase in food insecurity by 15.9 percentage points.

II. Does food insecurity, as exacerbated by climate impacts, affect the likelihood and intensity of conflict?

Having tested the relationship between climate anomalies and food security and arrived at a conclusion that increasing in climate anomalies (both temperature and rainfall) increase food insecurity. In step 2 we test whether food insecurity has an influence on conflict. We estimate three probit models for each of the conflict variable controlling for household level characteristics including year and district fixed effects. Additionally, we test the effect of the interaction between food insecurity and climate anomalies (both temperature and rainfall).

Table 5 presents the estimation results. The results indicate that consistently food insecurity (going without food) increases conflict. Specifically, going without food increases feeling unsafe by 9.6 percentage points, increase fear crime by 9 percentage points and increases fear theft by 19.1 percentage points. This suggest that lack of enough food is an incentive for people to engage in conflict related activities such as theft and crime in general. This is consistent with previous studies that have

found that food insecurity is correlate with emergence of conflict events (Fjelde, 2015; Raleigh *et al.*, 2015). It important to note here that the measures of conflict used, that is, feeling unsafe, fear crime and fear theft are used as proxies of insecurity community level. When the interaction of food insecurity and climate anomalies is considered, though not significant (interpreting the direction only) we can draw two interesting conclusions. First, the results of the impact of climate anomalies on conflict are mixed. On the one hand, increased in climate anomalies increases the probability that households will feel unsafe and also that they will fear crime. This may be related to the scarcity discourse which advance the argument that increase climate anomalies relative to the normal reduces the resources available including diminishing the household food security status, this, in turn increases the probability of conflict as competition towards the limited resources intensifies (Theisen, 2012). The interaction of climate and food insecurity is also found to increase the likelihood of feeling unsage and fear crime. Although these results are not statistically significant. On the other hand, we find that consistently, the interaction between climate anomalies (both temperature and rainfall) and food insecurity reduces the probability that household will fear theft occurrence. While it is expected that food insecurity interacted with climate anomalies will increase the chance of theft in the community, we argue that it is possible that not all conflict events are correlated with climate change. This argument is consistent with the argument of (Bollfrass and Shaver, 2015) who argue that diminished local farm output in sub-Saharan Africa resulting from increasing temperatures is unlikely to account for the entire increase in substate violence. Same for the results of the previous interaction, however, these results are also not statistically significant. The lack of significant may be related to the fact that there could be some household and community level covariates that we could not control for given the data limitations.

Table 5. Probit models of the influence of food insecurity on conflict

	(1) Feeling unsafe		**(2) Fear crime**		**(3) Fear theft**	
Variables	**dy/dx**	**Robust SE**	**dy/dx**	**Robust SE**	**dy/dx**	**Robust SE**
anom_tmax_12	0.059	0.717	-0.064	1.054	0.570**	0.702
anom_rain_12	0.438***	0.594	0.245	0.814	-0.172	0.961
Gone without food	0.096**	0.146	0.090**	0.148	0.191***	0.139
Gone_without_food_x_ anom_tmax_12	0.174	0.484	0.105	0.793	-0.117	0.478
Gone_without_food_x_ anom_rain_12	0.192	0.587	0.145	0.620	-0.085	0.621
Controls	YES		YES		YES	
Year FE	YES		YES		YES	
District FE	YES		YES		YES	
Observations	1,272		1,215		1,248	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Our findings support the dominant discourse of resource scarcity, which advance the argument deviations of climate from the normal reduce resources available and adversely affect food security and this exacerbate conflict (Raleigh *et al.*, 2015; Salehyan and Hendrix, 2014).

4. Conclusion

Whereas the data limitations did not allow us to make strong arguments for climate as a threat multiplier for conflict. Nonetheless, through a stepwise approach we have shown that food insecurity is a potential the mechanism through which climate change influences conflict. (i.e. we found non-significant p-values for the interaction of climate anomalies and food insecurity, thus we only interpreted the directional effects).

While we have shown that climate change affects conflict through increasing food insecurity, we have modelled the relationships independently. We suggest that future studies need to consider econometric techniques that consider these interdependent relationships.

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