Supplementary Information for “A Coupled Food Security and Refugee Movement Model for the South Sudan Conflict”

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ABSTRACT

This document serves as Supplementary Information for the paper “A coupled Food Security and Refugee Movement Model for the South Sudan Conflict”.

Supplementary Note 1. Input data analysis

To properly understand how these two data sets relate to one another, we look for linear correlations both at the geographical and temporal level. Indeed, for the purpose of this study other kinds of correlations can be neglected since only a strong linear correlation would justify leaving food security conditions out of the model.
In all cases, we take the mean square error (MSE) as a quality estimator, which can be directly computed from the sum of squared residuals (SSR) as indicated in equation 1.

$$SSR = \sum_i (y_i - f(x_i))^2 \qquad MSE = \frac{SSR}{N-2} \tag{1}$$

where f(x) is the resulting function of the fit and N the number of points. In Tables 1, 2 and 3, we present the resulting MSE values for each region and each period of time as well as some statistical considerations.

Table 1. Values of the computed MSE for the different regions of South Sudan. Ranging from 0.029 to 0.085, they provide a quantitative estimate of the quality of the spatial correlations between conflict occurrence and food insecurity.

State (region)	MSE
Central Equatoria	0.042
Eastern Equatoria	0.065
Jonglei	0.048
Lakes	0.058
Northern Bahr el Ghazal	0.029
Unity	0.072
Upper Nile	0.080
Warrap	0.085
Western Bahr el Ghazal	0.066
Western Equatoria	0.047

Average	**0.059**
Std. deviation	**0.017**

Table 2. Values of the computed MSE for the different periods of the conflict. Ranging from 0.042 to 0.133, they provide a quantitative estimate of the quality of the temporal correlations between conflict occurrence and food insecurity.

Month	**MSE**
December 2013	0.133
January 2014	0.118
February 2014	0.120
March 2014	0.054
April 2014	0.058
May 2014	0.110
June 2014	0.042
July 2014	0.072
August 2014	0.093
September 2014	0.120
October 2014	0.108
November 2014	0.075
December 2014	0.067
January 2015	0.050
February 2015	0.045
March 2015	0.091
April 2015	0.090
May 2015	0.094
June 2015	0.109
July 2015	0.078
August 2015	0.068
Average	0.086
Std. deviation	0.027

Considering that the variables of interest take values ranging from 0 to 1, in most cases the correlation is actually quite weak, with average values of the MSE above 0.05 both for the temporal and geographical analysis (see Tables 1 and 2). Furthermore, the quality of the fits also varies considerably as characterized by the standard deviation of the MSE, which overall indicates that conflict emergence cannot simply portray food security conditions in a model. Further supporting this claim, we observe an important variability in the parameters of the fits (i.e. the slope of correlations), with standard deviations of the same order as or even higher than the average values. Indeed, we observe that not only the quality but also the precise form of the correlations between the two data sets is highly variable, making it very difficult to express the effects of one in terms of the other.

It is worth noting as well that temporal correlations prove to be very consistent regarding the sign of the slope, with more than 96% of the cases having a positive relationship as compared to only 27% for spatial correlations (see Table 3). This result shows that an increase in violence will sometimes be followed by an increase in food insecurity in the country, but that this food insecurity won't necessarily happen at the same place. In other words, famine is not local to conflict zones but is still frequently higher when more conflict events occur. This could be taken as evidence that starving tactics may indeed have been implemented in this struggle, as suggested in the literature.

To conclude, in this section, we have shown through a linear correlation analysis of carefully chosen variables that food security conditions in South Sudan should be modelled as a separate independent parameter for realistic results. With such a result in mind, in the following sections, we present an easy implementation of this in the framework of the FLEE modelling approach and how the simulation results are affected by it.

Supplementary Note 2. The IPC index of the different regions at different times

Table 3. IPC indexes table: percentage of the population estimated to be in a stress situation or above for each state. The *Dates* column indicates the simulation day up to which that line is valid. The rest of the columns correspond to the different states: Western Bahr-el-Ghazal (WBG), Northern Bahr-el-Ghazal (NBG), Warrap, Lakes, Upper Nile (UN), Jonglei, Unity, Central Equatoria (CEQ), Western Equatoria (WEQ) and Eastern Equatoria (EEQ).

Dates	WBG	NBG	Warrap	Lakes	UN	Jonglei	Unity	CEQ	WEQ	EEQ
47	8	7	8	20	3	55	44	2	15	6
167	26	38	20	21	48	45	64	11	15	15
197	27	38	19	30	50	52	71	10	15	17
289	14	13	11	27	31	29	44	8	1	5
320	4	12	4	14	15	27	37	6	0	3
412	4	23	11	19	44	29	52	12	1	7
501	27	36	47	55	47	37	42	11	3	8
532	38	60	49	58	57	44	54	12	1	13
624	21	15	12	24	51	44	44	6	0	7