Supplementary Material For

Climate Change, Cash Crops, and Violence Against Civilians in the Sahel

This supplemental appendix first reports summary statistics for all variables used in our analyses in Table A1. Next, we report a summary figures. The first is for SPAM data for the three survey periods of interest in our data: 2005, 2010, and 2017 in Fig. A1. Recall that our analyses relies on the 2005 period to minimize endogeneity risk due to targeted civilians switching crops, which – as illustrated in the sensitivity analyses discussed below – does not alter our results statistically or substantively. Fig

We then proceed to report several robustness models used to test the sensitivity of our results. To this end, Table A2 first reports a set of specifications – model (4) – where we constrain our *Cash crop*$_i$ variable to only focus on cereals locations identified in the SPAM 2005 data (Yu et al., 2020) to ensure that our findings are robust to their inclusion in our cash crop category. The main models' results maintain their signs and significance in this specification. Model (5) in the same table then reports estimates for models where only areas with high levels of agricultural productivity (at least 40%) to ensure the results are not sensitive to potential survey reporting issues. As Table A2 illustrates, the results not only hold, they are even more pronounced in the case of militia; in the case of state forces, the coefficient changes sign to positive but it is practically zero substantively and statistically.

Model (6) in Table A3 then tests whether the results are robust to our decision to focus only on agriculturally producing area by estimating each full specification on a sample that includes all non-agriculturally producing 0.5 degree grid cells alongside agricultural ones. Model (7) then accounts for our decision to rely on pre-sample period values to account for endogeneity risk between VAC and civilian choice of crop production by using a cash crops indicator that includes information from the 2010 and 2017 surveys to the sample (where missing values for each year and month were interpolated using the last value carried forward approach) (Yu et al., 2020). Our findings are robust in both cases – the *Cash crop productivity*$_{it}$ coefficient estimates maintain their sign and significance from the main model in every case.

Table A4 then first account for the possibility that any associated effects between high cash crop productivity and VAC are the results of higher intensification of armed conflicts between state forces, rebels, and militia troops. To this end, we add indicators for the counts of such conflict attacks initiated by each respective actor to each of the three full specifications in Model (8). Model (9) in the same table then accounts for the risk that heterogeneities at higher levels – e.g., due to similar values on the same indicators across different 0.5 degree grids within the same country – are driving the results by clustering our standard errors at the country as opposed to 0.5 degree grid level. Again, the estimates of our key interaction of interest maintain their sign and significance across all specifications in Table A4.

In Table A5, we first turn to ensure that our results are robust to the inclusion of 0.5 degree grid months in Algeria and Mauritania, only small portions of whose territory is located inside the Sahel, by removing the countries from our sample in Model (10). Model (11) then ensures that annual – in addition to monthly – level variations, such as changes

in temperature and precipitation averages that are constant across different years, are not impacting the results by including year fixed effects in each model, instead of the time trend. In Model (12) in Table A6 we then add several potentially relevant country level variables to our indicators of interest to ensure they are not impacting our results. Here we include measures for the efficiency of the government, life expectancy at birth, and the total size of the entire countries population, all measured for each country and every year in the data, and obtained from the World Bank (The World Bank, 2022). Model (13) in the same table then accounts for *all* country level factors that vary annually (e.g., democracy, GDP, military expenditure) by adding fixed effects for country, year, and the interaction between them. In all cases, the results our robust across all specifications.

Next, it is possible that the effect we identify as within-cell actually reflect spatial trends, whereby VAC "spills over" from neighboring grid cells. To this end, Model (14) in Table A7 reestimate our main models with a binary indicator of whether conflict was reported in a nearby cell located to the north, south, east, or west of grid cell i for each of the three violence types examined. Another possibility is that seasonal trends in VAC unfold over a longer period of time than one month. To account for this, Model (15) in Table A7 includes two- and three-month VAC lags for each violence type in addition to the one-month lag to ensure the results are robust to this concern.

Moving on to Table A8, we next seek to ensure our results are not driven by our decision to rely on average levels of environmental health to model productivity. In Model (16) we accordingly construct our vegetation coverage and based on vegetation coverage anomalies instead of average levels in two steps. First, we calculated the mean and standard deviation of *Vegetation coverage*$_{it}$ for each grid cell in our sample over the entire period of analysis (Jan. 2006 – Dec. 2018). We then calculated anomalies as normalized Z scores using the formula: (*Vegetation coverage*$_{it}$ – *Vegetation coverage mean*$_i$)/ *Vegetation coverage SD*$_i$. Note that the resulting variable *Vegetation coverage (anom.)*$_{it}$'s range (-5.886 $\Leftrightarrow$ 7.306) is much larger than *Vegetation coverage*$_{it}$'s (0 $\Leftrightarrow$ 1), meaning that the associated coefficient estimates – substantively – are as well. Nevertheless, the results maintain their sign, statistical significance and – when adjusted for range – 0.013 for rebel VAC and 0.026 for militia VAC – magnitude, seeing the coefficients in the main models for the 0 $\Leftrightarrow$ 1 range are 0.007 (rebel VAC) and 0.023 (militia VAC).

Next, it is possible that the results are driven by VAC outliers in the sample. Accordingly, Model (17) in Table A8 re-estimates all models from the main study, where each dependent variable and its lag are operationalized as the natural log + 1 of the total monthly event count. Model (18) in Table A9 then estimates the full models on a simpler binary construction of each dependent variable and its lag, which are operationalized based on whether a given grid cell i experienced any VAC events by any respective actor in month t (for the DVs) or -1 (lags), =1, or not (=0).

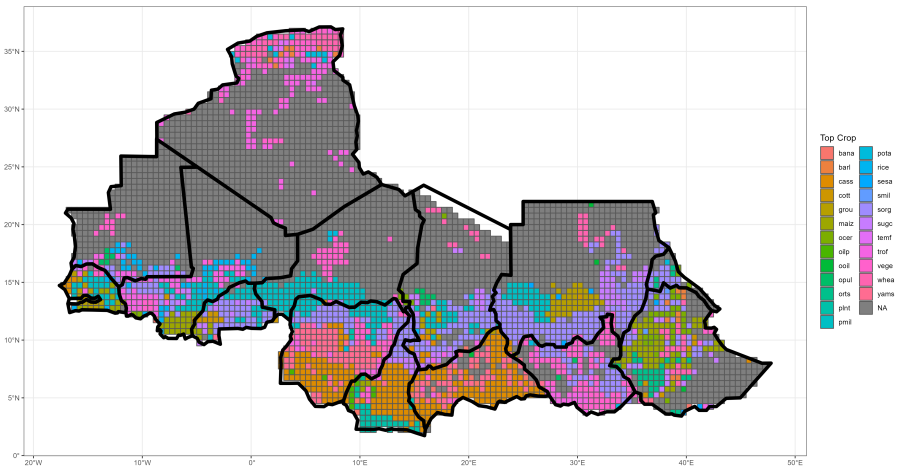
Model (19) in Table A9 then helps to ensure that our results are not driven by the specific standards of coding and thresholds used in the Armed Location and Conflict Event Dataset (Raleigh et al., 2010), which – in line with past research (e.g., O'Loughlin et al., 2012; Koren, 2018) – we used to operationalize our VAC variables. Here, we use data from the Geolocated Event Dataset (GED) (Sundberg and Melander, 2013) to operationalize our dependent VAC variables and their lag. In contrast to ACLED – which codes all violent events, whether these occurred as part of a civil war or not, or did not involve any casualties

– the GED only codes one-sided violence incidents occurring as part of a conflict with at least 25 combatant casualties, and which involved at least one civilian death. Additionally, while coding attacks by official state forces (military and police), the GED also does not distinguish between rebels and militias, including attacks by both actor types under the same "nonstate actor" category. AfroGrid includes GED data, distinguishing whether the initiating actors were state or nonstate actors (Schon and Koren, 2022). We leverage these data to code two indicators, one for state-led VAC and another one for nonstate-led VAC, and their lags. Model (17) in Table A8 then estimates our full specifications on these two variables. Despite the difference across the two datasets, the results maintain their sign, size, and significance, where *Cash crop productivity*$_{it}$ is negative and insignificant in the case of state forces, and negative and statistically significant in the nonstate VAC case, with roughly the same size as the same variable's coefficient in the main rebel VAC models. This provides a strong confirmation for the viability of our findings.

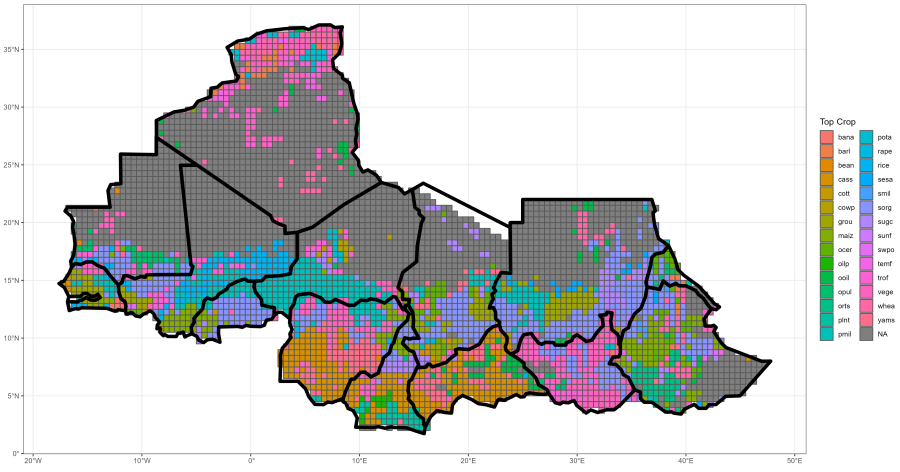
Another modeling-related concern relates to our decision to use ordinary least squares (OLS) and linear regression to model the impact of cash crop productivity on VAC. This decision was driven by recent econometric research (Angrist and Pischke, 2009; Allison, 2009), which overwhelmingly recommends that – when cross-sectional unit fixed effects are used – to rely on OLS estimation. Nevertheless, we are aware that other models are often utilized to model the event-count data such as the one used here, especially in situations where the dependent variable includes a very small ratio of events to zeros (non-events), as is the case here. Considering over-dispersion in the data, where VAC events are more likely once one has occurred, a zero-inflated negative binomial (ZINB) model, used in similar past assessments (Fjelde and Hultman, 2014; Bagozzi, Koren and Mukherjee, 2017), is useful. Accordingly, Table A10 reports a set of ZINB model corresponding to each VAC type. It was computationally impossible to run these models with grid cell fixed effects, so we replaced these with country fixed effects. For adjusting our estimates for zero-inflation, we use most of our independent variables: *Vegetation coverage*$_{it}$, *Temperature*$_{it}$, *Precipitation*$_{it}$, *Sahara transition zone*$_{it}$, *Nighttime light*$_{it}$, *Population*$_{it}$, and *GDP per capita*$_{it}$. The count stage includes all the same variables from the full OLS model specifications. Note that the use of country fixed effects allowed us to report the coefficients for *Cash crops (2005)*$_i$. Using these ZINB models we find that our results become, if anything, statistically and substantively even bigger, suggesting our results are robust to the use of grid cell fixed effects OLS models.

Finally, recall that negative coefficients between *Cash crop productivity*$_{it}$ and VAC are suspect of endogeneity. Accordingly, Table A11 estimates a set of generalized method of moments (GMM) models (Blundell and Bond, 1998) to instrument (using a system of equations) the effect of *Cash crop productivity*$_{it}$ on state VAC, which negative (even if insignificant), at time t. System GMMs use past values of the dependent and different independent variables (based on the discretion of the researcher) to create a system of equations that predict future values of these indicators, thereby exogenizing variations from these expected values. Considering our focus on the relationship between productivity and violence, we rely on past values of *State VAC*$_{it}$ and *Vegetation coverage*$_{it}$ as our instruments. To avoid potential biases that could arise from the inclusion of deep lags as instruments (Roodman, 2009), we rely on the two-to-five months lags as instruments. Additionally, considering the computational demands of estimating system GMM models in such a large sample, as well as the fact that GMM indicators are sensitive to longer lags (Roodman, 2009), we divided our sample into

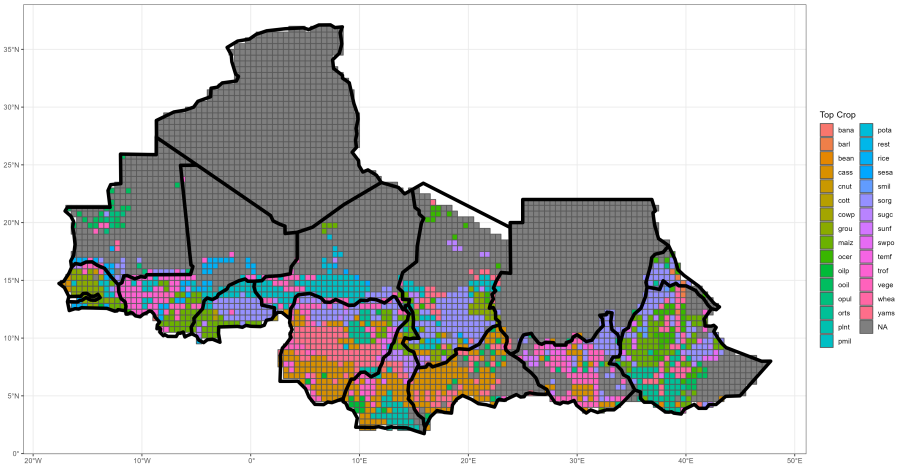
several shorter sub-samples spanning two or three years. Table A8 reports the estimate of these five GMM models. The instrumented coefficient of *Cash crop productivity*$_{it}$ maintains its negative sign in three periods (2013–2015, 2008–2009, and 2006–2007), and is significant in two case (2013–2015 and 2008–2009) to at least the $p < .1$ level; it is positive in two periods (2016–2018 and 2010–2012), and even significant in the latter (to the $p < .05$ level).



SPAM 2005

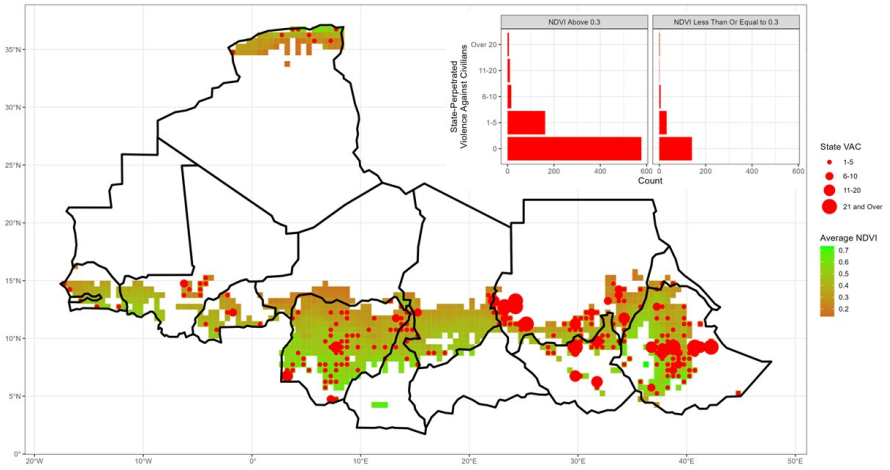


SPAM 2010

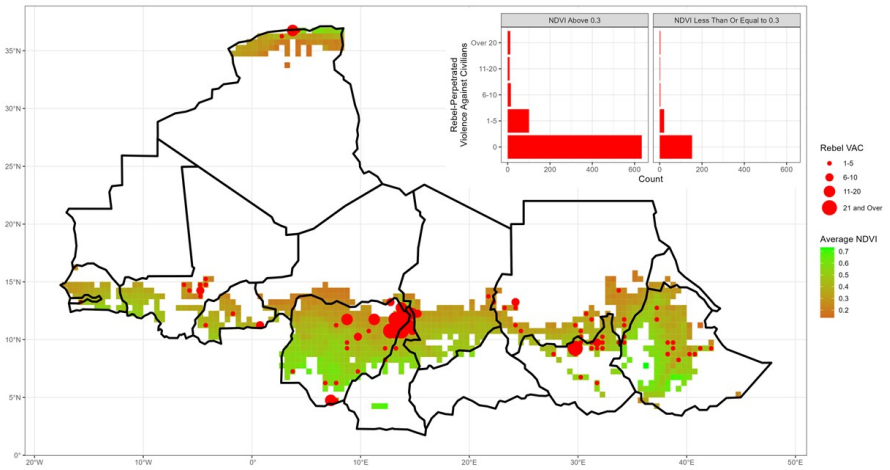


SPAM 2017

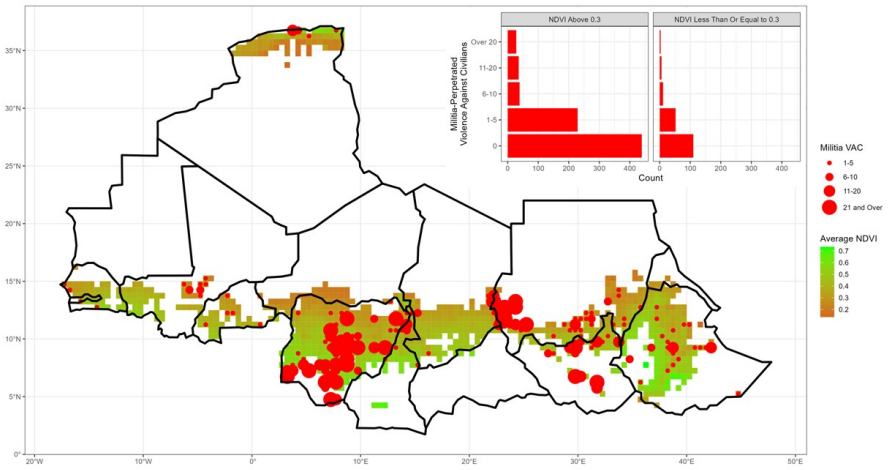
Figure A1: The Types of Crops Produced in Each Sahel Grid Cell, 2000-2017



State violence



Rebel violence



Militia violence

Figure A2: The rates of violence against civilians by state, rebel, and militia forces within agricultural areas over the 2006-2018 period

Table A1: Summary Statistics, Jan. 2006 – Dec. 2018

	Min	**Median**	**Mean**	**Max**	**Std. Dev.**
State VAC$_{it}$	0	0	0.004	25	0.096
Rebel VAC$_{it}$	0	0	0.004	9	0.091
Militia VAC$_{it}$	0	0	0.011	16	0.169
State VAC (GED$_{it}$	0	0	0.001	20	0.050
Nonstate VAC (GED)$_{it}$	0	0	0.003	11	0.078
Vegetation coverage$_{it}$	0.028	0.146	0.261	0.882	0.218
Cash crops (2005)$_i$	0	1	0.568	1	0.496
Temperature$_{it}$	1.9	27.2	26.622	38.2	5.655
Precipitation$_{it}$[1]		0.568	0.847	2.914	0.864
Sahara transition zone$_{it}$	0	0	0.153	1	0.360
Nighttime light$_{it}$[1]	1	1	1.917	5.066	1.229
Population$_{it}$[1]	0.933	4.075	3.850	7.011	1.247
GDP per capita$_{it}$[1]	1.742	1.854	1.851	1.938	0.050
Cereals (2005)$_i$	0	0	0.154	0.862	0.205
Cash crops$_{it}$	0	1	0.576	1	0.494
State armed conflict$_{it}$	0	0	0.008	25	0.155
Rebel armed conflict$_{it}$	0	0	0.004	10	0.086
Militia armed conflict$_{it}$	0	0	0.006	15	0.112
Government efficiency$_{it}$	0	1.147	1.769	10.50	2.167
Life expectancy at birth$_{it}$[1]	2.311	0.068	3.095	3.748	0.348
Country population$_{it}$[1]	6.465	7.501	7.378	8.292	0.433
State VAC (spatial)$_{it}$	0	0	0.004	1	0 0.066
Rebel VAC (spatial)$_{it}$	0	0	0.004	1	0.064
Militia VAC (spatial)$_{it}$	0	0	0.013	1	0.114
Vegetation coverage (anom.)$_{it}$	-5.886	-0.126	-4.12e-18	7.306	0.997

[1] log base 10.

Table A2: Determinants of violence against civilians in the Sahel – sensitivity analysis I

	Cereals			*High cropland*		
	State	Rebels	Militias	State	Rebels	Militias
		(4)			(5)	
Vegetation coverage$_{it}$	0.002	0.002	−0.018***	−0.006	−0.001	−0.020*
	(0.003)	(0.002)	(0.007)	(0.004)	(0.003)	(0.012)
Cash crop productivity$_{it}$	−0.003	0.007**	0.021***	0.003	0.007*	0.037***
	(0.003)	(0.003)	(0.006)	(0.004)	(0.004)	(0.010)
DV_{it-1}	1.296***	1.303***	0.239***	0.990***	1.422***	0.199***
	(0.176)	(0.189)	(0.021)	(0.226)	(0.309)	(0.025)
Temperature$_{it}$	0.0001	0.0002***	0.0002	−0.0001	0.00001	0.001***
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0003)
Precipitation$_{it}$[1]	−0.00003	0.001*	0.002***	−0.0004	0.001**	0.005***
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.001)	(0.001)
Sahara transition zone$_{it}$	0.001	0.001	0.003	0.002	0.002	0.004
	(0.001)	(0.004)	(0.002)	(0.002)	(0.009)	(0.004)
Nighttime light$_{it}$[1]	−0.0005	−0.0003	0.002	−0.002**	0.0003	−0.005***
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.001)	(0.002)
Population$_{it}$[1]	−0.0004	0.006	0.003	0.038	0.039*	0.046
	(0.006)	(0.006)	(0.024)	(0.029)	(0.022)	(0.054)
GDP per capita$_{it}$[1]	−0.367***	0.132	−0.502***	−0.231**	0.013	−0.541***
	(0.112)	(0.080)	(0.153)	(0.104)	(0.057)	(0.148)
τ	0.0002***	0.00002	0.0004***	0.0002***	0.0001*	0.0005***
	(0.00003)	(0.00003)	(0.0001)	(0.00002)	(0.00003)	(0.0001)
Observations	342,108	342,108	342,108	145,860	145,860	145,860
R^2	0.121	0.177	0.183	0.098	0.228	0.163
Adjusted R^2	0.115	0.172	0.178	0.092	0.222	0.157

Coefficients reported with standard errors clustered by grid-cell in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); grid cell and month fixed effects were included in each regression although none is reported here; [1] log base 10.

Table A3: Determinants of violence against civilians in the Sahel – sensitivity analysis II

	All 0.5∘ grid cells (6)			*TV cropland* (7)		
	State	Rebels	Militias	State	Rebels	Militias
Vegetation coverage$_{it}$	−0.0001	−0.001	−0.015***	0.002	−0.001	−0.010*
	(0.002)	(0.002)	(0.005)	(0.003)	(0.003)	(0.006)
Cash crops$_{it}$				0.001	−0.005***	−0.007***
				(0.001)	(0.001)	(0.002)
Cash crop productivity$_{it}$	−0.001	0.008**	0.018***	−0.001	0.009***	0.010**
	(0.003)	(0.003)	(0.006)	(0.003)	(0.003)	(0.005)
DV_{it-1}	1.227***	1.254***	0.236***	1.287***	1.328***	0.218***
	(0.170)	(0.184)	(0.020)	(0.194)	(0.191)	(0.022)
Temperature$_{it}$	0.00004	0.0001***	0.0001*	0.0001	0.0002***	0.0003**
	(0.00005)	(0.00004)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Precipitation$_{it}$[1]	0.00002	0.0004*	0.001***	−0.00002	0.001*	0.002***
	(0.0003)	(0.0002)	(0.0004)	(0.0005)	(0.0004)	(0.001)
Sahara transition zone$_{it}$	0.001	0.001	0.003	−0.0004	0.001	−0.0004
	(0.001)	(0.003)	(0.002)	(0.001)	(0.004)	(0.002)
Nighttime light$_{it}$[1]	0.001***	0.001**	0.005***	−0.001*	−0.001	0.0001
	(0.0003)	(0.0003)	(0.001)	(0.001)	(0.0004)	(0.001)
Population$_{it}$[1]	−0.008***	−0.003	−0.020***	−0.003	0.005	−0.025
	(0.001)	(0.002)	(0.005)	(0.006)	(0.007)	(0.022)
GDP per capita$_{it}$[1]	−0.237***	0.107**	−0.250**	−0.406***	0.096	−0.640***
	(0.075)	(0.053)	(0.103)	(0.118)	(0.086)	(0.167)
τ	0.0001***	0.00000	0.0002***	0.0002***	0.00004	0.0005***
	(0.00002)	(0.00001)	(0.00003)	(0.00004)	(0.00003)	(0.0001)
Observations	700,440	700,440	700,440	346,332	346,332	346,332
R^2	0.115	0.172	0.182	0.114	0.181	0.156
Adjusted R^2	0.109	0.166	0.177	0.107	0.174	0.149

Coefficients reported with standard errors clustered by grid-cell in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); grid cell and month fixed effects were included in each regression although none is reported here;[1] log base 10.

Table A4: Determinants of violence against civilians in the Sahel – sensitivity analysis III

	Civil war (8)			*Country SEs* (9)		
	State	Rebels	Militias	State	Rebels	Militias
Vegetation coverage$_{it}$	0.001	0.001	−0.021***	0.001	0.001	−0.020***
	(0.003)	(0.003)	(0.007)	(0.004)	(0.003)	(0.006)
Cash crop productivity$_{it}$	−0.001	0.007**	0.024***	−0.001	0.007**	0.023*
	(0.003)	(0.003)	(0.007)	(0.004)	(0.003)	(0.012)
DV_{it-1}	1.159***	1.207***	0.218***	1.296***	1.303***	0.239***
	(0.146)	(0.170)	(0.019)	(0.220)	(0.154)	(0.043)
Temperature$_{it}$	0.0001	0.0002***	0.0002	0.00005	0.0002**	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0004)
Precipitation$_{it}$[1]	0.0003	0.001**	0.003***	−0.00005	0.001**	0.002
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.0004)	(0.002)
Sahara transition zone$_{it}$	0.002	0.001	0.004	0.001	0.001	0.003
	(0.001)	(0.004)	(0.002)	(0.001)	(0.002)	(0.003)
Nighttime light$_{it}$[1]	−0.001**	−0.001	0.001	−0.0005	−0.0003	0.002
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.001)	(0.002)
Population$_{it}$[1]	−0.003	0.004	0.004	−0.0004	0.006	0.003
	(0.006)	(0.006)	(0.022)	(0.007)	(0.007)	(0.022)
GDP per capita$_{it}$[1]	−0.231***	0.212***	−0.392***	−0.367***	0.132**	−0.502**
	(0.071)	(0.081)	(0.125)	(0.088)	(0.067)	(0.209)
State armed conflict$_{it}$	0.133***	0.057***	0.078***			
	(0.039)	(0.010)	(0.012)			
Rebel armed conflict$_{it}$	0.070***	0.105***	0.040**			
	(0.023)	(0.017)	(0.017)			
Militia armed conflict$_{it}$	0.021***	0.014***	0.251***			
	(0.006)	(0.005)	(0.037)			
τ	0.0001***	−0.00001	0.0003***	0.0002***	0.00002	0.0004***
	(0.00002)	(0.00003)	(0.00005)	(0.00005)	(0.00003)	(0.0001)
Observations	342,108	342,108	342,108	342,108	342,108	342,108
R^2	0.165	0.195	0.214	0.121	0.177	0.183
Adjusted R^2	0.160	0.190	0.209	0.115	0.172	0.178

Coefficients reported with standard errors clustered by grid-cell in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); grid cell and month fixed effects were included in each regression although none is reported here; [1] log base 10.

Table A5: Determinants of violence against civilians in the Sahel – sensitivity analysis IV

	No Alg. & Mau. (10)			*YFEs* (11)		
	State	Rebels	Militias	State	Rebels	Militias
Vegetation coverage$_{it}$	0.002	0.002	−0.022***	0.001	0.001	−0.022***
	(0.004)	(0.003)	(0.008)	(0.003)	(0.003)	(0.007)
Cash crop productivity$_{it}$	−0.001	0.007**	0.023***	−0.001	0.007**	0.023***
	(0.003)	(0.003)	(0.007)	(0.003)	(0.003)	(0.007)
DV_{it-1}	1.304***	1.329***	0.239***	1.295***	1.302***	0.238***
	(0.177)	(0.189)	(0.021)	(0.176)	(0.189)	(0.020)
Temperature$_{it}$	0.0001	0.0003***	0.0001	0.00005	0.0002***	0.0002
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Precipitation$_{it}$[1]	−0.0002	0.001	0.002**	−0.0001	0.001*	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0004)	(0.001)
Sahara transition zone$_{it}$	0.001	0.001	0.002	0.001	0.0004	0.004
	(0.001)	(0.004)	(0.002)	(0.001)	(0.004)	(0.002)
Nighttime light$_{it}$[1]	−0.001**	−0.001	−0.0001	−0.001**	−0.0005	−0.0005
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.0004)	(0.001)
Population$_{it}$[1]	−0.011	0.001	−0.023	0.001	0.006	0.005
	(0.008)	(0.008)	(0.030)	(0.006)	(0.006)	(0.024)
GDP per capita$_{it}$[1]	−0.442***	0.098	−0.688***	−0.356***	0.143*	−0.462***
	(0.122)	(0.088)	(0.168)	(0.114)	(0.079)	(0.155)
τ	0.0002***	0.00005	0.001***			
	(0.00004)	(0.00004)	(0.0001)			
Observations	302,172	302,172	302,172	342,108	342,108	342,108
R^2	0.122	0.180	0.184	0.121	0.177	0.184
Adjusted R^2	0.116	0.175	0.179	0.115	0.172	0.179

Coefficients reported with standard errors clustered by grid-cell in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); grid cell and month fixed effects were included in each regression although none is reported here; [1] log base 10.

Table A6: Determinants of violence against civilians in the Sahel – sensitivity analysis V

	Country factors (12)			*Country × YFEs* (13)		
	State	Rebels	Militias	State	Rebels	Militias
Vegetation coverage$_{it}$	0.001	0.003	−0.019***	−0.001	0.0004	−0.024***
	(0.002)	(0.003)	(0.007)	(0.003)	(0.003)	(0.007)
Cash crop productivity$_{it}$	−0.0005	0.007**	0.023***	−0.001	0.007**	0.024***
	(0.003)	(0.003)	(0.007)	(0.003)	(0.003)	(0.007)
DV_{it-1}	1.231***	1.302***	0.242***	1.273***	1.283***	0.230***
	(0.185)	(0.196)	(0.022)	(0.175)	(0.187)	(0.020)
Temperature$_{it}$	0.0001	0.0002***	0.0002	0.00002	0.0002***	0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Precipitation$_{it}$[1]	0.00002	0.001*	0.002**	−0.0002	0.001*	0.002**
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.0004)	(0.001)
Sahara transition zone$_{it}$	0.001	0.001	0.002	0.001	0.001	0.004
	(0.001)	(0.004)	(0.002)	(0.001)	(0.004)	(0.003)
Nighttime light$_{it}$[1]	−0.0001	0.0002	0.001	−0.003***	−0.001	−0.006***
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.001)	(0.002)
Population$_{it}$[1]	−0.0004	0.006	0.002	0.003	0.004	0.006
	(0.007)	(0.006)	(0.024)	(0.008)	(0.007)	(0.028)
GDP per capita$_{it}$[1]	−0.348***	−0.041	0.482**			
	(0.057)	(0.049)	(0.238)			
Government efficiency$_{it}$	−0.001	−0.001**	−0.005***			
	(0.001)	(0.0003)	(0.001)			
Life expectancy at birth$_{it}$[1]	0.014**	0.008**	−0.047***			
	(0.006)	(0.004)	(0.008)			
Country population$_{it}$[1]	−0.007	0.024**	−0.082***			
	(0.016)	(0.010)	(0.027)			
τ	0.0002***	0.00003*	0.0002***			
	(0.00002)	(0.00002)	(0.00005)			
Observations	334,452	334,452	334,452	342,108	342,108	342,108
R^2	0.110	0.182	0.184	0.124	0.180	0.189
Adjusted R^2	0.104	0.176	0.178	0.117	0.174	0.183

Coefficients reported with standard errors clustered by grid-cell in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); grid cell and month fixed effects were included in each regression although none is reported here; [1] log base 10.

Table A7: Determinants of violence against civilians in the Sahel – sensitivity analysis VI

	Spatial Lag (14)			*3rd Time Lag* (15)		
	State	Rebels	Militias	State	Rebels	Militias
Vegetation coverage$_{it}$	0.00000	0.001	−0.020***	0.001	0.001	−0.022***
	(0.003)	(0.003)	(0.007)	(0.004)	(0.003)	(0.008)
Cash crop productivity$_{it}$	−0.001	0.007**	0.021***	−0.003	0.006*	0.024***
	(0.003)	(0.003)	(0.007)	(0.004)	(0.003)	(0.007)
DV_{it-1}	1.145***	1.067***	0.191***	1.071***	1.008***	0.185***
	(0.205)	(0.213)	(0.025)	(0.135)	(0.131)	(0.015)
Temperature$_{it}$	0.00001	0.0002***	0.0001	0.00003	0.0002***	0.0003**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Precipitation$_{it}$[1]	0.00002	0.001*	0.002**	−0.0002	0.001*	0.002**
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.0004)	(0.001)
Sahara transition zone$_{it}$	0.001	0.001	0.003	0.001	0.001	0.003
	(0.001)	(0.004)	(0.002)	(0.001)	(0.004)	(0.002)
Nighttime light$_{it}$[1]	−0.0004	−0.0004	0.002	−0.0004	−0.0004	0.001
	(0.001)	(0.0004)	(0.001)	(0.0004)	(0.0003)	(0.001)
Population$_{it}$[1]	−0.00002	0.001**	0.002**	−0.0001	0.001*	0.002***
	(0.001)	(0.0004)	(0.001)	(0.001)	(0.0005)	(0.001)
GDP per capita$_{it}$[1]	−0.356***	0.124	−0.436***	−0.295***	0.091	−0.382***
	(0.111)	(0.078)	(0.144)	(0.091)	(0.061)	(0.117)
DV (spatial)$_{it}$	0.068*** 0.108***	0.146***				
	(0.025)	(0.024)	(0.023)			
DV_{it-2}				0.101***	0.144***	0.127***
				(0.020)	(0.027)	(0.013)
DV_{it-3}				0.097***	0.110***	0.119***
				(0.018)	(0.022)	(0.015)
τ	0.0002***	0.00002	0.0003***	0.0001***	0.00002	0.0003***
	(0.00003)	(0.00003)	(0.0001)	(0.00003)	(0.00002)	(0.00004)
Observations	339,937	339,944	339,983	342,108	342,108	342,108
R^2	0.124	0.181	0.190	0.142	0.209	0.213
Adjusted R^2	0.118	0.176	0.184	0.136	0.204	0.208

Coefficients reported with standard errors clustered by grid-cell in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); grid cell and month fixed effects were included in each regression although none is reported here; [1] log base 10.

Table A8: Determinants of violence against civilians in the Sahel – sensitivity analysis VII

	NDVI Anomaly (16)			*Log DVs* (17)		
	State	Rebels	Militias	State	Rebels	Militias
Vegetation coverage (anom.)$_{it}$	0.001	0.00000	−0.001*			
	(0.0003)	(0.0002)	(0.001)			
Vegetation coverage$_{it}$				−0.0003	0.0004	−0.009***
				(0.002)	(0.001)	(0.003)
Cash crop productivity (anom.)$_{it}$	−0.0003	0.001*	0.002***			
	(0.0004)	(0.0004)	(0.001)			
Cash crop productivity$_{it}$				−0.0001	0.003**	0.011***
				(0.002)	(0.002)	(0.003)
DV_{it-1}	1.296***	1.303***	0.239***	0.653***	0.726***	0.236***
	(0.176)	(0.189)	(0.021)	(0.074)	(0.091)	(0.017)
Temperature$_{it}$	0.0001	0.0002***	0.0003**	0.00001	0.0001***	0.0001*
	(0.0001)	(0.0001)	(0.0001)	(0.00004)	(0.00003)	(0.0001)
Precipitation$_{it}$[1]	−0.0001	0.001**	0.002**	−0.00002	0.0005**	0.001***
	(0.001)	(0.0004)	(0.001)	(0.0002)	(0.0002)	(0.0004)
Sahara transition zone$_{it}$	0.001	0.001	0.003	0.0002	−0.0005	0.001
	(0.001)	(0.004)	(0.002)	(0.001)	(0.001)	(0.001)
Nighttime light$_{it}$[1]	−0.001	−0.0003	0.002	−0.0003	0.0001	0.001**
	(0.001)	(0.0004)	(0.001)	(0.0002)	(0.0002)	(0.0005)
Population$_{it}$[1]	−0.0004	0.006	0.003	−0.001	0.002	0.001
	(0.006)	(0.006)	(0.024)	(0.004)	(0.003)	(0.012)
GDP per capita$_{it}$[1]	−0.368***	0.132	−0.500***	−0.190***	0.063	−0.299***
	(0.112)	(0.080)	(0.153)	(0.049)	(0.038)	(0.079)
τ	0.0002***	0.00002	0.0004***	0.0001***	0.00002	0.0002***
	(0.00003)	(0.00003)	(0.0001)	(0.00002)	(0.00001)	(0.00003)
Observations	342,108	342,108	342,108	342,108	342,108	342,108
R^2	0.121	0.177	0.183	0.127	0.173	0.202
Adjusted R^2	0.115	0.172	0.178	0.121	0.168	0.197

Coefficients reported with standard errors clustered by grid-cell in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); grid cell and month fixed effects were included in each regression although none is reported here; [1] log base 10.

Table A9: Determinants of violence against civilians in the Sahel – sensitivity analysis VIII

	Binary DVs			*GED*	
	State	Rebels	Militias	State	Nonstate
	(18)			(19)	
Vegetation coverage$_{it}$	−0.001	0.001	−0.008**	0.002	−0.002
	(0.002)	(0.002)	(0.004)	(0.002)	(0.003)
Cash crop productivity$_{it}$	0.001	0.003	0.010***	−0.001	0.007**
	(0.002)	(0.002)	(0.003)	(0.001)	(0.003)
DV_{it-1}	0.149***	0.190***	0.172***	0.143***	0.304***
	(0.017)	(0.022)	(0.012)	(0.049)	(0.051)
Temperature$_{it}$	0.00000	0.0001***	0.0002**	0.00002	0.0002***
	(0.00004)	(0.00004)	(0.0001)	(0.00005)	(0.0001)
Precipitation$_{it}$[1]	0.00003	0.001**	0.001***	0.0003	0.0005
	(0.0003)	(0.0002)	(0.0004)	(0.0002)	(0.0004)
Sahara transition zone$_{it}$	−0.0001	−0.001	0.001	0.002***	−0.0003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Nighttime light$_{it}$[1]	−0.0004	0.0004	0.001**	−0.00001	0.001
	(0.0003)	(0.0003)	(0.0005)	(0.0003)	(0.001)
Population$_{it}$[1]	−0.002	0.002	−0.001	0.006	−0.002
	(0.004)	(0.004)	(0.013)	(0.006)	(0.003)
GDP per capita$_{it}$[1]	−0.220***	0.063*	−0.372***	−0.096***	0.181***
	(0.053)	(0.038)	(0.087)	(0.032)	(0.030)
τ	0.0001***	0.00002	0.0002***	0.00003**	−0.00000
	(0.00002)	(0.00001)	(0.00003)	(0.00001)	(0.00001)
Observations	342,108	342,108	342,108	342,108	342,108
R^2	0.093	0.129	0.164	0.048	0.229
Adjusted R^2	0.087	0.124	0.159	0.042	0.224

Coefficients reported with standard errors clustered by grid-cell in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); grid cell and month fixed effects were included in each regression although none is reported here; [1] log base 10.

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Table A10: Determinants of violence against civilians in the Sahel – sensitivity analysis IX

		ZINB (20)	
	State	Rebels	Militias
Count stage			
Cash crops (2005)$_i$	-0.381^{**}	0.031	-0.966^{***}
	(0.171)	(0.143)	(0.096)
Vegetation coverage$_{it}$	-1.559^{***}	-1.284^{***}	-1.390^{***}
	(0.402)	(0.470)	(0.229)
Cash crop productivity$_{it}$	0.325	0.840^{***}	1.185^{***}
	(0.298)	(0.288)	(0.184)
DV_{it-1}	2.645^{***}	3.636^{***}	0.215^{***}
	(0.102)	(0.133)	(0.006)
Temperature$_{it}$	-0.103^{***}	-0.009	-0.033^{***}
	(0.014)	(0.018)	(0.009)
Precipitation$_{it}$[1]	0.106	-0.067	0.169^{***}
	(0.076)	(0.079)	(0.045)
Sahara transition zone$_{it}$	0.062	0.074	0.622^{***}
	(0.141)	(0.111)	(0.114)
Nighttime light$_{it}$[1]	-0.669^{***}	-0.411^{***}	-0.021
	(0.056)	(0.046)	(0.030)
Population$_{it}$[1]	1.188^{***}	-0.117	0.694^{***}
	(0.120)	(0.097)	(0.053)
GDP per capita$_{it}$[1]	-13.751^{*}	41.758^{***}	10.810^{**}
	(8.098)	(8.399)	(4.996)
τ	0.012^{***}	-0.001	0.006^{***}
	(0.002)	(0.002)	(0.001)
Constant	18.695	-75.269^{***}	-25.402^{***}
	(14.269)	(14.693)	(8.783)
Inflation stage			
Vegetation coverage$_{it}$	-0.525	-1.530^{***}	-0.362
	(0.397)	(0.453)	(0.251)
Temperature$_{it}$	-0.043^{***}	-0.036^{**}	0.068^{***}
	(0.014)	(0.017)	(0.011)
Precipitation$_{it}$[1]	0.037	0.188^{**}	-0.117^{***}
	(0.077)	(0.077)	(0.045)
Sahara transition zone$_{it}$	-0.397^{***}	-0.051	0.052
	(0.149)	(0.126)	(0.115)
Nighttime light$_{it}$[1]	-1.117^{***}	-0.556^{***}	-0.418^{***}
	(0.059)	(0.045)	(0.031)
Population$_{it}$[1]	-0.469^{***}	-0.729^{***}	-0.642^{***}
	(0.130)	(0.094)	(0.048)
GDP per capita$_{it}$[1]	-9.476^{***}	13.893^{***}	-7.387^{***}
	(2.434)	(1.670)	(1.366)
Constant	28.000^{***}	-15.168^{***}	18.784^{***}
	(4.591)	(3.039)	(2.491)
Observations	342,108	342,108	342,108
Log Likelihood	$-9{,}323.415$	$-10{,}372.700$	$-25{,}830.620$

Coefficients reported with standard errors clustered by grid-cell in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); country and month fixed effects were included in the count stage of each regression although none is reported here; [1] log base 10.

Table A11: Determinants of violence against civilians in the Sahel – system GMM models

	2016–2018	2013–2015	2010–2012	2008–2009	2006–2007
	(21a)	(21b)	(21c)	(21d)	(21e)
Vegetation coverage$_{it}$	0.020***	0.015***	0.002*	0.001	0.0002
	(0.004)	(0.003)	(0.001)	(0.001)	(0.001)
Cash crop productivity$_{it}$	−0.007**	−0.012***	−0.001	−0.001*	−0.0005
	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)
DV_{it-1}	0.319***	0.327***	0.169***	0.062	0.106**
	(0.039)	(0.050)	(0.048)	(0.041)	(0.049)
Temperature$_{it}$	0.0001	0.0001***	0.0001**	0.0001***	−0.00004***
	(0.0001)	(0.0001)	(0.00002)	(0.00002)	(0.00002)
Precipitation$_{it}$[1]	−0.001***	−0.001***	−0.00002	0.0002	−0.0002
	(0.0004)	(0.0004)	(0.0002)	(0.0002)	(0.0002)
Sahara transition zone$_{it}$	0.001	0.002***	0.0001	−0.00002	0.0002
	(0.001)	(0.001)	(0.0003)	(0.0002)	(0.0002)
Nighttime light$_{it}$[1]	−0.001**	0.001***	0.001***	0.0004***	0.0002*
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Population$_{it}$[1]	0.003***	0.001***	0.0001	0.0002***	0.0002**
	(0.0003)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
GDP per capita$_{it}$[1]	0.049***	0.035***	0.002	0.001	−0.006***
	(0.009)	(0.006)	(0.002)	(0.002)	(0.002)
Observations	161,784	161,784	161,784	107,856	107,856
0.5*circ* grid cells	4,494	4,494	4,494	4,494	4,494
Sargan test	1357.965***	1375.832***	2075.274***	1860.645***	2055.609***
AR(1)	-9.2133***	-7.027***	-5.555***	-5.288***	-4.118***
Wald test (coefficients)	170.674*** (df=10)	82.017*** (df=10)	69.805*** (df=10)	52.023*** (df=10)	21.817*** (df=9)

Coefficients reported with standard errors in parentheses; *p<0.1; **p<0.05; ***p<0.01 (two-tailed); the instruments used in system GMM estimators were two-to-five month lags of *State VAC*$_{it}$ and *Vegetation coverage*$_{it}$; [1] log base 10.