

# Adverse rainfall shocks and civil war

## Myth or reality?

Ricardo Maertens

Universitat Pompeu Fabra

ABCDE

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A **civil war** is (Gleditsch et al., 2002):

- Armed conflict that involves the government of the state
- Causes at least 1000 battle-related deaths per year

- Widespread belief that adverse rainfall shocks fuel civil war  
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- Empirical research on this link is inconclusive (Miguel et al., 2004; Burke et al., 2009; Ciccone, 2011; Couttenier and Soubeyran, 2014)
  - There is a significant effect of adverse rainfall shocks on inter-group violence risk at the local level (Croft et al., 2015; Harari and La Ferrara, 2013)

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- Civil wars are enormously costly in terms of human lives, suffering, and resources
- Climate change will increase the incidence of extreme rainfall events world-wide (IPCC, 2014); predicted reductions in agricultural yields by the mid-century range between 8% and 22% in SSA (Schlenker and Lobell, 2010)

Rainfall shock → Agricultural production → Civil war?

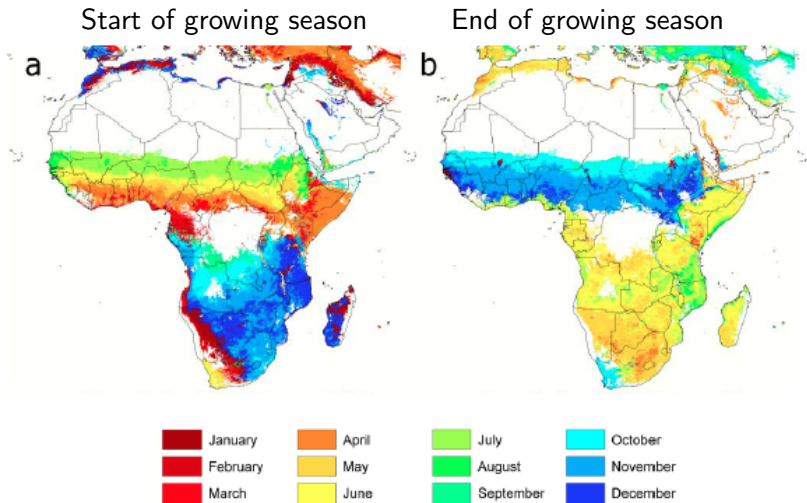
I revisit the empirical relationship between rainfall and civil war in (Sub-Saharan) African countries considering that (Guiteras, 2009; Lobell et al., 2011; Schlenker and Roberts, 2009, 2010; Schlenker and Lobell, 2010):

- Rainfall during the growing season and over agricultural areas are among the main determinants of crop growth
- The total amount of rainfall during the growing season and agricultural yields have an hump shaped relationship

[1] Agricultural rainfall  $\rightarrow$  [2] Agricultural production  
[3] Agricultural rainfall  $\rightarrow$  Civil war



Figure: Growing seasons



# Rainfall and agricultural output

$$y_{c,t} = \beta_1 \text{rain}_{c,t} + \beta_2 \text{rain}_{c,t}^2 + \gamma \text{temp}_{c,t} + \delta_c + \delta_t + t_c + \epsilon_{c,t}, \quad (1)$$

- $y$ : crops gross production index
- $\text{rain}$ : agricultural rainfall (in dm)
- $\text{temp}$ : mean temperature or a full set of temperature bins (in °C)
- $\delta_c$ : country fixed-effect
- $\delta_t$ : year fixed-effects
- $t_c$ : country-specific linear trend

# Rainfall and agricultural output

Table: Agricultural production and agricultural rainfall in Africa 1981-2013

	(1)	(2)	(3)	(4)
rain	0.883 (0.603)	5.380*** (1.217)	0.796 (0.583)	5.128*** (1.173)
rain <sup>2</sup>		-0.214*** (0.047)		-0.203*** (0.046)
Observations	1,650	1,650	1,650	1,650
Obs. decr. (%)	n.a.	19.27	n.a.	19.21
Adjusted R <sup>2</sup>	0.822	0.828	0.826	0.831
Mean temp.	Y	Y	N	N
Temp. bins	N	N	Y	Y

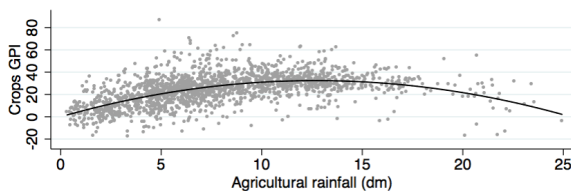
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Note: The graph shows augmented component-plus-residual plots of the relationships between agricultural output and agricultural rainfall.

$$war_{c,t} = \beta_1 rain_{c,t} + \beta_2 rain_{c,t}^2 + \gamma temp_{c,t} + \delta_c + \delta_t + t_c + \epsilon_{c,t}, \quad (2)$$

- *war*: civil war onset (not defined if civil war onset is ongoing in  $t - 1$ )
- *rain*: agricultural rainfall (in dm)
- *temp*: mean temperature or a full set of temperature bins (in °C)
- $\delta_c$ : country fixed-effect
- $\delta_t$ : year fixed-effects
- $t_c$ : country-specific linear trend

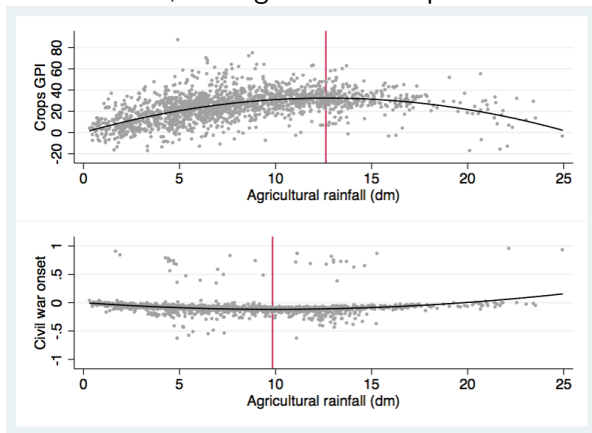
**Table:** The effect of agricultural rainfall on civil war onset risk

	Africa 1981-2013			SSA 1981-1999			SSA 1981-2013		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
rain	-0.024** (0.011)	0.002 (0.004)		-0.044** (0.022)	0.003 (0.007)		-0.030** (0.013)	0.002 (0.005)	
rain <sup>2</sup>	0.001** (0.001)			0.002** (0.001)			0.001** (0.001)		
rain growth			0.011 (0.008)			0.005 (0.017)			0.014 (0.011)
Observations	1,538	1,538	1,536	662	662	662	1,228	1,228	1,227
Temp. bins	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Estimation method is OLS. All regressions include country fixed-effects, year fixed-effects, and country-specific time trends. Robust standard errors are clustered at the country level and are presented in brackets. Agricultural variables summarize information during the growing seasons and over agricultural land. Significance: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

# Rainfall, civil war, and agricultural output

## Rainfall, civil war onset, and agricultural output in Africa 1981-2013



Note: The graph shows augmented component-plus-residual plots of the relationships between agricultural output and agricultural rainfall (top panel) and civil war onset and agricultural rainfall (bottom panel). The underlying regressions corresponds to equations 1 (top panel) and 2 (bottom panel) where *temp* is the full set of temperature bins.

# Magnitude of the effect of rainfall on civil war

**Table:** The effects of a 1 s.d. decrease and increase in agricultural rainfall on civil war onset risk (%) evaluated at different percentiles of the distribution of agricultural rainfall

	10 <sup>th</sup>	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	90 <sup>th</sup>
<u>Africa 1981-2013 (2.2%)</u>					
- 1 s.d.	2.2 [98.1]	1.6 [70.5]	0.9 [39.1]	-0.1 [6.5]	-0.9 [40.8]
+ 1 s.d.	-1.8 [83.3]	-1.2 [55.7]	-0.5 [24.3]	0.5 [21.1]	1.2 [55.6]
<u>SSA 1981-2013 (2.6%)</u>					
- 1 s.d.	2.9 [94.8]	2.2 [71.7]	1.0 [34.3]	- 0.5 [16.0]	-1.6 [52.5]
+ 1 s.d.	-2.4 [78.4]	-1.7 [55.3]	-0.5 [18.0]	1.0 [32.3]	2.1 [68.9]

Notes: Baseline probabilities of civil war onset in brackets. The effects of +/- 1.s.d. of agricultural rainfall on civil war risk as a share of the baseline probability in square brackets.



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- These results reconcile the robust relationship between rainfall and inter-group violence in Africa at the local level (Harari and La Ferrara, 2013) with the inconclusive evidence linking rainfall to civil war at the country level
- These results inform the debate on the effects of adverse rainfall shocks and climate change