Freshwater Availability and the Occurrence of Civil Conflict in Africa

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Motivation

➢Climate change, together with population growth, and economic development promise a future burdened with water stress.

➢This study investigates the relationship between renewable freshwater resources in the form of runoff and occurrences of civil conflict in Africa.

Hypotheses

➢Below average runoff is correlated with increased events of conflict.

➢High inter-annual variability of runoff is correlated with increased events of conflict.

➢High spatial variability of runoff within a basin is correlated with increased events of conflict.

Methodology

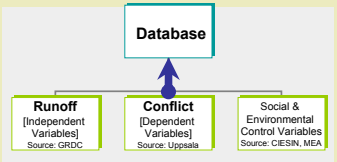


Fig. 1. Database construction.

➢This study merges biogeophysical and social science data sets to investigate the relationship between freshwater availability and outbreaks of civil conflict on the African continent with the basin as the level of observation.

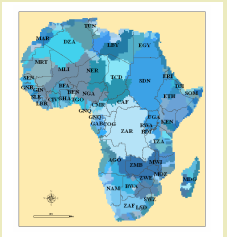


Fig. 2.

Ninety-nine major African basins and the countries that contain them.

Source: GRDC

National Boundaries

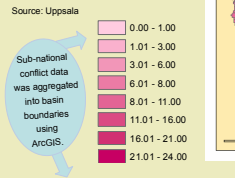
Basin Boundaries

Methodology (cont.)

Fig. 3.

Total number of low level conflicts events,1976-2001.

Source: Uppsala



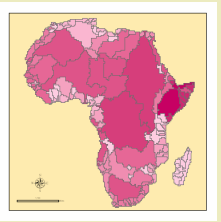


Fig. 4.

Total number of high level conflict events,1976-2001.

Source: Uppsala

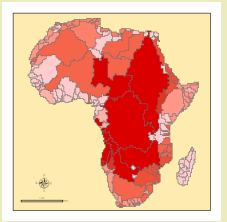
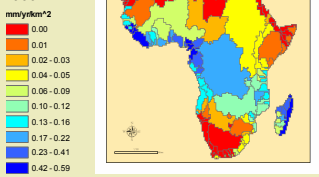


Fig. 5.

Mean runoff per basin area 1975-2000.

Source: GRDC



➢We performed linear regressions with conflict as the dependent variable. These models integrated data for hydrology, land area, forest and mountain cover, population, growth rate, and poverty levels.

	Variable	Description	Regression Model #						
			0	1	2	3	4	5	6	7*
Conflict	Low Level Conflict	Events with .25 to 1000 battle deaths								
	High Level Conflict	Events with > 1000 battle deaths								
Hydrology	Runoff	Mean runoff per basin area		x	x	x	x	x	x	x
	Temporal Variance	Standard deviation of yearly runoff normalized by mean		x	x	x	x	x	x	x
	Spatial Variance	Mean of standard deviation of grid runoff weighted by area		x	x	x	x	x	x	x
Controls	Area	Land area within each basin	x	x	x	x	x	x	x	x
	Poverty	Infant mortality rate weighted by population, deaths/live births			x	x	x		x	x
	Population density	1990 population per basin area				x			x	x
	Population Growth Rate	LN((2000 population/ 1990 population) /10 yrs)*100					x			
	Forest	Forested land area per basin area						x	x	x
	Mountain	Mountainous land area per basin area						x	x	x

* This method uses stepwise with backwards removal while others use enter.

Table 1. Regression model variable descriptions.

Results

➢Tables 2 & 3 display our results for the linear regressions. Models 0-7 were implemented to explore the impact of the socio-environmental variables on conflict.

Low Level Conflict								
Model Number	0	1	2	3	4	5	6	7
Area	0.000***	0.000***	0.000**	0.000***	0.000***	0.000*	0.000***	0.000***
Runoff		-2.856	-4.836	-4.748	-5.262	-0.760	-3.014	
Temporal Variance		0.435	1.075**	1.301**	1.121***	0.506	0.649	
Spatial Variance		0.606***	0.809***	0.906***	0.821***	0.473**	0.699***	0.603***
Poverty			0.068***	0.072***	0.080***		0.076***	0.070***
Population				0.450			0.277	
Growth Rate					-0.731			
Forest						1.189	-0.879*	-1.242***
Mountain						-2.442	0.591	0.698*
Constant	5.270***	3.778***	-2.676	-4.786*	-2.706	-26.734	-4.709	-3.465*
Adjusted R square	0.142	0.260	0.386	0.386	0.410	0.274	0.406	0.414

Significant at *p<.1, **p<.05, and ***p<.01.

Table 2. Linear regression models of low level conflict events.

High Level Conflict								
Model Number	0	1	2	3	4	5	6	7
Area	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Runoff		-14.396**	-16.427***	-16.408***	-16.204**	-12.499**	-17.557***	-18.387***
Temporal Variance		-0.042	0.614	0.663	0.590	-0.025	1.106	
Spatial Variance		-0.155	0.054	0.075	0.048	-0.230	0.322	
Poverty			0.070**	0.071**	0.064***		0.074***	0.073***
Population				0.098			-0.414	
Growth Rate					0.382			
Forest						0.824	1.040	
Mountain						-2.610	1.578***	1.465***
Constant	5.057***	-1.221***	0.804	0.346	0.820	-14.108	5.957	4.077**
Adjusted R square	0.249	0.282	0.353	0.345	0.349	0.277	0.405	0.406

Significant at *p<.1, **p<.05, and ***p<.01.

Table 3. Linear regression models of high level conflict events.

➢Model 7 removes all variables except those that remain statistically significant.

➢ For low intensity conflict, spatial variance of runoff remains significant with a positive correlation.

➢For high intensity conflict, runoff levels remain significant with a negative correlation.

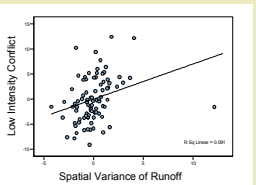
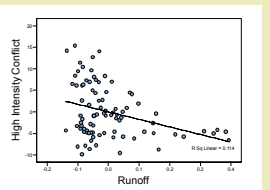


Fig. 6.

Partial regression plot of low intensity conflict versus spatial variance of runoff, model 6.

Fig. 7.

Partial regression plot of high intensity conflict versus runoff level model 6.



Results (cont.)

➢Model 6 accounts for 41% of the variance for low intensity conflict. Spatial variance of runoff has a coefficient of .699 with a significance of p<.01.

➢Model 6 accounts for 41% of the variance for high intensity conflict. Mean runoff has a coefficient of -18.387 with a significance of p<.01.

Discussion

➢The hypothesis that greater temporal variance correlated with increased events of conflict was not supported by the evidence.

➢ Low intensity conflict may have been positively correlated with spatial variance because unequal natural resource distribution usually equates with unequal wealth distribution, fostering grievances within the population.

➢High intensity conflict could have negatively correlated with average runoff levels because water scarcity may increase the likelihood of violence by reducing the potential for agricultural production and increasing the relative rates of return for rebellion.

Acknowledgements

Thanks to Marc Levy, Malanding Jaiteh, and Christian Webersik for assistance in the preparation of data and for suggestions throughout the project.

References

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➢Global Runoff Data Centre. www.grdc.sr.unh.edu

➢Levy, M. A., C. Thorkelson, et al. (2005). Freshwater Availability Anomalies and Outbreak of Internal War: Results from a Global Spatial Time Series Analysis. Human Security and Climate Change, Asker.

➢Millennium Ecosystem Assessment. www.maweb.org

➢RLG cultural materials: Research Libraries Group. http://culturalmaterials.rlg.org

➢*Uppsala Conflict Database*. www.pcr.uu.se/database

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