Online appendix

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Africa grid and GRUMP urbanization data

Figure A 1: Africa Grid with GRUMP data

Figure A 1 presents three renderings of Africa. The first, on the left, shows our Africa grid, built at a resolution of 0.46 x 0.46 degrees per grid cell, on which all our analyses are based. The middle image renders the GRUMP urbanisation data at their native resolution. The third image on the right show the GRUMP data reduced to the resolution of our grid. As can be seen, urban areas are lost due to interpolation. This is most easily evident along the Nile Valley. As such, the urban areas were expanded before the resolution was reduced, as is described in the paper. By subtracting the expanded areas from the expanded areas, we were able to create our peri-urban areas.

Areas of unrest

Figure A 2 presents zones of unrest in Africa. Blue indicates states in which the cell with the most unrest was peri-urban; red: cell with the most unrest was urban core; yellow: both urban and peri-urban cells with the most unrest.

In the majority (41 out of 50) of states we analyse, most unrest occurred in peri-urban cells. The only cases where this is not true are Egypt, Ivory Coast, Libya, Mauritius, Morocco, South Africa and Zimbabwe (where the cells with most unrest were core urban cells) and Equatorial Guinea and Mozambique (where the cells with the most unrest were tied between urban and peri-urban).

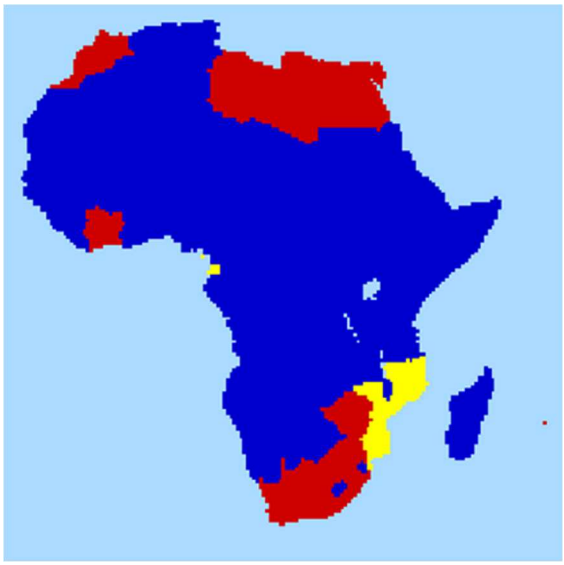
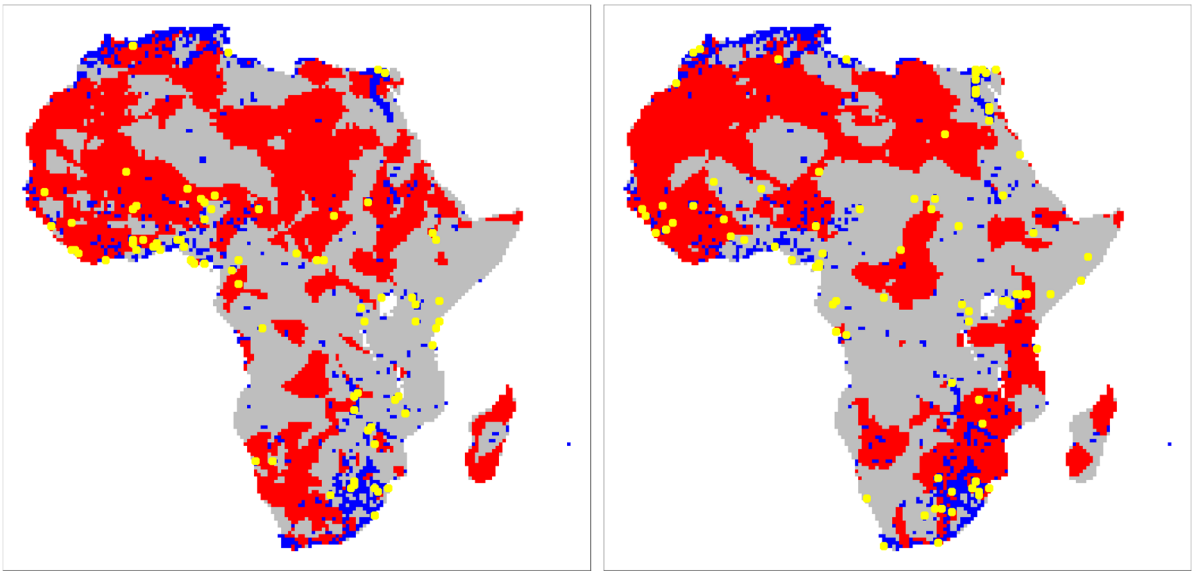


Figure A 2: African unrest cells

Descriptive evidence

Figure A 3 is a plot of the data at the grid level for the years 1998 and 2008, which were years where drought events were particularly extensive geographically. The red areas represent the areas that have experienced droughts, the blue areas indicate urban core and peri-urban areas, and the yellow dots represent unrest events based on the SCAD data (area of yellow dots has been expanded to highlight details).



1998 2008

Figure A 3: Urban areas, urban unrest, and droughts in 1998 and 2008

The two maps suggest that there is temporal and spatial variation in the locations that have experienced droughts, but also there is variation in the location and timing of unrest. Theoretically, we expect to see more unrest in densely populated areas urban core areas rather than in peri-urban areas that generally have lower overall population densities. Indeed, as was shown earlier in Table 1 in the main manuscript, in *relative* terms, there is a greater likelihood of unrest in urban core areas than in peri-urban or rural areas.

To get a sense if grids that have experienced population growth in the time period that we are examining tend to also experience riots, we look at the top five grid cells that had the largest population change from 1997 to 2010. All top five grids include major cities and have high level of SCAD incidents: Alexandria, Egypt (18 SCAD incidents); Libreville, Gabon (23 SCAD incidents); Accra, Ghana (20 SCAD incidents); Ibadan, Nigeria (Nigeria's third largest city: 16 SCAD incidents); and Bulawayo, Zimbabwe (41 SCAD incidents). Harare (Zimbabwe) has experienced the most cases of SCAD incidents with riots often erupting in Mbare, the Southern working-class suburb of Harare. Mbare is an old township --being established in 1907-- in the outskirts of what is now known as Harare, and it has a tumultuous history. Nevertheless, recent high population growth and national political dynamics has rendered Mbare a hotbed of political activism.

Urban, peri-urban and rural descriptive statistics

Table A 1 presents mean values for infant mortality rate, infrastructure, population, night light level and disaggregated GDP across urban, peri-urban and rural areas in Africa. Standard deviations are presented in brackets.

	Urban	**Peri-urban**	**Rural**
Infant mortality rate	531 (305)	668 (368)	911 (439)
Infrastructure	3746 (5274)	1477 (2150)	429 (599)
Population	5.65 (1.69)	4.81 (1.45)	3.68 (1.33)
Night light	15.85 (21.39)	2.58 (7.91)	0.09 (1.33)
Disaggregated GDP	5515 (4449)	2513 (2509)	274 (461)

Table A 1: Descriptive statistics for urban, peri-urban and rural areas

Robustness check: ethnicity

Table A 2 is an expanded version of Model 1 from Table 2 in the manuscript. It adds three new models to look at ethnicity and includes an interactive term. Model 2 presents a count of ethnic groups per grid cell: it is significant. Model 3 cubes this count, as there is some expectation in the literature that the relationship between the number of ethnic groups and conflict may be curvilinear: it is not significant. Model 4 test for the presence of excluded ethnic groups: this is significant. In models 2-4, the significance of our key variables is not altered in any way.

	Dependent variable:			
	scad1.6 > 0			
	(1)	(2)	(3)	(4)
Grid pop growth	0.088***	0.089***	0.087***	0.094***
	(0.024)	(0.025)	(0.024)	(0.025)
Grid population	0.00003***	0.00003***	0.00003***	0.00003***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Urban core	0.746***	0.772***	0.739***	0.757***
	(0.111)	(0.111)	(0.113)	(0.111)
Grid year	-0.021**	-0.021**	-0.021**	-0.021**
	(0.010)	(0.010)	(0.010)	(0.010)
Density of infrastructure	0.0001***	0.0001***	0.0001***	0.0001***
	(0.00002)	(0.00002)	(0.00002)	(0.00002)
Grid distance to capital (km)	-0.002***	-0.002***	-0.002***	-0.002***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Log GDP grid per capita	-1.569**	-1.377**	-1.579**	-1.465**
	(0.731)	(0.693)	(0.734)	(0.703)
SCAD (lag)	2.572***	2.590***	2.563***	2.509***
	(0.395)	(0.394)	(0.396)	(0.395)
GeoEPR number of ethnic groups		-0.115***		
		(0.040)		
GeoEPR number of ethnic groups cubed			0.0005	
			(0.001)	
GeoEPR excluded ethnic group(s) (binary)				-0.316***
				(0.102)
Constant	40.310**	40.465**	40.441**	39.887**
	(20.192)	(20.188)	(20.197)	(20.184)
Observations	10,738	10,738	10,738	10,738
Log Likelihood	-2,715.101	-2,710.818	-2,715.033	-2,709.998
Akaike Inf. Crit.	5,448.203	5,441.636	5,450.065	5,439.995
Note:				*p<0.1; **p<0.05; ***p<0.01

Table A 2: Models presented in the main article, with ethnicity added (Models 5 and 6)

Robustness check: political capacity, plus global food price index

Table A 3 adds measures of political capacity: political stability, government effectiveness, voice and accountability. It also includes the global food prices index.

	Dependent variable:						
	scad1.6 > 0						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Grid population	0.00003***	0.00003***	0.00003***	0.00003***	0.00003***	0.00003***	0.00003***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Grid pop growth	0.088***	0.006	0.088***	0.065***	-0.022	-0.033	-0.034
	(0.024)	(0.027)	(0.024)	(0.025)	(0.028)	(0.027)	(0.027)
Urban core	0.746***	1.098***	0.746***	0.786***	0.950***	0.964***	0.964***
	(0.111)	(0.108)	(0.111)	(0.111)	(0.113)	(0.114)	(0.114)
Grid year	-0.021**	0.006	-0.021**	-0.022**	-0.034***	-0.038***	-0.020
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.016)
Density of infrastructure	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***
	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)
Grid distance to capital (km)	-0.002***	-0.001***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Log GDP per capita	-1.569**		-1.569**	-1.278*	-0.269	-0.169	-0.166
	(0.731)		(0.731)	(0.686)	(0.516)	(0.521)	(0.520)
SCAD (lag)	2.572***	2.172***	2.572***	2.427***	2.109***	2.093***	2.074***
	(0.395)	(0.381)	(0.395)	(0.395)	(0.398)	(0.398)	(0.399)
GDI		-0.0003***					
		(0.00003)					
Political stability				-0.302***	0.164***	0.087	0.090
				(0.046)	(0.056)	(0.061)	(0.061)
Government effectiveness					-1.058***	-1.262***	-1.264***
					(0.086)	(0.107)	(0.107)
Voice and accountability						0.299***	0.295***
						(0.092)	(0.093)
Food price index							-0.005
							(0.004)
Constant	40.310**	-13.925	40.310**	40.727**	65.547***	73.786***	37.403
	(20.192)	(20.282)	(20.192)	(20.224)	(20.337)	(20.575)	(31.540)
Observations	10,738	11,379	10,738	10,738	10,738	10,738	10,738
Log Likelihood	-2,715.101	-2,791.701	-2,715.101	-2,693.642	-2,613.097	-2,607.789	-2,606.594
Akaike Inf. Crit.	5,448.203	5,601.403	5,448.203	5,407.283	5,248.193	5,239.578	5,239.187
Note:							*p<0.1; **p<0.05; ***p<0.01

Table A 3: measures of political capacity, plus global food price index

Robustness check: using ACLED instead of SCAD

Table A 4 reproduces Table 2, but this time uses ACLED riots and protests as the dependent variable instead of SCAD.

	Dependent variable:			
	acledProtestsAndRiotsCount > 0			
	(1)	(2)	(3)	(4)
Grid pop growth	0.032*	0.030	0.052***	-0.206***
	(0.019)	(0.020)	(0.020)	(0.068)
Grid population	0.00002***	0.00002***	0.00003***	0.00001***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Urban core	0.733***	0.743***		
	(0.098)	(0.102)		
Distance from drought area (lag) (past 12 months)		-0.108		
		(0.069)		
Drought (past 12 months)		-0.164**		
		(0.065)		
Grid year	0.047***	0.038***	0.046***	0.048**
	(0.008)	(0.010)	(0.009)	(0.024)
Density of infrastructure	0.0001***	0.0001***	0.0001***	0.0001***
	(0.00001)	(0.00002)	(0.00002)	(0.00003)
Grid distance to capital (km)	-0.001***	-0.001***	-0.001***	-0.002***
	(0.0001)	(0.0001)	(0.0001)	(0.0004)
Log GDP grid per capita	-1.796***	-1.889***	-1.344**	-12.439*
	(0.574)	(0.637)	(0.544)	(6.854)
ACLED (lag)	4.891***	4.830***	5.137***	3.441***
	(0.302)	(0.328)	(0.322)	(0.929)
Constant	-96.395***	-77.445***	-94.022***	-97.632**
	(16.778)	(19.350)	(17.939)	(48.895)
Observations	10,738	9,912	9,958	780
Log Likelihood	-3,690.490	-3,332.865	-3,272.415	-389.696
Akaike Inf. Crit.	7,398.980	6,687.729	6,560.831	795.392
Note:				*p<0.1; **p<0.05; ***p<0.01

Table A 4: Reproduction of Table A 2 using ACLED instead of SCAD

Robustness check: interaction pop growth and drought

Table A5 reproduces Table 2 from the main manuscript, and adds an extra model (Model 5) showing the interaction between population growth and drought.

	Dependent variable:				
	scad1.6 > 0				
	(1)	(2)	(3)	(4)	(5)
Grid pop growth	0.088***	0.093***	0.113***	-0.139*	0.124***
	(0.024)	(0.025)	(0.026)	(0.073)	(0.036)
Grid population	0.00003***	0.00003***	0.00003***	0.00001***	0.00003***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Urban core	0.746***	0.763***			0.763***
	(0.111)	(0.115)			(0.115)
Distance from drought area (lag) (past 12 months)		-0.075			-0.077
		(0.081)			(0.081)
Drought (past 12 months)		-0.222***			-0.100
		(0.077)			(0.125)
Grid year	-0.021**	-0.021*	-0.024**	-0.012	-0.021*
	(0.010)	(0.011)	(0.011)	(0.028)	(0.011)
Density of infrastructure	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***
	(0.00002)	(0.00002)	(0.00002)	(0.00003)	(0.00002)
Grid distance to capital (km)	-0.002***	-0.002***	-0.001***	-0.004***	-0.002***
	(0.0002)	(0.0002)	(0.0002)	(0.001)	(0.0002)
Log GDP grid per capita	-1.569**	-1.413*	-1.146*	-17.493*	-1.425**
	(0.731)	(0.724)	(0.688)	(9.953)	(0.727)
SCAD (lag)	2.572***	2.618***	2.537***	1.308	2.621***
	(0.395)	(0.405)	(0.429)	(1.156)	(0.405)
Int(Pop growth * Drought)					-0.062
					(0.050)
Constant	40.310**	38.965*	46.340**	24.204	39.000*
	(20.192)	(23.005)	(21.816)	(55.985)	(23.014)
Observations	10,738	9,912	9,958	780	9,912
Log Likelihood	-2,715.101	-2,520.988	-2,381.695	-303.944	-2,520.212
Akaike Inf. Crit.	5,448.203	5,063.977	4,779.390	623.888	5,064.425

Note: *p<0.1; **p<0.05; ***p<0.01

Comparison of SCAD and ACLED data

Figure A 4 compares SCAD with ACLED riots and protests data.

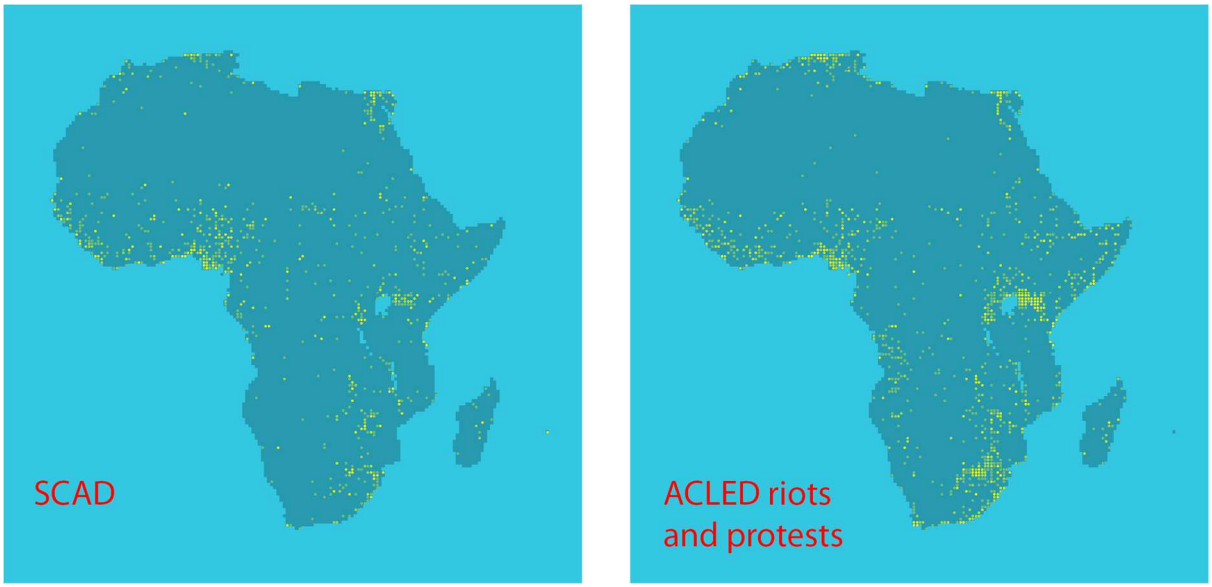


Figure A 4: Comparison of SCAD and ACLED data

For the construction of the ACLED dependent variable we have included the following categories for 'protests': *Peaceful protest* (3967 events), *Protest with intervention* (655), and *Excessive force against protesters* (242), while for 'riots' we have included *Violent demonstration* (2732) and *Mob violence* (893). As displayed in Figure A4, the spatial distribution is broadly similar between ACLED and SCAD, with ACLED having about twice as many events for our geographical selection than SCAD (SCAD: 4166, ACLED: 8489).

Construction of the infrastructure variable

By logging the total length of roads in each of their grid cells, Buhaug & Rød (2006) were able to find that separatist conflicts were more likely in regions with less than average road density, while governmental conflicts have been more likely in areas with more developed road networks. Raleigh & Hegre (2009) also look at roads. By determining whether grid cells contain primary, secondary or informal/ no roads, they find, against their expectations, that conflicts are 47% less likely in cells with informal/ no roads. Yet both of these studies depend on the ESRI's Digital Chart of the World which, as well as being very out of date, is widely acknowledged as having many issues with accuracy and completeness (see Langaas 1995 and Smith and Langaas 1995 for comprehensive descriptions).

The infrastructure proxy variable is shown in Figure A 5: the brighter the grid cell, the more complex the infrastructure. For each grid cell, we have downloaded a Google Map image and recorded its file size. As the map images are stored in Portable Network Graphics (PNG) format, the file size inherently increases with the complexity of the map image. While the image may look like a night-light image, the two variables are not well correlated (0.24).

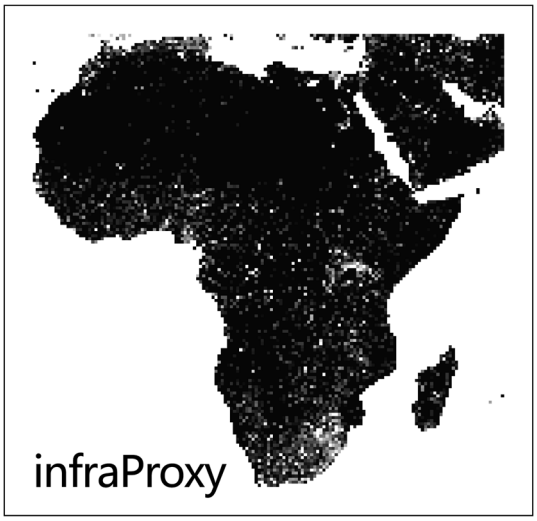


Figure A 5: Infrastructure proxy, brightened to highlight details

Geo-location of US embassies in Africa

Figure A 6 presents the location of US embassies in Africa.

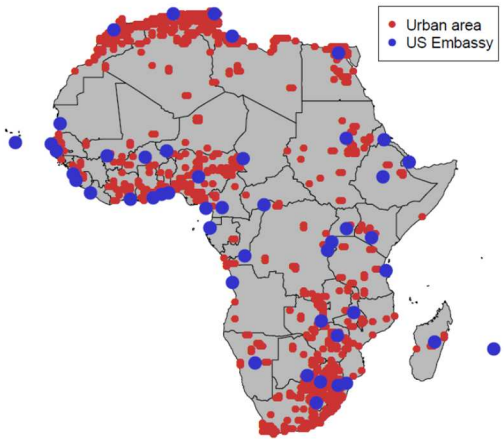


Figure A 6: Location of US embassies