Online Appendix A: Classification for Improved Sanitation and Water Access.

We followed World Health Organization (WHO) and United Nations Children's Fund (UNICEF)'s *core questions on drinking-water and sanitation for household surveys* to define improved water facilities.[1] In the DHS data, there are more types of facilities than those covered by WHO/UNICEF classification: most of these are different spelling and names used. We provide Table A-1 in here to show the detailed classifications of improved water access.

Table A-1: Classification for improved sanitation and water access.

Water Access Facility Type	Improved	Sanitation Facility Type	Improved
public tap	1	traditional pit toilet	0
piped into dwelling	1	flush toilet	1
open public well	0	ventilated improved pit latrine	1
piped into compound/plot	1	no facility, bush, field	0
river, stream	0	no facility/bush/field	0
other	0	pit latrine - without slab / open pit	0
rainwater	0	pit latrine - with slab	1
spring	0	composting toilet	1
bottled water	0	flush - to piped sewer system	1
pond, lake	0	flush - to septic tank	1
covered well in compound/plot	1	pit latrine - ventilated improved pit (vip)	1
covered public well	1	hanging toilet / hanging latrine	0
dam	0	flush - to pit latrine	1
open well in compound/plot	0	flush - to somewhere else	0
protected well	1	flush - don't know where	1
unprotected spring	0	bucket toilet	0
protected spring	1	traditional pit latrine	0
unprotected well	0	improved (ventilated) pit latrine	1
piped to yard/plot	1	no facility / bush / field	0
tube well or borehole	1	pit latrine with slab	1
tanker truck	0	ventilated improved pit latrine (vip)	1
public tap/standpipe	1	flush to pit latrine	1
river/dam/lake/ponds/stream/canal/irrigation channel	0	pit latrine without slab / open pit	0
cart with small tank	0	flush to piped sewer system	1
covered well	1	flush to septic tank	1
open spring	0	flush, don't know where	1
river	0	flush to somewhere else	0
covered spring	1	pit latrine without slab/open pit	0
open well	0	hanging toilet/latrine	0
piped outside compound	0		
pond/lake/dam	0		
piped into compound	1		

river/dam/lake/pond/stream/canal/irrigation channel	0
piped in dwelling	1
river/dam/lake/ponds/stream/canal/irrigation channel	0

Online Appendix B: Summary and Correlation Statistics.

Table B-1: Summary Statistics.

Variable Names	N	Mean	SD	Min	Max
UCDP-GED event (binary)	4194	0.04	0.20	0	1
SPI6	4191	0.21	0.63	0.00	2.50
SPI6$_{lag:1}$	4194	0.21	0.50	0.00	2.50
SPI6$_{lag:3}$	4194	0.22	0.40	0.00	2.14
SPI6$_{lag:5}$	4194	0.22	0.35	0.00	1.72
GDP per capita (logged)	4193	6.81	0.51	5.35	12.75
Population (logged)	4194	10.84	1.75	2.20	15.69
Distance to border (logged)	4194	4.40	1.10	0.04	6.12
Distance to capital (logged)	4194	5.87	0.68	2.11	7.25
Urbanization	4194	0.86	2.33	0.00	40.33
Gas/oil	4194	0.03	0.17	0	1
Mineral facilities	4194	0.08	0.44	0	7
Pre-colonial inst	4112	1.57	0.96	0	4
Improved sanitation (%)	3360	15.27	21.45	0.00	100.00
Improved water (%)	3348	37.75	28.46	0.00	100.00
Electricity (%)	3360	14.55	23.22	0.00	100.00

Table B-2: Correlation Statistics.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1: UCDP-GED event (binary)	1.00	0.03	0.03	0.02	0.01	0.00	0.11	0.05	-0.00	0.13	0.09	0.02	-0.00	0.12	0.04	0.14
2: SPI6	0.03	1.00	0.85	0.70	0.61	-0.07	0.09	0.05	-0.03	0.03	0.03	0.01	0.01	-0.10	-0.08	-0.05
3: SPI6$_{lag}$:1	0.03	0.85	1.00	0.88	0.77	-0.09	0.11	0.06	-0.04	0.02	0.04	0.00	0.01	-0.14	-0.14	-0.09
4: SPI6$_{lag}$:3	0.02	0.70	0.88	1.00	0.94	-0.12	0.10	0.06	-0.04	0.02	0.03	-0.00	0.01	-0.18	-0.19	-0.12
5: SPI6$_{lag}$:5	0.01	0.61	0.77	0.94	1.00	-0.13	0.08	0.05	-0.05	0.01	0.02	-0.01	-0.01	-0.20	-0.21	-0.14
6: GDP per capita (logged)	0.00	-0.07	-0.09	-0.12	-0.13	1.00	0.23	0.04	-0.13	0.20	0.38	0.02	-0.19	0.31	0.10	0.40
7: Population (logged)	0.11	0.09	0.11	0.10	0.08	0.23	1.00	0.07	-0.47	0.43	0.14	0.07	0.11	0.06	0.08	0.30
8: Distance to border (logged)	0.05	0.05	0.06	0.06	0.05	0.04	0.07	1.00	-0.19	0.11	0.10	0.03	0.06	0.05	0.07	0.19
9: Distance to capital (logged)	-0.00	-0.03	-0.04	-0.04	-0.05	-0.13	-0.47	-0.19	1.00	-0.27	-0.04	-0.11	0.11	-0.00	-0.08	-0.13
10: Urbanization	0.13	0.03	0.02	0.02	0.01	0.20	0.43	0.11	-0.27	1.00	0.09	0.14	0.00	0.26	0.21	0.42
11: Gas/oil	0.09	0.03	0.04	0.03	0.02	0.38	0.14	0.10	-0.04	0.09	1.00	0.05	-0.00	0.16	0.10	0.28
12: Mineral facilities	0.02	0.01	0.00	-0.00	-0.01	0.02	0.07	0.03	-0.11	0.14	0.05	1.00	0.01	0.03	0.05	0.05
13: Pre-colonial inst	-0.00	0.01	0.01	0.01	-0.01	-0.19	0.11	0.06	0.11	0.00	-0.00	0.01	1.00	-0.09	0.09	-0.05
14: Improved sanitation (%)	0.12	-0.10	-0.14	-0.18	-0.20	0.31	0.06	0.05	-0.00	0.26	0.16	0.03	-0.09	1.00	0.31	0.46
15: Improved water (%)	0.04	-0.08	-0.14	-0.19	-0.21	0.10	0.08	0.07	-0.08	0.21	0.10	0.05	0.09	0.31	1.00	0.36
16: Electricity (%)	0.14	-0.05	-0.09	-0.12	-0.14	0.40	0.30	0.19	-0.13	0.42	0.28	0.05	-0.05	0.46	0.36	1.00

We conducted analysis replacing our dependent variable that uses the UCDP data, with ones using the ACLED data. The dependent variables used in this appendix are whether a grid-cell-year experienced any events defined by all ACLED events.

   The general findings are that first, all droughts variables have no effect on local conflicts/violence (Table C-1); and second, we do not find any mediating effect associated with any of the three local public goods variables (Table C-2). Finally, we find strong temporal and spatial dependencies for ACLED events; population, urbanization, oil and natural gas fields are also positively associated with higher chances of ACLED events while pre-colonial institutions seem to reduce the chances violence. Note that we do not find statistically significant effects associated with the urbanization variable and the oil and natural gas variable when we use UCDP-GED data in the main text.

Table C-1: Marginal effects of drought variables when using ACLED.

	Dependent variable:ACLED			
	(1)	(2)	(3)	(4)
SPI6	0.209			
	(0.152)			
SPI6$_{lag:1}$		0.183		
		(0.215)		
SPI6$_{lag:3}$			0.025	
			(0.318)	
SPI6$_{lag:5}$				−0.025
				(0.447)
GDP per capita	0.061	0.060	0.057	0.057
	(0.212)	(0.212)	(0.213)	(0.213)
Population	0.160**	0.160**	0.160**	0.160**
	(0.066)	(0.066)	(0.066)	(0.066)
Distance to border	−0.011	−0.012	−0.012	−0.012
	(0.076)	(0.076)	(0.076)	(0.076)
Distance to capital	0.116	0.117	0.116	0.115
	(0.145)	(0.145)	(0.145)	(0.145)
Urbanization	0.238***	0.238***	0.238***	0.238***
	(0.037)	(0.037)	(0.037)	(0.037)
Gas/oil	0.996***	0.989***	0.983***	0.982***
	(0.367)	(0.366)	(0.366)	(0.366)
Mineral facilities	0.210	0.212	0.215	0.215
	(0.156)	(0.156)	(0.157)	(0.156)
Pre-colonial inst	−0.184**	−0.180**	−0.176**	−0.177**
	(0.087)	(0.087)	(0.087)	(0.087)
Conflict history	3.503***	3.512***	3.515***	3.516***
	(0.365)	(0.365)	(0.365)	(0.365)
Spatial lag	1.206***	1.205***	1.228***	1.234***
	(0.372)	(0.372)	(0.374)	(0.374)
Constant	−8.208***	−8.215***	−8.182***	−8.165***
	(2.393)	(2.389)	(2.391)	(2.400)
Observations	2,775	2,776	2,776	2,776
Log Likelihood	−722.646	−723.283	−723.641	−723.642
Akaike Inf. Crit.	1,491.293	1,492.565	1,493.281	1,493.284

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

Table C-2: Local public goods, droughts in neighboring units, and chances of violent events: testing interactive effects using ACLED.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
					Dependent variable: ACLED							
SPI6	0.175				0.341				0.180			
	(0.181)				(0.214)				(0.193)			
SPI6$_{lag:1}$		0.145				0.267				0.166		
		(0.254)				(0.291)				(0.260)		
SPI6$_{lag:3}$			−0.137				−0.092				−0.122	
			(0.363)				(0.418)				(0.370)	
SPI6$_{lag:5}$				−0.158				−0.204				−0.149
				(0.498)				(0.563)				(0.506)
GDP per capita	0.094	0.101	0.093	0.091	0.177	0.178	0.174	0.173	0.113	0.114	0.114	0.113
	(0.216)	(0.216)	(0.217)	(0.217)	(0.220)	(0.220)	(0.220)	(0.220)	(0.216)	(0.216)	(0.216)	(0.216)
Population	0.186**	0.188***	0.188***	0.188**	0.193***	0.192***	0.192***	0.193***	0.198***	0.200***	0.198***	0.197***
	(0.073)	(0.073)	(0.073)	(0.073)	(0.073)	(0.073)	(0.074)	(0.074)	(0.073)	(0.073)	(0.073)	(0.073)
Distance to border	−0.002	−0.001	0.004	0.004	−0.003	−0.003	0.004	0.006	−0.011	−0.010	−0.007	−0.008
	(0.084)	(0.084)	(0.084)	(0.084)	(0.085)	(0.085)	(0.085)	(0.085)	(0.084)	(0.084)	(0.084)	(0.084)
Distance to capital	0.064	0.072	0.075	0.076	0.053	0.056	0.058	0.057	0.083	0.084	0.086	0.085
	(0.147)	(0.147)	(0.147)	(0.148)	(0.147)	(0.147)	(0.147)	(0.147)	(0.148)	(0.147)	(0.147)	(0.147)
Urbanization	0.223***	0.225***	0.223***	0.223***	0.218***	0.219***	0.218***	0.218***	0.207***	0.208***	0.207***	0.207***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.040)	(0.040)	(0.040)	(0.040)
Gas/oil	1.026***	0.997***	0.997***	0.996***	0.959**	0.945**	0.938**	0.943**	0.975***	0.959***	0.949**	0.952**
	(0.374)	(0.372)	(0.373)	(0.372)	(0.376)	(0.375)	(0.375)	(0.374)	(0.373)	(0.372)	(0.372)	(0.372)
Mineral facilities	0.188	0.191	0.195	0.194	0.206	0.208	0.210	0.209	0.187	0.195	0.197	0.196
	(0.176)	(0.175)	(0.176)	(0.175)	(0.176)	(0.176)	(0.176)	(0.175)	(0.173)	(0.174)	(0.174)	(0.174)
Pre-colonial inst	−0.201**	−0.191**	−0.192**	−0.192**	−0.197**	−0.194**	−0.193**	−0.192**	−0.197**	−0.189**	−0.189**	−0.190**
	(0.091)	(0.091)	(0.090)	(0.090)	(0.093)	(0.092)	(0.092)	(0.092)	(0.091)	(0.091)	(0.090)	(0.090)
Improved sanitation (%)	0.003	0.003	0.003	0.002								
	(0.004)	(0.004)	(0.004)	(0.004)								
Improved sanitation (%) × SPI6	0.019											
	(0.018)											
Improved sanitation (%) × SPI6$_{lag:1}$		−0.012										
		(0.053)										
Improved sanitation (%) × SPI6$_{lag:3}$			0.029									
			(0.074)									
Improved sanitation (%) × SPI6$_{lag:5}$				0.031								
				(0.077)								
Improved water (%)					0.004	0.004	0.003	0.003				

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
					(0.003)	(0.003)	(0.003)	(0.003)				
Improved water (%) × SPI6					−0.004							
					(0.004)							
Improved water (%) × SPI6$_{lag:1}$						−0.006						
						(0.006)						
Improved water (%) × SPI6$_{lag:3}$							−0.002					
							(0.007)					
Improved water (%) × SPI6$_{lag:5}$								0.001				
								(0.008)				
Electricity (%)									0.005	0.006	0.005	0.005
									(0.004)	(0.004)	(0.004)	(0.004)
Electricity (%) × SPI6									0.003			
									(0.006)			
Electricity (%) × SPI6$_{lag:1}$										−0.004		
										(0.008)		
Electricity (%) × SPI6$_{lag:3}$											−0.0002	
											(0.009)	
Electricity (%) × SPI6$_{lag:5}$												0.001
												(0.010)
Conflict history	3.499***	3.521***	3.523***	3.523***	3.587***	3.594***	3.602***	3.604***	3.511***	3.512***	3.519***	3.519***
	(0.390)	(0.390)	(0.391)	(0.391)	(0.396)	(0.395)	(0.396)	(0.395)	(0.391)	(0.391)	(0.391)	(0.391)
Spatial lag	0.946**	0.938**	0.962**	0.966**	0.923**	0.937**	0.951**	0.937**	0.908**	0.895**	0.930**	0.928**
	(0.397)	(0.397)	(0.399)	(0.398)	(0.403)	(0.404)	(0.406)	(0.404)	(0.397)	(0.398)	(0.400)	(0.399)
Constant	−8.257***	−8.382***	−8.356***	−8.342***	−9.092***	−9.110***	−9.103***	−9.083***	−8.654***	−8.689***	−8.662***	−8.623***
	(2.431)	(2.424)	(2.427)	(2.435)	(2.464)	(2.459)	(2.462)	(2.471)	(2.429)	(2.424)	(2.425)	(2.432)
Observations	2,470	2,471	2,471	2,471	2,458	2,459	2,459	2,459	2,470	2,471	2,471	2,471
Log Likelihood	−643.117	−644.343	−644.385	−644.398	−631.537	−632.268	−632.724	−632.768	−642.637	−643.381	−643.574	−643.589
Akaike Inf. Crit.	1,336.233	1,338.686	1,338.770	1,338.796	1,313.074	1,314.536	1,315.447	1,315.535	1,335.274	1,336.762	1,337.149	1,337.179

Note:

*p<0.1; **p<0.05; ***p<0.01

Online Appendix D: More Model Specifications and Controlling for Land Types and Foreign Aid.

In order to see whether the mediating effect of the improved sanitation variable is robust to more model specifications, in this online appendix, we started with a much "reduced" model specification – keeping only GDP per capita, Population, drought variables (SPI6 and $SPI6_{lag:1}$), improved sanitation – and added in more variables (Distance to border, Distance to capital, Urbanization, Gas/oil, Mineral facilities, and Pre-colonial institutions) step by step. The results in Table D-1 are very similar to what we have found in model specification 1-4 in Table 3 of the main text, which shows that improved sanitation's mediating effect is not driven by specific model specifications.

Moreover, whether a drought affects cropland or barren land may matter a lot to the local economy and community. In this online appendix, we further control for the effects of land types – at the grid-cell level, the percentages of pasture area (Pasture area (%)), agricultural land (Agricultural area (%)), grass land (Grasslands (%)), barren land (Barren areas (%)) and pasture and agricultural lands combined (Pasture area (%) + Agricultural area (%)). None of the land types affects the chances of local conflicts (Table D-2). At the same time, similar to findings from Table 3, we find empirical support for the mediating effect of improved sanitation.

Finally, a related and important question concerns whether or not local public goods are provided by the government at all. If for example, the water line is installed as part of an international development aid project, it is hard for local population to make the connection to the country's government. Therefore, we control for aid projects within the DHS clusters. We hope this can partly address the concern that other international assistance efforts might also affect local public goods. Note that geo-coding foreign aid projects is still an ongoing research effort: for example, the Aid Data project has coded all projects approved from 1995-2014 of the World Bank IBRD/IDA lending lines (World Bank IBRD-IDA, Level 1, Version 1.4.1). Being probably the most comprehensive geo-coded aid data for Africa, it does not include aid projects from other international institutions and from donor countries directly.

Another concern using this data set for grid cell level analysis is that for an aid project that involves multiple locations and years of implementation, one lacks information on how the commitment and disbursement amounts are distributed between different locations and over time. We have to evenly divide the commitment and disbursement amounts to all location-years. For these empirical limitations, we only report the results in the revised online appendix D of the revised manuscript.

More specifically, we create two variables: Aid: commitment is the grid-cell level yearly amount of aid commitment; Aid: disbursement the grid-cell level yearly amount of aid disbursement – note that the disbursement amount variable has more zero-value observations, but it essentially give similar results: after controlling for grid-cell level aid, the results concerning the mediating effects of local public goods are very similar to what we found in the unrevised manuscript. At the same time, aid, either measured by commitment or disbursement amount, does not affect conflicts. Because of space limit, we only reported results concerning improved sanitation – which has the most significant mediating effect on drought – here and in online appendix D; results with improved water access and electricity access are very similar to models without controlling for aid: they are available upon request.

Table D-1: Testing the mediating effects of Improved sanitation with more model specifications, using UCDP-GED as dependent variable.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GDP per capita	0.520**	0.497**	0.497**	0.412	0.575**	0.526**	0.507**	0.507**	0.431*	0.592**
	(0.224)	(0.229)	(0.229)	(0.256)	(0.251)	(0.224)	(0.228)	(0.228)	(0.253)	(0.248)
Population	0.238***	0.240***	0.241***	0.230***	0.250***	0.238***	0.242***	0.244***	0.234***	0.254***
	(0.075)	(0.081)	(0.087)	(0.088)	(0.089)	(0.075)	(0.081)	(0.087)	(0.088)	(0.088)
Distance to border		0.106	0.106	0.090	0.105		0.093	0.092	0.079	0.093
		(0.120)	(0.120)	(0.121)	(0.122)		(0.120)	(0.120)	(0.121)	(0.122)
Distance to capital		0.079	0.079	0.059	0.204		0.082	0.080	0.065	0.210
		(0.190)	(0.194)	(0.197)	(0.210)		(0.190)	(0.193)	(0.197)	(0.210)
Urbanization			−0.001	0.002	0.006			−0.001	0.001	0.004
			(0.029)	(0.030)	(0.031)			(0.029)	(0.030)	(0.031)
Gas/oil				0.320	0.276				0.290	0.242
				(0.416)	(0.432)				(0.413)	(0.429)
Mineral facilities				0.095	0.133				0.087	0.128
				(0.176)	(0.175)				(0.175)	(0.174)
Pre-colonial inst					−0.221*					−0.203
					(0.128)					(0.128)
SPI6	0.527**	0.515**	0.515**	0.514**	0.537***					
	(0.206)	(0.207)	(0.208)	(0.207)	(0.208)					
Improved sanitation (%) × SPI6	−0.044	−0.043	−0.043	−0.044	−0.044					
	(0.028)	(0.027)	(0.027)	(0.027)	(0.027)					
SPI6$_{lag}$:1						0.780***	0.763**	0.764**	0.758**	0.774***
						(0.296)	(0.298)	(0.298)	(0.297)	(0.297)
Improved sanitation (%) × SPI6$_{lag}$:1						−0.081**	−0.079*	−0.079*	−0.081**	−0.080**
						(0.041)	(0.041)	(0.041)	(0.040)	(0.040)
Improved sanitation (%)	0.013***	0.013***	0.013**	0.013**	0.014***	0.014***	0.014***	0.014***	0.014***	0.015***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Conflict history	2.958***	2.957***	2.958***	2.931***	2.862***	2.942***	2.938***	2.942***	2.917***	2.853***
	(0.349)	(0.351)	(0.359)	(0.362)	(0.369)	(0.349)	(0.350)	(0.358)	(0.361)	(0.368)
Spatial lag	3.576***	3.586***	3.586***	3.509***	3.265***	3.539***	3.543***	3.544***	3.473***	3.226***
	(0.787)	(0.794)	(0.794)	(0.800)	(0.804)	(0.785)	(0.793)	(0.793)	(0.798)	(0.803)
Constant	−13.536***	−14.262***	−14.266***	−13.344***	−15.521***	−13.588***	−14.322***	−14.331***	−13.521***	−15.686***
	(2.082)	(2.692)	(2.697)	(2.963)	(3.055)	(2.081)	(2.679)	(2.686)	(2.933)	(3.026)
Year-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Observations	3,357	3,357	3,357	3,357	3,296	3,360	3,360	3,360	3,360	3,299
Log Likelihood	−413.811	−413.407	−413.406	−412.930	−404.145	−412.619	−412.302	−412.301	−411.903	−403.156
Akaike Inf. Crit.	879.623	882.813	884.813	887.861	872.289	877.239	880.605	882.602	885.805	870.313

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

Table D-2: Testing the mediating effects of Improved sanitation with controls for land types, using UCDP-GED as dependent variable.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GDP per capita	0.909***	0.994***	0.916***	0.969***	0.957***	0.926***	1.007***	0.933***	0.979***	0.981***
	(0.344)	(0.345)	(0.336)	(0.340)	(0.349)	(0.342)	(0.344)	(0.334)	(0.338)	(0.347)
Population	0.194**	0.166	0.225**	0.209**	0.218**	0.197**	0.162	0.225**	0.211**	0.211**
	(0.092)	(0.113)	(0.090)	(0.092)	(0.102)	(0.092)	(0.112)	(0.090)	(0.092)	(0.102)
Distance to border	0.150	0.164	0.158	0.160	0.157	0.139	0.150	0.145	0.146	0.145
	(0.126)	(0.127)	(0.127)	(0.127)	(0.127)	(0.126)	(0.127)	(0.127)	(0.127)	(0.127)
Distance to capital	0.218	0.270	0.287	0.267	0.258	0.220	0.266	0.282	0.263	0.261
	(0.221)	(0.218)	(0.219)	(0.219)	(0.222)	(0.222)	(0.218)	(0.219)	(0.219)	(0.222)
Urbanization	−0.001	0.003	0.005	0.004	0.003	−0.001	0.002	0.004	0.002	0.002
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Gas/oil	0.249	0.311	0.334	0.377	0.375	0.245	0.285	0.316	0.359	0.360
	(0.486)	(0.480)	(0.466)	(0.467)	(0.466)	(0.485)	(0.479)	(0.465)	(0.466)	(0.466)
Mineral facilities	0.138	0.151	0.103	0.145	0.142	0.129	0.145	0.096	0.136	0.136
	(0.176)	(0.176)	(0.179)	(0.175)	(0.176)	(0.175)	(0.175)	(0.178)	(0.175)	(0.175)
Pre-colonial inst	−0.223*	−0.207	−0.230*	−0.216*	−0.218*	−0.205	−0.188	−0.212	−0.198	−0.198
	(0.130)	(0.130)	(0.130)	(0.129)	(0.131)	(0.129)	(0.129)	(0.130)	(0.129)	(0.130)
Pasture area (%)	−0.009					−0.008				
	(0.009)					(0.009)				
Agricultural area (%)		0.005					0.006			
		(0.008)					(0.008)			
Grasslands (%)			0.016					0.014		
			(0.011)					(0.011)		
Barren areas (%)				−0.002					−0.002	
				(0.011)					(0.011)	
Pasture area (%) + Agricultural area (%)					−0.001					0.0003
					(0.007)					(0.007)
SPI6	0.519**	0.527**	0.531**	0.527**	0.525**					
	(0.207)	(0.207)	(0.207)	(0.207)	(0.207)					
Improved sanitation (%) × SPI6	−0.038	−0.037	−0.038	−0.038	−0.039					
	(0.026)	(0.026)	(0.025)	(0.026)	(0.026)					
SPI6$_{lag:1}$						0.750**	0.766***	0.759**	0.759**	0.759**
						(0.299)	(0.297)	(0.297)	(0.298)	(0.298)
Improved sanitation (%) × SPI6$_{lag:1}$						−0.065*	−0.067*	−0.065*	−0.067*	−0.067*
						(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Improved sanitation (%)	0.012**	0.012**	0.013**	0.012**	0.012**	0.013**	0.013**	0.014***	0.014**	0.013**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)

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Conflict history	2.802***	2.796***	2.784***	2.786***	2.789***	2.790***	2.788***	2.777***	2.778***	2.780***
	(0.380)	(0.380)	(0.380)	(0.380)	(0.380)	(0.379)	(0.379)	(0.379)	(0.379)	(0.379)
Spatial lag	2.977***	3.004***	2.997***	3.015***	3.017***	2.968***	2.989***	2.984***	3.001***	3.006***
	(0.881)	(0.881)	(0.882)	(0.881)	(0.880)	(0.881)	(0.881)	(0.881)	(0.880)	(0.880)
Constant	−17.536***	−18.384***	−18.474***	−18.538***	−18.463***	−17.703***	−18.386***	−18.535***	−18.571***	−18.595***
	(3.716)	(3.613)	(3.555)	(3.588)	(3.626)	(3.700)	(3.602)	(3.540)	(3.573)	(3.616)
Year-fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	3,244	3,244	3,244	3,244	3,244	3,244	3,244	3,244	3,244	3,244
Log Likelihood	−392.305	−392.538	−391.702	−392.742	−392.744	−391.683	−391.746	−391.173	−392.018	−392.027
Akaike Inf. Crit.	850.610	851.076	849.405	851.484	851.487	849.366	849.491	848.346	850.036	850.054

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table D-3: Testing the mediating effects of improved sanitation, using UCDP-GED as dependent variable, and controlling for foreign aid.

	Dependent variable: UCDP-GED			
	(1)	(2)	(3)	(4)
GDP per capita	0.569**	0.583**	0.587**	0.600**
	(0.253)	(0.250)	(0.250)	(0.247)
Population	0.254***	0.244***	0.257***	0.247***
	(0.090)	(0.089)	(0.090)	(0.089)
Distance to border	0.105	0.105	0.093	0.093
	(0.122)	(0.122)	(0.122)	(0.122)
Distance to capital	0.205	0.203	0.211	0.209
	(0.211)	(0.210)	(0.210)	(0.209)
Urbanization	0.009	−0.001	0.008	−0.003
	(0.034)	(0.033)	(0.034)	(0.033)
Gas/oil	0.287	0.255	0.253	0.221
	(0.434)	(0.433)	(0.431)	(0.430)
Mineral facilities	0.132	0.136	0.127	0.131
	(0.175)	(0.175)	(0.174)	(0.174)
Pre-colonial inst	−0.223*	−0.218*	−0.205	−0.200
	(0.128)	(0.128)	(0.128)	(0.128)
SPI6	0.538***	0.538***		
	(0.208)	(0.208)		
SPI6$_{lag}$:1			0.775***	0.775***
			(0.297)	(0.298)
Improved sanitation (%) × SPI6	−0.044[a]	−0.044[b]		
	(0.027)	(0.027)		
Improved sanitation (%) × SPI6$_{lag}$:1			−0.080**	−0.080**
			(0.040)	(0.041)
Improved sanitation (%)	0.014***	0.014***	0.015***	0.015***
	(0.005)	(0.005)	(0.005)	(0.005)
Aid: commitment	−0.009		−0.009	
	(0.035)		(0.034)	
Aid: disbursement		0.021		0.020
		(0.037)		(0.037)
Conflict history	2.860***	2.872***	2.850***	2.863***
	(0.369)	(0.370)	(0.368)	(0.369)
Spatial lag	3.273***	3.252***	3.233***	3.212***
	(0.805)	(0.804)	(0.803)	(0.803)
Constant	−15.529***	−15.504***	−15.697***	−15.665***
	(3.061)	(3.046)	(3.031)	(3.019)
Year-fixed effects	yes	yes	yes	yes
Country-fixed effects	Yes	Yes	Yes	Yes
Observations	3,296	3,296	3,299	3,299
Log Likelihood	−404.111	−403.998	−403.124	−403.011
Akaike Inf. Crit.	874.222	873.996	872.247	872.022

Note: a: p-value is 0.106; b: p-value is 0.103; *p<0.1; **p<0.05; ***p<0.01.

Online Appendix E: Controlling for the endogenous public goods provisions.

In this section, we control for the variables that past studies have shown to affect public goods provisions. We have followed studies such as Lee 2017 to search for variables suggested by the literature. For instance, it is likely that local services are provided to areas and groups which are politically relevant to leaders. Moreover, leaders might try to prevent a conflict from emerging by investing in public services in areas with a higher a priori risk of conflict onset – these are often politically and economically marginalized areas, which we control in this section of the online appendices.

Here, we first use the political exclusion variable "excluded" from the EPR; second, life expectancy data is not available at the grid cell level as far as we know, so we turn to a similarly important public health variable – infant mortality rates. More specifically, the variable *excluded* counts the number of excluded groups (discriminated or powerless) as defined in the GeoEPR/EPR data on the status and location of politically relevant ethnic groups settled in the grid cell for the given year, derived from the GeoEPR/EPR 2014 update 2 dataset (Vogt et al. 2015).

The variable *infant mortality* measures the average infant mortality rate within the grid cell, based on raster data from the SEDAC Global Poverty Mapping project (Storeygard et al. 2008).[2] Note that the *infant mortality* indicator is a snapshot for the year 2000 only so we essentially using 2000 data for all years included in our analysis – this clearly not perfect, but this is the only infant mortality data at the grid-cell level as far as we know. Interestingly, these two variables – excluded and infant mortality – are correlated at 0.35 level in our data: areas with more excluded ethnic groups are associated with higher infant mortality rates.

We have re-run the analysis, adding these two variables. Our main findings concerning the mediating effect of improved sanitation and to a lesser extent, that of improved water access do not change. Because of space limit, we only show the table with the results on improved sanitation in this online appendix. A few things to notice here: the excluded variable involves many missing values; its inclusion into the model reduces the total observations by about 500. However, the interactive effects between improved sanitation and droughts variables are almost the same compared to when we do not include these two additional variables. Moreover, the coefficients of these two variables are always positive which do not contradict common expectations that places with more ethnic groups that are politically excluded and with higher infant mortality rates are places with higher chances of violence. However, in all the model specifications, their coefficients are not statistically significant.

Table E1: Testing the mediating effects of improved sanitation, using UCDP-GED as dependent variable, and controlling for political exclusion and infant mortality.

	(1)	(2)	(3)	(4)	(5)	(6)
GDP per capita	0.525**	0.544**	0.484*	0.546**	0.562**	0.505*
	(0.263)	(0.253)	(0.266)	(0.259)	(0.250)	(0.263)
Population	0.266***	0.219**	0.231**	0.268***	0.223**	0.233**
	(0.094)	(0.091)	(0.096)	(0.094)	(0.091)	(0.096)
Distance to border	0.053	0.105	0.051	0.037	0.094	0.037
	(0.124)	(0.123)	(0.126)	(0.124)	(0.123)	(0.126)
Distance to capital	0.146	0.098	0.016	0.152	0.105	0.024

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[2] The original pixel value is the number of children per 10,000 live births that die before reaching their first birthday.

	(1)	(2)	(3)	(4)	(5)	(6)
	(0.211)	(0.225)	(0.226)	(0.211)	(0.224)	(0.226)
Urbanization	0.002	0.008	0.005	0.0003	0.006	0.003
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Gas/oil	0.285	0.327	0.354	0.258	0.294	0.328
	(0.445)	(0.437)	(0.453)	(0.442)	(0.434)	(0.450)
Mineral facilities	0.118	0.141	0.127	0.112	0.134	0.120
	(0.177)	(0.174)	(0.176)	(0.176)	(0.173)	(0.175)
Pre-colonial inst	−0.229*	−0.226*	−0.235*	−0.211	−0.208	−0.217
	(0.134)	(0.129)	(0.136)	(0.134)	(0.128)	(0.135)
Excluded	0.123		0.133	0.097		0.108
	(0.238)		(0.240)	(0.240)		(0.242)
Infant mortality		0.001	0.001		0.001	0.001
		(0.001)	(0.001)		(0.001)	(0.001)
SPI6	0.542***	0.523**	0.525**			
	(0.208)	(0.209)	(0.210)			
SPI6$_{lag}$:1				0.778***	0.760**	0.761**
				(0.299)	(0.301)	(0.303)
Improved sanitation (%) × SPI6	−0.043[a]	−0.042[b]	−0.041[c]			
	(0.027)	(0.027)	(0.027)			
Improved sanitation (%) × SPI6$_{lag}$:1				−0.085**	−0.076*	−0.080*
				(0.042)	(0.040)	(0.042)
Improved sanitation (%)	0.014***	0.014***	0.013**	0.015***	0.015***	0.015***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Conflict history	2.863***	2.890***	2.884***	2.867***	2.879***	2.886***
	(0.382)	(0.371)	(0.384)	(0.381)	(0.370)	(0.383)
Spatial lag	2.992***	3.300***	3.032***	2.949***	3.260***	2.990***
	(0.820)	(0.806)	(0.822)	(0.818)	(0.805)	(0.821)
Constant	−14.631***	−15.307***	−14.335***	−14.791***	−15.465***	−14.488***
	(3.127)	(3.072)	(3.153)	(3.095)	(3.044)	(3.122)
Year-fixed effects	yes	yes	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes	yes	yes
Observations	2,748	3,296	2,748	2,751	3,299	2,751
Log Likelihood	−388.936	−403.221	−387.609	−387.800	−402.285	−386.559
Akaike Inf. Crit.	837.872	872.442	837.217	835.599	870.570	835.119

Note: a: p-value is 0.109; b: p-value is 0.117; c: p-value is 0.125. *p<0.1; **p<0.05; ***p<0.01.

Online Appendix F: Creating spatial lags of the SPI6 variable in a grid-cell structure.

In this section, we further clarify how we created the spatial lags of the SPI6 variable. Indeed, we are not the first to test whether neighboring droughts affects conflicts in a given location. Similar to Harari and La Ferrara (2012), we create series of spatial lags of the SPI6 variable. $SPI6_{lag:1}$ measures the mean SPI6 level among adjacent grid-cells; $SPI6_{lag:3}$ measures the mean SPI6 level among grid-cells that are within three orders of proximity in the grid-cell structure; $SPI6_{lag:5}$ is the mean SPI6 level among grid-cells that are within five orders of proximity in a given year. Figure F-1 of this online appendix illustrates for a grid-cell i, the adjacent grid-cells, grid-cells within three orders of proximity and those within five orders of proximity respectively.

Figure F-1: creating spatial lags of the SPI6 variable in a grid-cell structure.

a): adjacent grid-cells;   b): within three orders of proximity;   c): within five orders of proximity.
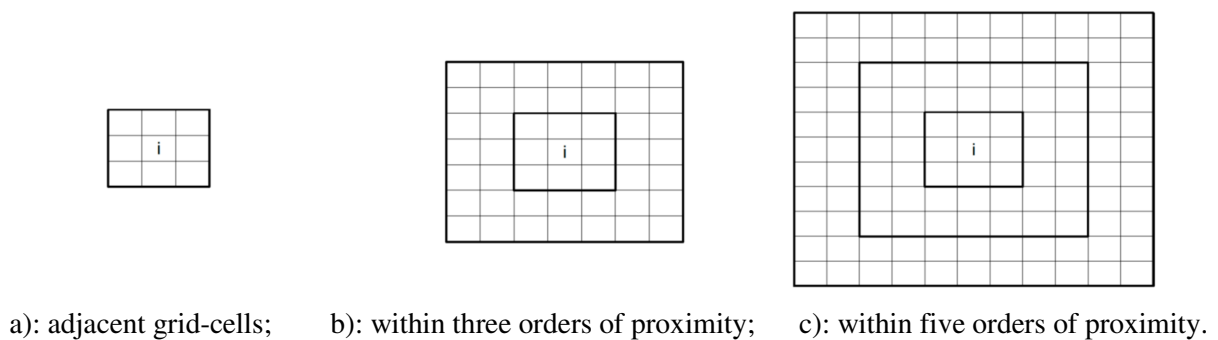
Online Appendix G: Additional Robustness Checks.

Using Different Grid Size: This section presents results when we experiment with different grid size. We chose to use grid cells of 1° by 1°, which is 4 times the size of the grids used in the main analysis: note this reduces the number of observations by around 75%. We found that our main results re the mitigating effect of improved sanitation still hold. Table G-1 presents series of model specifications: the interaction term between drought and improved sanitation (Improved sanitation (%) × SPI6$_{lag}$:1) is always negative and statistically significant.

Table G-1: Testing the mediating effects of improved sanitation, using UCDP-GED as dependent variable, and grid cells of size 1° by 1°.

	Improved sanitation			
	(1)	(2)	(3)	(4)
GDP per capita	0.237	0.105	−0.091	−0.061
	(0.279)	(0.286)	(0.294)	(0.297)
Population	0.284***	0.193*	0.098	0.098
	(0.089)	(0.103)	(0.114)	(0.113)
Distance to border		0.416***	0.413***	0.422***
		(0.153)	(0.155)	(0.157)
Distance to capital		−0.024	−0.012	0.020
		(0.258)	(0.266)	(0.271)
Urbanization			0.134	0.148*
			(0.089)	(0.090)
Gas/oil			0.923*	1.006**
			(0.495)	(0.500)
Mineral facilities			0.025	0.005
			(0.127)	(0.128)
Pre-colonial inst				−0.215
				(0.177)
SPI6$_{lag}$:1	0.891**	0.849**	0.804**	0.812**
	(0.395)	(0.405)	(0.399)	(0.397)
Improved sanitation (%) × SPI6$_{lag}$:1	−0.173*	−0.150[a]	−0.148*	−0.145*
	(0.101)	(0.092)	(0.087)	(0.086)
Improved sanitation (%)	0.007	0.007	0.002	0.003
	(0.008)	(0.008)	(0.008)	(0.008)
Conflict history	1.519***	1.396***	1.239**	1.133**
	(0.475)	(0.482)	(0.497)	(0.500)
Spatial lag	8.489***	9.325***	9.012***	8.729***
	(1.563)	(1.636)	(1.631)	(1.623)
Constant	−10.191***	−9.634***	−7.230**	−7.555**
	(2.487)	(3.474)	(3.575)	(3.585)
Year-fixed effects	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes
Observations	1,081	1,081	1,081	1,063
Log Likelihood	−245.713	−241.076	−238.145	−236.769
Akaike Inf. Crit.	543.426	538.152	538.290	537.538

Note: a: p-value is 0.104; *p<0.1; **p<0.05; ***p<0.01.

Results without Using Interpolated DHS Data: We are aware of the concern on spatial interpolation. In the paper, if a grid cell has no data for a given year, we only use the neighboring cell values to interpolate. More specifically, we only used one order proximity adjacent grid cells to interpolate by taking their average. Our intuition is that if we don't know

the information of a grid cell, we borrow information from the nearest adjacent neighboring cells. We are aware that there is uncertainty involved when using this type of spatial interpolation; therefore, we ran the analysis without using the interpolated part of the data (see Table G-2). The results, even though now we have only almost half of the observations compared with using interpolated data, still support our main findings, see for example, the table below which tests the interactive effect between drought and improved sanitation.

Table G-2: Testing the mediating effects of improved sanitation, using UCDP-GED as dependent variable, and the without interpolated DHS data.

| | Improved sanitation | | | | |
	(1)	(2)	(3)	(4)	(5)
GDP per capita	0.665**	0.645**	0.648**	0.598*	0.831***
	(0.285)	(0.289)	(0.290)	(0.324)	(0.318)
Population	0.249**	0.244**	0.254*	0.245*	0.255*
	(0.113)	(0.121)	(0.132)	(0.134)	(0.132)
Distance to border		0.084	0.078	0.065	0.119
		(0.164)	(0.167)	(0.169)	(0.172)
Distance to capital		0.058	0.046	0.041	0.233
		(0.232)	(0.238)	(0.243)	(0.261)
Urbanization			−0.006	−0.006	−0.003
			(0.031)	(0.033)	(0.034)
Gas/oil				0.161	0.010
				(0.489)	(0.508)
Mineral facilities				0.092	0.150
				(0.190)	(0.187)
Pre-colonial inst					−0.225
					(0.152)
$SPI6_{lag}:1$	0.883**	0.860**	0.864**	0.865**	0.895**
	(0.404)	(0.409)	(0.410)	(0.408)	(0.411)
Improved sanitation (%) × $SPI6_{lag}:1$	−0.149**	−0.145**	−0.145**	−0.146**	−0.144**
	(0.062)	(0.062)	(0.062)	(0.061)	(0.062)
Improved sanitation (%)	0.015***	0.015***	0.016***	0.015***	0.018***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Conflict history	2.662***	2.659***	2.675***	2.655***	2.547***
	(0.422)	(0.423)	(0.431)	(0.437)	(0.447)
Spatial lag	4.177***	4.215***	4.217***	4.186***	3.942***
	(1.007)	(1.022)	(1.022)	(1.030)	(1.036)
Constant	−13.769***	−14.228***	−14.282***	−13.715***	−16.673***
	(2.582)	(3.240)	(3.253)	(3.679)	(3.812)
Year-fixed effects:	yes	yes	yes	yes	yes
Country-fixed effects:	yes	yes	yes	yes	yes
Observations	1,950	1,950	1,950	1,950	1,917
Log Likelihood	−270.172	−270.040	−270.020	−269.830	−264.279
Akaike Inf. Crit.	592.343	596.080	598.040	601.660	592.559

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

Results Including Desert Grid-cells: In our main analysis, we followed Theisen et al 2011/12 (pp 92): "We excluded grid cells with little or no measurable amount of precipitation in a normal year (less than 100 millimeters); these areas are mostly uninhabited and, by definition, never experience drought." During this robustness check excercise, we ran the analysis with all grid cells: this only adds about 40 more observations. The results do not change (Table G-3).

Table G-3: Testing the mediating effects of local public goods, using UCDP-GED as dependent variable, using all grid-cells.

	Improved Sanitation				Improved Water Access				Electricity Access			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GDP per capita	0.141	0.573**	0.163	0.590**	0.174	0.566**	0.176	0.573**	0.121	0.648***	0.127	0.658***
	(0.256)	(0.251)	(0.256)	(0.249)	(0.256)	(0.249)	(0.255)	(0.247)	(0.256)	(0.243)	(0.255)	(0.242)
Population	0.201**	0.255***	0.205**	0.259***	0.212**	0.268***	0.214**	0.270***	0.191**	0.266***	0.196**	0.270***
	(0.087)	(0.088)	(0.087)	(0.088)	(0.086)	(0.088)	(0.086)	(0.088)	(0.088)	(0.088)	(0.088)	(0.088)
Distance to border	0.102	0.102	0.086	0.090	0.109	0.103	0.103	0.093	0.088	0.086	0.084	0.078
	(0.111)	(0.122)	(0.111)	(0.122)	(0.111)	(0.121)	(0.112)	(0.121)	(0.112)	(0.121)	(0.112)	(0.121)
Distance to capital	0.048	0.198	0.047	0.204	0.094	0.229	0.105	0.232	0.047	0.255	0.064	0.261
	(0.183)	(0.210)	(0.180)	(0.210)	(0.183)	(0.209)	(0.182)	(0.208)	(0.184)	(0.208)	(0.181)	(0.205)
Urbanization	0.006	0.005	0.004	0.004	0.019	0.019	0.019	0.019	0.008	−0.007	0.009	−0.007
	(0.029)	(0.031)	(0.029)	(0.031)	(0.029)	(0.031)	(0.029)	(0.031)	(0.030)	(0.031)	(0.030)	(0.031)
Gas/oil	0.373	0.275	0.324	0.240	0.383	0.298	0.355	0.276	0.352	0.162	0.311	0.129
	(0.422)	(0.432)	(0.418)	(0.429)	(0.423)	(0.429)	(0.419)	(0.425)	(0.412)	(0.425)	(0.407)	(0.421)
Mineral facilities	0.133	0.133	0.126	0.128	0.096	0.089	0.095	0.086	0.090	0.096	0.098	0.100
	(0.172)	(0.175)	(0.170)	(0.174)	(0.172)	(0.174)	(0.170)	(0.173)	(0.172)	(0.176)	(0.170)	(0.175)
Pre-colonial inst	−0.240**	−0.215*	−0.231*	−0.198	−0.252**	−0.231*	−0.248**	−0.229*	−0.242**	−0.233*	−0.238**	−0.231*
	(0.121)	(0.127)	(0.120)	(0.127)	(0.120)	(0.126)	(0.120)	(0.125)	(0.120)	(0.126)	(0.120)	(0.126)
SPI6	0.533**	0.538***			0.498**	0.495**			0.356*	0.374*		
	(0.207)	(0.208)			(0.221)	(0.223)			(0.196)	(0.199)		
SPI6$_{lag:1}$			0.773***	0.776***			0.714**	0.714**			0.561**	0.587**
			(0.298)	(0.298)			(0.313)	(0.317)			(0.279)	(0.287)
Improved sanitation (%)	0.013**	0.014***	0.013***	0.015***								
	(0.005)	(0.005)	(0.005)	(0.005)								
Improved water (%)					0.005	0.005	0.005	0.005				
					(0.004)	(0.004)	(0.004)	(0.004)				
Electricity (%)									0.008*	0.014***	0.007*	0.014***
									(0.004)	(0.005)	(0.004)	(0.005)
Improved sanitation (%) × SPI6	−0.041[a]	−0.044[b]										
	(0.027)	(0.027)										
Improved sanitation (%) × SPI6$_{lag:1}$			−0.061*	−0.080**								
			(0.036)	(0.041)								
Improved water (%) × SPI6					−0.006	−0.006						

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
					(0.005)	(0.005)						
Improved water (%) × SPI6$_{lag}$:1							−0.007	−0.007				
							(0.006)	(0.006)				
Electricity (%) × SPI6									−0.003	−0.005		
									(0.006)	(0.006)		
Electricity (%) × SPI6$_{lag}$:1											−0.003	−0.006
											(0.008)	(0.008)
Conflict history	2.950***	2.866***	2.943***	2.856***	2.933***	2.865***	2.934***	2.865***	2.931***	2.856***	2.931***	2.855***
	(0.367)	(0.369)	(0.366)	(0.368)	(0.367)	(0.369)	(0.366)	(0.369)	(0.365)	(0.369)	(0.365)	(0.369)
Spatial lag	3.789***	3.273***	3.790***	3.234***	3.849***	3.399***	3.871***	3.418***	3.855***	3.284***	3.854***	3.281***
	(0.796)	(0.804)	(0.795)	(0.803)	(0.796)	(0.804)	(0.796)	(0.803)	(0.795)	(0.803)	(0.795)	(0.803)
Constant	−10.895***	−15.520***	−11.055***	−15.685***	−11.699***	−15.941***	−11.798***	−16.023***	−10.700***	−16.728***	−10.908***	−16.881***
	(2.639)	(3.059)	(2.622)	(3.030)	(2.655)	(3.035)	(2.638)	(3.007)	(2.652)	(3.011)	(2.629)	(2.980)
Year-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-fixed effects	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Observations	3,336	3,336	3,339	3,339	3,324	3,324	3,327	3,327	3,336	3,336	3,339	3,339
Log Likelihood	−411.787	−404.382	−411.457	−403.392	−415.464	−408.892	−415.442	−408.844	−415.697	−406.657	−415.508	−406.414
Akaike Inf. Crit.	877.574	872.765	876.914	870.784	884.927	881.783	884.885	881.687	885.393	877.314	885.016	876.829

Note: a: p-value is 0.121; b: p-value is 0.104; *p<0.1; **p<0.05; ***p<0.01.