Supplemental Appendix
Rainfall Inequality, Political Power, and Ethnic Conflict in Africa

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Appendix A – Data

In this appendix we describe in more detail the data sources used in the analysis and the way the different variables were constructed. The exposition mirrors the structure of Section 2 in the main text.

A.1. Key Variables

Ethnic Power Relations Information on the power relationships across ethnic groups is taken from the Ethnic Power Relations (EPR) dataset provided by Girardin et al. (2015). The dataset contains disaggregated information on all politically relevant ethnic groups within a country, including their estimated size and their level of access to state executive power. As mentioned in the main text, the classification of ethnic groups is based on expert panels, which combine multiple national and international sources.[1]

The EPR dataset classifies each politically relevant ethnic group into one of three main categories of access to executive power, each one composed by two sub-categories. First, an ethnic group can rule alone, as a *Monopolist* or a *Dominant* group, depending on whether there is space for limited inclusion of other parties in the executive body or not. Second, a group can formally or informally share executive power with other ethnic groups, being either a *Senior Partner* or a *Junior Partner* in the arrangement. Finally, a group can be excluded from power, and thus be a *Powerless* or *Discriminated* group, depending on whether there is explicit active discrimination against it or not. Importantly, whenever political changes occurred in the same year as a conflict, the coding purposely reflects the power relations *before* the outbreak of the violence, to avoid endogeneity issues.

The EPR dataset can be directly matched with the GeoEPR map provided by Wucherpfennig et al. (2011), which records the spatial location of the ethnic groups. Importantly, the EPR dataset can also be linked to the Uppsala Conflict Data Program (UCDP) Actor Dataset (2014). In this way it is possible to know whether any rebel group that is included in the UCDP dataset and that has been involved in a civil conflict against the central state can be associated to a specific ethnic group. Ethnic groups ruling alone can never

[1] Ethnicity is defined as "*a subjectively experienced sense of commonality based on a belief in common ancestry and shared culture*". Politically relevant ethnic groups are those that either have at least one significant political actor claiming to represent their interests in the national political arena or are systematically and intentionally discriminated against in the domain of public politics (Girardin et al., 2015).

appear involved in any ethnic conflict according to this definition, as they can never fight the central state, which is under their sole control.

Rainfall & Growing season For our analysis, we rely on the ERA5 dataset, which contains rainfall data provided by the European Centre for Medium-Term Weather Forecasting (ECMWF) (Hersbach et al., 2023).[2] The dataset provides re-analysis of weather data, obtained through a 4D-Var climatic model (called IFS CY41R2) that harmonizes information from a variety of primary sources, which include weather stations, ships, aircraft, weather balloons, radiosondes, and satellites orbiting the earth (for more details, see Kållberg et al. (2004)). This appears to be one of the best available sources for historical and present African weather data, especially given the low quality of rainfall gauge data that are available for this region.[3] The ERA5 dataset provides rainfall information at twelve-hour frequency from 1950 until today, in gridded format at a resolution of 30 kilometer.

To construct rainfall during the *growing season*, we follow a similar approach as Kudamatsu et al. (2016). The main input is provided by the Normalized Difference Vegetation Index (NDVI) dataset provided by Tucker et al. (2005) and FEWS NET (2025), which contains bi-weekly measures of plant growth since January 1982, with a resolution of 8×8 km. More specifically, the NDVI dataset is generated using satellite images that record red and infra-red radiances and reflectances, which are highly correlated with photosynthetically active biomass, chlorophyll abundance, and energy absorption, and which therefore allow estimating plant growth on the hearth surface. We use TIMESAT – a software developed by Jönsson and Eklundh, two Swedish ecologists – to remove the noise from the NDVI data, due for instance to cloud cover. The program uses an adaptive Savitzky-Golay filtering method as well as methods based on upper envelope weighted fits to asymmetric Gaussian and double logistic model functions. From the fitted model functions a number of phenological parameters can be extracted, including the beginning and end of the growing season, which are defined as the time period in between 20 percent above one trough of the smoothed NDVI index to 20 percent above the next trough (see Jönsson and Eklundh (2004) for more details). This allows us to determine the growing season within each 8×8 km NDVI pixel. Given that year-specific variations in the growing season are endogenous to weather con-

[2]The dataset can be downloaded from `10.24381/cds.adbb2d47` (Accessed on 7 January 2026).

[3]See Kudamatsu et al. (2016) for a discussion of the advantages of this source over alternatives.

ditions (as farmers likely adapt their behavior according to the weather), we average start and end dates over the study period for each pixel.[4] Figures A.1 and A.2 illustrate the distribution of the average beginning and length of the growing season in the region of interest for our study. For the analysis, we then aggregate that fine-gridded NDVI-based measure at the 30 × 30 kilometer of our rainfall grid and we define a rainfall grid-cell specific growing season as the average growing season for that cell over the available years of datal. The yearly rainfall during the growing season for each ethnic group and each country is then obtained by overlaying the grids with the spatial ethnicity and administrative maps, as reported in Figure 1.

A.2. Additional Controls

Agricultural Output The measures of agricultural production are taken from FAO (2025), which records information on four key aggregates (cereals, crops, agriculture, and food) over the period 1961-2020.[5] Estimates are based on information collected from governments as well as from national and international agencies and organizations.[6] We consider gross production indexes, which record, for each category, the aggregate volume of production for each year relative to the base period 2001-2001. More specifically, production quantities of each commodity are weighted by 2014-2016 average international commodity prices and summed for each year; the aggregate for a given year is then divided by the average aggregate for the base period 2014-2016, to obtain

[4]Whenever more than one growing season is identified (which happens in 8.1 percent of the cases), we follow Kudamatsu et al. (2016) and focus on the first growing season of the year. Across our sample, 3.8 percent of the observations have no growing season at all, while 7.5 percent have a 12-months growing season.

[5]Production records for these four aggregates include the quantities of the commodities sold in the market (i.e. marketed production) and the quantities consumed or used by the producers (i.e. auto-consumption). Moreover, when calculating production indexes for agriculture and food, all intermediate primary inputs of agricultural origin are deducted. Finally, the category of food production includes all commodities that are considered edible and that contain nutrients, including commodities derived as a result of further processing.

[6]Governments have supplied most of the information in the form of replies to annual FAO questionnaires. Information supplied by other national or international agencies or organizations have also been used. According to FAOstat, to make the coverage as complete as possible, in some cases official governmental data are supplemented with data from unofficial sources.

the final index.

Temperature Information on temperature is provided by ECMWF, with the same frequency and format as information on rainfall. The construction of the temperature-based inequality measure closely mirrors the construction of the rainfall-based measures.

Malaria Prevalence In order to construct the index for malaria risk we follow again Kudamatsu et al. (2016). The index is based on a combination of four temperature and rainfall conditions that determine the ability of malaria parasites and vector to survive and regenerate. More specifically, we use monthly rainfall and temperature measures aggregated by grid-cell to generate a monthly indicator variable that takes on the value of 1 when the following four conditions are met: 1) average monthly rainfall in the previous 3 months is at least 60mm; 2) rainfall in at least one of these months is above 80mm; 3) no month in the previous 12 has an average temperature below 5°C; 4) The average temperature in the previous 3 months exceeds the sum of 19.5°C and the standard-deviation of monthly average temperature in the past 12 months (see Kudamatsu et al. (2016) for more details). For each grid-cell we then compute the share of months within a year in which the malaria-prevalence index takes on the value of 1. Finally, we take the weighted average of this measure across all grids covering an ethnic group homeland in order to obtain an ethnic-specific measure of malaria prevalence.[7]

[7]Weights refer to the share of the ethnic group homeland covered by each grid-cell and account for the fact that some cells do not fall completely within the ethnic borders.

References

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[2] **FEWS NET**. 2025. *USGS Early Warning data portal*. Available at https://earlywarning.usgs.gov/fews/ (Accessed on 7 January 2026).

[3] **Girardin, Luc, Philipp Hunziker, Lars-Erik Cederman, Nils-Christian Bormann, and Manuel Vogt.** 2015. *GROWup - Geographical Research On War, Unified Platform*. ETH Zurich. Available at https://www.prio.org/data/4 (Accessed on 7 January 2026).

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[7] **Kudamatsu, Masayuki, Torsten Persson, and David Strömberg.** 2016. Weather and infant mortality in Africa. *Mimeo*.

[8] **Tucker, Compton, Jorge Pinzon, Molly Brown, Daniel Slayback, Edwin Pak, Robert Mahoney, Eric Vermote, and Nazmi Saleous.** 2005. An Extended AVHRR 8-Km NDVI Dataset Compatible with MODIS and SPOT Vegetation NDVI Data. *International Journal of Remote Sensing*, 26(20): 4485-4498.

[9] **UCDP.** 2014. *UCDP Actor Dataset 2.2-2014*. Uppsala University.

[10] **Wucherpfennig, Julian, Nils Weidmann, Luc Girardin, Lars-Erik Cederman, and Andreas Wimmer.** 2011. Politically relevant ethnic groups across space and time: Introducing the

GeoEPR dataset. *Conflict Management and Peace Science*, 28(5): 423-437. Dataset available at `https://www.ecmwf.int/en/elibrary/10595-era-40-archive-revised-october-2007` (Accessed on 7 January 2026).

Figure A.1: Growing Season Start

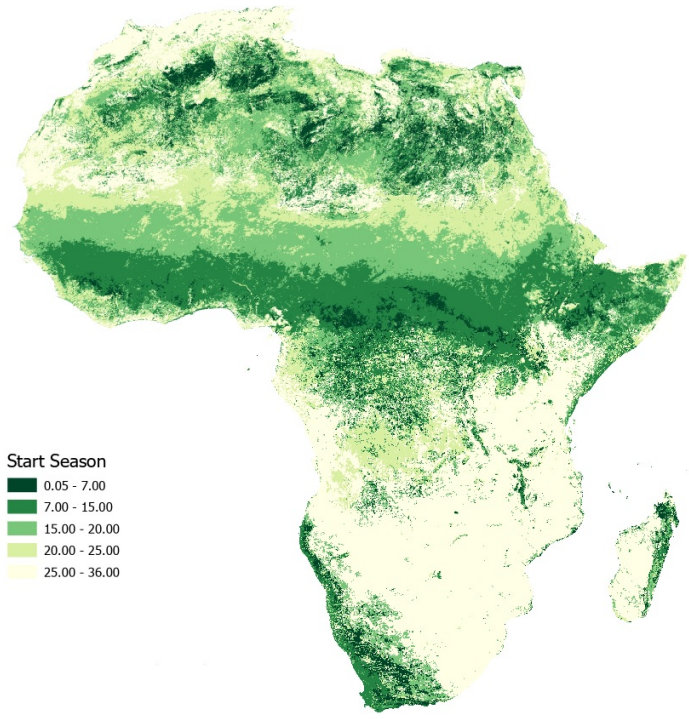


Figure A.2: Growing Season Length

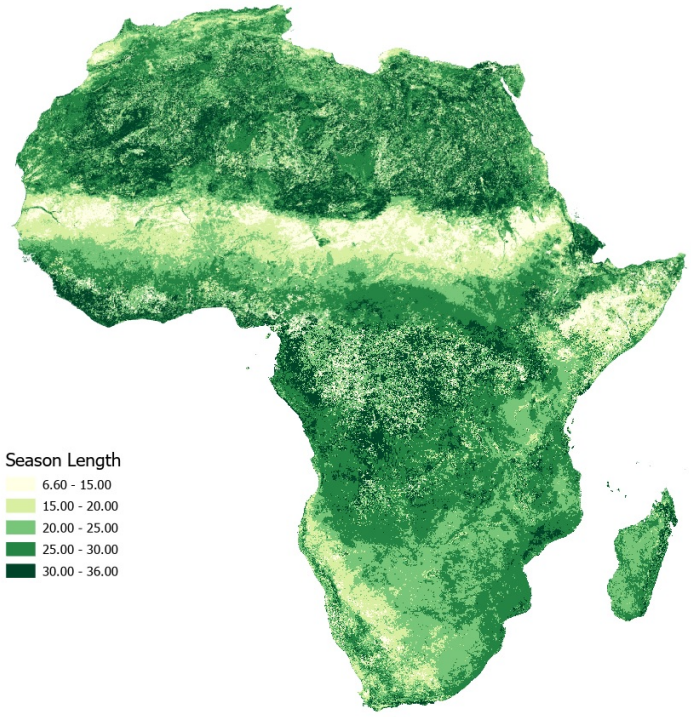


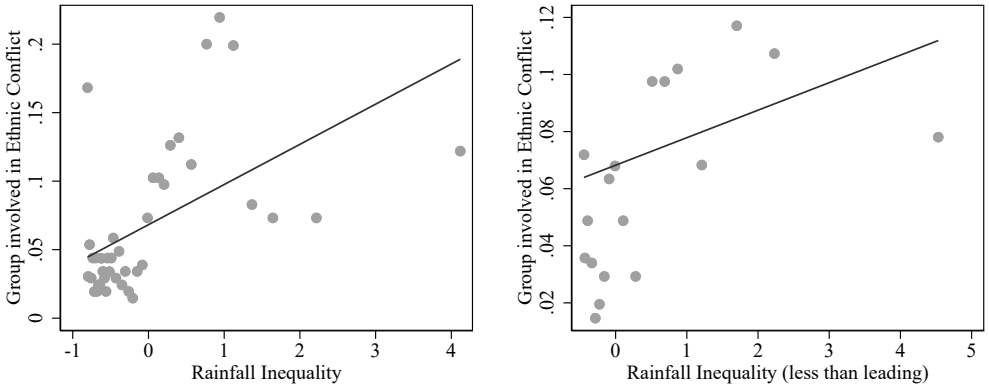
Table A.1: List of countries

	Total Years	# of Ethnic Groups
Algeria	59	2
Angola	46	5
Benin	59	4
Botswana	55	8
Burundi	51	2
Cameroon	61	6
Central African Republic	58	5
Chad	60	5
Congo	61	6
Cote D'Ivoire	61	5
Democratic Republic of the Congo	44	12
Djibouti	44	2
Egypt	71	2
Equatorial Guinea	53	5
Eritrea	28	5
Ethiopia	70	9
Gabon	61	5
Gambia	29	4
Ghana	64	5
Guinea	62	3
Guinea-Bissau	30	3
Kenya	45	8
Liberia	60	5
Libya	70	4
Madagascar	42	2
Malawi	57	3
Mali	61	3
Mauritania	61	4
Morocco	65	3
Mozambique	40	3
Namibia	25	11
Niger	60	5
Nigeria	61	6
Rwanda	59	2
Senegal	61	5
Sierra Leone	52	4
South Africa	70	13
South Sudan	10	10
Sudan	65	16
Tanzania	56	5
Togo	61	2
Uganda	54	8
Zimbabwe	41	4

Notes: The table lists all countries included in the main analysis. For each country, the table indicates the number of years within the study period (1950-2020) in which the country appears in the sample and the number of politically relevant ethnic groups whose boundaries are located within each country (from the dynamic GeoEPR map).

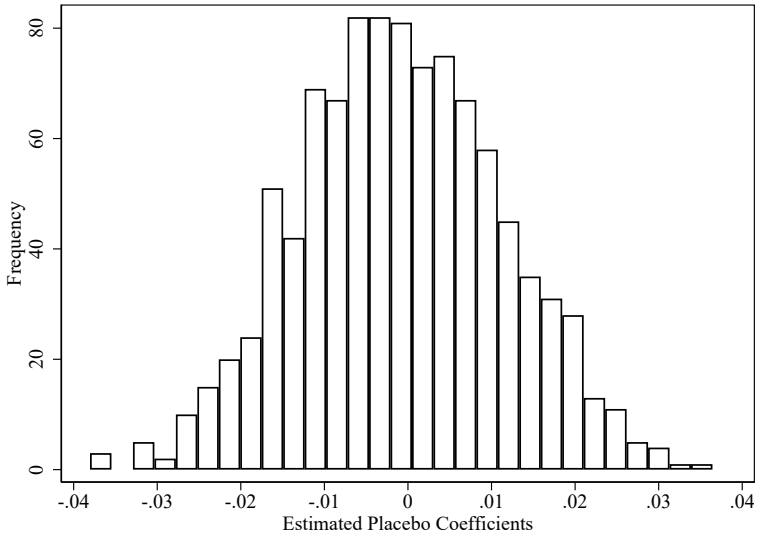
Appendix B – Additional Figures and Tables

Figure B.1: Rainfall Inequality and Ethnic Conflict



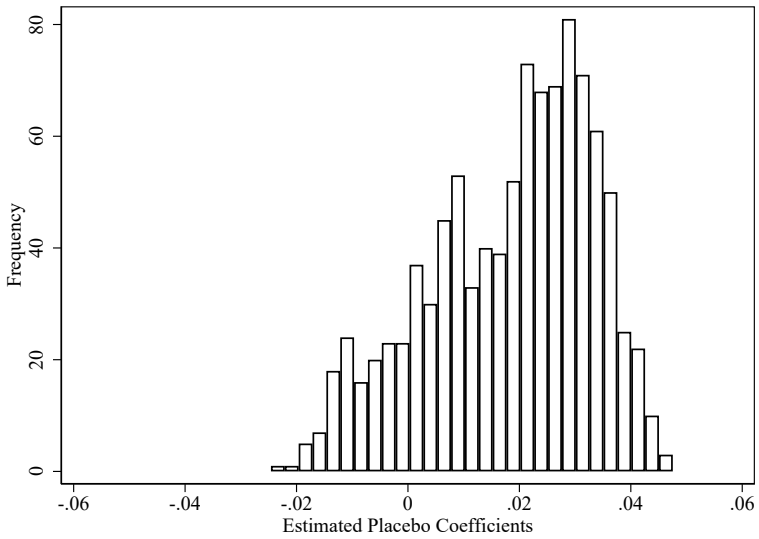
Notes: The graphs illustrate the unconditional relationship in the sample between Ethnic Conflict and RI_i^{power} (left) or RI_i^{power-} (Right). Dots indicate averages across equal-size bins. A linear regression line based on the ungrouped data is also shown.

Figure B.2: Placebo with random redefinition of ethnic groups boundaries



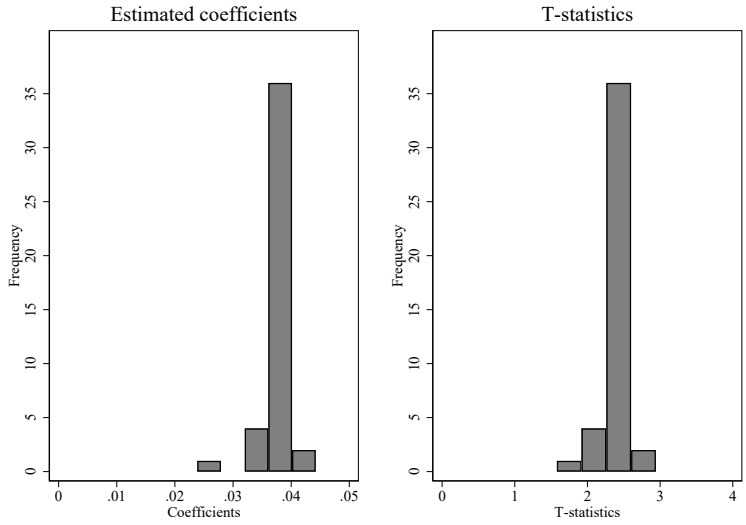
Notes: The figure reports the distribution of the coefficients of an alternative placebo RI_i^{power} measure, constructed by randomly redrawing the ethnic boundaries, fixing the original area distribution. The random re-drawing was repeated 1000 times and each time we run a regression based on the specification reported in column 4 of Table 2, where we replace the original measure with the placebo one.

Figure B.3: Placebo with random distribution of power across ethnic groups



Notes: The figure reports the distribution of coefficients of a placebo RI_i^{power} measure, constructed by randomly re-assigning the identity of the group in power within the country (while keeping constant the number of switches in power over the study period). The random assignment was repeated 1000 times and each time we run a regression based on the specification reported in column 3 of Table 2, where we replace the original measure with the placebo one.

Figure B.4: RI_i^{power} estimates dropping one country at a time



Notes: The figure reports the distribution of the coefficients on Rainfall Inequality RI_i^{power} (left) and of the associated t-statistics (right), when dropping one country at a time. The estimate is based on the specification reported in column 4 of Table 2.

Table B.1: Summary statistics – Additional Variables

	Mean	Min	Max	Std.dev.	Obs
PANEL 1: Ethnicity-Level Measures					
Rainfall, growing season	2.79	0.00	11.31	2.01	8208
Rainfall, non-growing season	0.41	0.00	4.15	0.49	8208
Rainfall SD, growing season	0.00	−3.80	5.19	0.98	8208
Rainfall SD, non-growing season	−0.00	−3.31	5.62	0.99	8208
Oil share	0.06	0.00	1.00	0.19	8208
PANEL 2: Country-Level Measures					
Agriculture, gross production index	60.67	10.15	180.19	29.85	1952
Cereals, gross production index	62.23	6.14	337.13	36.52	1895
Crops, gross production index	59.73	5.73	208.20	30.88	1952
Food, gross production index	59.57	9.74	181.51	30.28	1952

Notes: **Oil Share** is constructed following Morelli and Rohner (2015) and indicates the share of the country's surface covered with oil and gas that falls within the ethnic group's territory. ***Panel 2*** includes variables used in Table B.2, defined at the country level.

Table B.2: Validation check

Dependent Variable:	Cereals Gross Production Index		Crops Gross Production Index		Agriculture Gross Production Index		Food Gross Production Index	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rainfall, growing season	22.915***	22.831**	13.926***	13.764***	8.640***	7.786**	9.019***	7.889**
	(6.799)	(9.938)	(4.389)	(5.185)	(2.927)	(3.749)	(3.040)	(3.933)
Rainfall, non-growing season		0.421		0.793		4.182		5.534
		(20.444)		(7.510)		(6.197)		(6.575)
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
R^2	0.70	0.70	0.86	0.86	0.89	0.89	0.90	0.90
N	1895	1895	1952	1952	1952	1952	1952	1952

Note: Production indexes are taken from FAO and record the relative level of the aggregate volume of production for each year in comparison with the base period 2014-2016. They include both marketed production and auto-consumption. When calculating indexes of agricultural and food production, all intermediate primary inputs of agricultural origin are deducted. Food production includes commodities that are considered edible and that contain nutrients and includes commodities derived as a result of further processing. The sample includes available data for 42 African countries and 60 years (1961-2020). Two-way clustered standard errors by year and country in parentheses. The average rainfall variables have been transformed using inverse hyperbolic sine. The p-values at the bottom of the table refer to the test of the null hypothesis of equal effect between average rainfall during the growing vs. non-growing season. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table B.3: Relationship between rainfall and likelihood to be *leading* group

Dependent Variable:	Ethnic group is *leading* group					
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall, growing season	0.002	−0.003				
	(0.008)	(0.007)				
Rainfall, non-growing season	−0.034	−0.048				
	(0.042)	(0.037)				
Rainfall, growing season (t-1)		−0.006				
		(0.006)				
Rainfall, non-growing season (t-1)		0.010				
		(0.032)				
Rainfall, growing season (t-2)		−0.003				
		(0.006)				
Rainfall, non-growing season (t-2)		0.044				
		(0.033)				
Rainfall SD, growing season			0.000	−0.001		
			(0.003)	(0.003)		
Rainfall SD, non-growing season			−0.007	−0.008**		
			(0.004)	(0.004)		
Rainfall SD, growing season (t-1)				−0.002		
				(0.002)		
Rainfall SD, non-growing season (t-1)				−0.002		
				(0.003)		
Rainfall SD, growing season (t-2)				−0.001		
				(0.003)		
Rainfall SD, non-growing season (t-2)				0.001		
				(0.004)		
Oil share					0.096	
					(0.072)	
Hectars of Crops Harvested (circa 2000)						0.000
						(0.000)
Year FE	yes	yes	yes	yes	yes	no
Country-Ethnicity FE	yes	yes	yes	yes	yes	no
Leader FE	yes	yes	yes	yes	yes	no
Country FE	no	no	no	no	no	yes
R^2	0.80	0.81	0.80	0.81	0.80	0.46
Ethnicities	250	249	250	249	250	
Countries	43	43	43	43	43	
N	10511	9923	10511	9923	10511	214

Note: The dependent variable is an indicator that takes on the value of 1 if the ethnic group is a leading ethnic group in the country. **Oil Share** is constructed following Morelli and Rohner (2015) and indicates the share of the country's surface covered with oil and gas that falls within the ethnic group's territory. Regression 6 only includes a cross-section of the 217 ethnic groups that were active over the period 1995-2005; the dependent variable in that case captures whether the ethnic group was ever in power during any of those years, while **Hectares of Crops Harvested** captures the total amount of hectares harvested with the 5 main crops (millet, maize, rice, sorghum, or wheat), divided by the ethnic homeland size, as recorded around 2000. The original data comes in gridded format with 10km x 10km resolution. See Monfreda, Ramankutty, and Foley (2008) for more details on the data. The full sample includes 250 ethnic groups, 43 countries, and 71 years. Two-way clustered standard errors by year and country in parentheses, with the except of column 6 where they are clustered by country only. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table B.4: Robustness Checks II

Dependent Variable:	Rebel group fighting in the name of the ethnic group				
Specification:	Probit		*OLS*		
Sample:	Full Sample				SSA
	(1)	(2)	(3)	(4)	(5)
RI^{power}, growing season	0.326***	0.366***	0.040**	0.037**	0.035**
	(0.073)	(0.121)	(0.018)	(0.015)	(0.016)
Oil share				0.045	
				(0.055)	
Year FE	yes	yes	yes	yes	yes
Country-Ethnicity FE	yes	yes	yes	yes	yes
Leader FE	no	yes	yes	yes	yes
Group-Dyad FE	no	no	yes	no	no
R^2	.	.	0.44	0.39	0.39
Ethnicities			223	223	216
Countries			43	43	39
N	2604	2388	8208	8208	7815

Note: The dependent variable is an indicator that takes on the value of 1 if there is a rebel group fighting the central state in the name of the ethnic group. Leading groups are excluded from the analysis. **RI^{power}** indicates Rainfall Inequality between an ethnic group and the *leading* group, normalized by the average rainfall in the country. All inequality variables have been standardized. **Oil Share** indicates the share of the country's surface covered with oil and gas that falls within the ethnic group's territory. Regressions 1 and 2 use a probit model instead of OLS. Regression 4 only considers Sub-Sahara African (SSA) countries. *Basic Controls* include rainfall and temperature during the growing season. The full sample includes 223 ethnic groups, 43 countries, and 71 years. Two-way clustered standard errors by year and country in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table B.5: Channels II

Dependent Variable:	Rebel group fighting in the name of the ethnic group					
"Excluded" Definition:	*Full*	*No Self-Exclusion*	*No Discrimination*	*Full*	*No Self-Exclusion*	*No Discrimination*
	(1)	(2)	(3)	(4)	(5)	(6)
RI^{power}, growing season	−0.010	−0.011	0.015	−0.019	−0.020	0.007
	(0.014)	(0.013)	(0.010)	(0.018)	(0.018)	(0.014)
Excluded × RI^{power}	0.050***	0.050***	0.040**	0.045***	0.045***	0.037**
	(0.013)	(0.012)	(0.018)	(0.011)	(0.011)	(0.014)
Excluded × RI^{power} × Exceptional Rain				−0.006	−0.001	−0.009
				(0.044)	(0.044)	(0.040)
Year FE	yes	yes	yes	yes	yes	yes
Country-Ethnicity FE	yes	yes	yes	yes	yes	yes
Leader FE	yes	yes	yes	yes	yes	yes
R^2	0.44	0.45	0.45	0.44	0.45	0.45
Ethnicities	223	223	195	223	223	195
Countries	43	43	42	43	43	42
N	7982	7971	6538	7982	7971	6538

Note: The dependent variable is an indicator that takes on the value of 1 if there is a rebel group fighting the central state in the name of the ethnic group. Leading groups are excluded from the analysis. **RI^{power}** indicates Rainfall Inequality between an ethnic group and the *leading* group, normalized by the average rainfall in the country. All inequality variables have been standardized. **Excluded** is an indicator variable that takes on the value of 1 if the ethnic group was excluded from political power the previous year. The sample in columns 2 and 5 excludes ethnic groups that classify as "self excluded" from power, while the sample in columns 3 and 6 excludes also groups that are openly discriminated against. **Exceptional rain** is an indicator variable that takes on the value of 1 when the homeland of the ethnic receives an amount of rainfall during the growing season that is more than 2 SD away from the average over the period 1950-2020 *Basic Controls* include rainfall and temperature during the growing season. All components of the interaction terms are always included in the regressions, although they are sometimes omitted. The sample includes 223 ethnic groups, 43 countries, and 71 years. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Appendix C – Country Level Analysis

The analysis in the main text is run at the (country-)ethnicity level. This enabled us to run the rich empirical model described in section 3, where, among other things, we control for any ethnic-specific factors, achieving what we believe to be a much stronger identification than what has been typically possible in the previous literature on inequality and conflict, which mostly relied on country-wide (and often time-invariant) measures of inequality (e.g., Østby, 2008; Lessman and Steinkraus, 2019). However, in order to speak more closely to this literature, in this appendix we turn our discussion of the linkages between rainfall inequality, ethnic conflicts, and power relations to the more aggregated country-level. We start by detailing the new dataset that we use for the country-level analysis, we then describe our empirical strategy, and finally present the results. Overall, the country level results mirror our findings at the ethnicity level and pass a similar set of robustness and placebo checks.

C.1. Data

Ethnicity For our main analysis at the country level we rely on the definition and location of ethnic groups provided by the Geo-Referencing of Ethnic Group (GREG) map from Weidman et al. (2010). The map was created by digitalizing and merging the 57 maps that constitute the *Soviet Atlas Narodov Mira*, which describes the spatial distribution of 928 ethnic groups around the world as of the early 60s. The *Soviet Atlas* combines a number of different sources, such as population census data, ethnographic publications of government agencies, and geographic maps assembled by the institute of Ethnography at the USSR Academy of Science. Although there is no official definition of ethnic group in the original dataset, the classification has been recently validated by looking at ethnic intermarriages: ethnic groups defined in the Atlas are mostly endogamous, although in some cases further endogamous subgroups could be identified – i.e., ethnic divisions appear to be underreported (Bridgman, 2008). The advantage of this dataset, compared to the EPR dataset used in the main text, is that it contains more ethnicities and less empty gaps (as visible from comparing Figure C.1 and Figure 1), which allows for a richer construction of our country-wide ethnic inequality variable. The downside (and the reason why we did not use it in the main text) is that it does not contain information on access to political power.[1] Our main dataset at the country level includes

[1]This is also the reason why, whenever discussing the role of power relations, we will have to shift to the EPR dataset even in this section.

217 ethnicities across 45 countries (see Table C.1). Whenever an area is assigned to multiple ethnicities, we assume them as having equal size over that area. While using historic ethnic homelands addresses endogeneity concerns, one might wonder how the ethnic distribution changed over time and how well the *Soviet Atlas* map reflects more recent ethnic diversity in Africa. There are a number of studies suggesting that migration patterns are unlikely to have significantly reshaped the overall location of the main ethnic groups, even after major conflict episodes, such as those in Sierra Leone or Rwanda (Glennerster et al., 2013; UN, 1996). Moreover, if anything, a low accuracy of the data should add noise to our estimations, biasing our results downwards.

Conflicts To construct our dependent variable for this extended sample of countries, we rely on the Ethnic Armed Conflict (EAC) dataset created by Cederman et al. (2012). The dataset builds on the conflicts recorded by the Armed Conflict Data database developed by the International Peace Research Institute of Oslo and the University of Uppsala (Gleditsch et al., 2002). The PRIO/Uppsala database records all conflicts with a threshold of 25 battle deaths per year, since 1946. An armed conflict is defined as a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths within a year. The dataset records information at the country level on a yearly basis and, among other things, distinguishes between civil and interstate conflicts. For each civil conflict included in the PRIO/Uppsala database the EAC dataset identifies whether: 1) the armed organizations involved explicitly pursued ethno-nationalist aims, motivations, and interests and 2) they recruited fighters and forged alliances on the basis of ethnic affiliations.[2] We generate an indicator variable for the presence of an ethnic conflict in a country in a given year, if the two conditions listed above are fulfilled.[3]

[2]The EAC dataset is based on version 3-2005b of the PRIO/Uppsala dataset. Cederman et al. (2012) introduced few corrections in their dataset: 1) the EAC dataset does not consider as civil conflicts the 1975-1989 conflict in West Sahara (a territory not recognized in the COW state system), the 1966-1988 conflict in South Africa (as it is the Namibian war of independence) and the 1962-1991 conflict in Ethiopia (as it is the Eritrean war of independence), which are therefore also excluded from our analysis; 2) there are few corrections in the coding of conflicts in Chad, and also in this case we follow the EAC approach for consistency; 3) there are a few changes in the sub-IDs coding, which we were able to harmonize thanks to the support kindly provided by the authors.

[3]This is the same criterion used by the authors to define an ethnic conflict. The two conditions are in any case always jointly satisfied, with the only exception of Ethiopia between 1996 and 1999, when only condition 1 is satisfied. Considering this conflict as

Other Controls In the robustness check section, we also consider a set of additional variables that have been found to affect conflict prevalence. While acknowledging that some of these variables are likely endogenous to conflict itself, we will show that our findings remain very robust to their inclusion. Data on *population*, *GDP per capita* (at 2017 constant prices) and data on *imports* and *exports* are taken from Penn World Table 10.0 (Feenstra et al., 2022). Data on *institutional quality* is taken from the Polity IV database, provided by the Center for Systemic Peace (Marshall, 2017).[4] Figures on *aid inflows*, recorded as gross disbursement in constant USD dollars, are taken from the Creditor Reporting System database kept by the OECD (2025).[5] Information on *natural disasters* is taken from the Emergency Events Database (EM-DAT) kept by the Centre for Research on the Epidemiology of Disasters (EM-Dat, 2025).[6] Finally, information on the geographic location and discovery date of *oil and gas fields* is taken from the PETRODATA dataset, provided by

ethnic leaves our results unaffected (available on request).

[4]The standard polity IV index is constructed combining two comprehensive variables: 1) the democracy indicator, which is an additive eleven-point scale (0-10) variable derived from coding of the competitiveness of political participation, the openness and competitiveness of executive recruitment and constraints on the chief executive. 2) the autocracy indicator, which is another additive eleven-point scale (0-10) variable derived from coding of the competitiveness of political participation, the regulation of participation, the openness and competitiveness of executive and constraints on the chief executive. The final index is computed by subtracting the autocracy score from the democracy score; the resulting unified polity scale ranges therefore from +10 (strongly democratic) to -10 (strongly autocratic). See Marshall et al. (2017) for further details.

[5]The database records worldwide flows in Official Development Assistance (ODA) since 1973, disaggregated by donor, recipient and purpose. In order to construct our variable we aggregate all flows received by each country in a given year. ODA is defined as *"those flows to developing countries and multilateral institutions provided by official agencies, including state and local governments, or by their executive agencies, each transaction of which meets the following tests: i) it is administered with the promotion of the economic development and welfare of developing countries as its main objective; and ii) it is concessional in character and conveys a grant element of at least 25 per cent."*

[6]The EM-DAT dataset records all natural disasters since 1900 that fulfill at least one of these four criteria: 1) 10 or more people reported killed; 2) 100 or more people reported affected; 3) declaration of a state of emergency; 4) call for international assistance. For each disaster the database combines information from different sources, including UN agencies, non-governmental organizations, insurance companies, research institutes, and press agencies, and reports, among other things, the number of people that died, the number of people affected and the estimated total damages. We define our variable as the total number of individuals affected by the natural disaster, obtained by summing up the number of individuals that died (which includes missing individuals), were injured, lost their house and/or required basic survival needs (such as food, water, shelter, sanitation or immediate medical assistance) as a consequence of the disaster.

Lujala et al. (2007).[7] Overall, given the coverage of the different sources and datasets, we are left with a (balanced) sample of 45 countries, covering the 46 years from 1960 to 2005. Summary statistics are reported in Table C.2.

C.2. Empirical Strategy

We start by constructing a yearly measure of rainfall inequality between ethnic groups living within the same country, to study the impact of rainfall inequality on ethnic conflicts, abstracting from power relations. More specifically, our measure of Between-Group Rainfall Inequality (BGRI) is inspired by the standard Gini coefficient and is calculated for each country and year as

$$BGRI_{c,t} = \frac{1}{2\bar{r}_{c,t}} \sum_{i=1}^{E} \sum_{j=1}^{E} n_i n_j \mid r_{i,c,t} - r_{j,c,t} \mid, \tag{C.1}$$

where E indicates the number of ethnic groups whose homeland is located within the country c, n_i is the relative size of ethnic group i,[8] $r_{i,c,t}$, is, as above, the amount of rain that fell over ethnic group i's homeland during the year, and $\bar{r}_{c,t}$ is the average amount of rain that fell over the whole country during the year (to allow for cross-country comparisons).

Main Specification Our main specification investigates the relationship between rainfall-based inequality and the prevalence of ethnic conflict at the country level. We therefore estimate

$$EthnicConflict_{c,t} = \lambda BGRI_{c,t} + \Psi \mathbf{X}_{c,t} + \tau_c + \phi_t + \kappa_c t + \eta_{c,t}, \tag{C.2}$$

where the dependent variable is an indicator taking on the value of 1 if country c experienced ethnic conflict in year t, $BGRI$ is our rainfall-based inequality measure, and $\mathbf{X}_{c,t}$ is a vector of controls that will be detailed below. Compared to our analysis at the ethnicity level, we clearly cannot include any ethnic-level control, but we nevertheless include a rich set of fixed effects. Country fixed effects τ_c capture characteristics, such as history, topography, the colonial past, culture, or institutions that do not change over time (or do so only over a longer time horizon than the one considered here). We we also include year

[7] Two different datasets are available for onshore and offshore fields. For our analysis, we focus on onshore fields.

[8] In cases in which different ethnic groups' homelands overlap, we equally divide the overlapping area among the different groups, thus assuming they have equal size over that area.

fixed effects ϕ_t and country-specific linear time trends $\kappa_c t$ to control for time-specific common shocks across the African continent, as well as for country-specific trends and dimensions that change smoothly over time (e.g. years since independence). Finally, $\eta_{c,t}$ is the error term. Again, we allow standard errors to be correlated over time for the same country and across countries for the same year.

C.3. Main Results

Our first results are reported in Table C.3. Regression 1, without any controls, shows a positive relationship between BGRI and ethnic conflict prevalence, with a point estimate of 0.385, statistically significant at the 95 percent confidence level. When we add the full set of country and year fixed effects, as well as country-specific linear time trends (regression 2), the relationship strengthens both in magnitude (0.405) and significance. The estimated effect is large: considering the full sample, one standard-deviation increase in BGRI (equal to 0.18) leads to a 7.3 percentage point increase in ethnic conflict prevalence, which implies a 60 percent increase in ethnic conflict prevalence compared to the average prevalence in the sample (12 percent). Figure C.2 graphically illustrates the positive relationship between BGRI and ethnic conflict across the sample.

The effect of BGRI also shows some time persistence. The coefficient on lagged inequality is relatively large up to two years in the past, and significant at conventional levels for the first lag (regression 3). As also shown in the main paper, the effects are not simply driven by local rainfall levels or by country-specific climatic conditions: both regressions 2 and 3 control for the average rainfall and temperature in the country.

Falsification Tests We next perform a number of falsification tests, reported in the first columns of Table C.4. These tests closely resembles the ones we present in the main paper. In particular, neither inequality based on rainfall outside of the growing season nor rainfall inequality in year $t + 1$ have any significant effect on ethnic conflict prevalence in year t (regressions 2 and 3). Besides, the data at the country level allows to perform two additional tests. First, since our measure focuses on ethnic inequality, it should not be able to predict non-ethnic conflict.[9] In line with this conjecture, regression 1

[9]Note that, by definition, we do not have information on non-ethnic conflict at the ethnicity level.

shows that when we replace the dependent variable with an indicator for civil conflicts that are not classified as ethnic by the EAC dataset, the estimate becomes statistically insignificant and, if anything, negative.

An additional concern is that the ethnic homelands map might simply be picking up administrative unit boundaries, potentially affecting the interpretation of our results. To ease this concern we re-compute the BGRI measure using the 1990 level 1 administrative borders (typically corresponding to regions or districts) provided by GAUL. A horse-race with our original ethnicity-based measure is clearly lost (regression 4).

Finally, we show once more that we cannot replicate the results when using 1000 randomly-drawn country boundaries (fixing the original area distribution) to recalculate our BGRI measure. The distribution of the estimated coefficients is reported in Figure C.3, which shows that only 6.1 percent of the placebo estimates are larger (in absolute value) than the estimate of the corresponding true-boundary measure.

Robustness checks We next run a set of robustness checks. The tests again closely resembles the ones in the main paper and results are again reported in Table C.4. In particular, results are robust to controlling for the share of ethnic groups in the country that received an unusually high amount of rain (i.e., 2 standard-deviations above the average), lagged conflict, and our measure of malaria prevalence.

In Table C.5, we perform a number of additional robustness checks and show that our results are robust to: 1) using a probit model; 2) adding a rich set of additional controls, such as GDP per capita, population size, years of peace, share of imports and exports, gross aid inflows, an indicator for whether a country is autocratic (POLITY IV score below -5), the total number of people affected by natural disasters, an inequality measure based on oil and gas resources, the share of neighboring countries with an ongoing ethnic conflict and the share of neighboring countries with an autocratic regime as well as the lags of all these variables; 3) restricting the sample to Sub-Saharan Africa. As an additional check, we also re-run our regression, dropping one country at a time. Despite the relatively small number of countries in the sample, the coefficient of interest remains stable and statistically significant throughout, ranging from 0.33 to 0.48 (Figure C.4).

The Role of Ethnic Power Relationships The analysis conducted so far at the country level revealed a strong link between inequality in the distribution of rainfall between ethnic groups and ethnic conflict prevalence. Our main analysis conducted at the ethnicity level, however, focused more specifically

on the role of access to political power. In this last section we therefore move to discuss how the observed relationship between inequality and conflict depends on the distribution of political power across the different ethnic groups. In order to do so, we have to revert back to the use of the EPR dataset, despite its smaller coverage, as it is the only dataset that provides information on the power relations between ethnic groups.

As a first step, we check whether our cross-country results obtained with the GREG data are confirmed also when using the GeoEPR data, despite the different definition of ethnicity and the smaller coverage. Table C.6 reports the estimates. Regression 1 shows that the estimated coefficient on BGRI is similar in magnitude to what we obtained with the GREG dataset (0.065), although it is less precisely estimated.

But in order to understand how rainfall inequality interacts with political inequality, with the EPR data we can now take ethnic power relations explicitly into account. As we did in the main analysis, we identify the *leading* group within a country as the one that either rules alone (i.e., is *Dominant* or *Monopolist*) or is *Senior Partner* in settings where a power sharing agreement is in place. We then re-compute the BGRI measure by only considering rainfall differences between the leading ethnic group in the country and the other groups. We then rerun regression (C.1) using the new "power-adjusted" inequality measure.

Regression 2 shows that the new measure has a large and significant effect on ethnic conflict prevalence. Next, we run two additional horse races between the power-adjusted measure and the simple BGRI measure (column 3) or with an alternative BGRI measure where instead of defining the leading group based on political power, we define it based on the size (column 4).[10] The point estimate on the power-adjusted measure remains positive, large, and significant, whereas the other two measures clearly appear to have no independent effect on ethnic conflict prevalence. These tests thus confirm that it is political power that matters and that inequality with respect to the leading group is what drives the results.

[10]The correlation between the standard BGRI measure and the power-based measure is 0.79.

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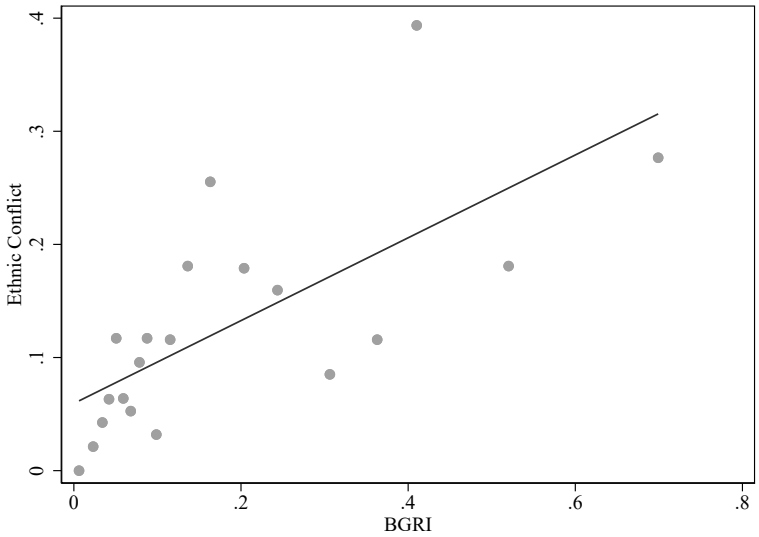
Figure C.1: Dataset construction – GeoEPR

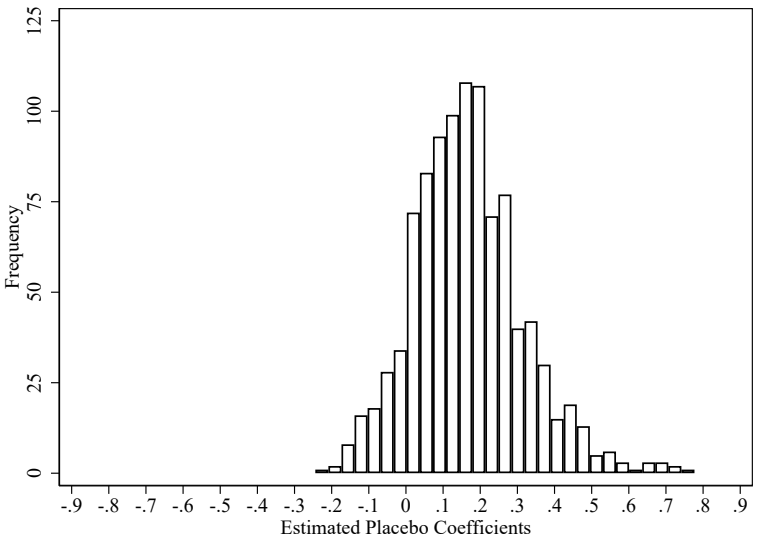
Notes: The figure shows how we constructed the dataset, by spatially merging three different data sources: the ECMWF rainfall grid with resolution 30 km $\times$ 30 km, the GREG map of ethnic homeland boundaries (gray lines), and an administrative map of Africa (red lines). Areas in white are excluded from the analysis because lack of data.

Figure C.2: BGRI and Ethnic Conflict



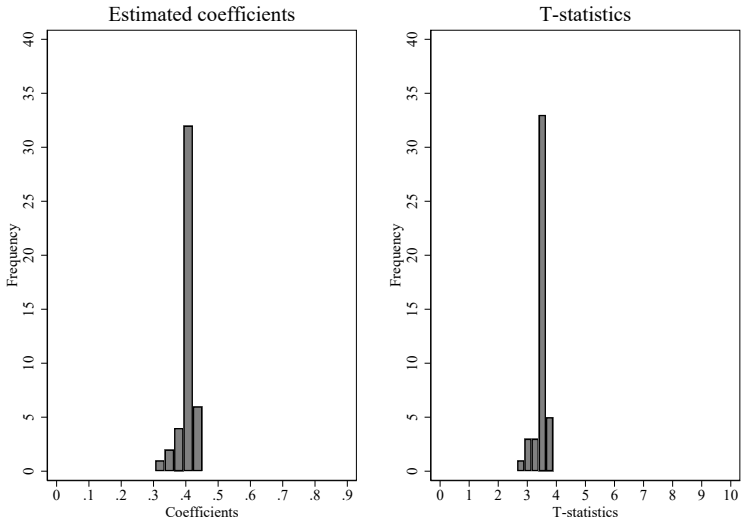
Notes: The graph illustrates the unconditional relationship between Ethnic Conflict and Between-Group Rainfall Inequality (BGRI). Dots indicate averages across equal-size bins. A linear regression line based on the ungrouped data is also shown.

Figure C.3: Placebo with random redefinition of boundaries



Notes: The figure reports the distribution of the coefficients of an alternative "placebo" BGRI measure, constructed by randomly redrawing the GREG ethnic boundaries, fixing the original area distribution. The random re-drawing was repeated 1000 times and each time we run a regression based on our main specification reported in column 2 of Table C.3, where we replace the original measure with the placebo one.

Figure C.4: BGRI estimates dropping one country at a time



Notes: The figure reports the distribution of the coefficients on Between-Group Rainfall Inequality (BGRI) (left) and of the associated t-statistics (right), when dropping one country at a time. The estimate is based on the main specification reported in column 2 of Table C.3.

Table C.1: List of Countries – Country-level analysis

	Total Years	Years of Ethnic Conflict	Years of Non-Ethnic Conflict	# of Ethnic Groups
Algeria	46	0	15	8
Angola	46	29	0	13
Benin	46	0	0	9
Botswana	46	0	0	6
Burkina Faso	46	0	1	15
Burundi	46	15	0	2
Cameroon	46	1	0	20
Central African Republic	46	2	0	11
Chad	46	22	12	17
Congo	46	6	0	10
Cote D'Ivoire	46	3	0	12
Democratic Republic of the Congo	46	5	9	31
Djibouti	46	0	0	1
Egypt	46	0	6	4
Equatorial Guinea	46	0	0	4
Eritrea	46	0	3	10
Ethiopia	46	26	15	17
Gabon	46	0	1	7
Gambia	46	0	1	3
Ghana	46	0	3	12
Guinea	46	0	3	10
Guinea-Bissau	46	0	2	9
Kenya	46	0	1	16
Liberia	46	12	0	9
Libya	46	0	0	4
Malawi	46	0	0	5
Mali	46	2	0	10
Mauritania	46	0	0	4
Morocco	46	0	1	6
Mozambique	46	16	0	9
Namibia	46	0	0	8
Niger	46	4	0	11
Nigeria	46	6	0	27
Rwanda	46	11	0	2
Senegal	46	10	0	11
Sierra Leone	46	0	10	6
Somalia	46	0	19	4
South Africa	46	8	0	13
Sudan	46	33	1	30
Tanzania	46	0	0	30
Togo	46	2	0	11
Tunisia	46	0	1	4
Uganda	46	19	9	14
Zambia	46	0	0	11
Zimbabwe	46	8	0	10

Notes: The table lists all countries included in the sample, which covers the period 1960-2005. For each country, the table indicates the number of years within the study period in which the country experienced a *civil* conflict – defined as an armed conflict between the government of the state and one or more internal opposition group(s) that caused at least 25 battle-related deaths within that year. The table distinguishes between ethnic and non-ethnic civil conflicts. The list of civil conflicts and the classification of ethnic or non-ethnic conflict is based on the Ethnic Armed Conflict (EAC) dataset provided by Wimmer et al. (2009). The number of ethnic groups whose boundaries are located within each country is taken from the GREG map.

Table C.2: Summary statistics – Country-level analysis

	Mean	Min	Max	Std.dev.	Obs
A. Conflict					
Ethnic Conflict	0.12	0.00	1.00	0.32	2070
Non-Ethnic Conflict	0.05	0.00	1.00	0.23	2070
B. Inequality Variables					
BGRI, growing season	0.17	0.00	1.00	0.18	2070
BGRI, non-growing season	0.33	0.00	1.00	0.24	2070
BGRI, growing season, adm units	0.29	0.01	1.00	0.23	2070
C. Other Control Variables					
Rainfall, growing season	3.18	0.02	10.95	2.15	2070
Rainfall growth, growing season	0.04	−0.92	8.62	0.37	2025
Share groups with rain>2SD	0.02	0.00	1.00	0.11	2070
Temperature, growing season	23.90	14.14	28.77	2.90	2070
Malaria prevalence index	0.61	0.00	1.00	0.32	2070
GDP per capita (log)	10.12	6.78	14.14	1.48	1897
Population (log)	2.53	0.16	5.63	1.20	1897
Share of exports	0.13	0.00	0.89	0.14	1897
Share of imports	−0.16	−2.18	−0.00	0.17	1897
Individuals affected by natural disasters (log)	3.56	0.00	17.66	5.22	2070
Institutional quality POLITY IV	0.29	0.00	1.00	0.28	1885
Oil and Gas Gini	0.15	0.00	1.00	0.25	2070
Ethnic Conflict in neighboring countries (share)	0.16	0.00	1.00	0.24	2070
Inst quality in neighboring countries (avg)	0.31	0.00	0.94	0.22	2048

Notes: The table includes variables used for the analysis at the country level. All inequality measures have been normalized by taking $(X - X_{min})/(X_{max} - X_{min})$. **BGRI** is Between-Group Rainfall Inequality. ***Adm units*** indicates that the measure was computed considering administrative borders. The full sample includes 45 countries over the period 1960-2005.

Table C.3: Main effects at the country level

Dependent Variable:	Ethnic Conflict		
	(1)	(2)	(3)
BGRI, growing season	0.385**	0.405***	0.433***
	(0.172)	(0.116)	(0.076)
BGRI, growing season (t-1)			0.260**
			(0.103)
BGRI, growing season (t-2)			0.074
			(0.178)
Rainfall, growing season		0.016	0.016
		(0.016)	(0.015)
Temperature, growing season		−0.011	−0.015
		(0.030)	(0.028)
Year Effects	no	yes	yes
Country Effects	no	yes	yes
Country Time Trends	no	yes	yes
R^2	0.05	0.50	0.51
N	2070	2070	1980

Note: The dependent variable **Ethnic Conflict** is an indicator variable that takes on the value of 1 if a country experienced ethnic conflict in a given year. **BGRI** indicates Between-Group Rainfall Inequality. The full sample includes 45 African countries and 46 years. Two-way clustered standard errors by year and country in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table C.4: Robustness checks

Dependent Variable:	Non-Ethnic	Ethnic Conflict					
Specification:		Non-Growing	Lead	Adm Units	Excessive rainfall	Additional Controls	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BGRI, growing season	−0.035	0.468***	0.368***	0.478***	0.403***	0.307***	0.330***
	(0.129)	(0.109)	(0.091)	(0.174)	(0.114)	(0.100)	(0.101)
BGRI, non-growing season		−0.153					
		(0.191)					
BGRI, growing season (t+1)			0.195				
			(0.122)				
BGRI, growing season, adm units				−0.083			
				(0.106)			
Share groups with rain>2SD					0.013		
					(0.042)		
Ethnic Conflict (t-1)						0.595***	
						(0.062)	
Malaria prevalence index							−0.294
							(0.206)
Basic Controls	yes	yes	yes	yes	yes	yes	yes
Year Effects	yes	yes	yes	yes	yes	yes	yes
Country Effects	yes	yes	yes	yes	yes	yes	yes
Country Time Trends	yes	yes	yes	yes	yes	yes	yes
R^2	0.39	0.50	0.51	0.50	0.50	0.68	0.50
N	2070	2070	2025	2070	2070	2025	2070

Note: The dependent variable **Non-Ethnic** is an indicator variable that takes on the value of 1 if a country experienced a non-ethnic conflict in a given year. The dependent variable **Ethnic Conflict** is an indicator variable that takes on the value of 1 if a country experienced ethnic conflict in a given year. **BGRI** indicates Between-Group Rainfall Inequality. **BGRI, adm units**, used in column 4 was computed considering level 1 administrative boundaries rather than ethnic homeland's boundaries. **Share groups with rain>2SD** captures the share of ethnic groups whose homelands received an amount of rain during the growing season that is more than 2 standard deviations above the average amount they received during the period 1960-2005. *Basic Controls* include rainfall and temperature during the growing season. The full sample includes 45 African countries and 46 years. Two-way clustered standard errors by year and country in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table C.5: Additional robustness checks

Dependent Variable:	Ethnic Conflict					
Model:	Probit	OLS				
Sample:		Full Sample				SSA
	(1)	(2)	(3)	(4)	(5)	(6)
BGRI, growing season	2.799***	0.395***	0.394***	0.393***	0.365**	0.435***
	(0.176)	(0.142)	(0.104)	(0.152)	(0.157)	(0.130)
Ethnic Conflict (t-1)				0.161	0.153	
				(0.105)	(0.110)	
Basic Controls	yes	yes	yes	yes	yes	yes
Additional Controls	no	yes	no	yes	yes	no
Neighbors Controls	no	no	yes	yes	yes	no
Lagged Controls	no	no	no	no	yes	no
Year Effects	yes	yes	yes	yes	yes	yes
Country Effects	yes	yes	yes	yes	yes	yes
Country Time Trends	yes	yes	yes	yes	yes	yes
R^2		0.74	0.51	0.75	0.76	0.49
N	966	1744	2048	1715	1693	1840

Note: The dependent variable **Ethnic Conflict** is an indicator variable that takes on the value of 1 if a country experienced ethnic conflict in a given year. **BGRI** indicates Between-Group Rainfall Inequality. *Basic Controls* include rainfall and temperature during the growing season. *Additional Controls* refer to: (log) GDP per capita, (log) population, (log) individuals affected by natural disasters, (log) gross aid disbursements, share of imports and exports exports, institutional quality (Polity IV score), years without conflicts, Oil and Gas Gini, malaria prevalence. *Neighbor Controls* refers to the average prevalence of ethnic conflicts and the average institutional quality indicator in neighboring countries. *Lagged Controls* refers to lags $t-1$ for all control variables, with the only exception of the variable capturing the number of years without ethnic conflicts. We refer to Appendix A for a more detailed definition of the variables. Column 1 includes 21 countries and 46 years and standard errors (in parentheses) are bootstrapped. Column 6 only includes 40 Sub-Saharan countries. Unless otherwise specified, the sample includes 45 African countries and 46 years and standard errors (in parenthesis) are two-way clustered by year and country. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table C.6: Ethnic Power Relations – Country level

Dependent Variable:	Ethnic Conflict			
	(1)	(2)	(3)	(4)
BGRI, growing season (EPR)	0.065		−0.365	
	(0.242)		(0.283)	
$BGRI^{power}$, growing season		0.450**	0.610**	0.458*
		(0.223)	(0.310)	(0.263)
$BGRI^{size}$, growing season				−0.017
				(0.409)
Basic Controls	yes	yes	yes	yes
Year Effects	yes	yes	yes	yes
Country Effects	yes	yes	yes	yes
Country Time Trends	yes	yes	yes	yes
R^2	0.56	0.57	0.57	0.57
N	1647	1647	1647	1647

Note: The dependent variable **Ethnic Conflict** is an indicator variable that takes on the value of 1 if a country experienced ethnic conflict in a given year. **BGRI** indicates Between-Group Rainfall Inequality. $\mathbf{BGRI}^{power}$ indicates that the inequality measure is constructed with respect to the rain that fell over the homeland of the *leading* (i.e., *Monopolist*, *Dominant* or *Senior Partner*) ethnic group in the country. $\mathbf{BGRI}^{size}$ indicates that the inequality measure is constructed with respect to the rain that fell over the homeland of the ethnic group with the largest population. *Basic Controls* include rainfall and temperature during the growing season. The sample includes 41 African countries and 46 years. Two-way clustered standard errors by year and country in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.