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Abstract

In this paper, the mechanisms of climate change impacts on the incidence of civil conflict are tested separately in Sub-Saharan Africa (SSA) compared to the Middle East and North Africa (MENA) for the period 1981 to 2015. We draw several conclusions: **(i)** Climate has a significant impact on economic development, through economic growth rate in the MENA, and food production in SSA. **(ii)** Economic growth rate and food production index are significant indicators for social stability reduce the risk of civil conflict, in SSA and MENA, respectively. **(iii)** A direct impact of climate change on civil conflict is identified.**(iv)** Conflict in the previous year increases the probability of civil conflict in SSA by 0.30 pp , and in the MENA by 0.50 pp. Moreover, as the type of political system and accountability are important control variables in SSA, water availability reduces the risks of conflict in the MENA region. However, there appears to be evidence of different mechanisms in different regions. However, the identification of stable mechanisms needs to be precisely addressed in future work.

Keywords: Climate impact mechanisms, conflict, economic development, MENA, SSA

1 Introduction

Climate change is a global phenomenon, but its impacts are unequally distributed across regions of the world (Darwin, 1995) due to the diversity of agriculture systems, the resilience of human systems, and environmental sustainability. Climate change, in the absence of appropriate policy responses, can exacerbate already existed political crises and ultimately lead to civil wars in some territories. Most of the severe negative impacts appear in regions that are (i) highly vulnerable to climate change because they rely on rainfed agricultural systems that provide a livelihood for a large percentage of these regions' populations (Serdeczny et al., 2017). (ii) Where it suffers from water scarcity as in the Middle East and North Africa's region, where is likely to experience additional declines in agricultural yields, resulting in negative effects on rural incomes and food security (Zhu et al., 2009; Breisinger et al., 2010). Consequently, economic consequences may lead to conflicts that are unlikely to occur in developed countries. Africa has been already identified as one of the regions of the world most vulnerable to the impacts of climate change (Niang et al., 2017). At the same time, the major focus for civil wars in recent years has been in sub-Saharan Africa, where 29 of 43 countries suffered from civil conflict during the 1980s and 1990s (Miguel et al., 2004). Likewise, the Middle East and North Africa region is expected to become hotter and drier in the future due to climate change next to its growing dependence on international markets for key staple food products[1] (OECD-FAO, 2018). In the dataset, which we use to analyze the results of this paper, 12 of the 18 countries (66%) in the MENA region experienced between 1981 and 2015 civil conflicts. In this paper, we demonstrate empirically climate change effects on the economies of countries from different regions of the developing world, and its relationship to civil conflict over the past four decades. We applied the same approach and similar model specifications as in another part of this research, using cross-country panel data. Economic growth rate and domestic food production are instrumented by rainfall and temperature, in addition to other control variables, i.e. variables on good governance and democracy as well as on demographic and environmental indicators.

Climate, economic development, and conflict relationship has been already demonstrated intensively in Africa. For instance, positive relationship has been proved between rainfall and income growth, and its significant relation to the rise of civil conflict probability in Sub-Sharan Africa for the period 1981-1999 (Miguel et al., 2004). This robust association has been also found between rainfall and higher food production, but only a weak and inconsistent link between agricultural production and civil conflict in the second step of the causal model by Buhaug et al. (2015) in SSA. Couttenier and Soubeyran (2014) has also proved the impact of extreme drought on the risk of conflict during the period 1977 -2005 in SSA, that the risk of war increases by more than 42% but only 2.5% of this

[1] OECD/FAO 2018: The Middle East and North Africa: Prospects and Challenges

effect is channelled through economic growth. On the other hand, Barrios et al. (2010) proved that rainfall has been a significant determinant for economic growth in Africa, but not for other developing countries. However, there is another part of the literature that reached different conclusions, like Ciccone (2011) when he extended the data from Miguel and his co-authors in 2004, concluded that there is no robust link between transitory income shocks and civil wars, but reveals strong spill-over effects (Ahrens, 2015), among others who have reached different conclusions (e.g.,(Burke et al., 2009; Buhaug, 2010; Koubi et al., 2012)). Not surprisingly, that such mixed or inconsistent results have been observed, even for a single geographic region, due to differences in climate shock measurement, applied approaches, and model specifications. However, this sequence of relations in the MENA region has not been studied as intensively as in Africa. Where for example, Gleick (2014) has pointed out that there is a long history of conflict over water because of the natural water scarcity, the early development of irrigated agriculture, and complex religious and ethnic diversity.

The socio-economic development and environmental characteristics of the MENA and SSA

The MENA:

The MENA region consists of a heterogeneous group of countries ranging from the high-income oil-exporting countries in the Gulf to middle income and lower-middle-income countries as well as least developed countries such as Yemen (OECD-FAO, 2018). The agricultural sector still has a significant share in the economies of most countries in the MENA region as a source of food and income especially for non-oil producing countries and is an important vehicle for economic growth (Siam, 2009). Therefore, the dominant policy in the region concerning development has been the modernization of the agricultural sector in terms of the production (modern irrigation systems and agricultural technology) of cereals and livestock initially and later in the development of fruits, vegetables, and cash crops from irrigated or partially irrigated land (Dixon et al., 2001). This could be a reason that smallholders could not benefit from public support and have left them small, technologically backward, and poor (OECD-FAO, 2018). According to Siam (2009) the demand for food imports has markedly increased because the region is characterized by a food shortage in most food commodities, thereby seriously aggravated the shortage of foreign exchange in the majority of the MENA countries, particularly the non-oil producing countries. About the proportion of arable land from the total land area in the region, it is limited, estimated at 53 million hectares in the year 2005, with per capita arable land of only 0.17 hectares, compared to 0.22 hectares at the global level. In addition to that agriculture uses 89% of the scarce water in the MENA region compared to 70% at the world level, it has been pointed out by Huang et al. (2016) that it is the driest region in the world according to the annual precipitation of 166 mm, and since the 1970s has became even dryer (Cook et al., 2015). The drought peaked during the period 2006 and 2009 (Al-Ansari, 2013), during this period e.g., Syria and Iraq in the region received 10 percent less precipitation compared to the four years prior to 2006 (Chenoweth et al., 2011). This is also evident from our dataset, Syria and Iraq received less precipitation during this period, 18 and 23 percent, respectively. Regarding the effect of temperature, in the region, it was at about 4°C above average in the 1960s (Carrington, 2015). The well-being indicator; Gross Domestic Product (GDP) of the region reached 734 billion dollars in 2006, which constituted 1.5% of the world GDP. Its population in the same year was (311 million), i.e. 4.8% of the world's population, growing by 2.4% annually during the period 1990- 2006, compared to 1.4% of the world population (Siam, 2009).

The SSA:
The continent of Africa is commonly divided into five regions, four of which are in Sub-Saharan Africa. The ethnicity is one of the key drivers of diversity in SSA, therefore, it is important to take it into account in socio-economic studies (Appiah et al., 2018). According to Olamosu and Wynne (2015), the gross domestic product of Nigeria and South Africa accounts for about three-quarters of the SSA's GDP. The contribution of the agricultural sector to the GDP ranges from less than 3% in Botswana and South Africa to more than 50% in Chad, represents 15% of GDP on average. This high contribution underlines the limited diversification of most economies in the region (OECD-FAO, 2016). However, the significant growth in SSA' agricultural output is driven by area expansion and intensification of cropping systems, as opposed to large-scale improvement in productivity (Brink and Eva, 2009), but the failure to keep pace with the demand resulting from population growth and income has led to an increase in demand for the import of commodities such as wheat, rice, and poultry (OECD-FAO, 2016), compared to agricultural modernization in the MENA. For SSA according to Iliffe (2017) during 2000-2007 significant GDP growth of 3.9 is registered. The population growth rate of SSA in 2006 was 2.7% (World Bank, 2016).
In the following sections, we present empirical results of economic and social responses to the impact of climate change over time in two vulnerable regions of the developing world that differ in their economic, social, political and environmental characteristics.

2 Data and methods

For the estimations of this paper, we use our new collected cross-country panel data including Sub-Saharan Africa (41 countries) and the Middle East and North Africa (18 countries), for SSA's countries, we have adopted same sample (countries and years) of

Miguel et al. (2004)[2] and extend it for the period from 1981 to 2015. This new setup contains data on climate, economic indicators, and civil conflict, as well as political factors, and social fragmentation with other country characteristics information. We focus on the conflict incidence (subsumes outbreak of a conflict and continuation of a conflict) as an indicator of conflict that results in at least 25 battle-related deaths in a given year. Conflict data; the UCDP/PRIO Armed Conflict Dataset-V18.1[3]. Economic shocks are measured by (1) annual economic growth rate; we use a complete and consistent time series expressed in constant price-US dollars provided by National Account Estimates of Main Aggregate-United Nations statistics division (UNSD, 2020). (2) food index from Food and Agriculture Organization of the United Nations (2016). For climate change, we have data on temperature from the World Bank Climate Change Knowledge Portal (2018), and precipitation data from Global Precipitation Climatology Project (GPCP) database version 2.3 (Adler et al., 2016) [4]. The advantage of the GPCP rainfall data that it includes at the same time both gauge and satellite data, corrects for systematic errors in gauge measures (Miguel et al., 2004). While data on Polity IV scores which indicates the level of democracy/ autocracy of a political system in-country (i) time (t) from Roser (2019) based on Wimmer and Min (2006). Based on Polity IV scores, we derived an indicator (changes in the political system) here we do not distinguish whether a political transition undergoing in a dictatorship or under democracy, this is thought to reflect stability. Besides, we examine the effect of quality of governance (accountability) (World Bank, 2014). Data on water indicators (FAO, 2017). The index of ethnic and religious diversity from Alesina et al. (2003). A detailed description of the variables used to perform the estimates in this paper is provided in Appendix A4.

Estimates of the impacts of climate change as mentioned are undertaken separately for SSA and MENA from 1981-2015, applying Instrumental variable approach. The model is first estimated applying Ordinary Least Squares (OLS) (equations (1) and (2)) using weather (temperature and rainfall) as instruments for economic growth rate and food production. We include several additional controls for comparison purposes, particularly those related to conflicts such as political and social controls. Country fixed effects and country-specific time trends are included in all regressions to capture time-invariant country characteristics and additional variation, respectively. Standard errors are clustered at the country level to allow for a potential correlation between observations for any given

[2]We kept the same sample of MMS (2004) when we revisited their work using different measurement strategies and sources of data in a previous part of this research. Therefore, for this part of the study, we extended their cross-country (SSA), including MENA countries from 1981 to 2015, data on similar variables has been updated with most recent versions of the corresponding databases.

[3]Conflict version 18.1, for download; http://ucdp.uu.se/downloads/.

[4]Adler et al., 2016. An Update (Version 2.3) of the GPCP Monthly Analysis. (in Preparation). Huffman, G.J., R.F. Adler, P. Arkin, A. Chang, R. Ferraro, A. Gruber, J. Janowiak, A. McNab, B. Rudolf, U. Schneider, 1997: The Global Precipitation Climatology Project (GPCP) Combined Precipitation Dataset. Bull. Amer. Meteor. Soc., 78(1), 5-20. Longitude and latitude points used in the calculation of the GPCP data versions 2.3 are in the Appendix A4.2

country at different times. The relationship between variables included in the analysis and the significance level could be overstated without clustering standard errors.

$$Gr\_gdp\_it = a_i + bX'_{it} + d_i year_t + e_{it}, \tag{1}$$

$$food\_index_{it} = a_i + bX'_{it} + d_i year_t + e_{it}, \tag{2}$$

The term e is a disturbance term, and these disturbances are allowed to be correlated across years for the same country in all regressions. Country fixed effects a_{ji} are included in all regressions to capture time-invariant country characteristics that may be related to civil conflict, and also country-specific time trends $year_t$ to capture additional variation over time.

Then in the second stage, we estimate the impact of quantified economic outcomes from the first stage (climate indirect), and the direct impact of climate on civil conflict incidences[5] as in equation (3). We apply the Generalized Method of Moments (GMM) model introduced by Hansen (1982) with lagged dependent variable (LDV). We test our samples concerning heteroskedasticity by Breusch-Pagan/Cook-Weisberg test; the null hypothesis that the error variance is constant was rejected with Prob > chi2 = 0:000 for both samples.

$$Conflict_{it} = \alpha_i + \beta \cdot gr\_gdp_{it} + \gamma \cdot food\_index_{it} + \delta \cdot X'_{it} + \sigma_i \cdot year_t + \epsilon_{it}. \tag{3}$$

We have applied IV OLS estimation implemented in STATA to choose instruments for endogenous variables: GDP growth rate and Food Index. The Sanderson-Windmeijer (SW) chi-squared and F-statistics test under-identification and weak identification of both endogenous variables, respectively. The null hypotheses were rejected (Table 1); SW Chi-squared with (L1- K1+1) degrees of freedom, where L1 is the number of excluded instruments and K1 is the number of endogenous regressors: for SSA's sample, SW chi-sq equals 134.16 with p-value 0.000 for GDP growth and 71.56 with p-value 0.000 for Food Index, and SW-F statistics account 24.34 and 12.98 for both regressors, respectively (greater than 10). For MENA, SW chi-sq equals 45.41 with p-value 0.000 and 183.73 with p-value 0.000, for GDP growth and Food Index, respectively. While SW-F statistics values are 7.90 and 31.98, for GDP growth and Food Index, respectively. Accordingly, the chosen instruments are considered strong.

Furthermore, Hansen J statistic test for over-identification restrictions after ivreg2 [6]. The joint null hypothesis of the Hansen J test is that the instruments are valid for both

[5]The incidence of civil war: defined by Elbadawi and Sambanis (2002) as the probability of observing either a new war onset or the continuation of an ongoing war or both (p. 307).

[6]Hansen-test is done after country fixed effects are removed because an estimated covariance matrix with dummy variables is not of full rank.

samples (Table 2), i.e. they are uncorrelated with the error term, the null hypothesis is rejected with p-value 0.000.

3 Main results

3.1 Climate impacts on economic growth and food production: first-stage estimations

Based on the estimates for all sample countries in a previous working paper[7], the effect of climate variability on the economic growth rate and food production is mainly the effect of temperature growth. A 1 pp change in annual temperature growth significantly reduces economic growth and food index by 0.31 pp and 0.23 pp, respectively. The increase in temperature during the 16 years after the year 2000 of our time series compared to the average temperature in the eighties is estimated at 2.17 pp. This implies a reduction in economic growth and food index by 0.67 pp and 0.49 pp, respectively, during the period after 2000 only due to the temperature change. However, applying the estimates to separate regions indicates the source of the predictive power of significance that we observed with our model in the first paper.

The OLS regression (Table 1) using the new source of rainfall data (the GPCP) that includes at the same time both gauge and satellite data, separately for SSA and MENA in this paper shows: (i) A positive correlation between precipitation and both economic indicators (economic growth rate and food production) but only significant for economic growth rate at a confidence level of 0.10 in the MENA sample with a coefficient estimate of 3.7%. (ii) Annual growth temperature is negatively related to both economic indicators, it is highly significant only for food production in SSA (coef. 33.2%) and economic growth rate in the MENA region (49.2%).

Additionally, **in the first stage model for SSA**, we observe for economic growth rate some other statistically significant coefficients; positive on total trade exports, and negative on political transition indicator in-country (i) time (t). With our data, it appears that the significant climate determinants for economic growth rate are water variables in the SSA region. Whereas for the food production index in SSA we also observe some common significant coefficients; positive on the share of agricultural land and the arable land, and accountability. In **the MENA region**, other than the positive impact of growth rainfall and the negative impact of growth temperature on GDP per capita, this indicator is affected positively significantly by growth trade exports and the share of agricultural land, but it is affected negatively highly significant by the share of arable land and transition in the political system. While the food index is negatively significantly

[7] If Climate Change Can Trigger Civil Conflict, Can Good Policy Trigger Peace? Empirical Evidence from Cross-Country Panel Data, by S. Khalifa, S. Petri, Ch. Henning, 2020.

affected by water stress and political indicators in particular, and positively by the share of urban population. Although theoretically, one would expect that good governess should affect economic indicators positively. It is indicated in a study by Emara and Jhonsa (2014) about governance and economic growth, that most MENA countries in the year 2009 have achieved a relatively high but fragile standard of living for their citizens in the that is not based on firm governance.

Overall, it is obvious that: (i) There is a positive link as exists in the literature for SSA e.g, by Miguel et al. (2004) between economic growth rate and growth rainfall and negative with annual growth temperature, significant in the MENA region with our new data and model specification. (ii) There is a high negative impact for the share of cultivated area "arable land" and a positive impact for the share of urban population on economic growth rate and food production, respectively, in the MENA region. (iii) Changes in a political system (instability) has a negative impact on economic growth rate in both regions.

Table 1: First stage results, SSA and MENA from 1981–2015. Dependent variables are: Economic growth rate and Food index

	SSA		**MENA**	
Expl. Variables	**growth rate**	**food_index**	**growth rate**	**food_index**
gr_oil_exp_wdi	0.000001	-0.000002	0.000006	-0.000009
	(0.680)	(0.276)	(0.791)	(0.683)
gr_trade_exports	0.136***	-0.0192**	0.0912***	-0.0142
	(0.000)	(0.039)	(0.000)	(0.154)
agri_land	0.00286	0.0194***	0.00683**	0.00659**
	(0.290)	(0.000)	(0.043)	(0.040)
arable_land	-0.214	0.408***	-1.034**	-0.107
	(0.189)	(0.001)	(0.040)	(0.822)
water_stress	0.00951**	-0.00399	-0.00005	-0.00079***
	(0.014)	(0.158)	(0.599)	(0.000)
strength_gr_polityiv	-0.00519**	-0.00105	-0.00952**	-0.00104
	(0.029)	(0.547)	(0.037)	(0.811)
gr_gpcp_neu	0.00329	0.00815	0.0371 *	0.00573
	(0.919)	(0.732)	(0.079)	(0.775)
gr_temp	-0.206	-0.332**	-0.492**	-0.232
	(0.370)	(0.049)	(0.006)	(0.169)
water_1km2	-0.0090**	0.0006	0.000615	-0.000617
	(0.016)	(0.825)	(0.595)	(0.575)
rainfall levels	0.00004	-0.00023***	-0.00001	0.00004
	(0.544)	(0.000)	(0.870)	(0.483)
polityiv_sh_tr	-0.00032	-0.00872***	-0.00405	-0.00703**
	(0.837)	(0.000)	(0.256)	(0.039)
accountab	0.00016	0.00278***	0.00246	-0.00363**
	(0.876)	(0.000)	(0.104)	(0.012)
urban_pop	-0.00358	0.00299	0.00403	0.0113**
	(0.264)	(0.205)	(0.338)	(0.005)
Constant	0.0224	-0.705***	-0.256	-0.452
	(0.939)	(0.001)	(0.505)	(0.216)
Observations	1324	1324	612	612
R^2	0.15	0.88	0.23	0.85
F	2.327	99.62	3.438	66.36

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.2 Economic shocks, direct climate impacts, and incidence of civil conflicts, second stage estimations

The results of this stage are introduced in Table 2 for SSA and MENA. First, not surprisingly, that civil conflict is more likely when there was a conflict in the previous year in both regions, increase of around 0.498 pp and 0.302 pp in the probability of current conflicts in the MENA and SSA, respectively. Second, regarding the impact of economic shocks on the civil conflict probability, it does not seem to function through the same economic indicators in both regions, although both indicators show negative coefficient signs on the incidence of civil conflict. i.e. in the MENA region climate change increases the probability of civil conflict significantly through reduction in food production index, and in SSA the effect appears through economic growth rate. Third, for the direct impact of climate variables on civil conflict incidence, our model yields negative coefficient signs on growth rainfall in both regions, significant in MENA (ceof. -0.061*). Other than that, for MENA countries fresh groundwater withdrawal reduce civil conflict incidence statistically significant. While in SSA, political indicators show statistically significant impact reducing conflict probability.

Overall, we find that (i) positive economic growth rate and domestic food production reduce the likelihood of civil conflict, in SSA and the MENA region, respectively. (ii) Annual growth rainfall directly reduces the probability of civil conflict significantly in the MENA region. (iii) Previous conflicts increase the possibility of civil conflicts in both regions, have a greater impact in the MENA region. (iv) As the type of political system and accountability are important to reduce the risks of conflict in SSA, water availability reduces the risks of conflict in the MENA.

Table 2: Second stage results (GMM) for SSA and MENA from 1981-2015. Dependent Variable: Civil conflict ≥25 deaths/ year

Exp. Variables	**SSA**	**MENA**
L.any_prio	0.302***	0.498***
	(0.000)	(0.000)
L2.any_prio	0.105 *	0.0156
	(0.073)	(0.797)
gr_gdp_c_con	-0.150**	-0.0295
	(0.030)	(0.790)
food_index	-0.0928	-0.205**
	(0.213)	(0.005)
gr_gpcp_neu	-0.0203	-0.0609 *
	(0.705)	(0.093)
gr_temp	0.174	0.125
	(0.654)	(0.731)
water_1km2	0.00142	-0.00657***
	(0.774)	(0.001)
rainfall levels	0.00009	0.00027*
	(0.390)	(0.075)
polityiv_sh_tr	-0.00644 *	0.00051
	(0.065)	(0.882)
accountab	-0.00524**	-0.00375
	(0.010)	(0.111)
urban_pop	0.0102	0.00479
	(0.169)	(0.575)
Constant	0.129*	0.852
	(0.076)	(0.257)
Observations	1238	576

*F*ixed effects and specific time trends are included in all regressions

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4 Discussion and conclusion

Estimates using new cross-country panel data during 1981-2015 for SSA and the MENA separately, show that climate change operates on economic indicators differently in both regions. **First**, rainfall has a positive impact on both economic growth rate and food production, with a statistically significant impact on the GDP per capita in the MENA region. However, this runs counter to the finding of Barrios et al. (2010) that precipitation is important for income growth in Africa but not for other developing countries. Quantitatively, a one unite rise of annual rainfall growth leads to a 3.7 percent rise in economic growth rate in MENA, compared to 4.9 percent as reported by Miguel et al. (2004) for SSA during 1981-99. **Second**, with respect to the effect of temperature, we emphasize the long known negative relationship between the increase in temperatures and the economic growth rate. One change in annual growth temperature reduces the economic growth rate by 0.49 pp in the MENA and 0.33 pp of domestic food production in SSA' sample, compared to 3.22 pp and 1.3 pp as reported by Odusola and Abidoye (2015) and Dell et al. (2012), respectively, for Africa. Thus, periodic floods or droughts is quite damaging to the economy i.e. food production in SSA is negatively significantly affected through annual rainfall levels (coef. 0.023 percent). Also, annual temperature variation in SSA affects food production negatively significantly at 5% level (point estimate of 0.332 pp), this is consistent with the finding of a case study of Kenya that temperature harms crop production and has a greater impact than rainfall (Ochieng et al., 2016). In general, temperature and rainfall variations are critical to the GDP growth rate in the MENA region, and temperature growth is critical to the food production index in sub-Saharan Africa. Water stress indicator seems to be a significant factor for food production index in MENA. This region has the lowest freshwater resource endowment in the world, and the demand of water and food production has been achieved through abstraction of groundwater, water harvesting and storage, wastewater reuse, desalinization plants and food imports (Verner, 2012), led to groundwater resource depletion (Waha et al., 2017) due to the over-extraction of available water, which is an important input into agricultural production. The effect of other natural resources such as the share of oil exports of total merchandise is positively correlated with the economic growth rate but insignificantly (the same relationship has been found by Miguel et al. (2004)), this results indicates that both regions do not rely heavily on oil exports significantly or affected by World oil prices, but a robust significant positive impact of total merchandise trade of a country exports to the world on the economic growth rate in both region has been found. Regarding the impact of the level of democracy/ autocracy on economic indicators, it affects both economic indicators negative but only statistically significant on food index. Descriptive statistics Table (Appendix A4) indicate that the average Polity IV estimates of most of the political systems in our samples laying between autocracies and anocracies.

In our estimation, this is evident from the significant negative impact of the transition in political systems on domestic food production in both regions. In the literature, a positive significant impact of the polity IV indicator has been found on the economic growth (Masaki and Van de Walle, 2014) that a one-point increase in the POLITY score is expected to produce a 0.10 percent increase in economic growth rate. While Miguel et al. (2004) for SSA in their model specification for economic growth rate did not observe any significant coefficient on polity IV lagged one year.

Now turning to the impact of economic shocks induced by climate variability and the direct impact of climate variation on the incidence of civil conflict in both regions, we confirm the main result of Miguel et al. (2004) that the reduction in per capita income growth induced by extreme weather events together with other country controls significantly increases the probability of civil conflict in SSA. In quantitative terms, a 10% reduction in economic growth rate leads to 1.5% increase in the probability of civil conflict in SSA. A 10% reduction in food production index leads to 2% increase in the probability of civil conflict in the MENA. The finding of the insignificant relationship between food production and civil conflict in SSA corresponds to the result of Buhaug et al. (2015), which we find rather statistically significant in the MENA region. Helman et al. (2020) has illustrated that the relationship between agricultural dependence and violence is stronger about four fold in the Middle East, although the share of agricultural area in Africa is greater than in the Middle East, 14% and %11, respectively, in their study. This is also evident from the descriptive statistics Table (Appendix A4) attached to this paper. Furthermore, a negative direct impact of climate variability exist between growth rainfall and risk of conflict in the MENA, thus, it is important to assess both direct and indirect impacts of climate change on the civil conflict when studying climate change. Chen et al. (2016) has proved that the decrease in current rainfall compared to the previous year increases the possibility of civil conflict. Moreover, our results proved that conflict begets conflict in both regions, but lagged dependent variable has a greater impact in the MENA region. The clear evidence of the impact of climate change is that higher temperature contributed more to climate change than reduced precipitation, especially in the MENA region. Second, results indicate that food production and economic growth rate are stabilizing factors against conflict, food production in MENA, and economic growth rate in SSA.

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Appendix A4

Summary of Variables

Dependent Variables	Independent variables	Variable Description	Source of data
1.GDP growth rate **2.Food production index**	***First stage variables*** **Climate variables**		
	1.Rainfall in millimeter	Annual rainfall/mm is computed by adding up all the monthly observations in a given year.	1.The World Bank Climate Change Knowledge Portal (2018).
	2.Rainfall/ mm (gpcp_neu)	Total yearly rainfall/mm for country *i* on a resolution of 2.5 latitude/longitude degree nodes in the given country (see Huffman (1997); Miguel et al. (2004)).	2. The Global Precipitation Climatology Project (GPCP) database version 2.3
	Rainfall growth	Gr rain= (rainfall*t* - rainfall*t-1*)/ (rainfall*t-1*)	
	3.Temperature (Celsius degree)	Annual averages are computed by adding up all of monthly observations in a given year divided by the number of months in that year	The World Bank Climate Change Knowledge Portal (2018).
	Temperature growth	Gr temp= (temp*t* - temp*t-1*)/ (temp*t-1*)	
	Political variables		
	1.PolityIV score 2.Change in the political system	Type of political regime for each country on a range from -10 (full autocracy) to +10 (full democracy). Regimes that fall into the middle of this spectrum are called anocracies. We transformed Polity IV scores, to be instead on a range from 1 to 20, for easiest interpretation **polityiv_sh_tr**. Indicates changes in Polity IV scores in year*t* compared to year*t-1* either toward democracy or backward to autocracy **strength_gr_polityiv**.	The project of Roser (2019), based on Polity IV Project (2013) and Wimmer and Min (2006).

	3.Accountability	Ranges from 0 (lowest) to 100 (highest) rank, reflects perceptions of the extent to which a country's citizens can participate in selecting their government, as well freedom of expression, association, and a free media.	The World Bank (2014)
	Environmental variables		
	1.Water withdrawal 2.Water stress%	The annual level of freshwater withdrawal, calculated averagely over each decade divided by country area as: *water_1km2*= 10^6 * *wasser_total/area.km2*, in 10^3 m^3/km2. Aggregated indicator (SDG 6.4.2.) freshwater withdrawal as a proportion of available freshwater resources.	AQUASTAT main database, Food and Agriculture Organization of the United Nations (FAO, 2017)
	3.Agricultural land 4.Arable land	The share of land area that is arable as defined by the FAO, under permanent crops and pastures. Land abandoned as a result of shifting cultivation is excluded. Arable land (hectares per person)	The World Bank (2016)
	Demographic/ social diversity		
	1.Ethnicity 2.Religion	fractionalizations index computed using the same formula applied to different underlying data (Ethnic and religion) $FRAC_m = 1 - \sum_{i=k}^{N} S_{km}^2$, where S_{km} is the share of group k in country m.	The Encyclopaedia Britannica (2001); CIA (2000); Levinson (1998). Religion data: The Encyclopaedia Britannica (2001)
	3.Urban population	Percentage of the total population	The World Bank (2018)
	Economic indicators		
	Oil exports	The proportion of merchandise exports)	The World Bank (2016)

	Trade exports	Total merchandise trade of a country exports to the world in US dollar at current prices	The World Trade Organization (2016)
3. Civil conflict	***Second stage***		
	1.Economic growth rate	GDP per capita estimates in constant price-US dollars.	The database of National Accounts Estimates of Main Aggregates-United Nations Statistics Division (UNSD, 2020).
	2.Food index	The aggregate volume of agricultural production for each year compared to the base period 2004-2006, covers food crops that are considered edible and that contain nutrients. Coffee and tea are excluded because, although edible, they have no nutritive value	Food and Agriculture Organization of the United Nations (2016)
	3.Lag civil conflict	Any conflict resulted at least 25 battel related death per year equals 1, otherwise 0[8].	The UCDP/ PRIO Armed Conflict Dataset, Version 18.1.

[8] All country-year observations are coded as ones based on the type (3 and 4) and the intensity level 1 or 2 of the PRIO/ Uppsala conflict data (at least 25 battle-related deaths per year), otherwise zeros.

Descriptive statistics

	SSA					***MENA***				
Variables	*Obs.*	*Mean*	*Std.Dev.*	*Min*	*Max*	*Obs.*	*Mean*	*Std.Dev.*	*Min*	*Max*
	Economic indicators									
Annual GDP	1399	1028.14	1402.77	82	10716	630	9970.43	13785.36	172	88565
GDP growth rate	1399	0.027	0.152	-0.645	1.78	630	0.037	0.146	-0.66	0.91
Food index	1399	0.877	0.304	0.281	2.07	630	0.84	0.32	0.071	2.033
	Civil Conflict Measures									
Civil conflict:≥25 deaths	1399	0.237	0.426	0	1	630	0.321	0.467	0	1
	Weather Variables									
Rainfall (CCKP 2018)	1399	903.57	562.13	49.27	2795.72	630	234.54	207.56	13.03	967.53
Rainfall (GPCP-V2.3)	1399	879.878	718.573	9.029	2715.39	630	539.74	372.10	60.97	1727.37
Temp.	1399	24.615	3.355	12.21	29.75	630	21.797	4.449	9.651	29.033
Growth Rainfall (CCKP)	1399	0.02	0.221	-0.659	1.69	630	0.085	0.52	-0.808	4.064
Growth rainfall (GPCP-V2.3)	1358	0.012	0.136	-0.611	1.369	612	0.039	0.318	-0.626	2.387
Growth Temperature	1399	0.001	0.018	-0.126	0.107	630	0.002	0.031	-0.164	0.133
	Other Country Characteristics									
water per 1km2	1399	5.182	8.506	0.031	60.01	630	54.64	72.96	1.53	352.06
water stress	1399	13.89	31.33	0	131.31	630	392.035	644.795	14.89	2347
arable land	1365	0.282	0.202	0.001	1.585	630	0.145	0.141	0.001	0.57
agri_land	1365	47.71	19.18	7.94	82.67	630	32.03	25.51	2.45	80.85
PolityIV	1399	9.09	5.75	0	19	630	5.42	5.47	0	19

	Other Country Characteristics									
Variables	*Obs*	*Mean*	*Std.Dev.*	*Min*	*Max*	*Obs*	*Mean*	*Std.Dev.*	*Min*	*Max*
Changes in PolityIV/ both directions	1398	0.525	1.81	0	15	630	0.275	1.261	0	12
Accountability	1399	29.61	17.45	0.99	74	630	24.63	15.13	0	71.92
Ethnic	1399	0.702	0.194	0.058	0.93	630	0.398	0.218	0	0.746
Religion	1399	0.552	0.231	0.003	0.86	630	0.26	0.25	0.00	0.79
Urban pop.	1399	33.42	16.15	5	88	630	69.45	19.149	21	100
Growth trade exports	1399	0.09	0.327	-0.73	3.81	630	0.11	0.54	-0.96	8.39
Growth oil exports	1399	53.45	1583.54	-1	58572.3	630	12.51	246.19	-1	5950.57

Appendix A4.2

Longitude and latitude points used in the calculation of the GPCP' data version 2.3 yearly rainfall estimates. For sub-Saharan Africa' sample we used same points have been used by Miguel et al. (2004) .

Country	Node	Latitude	Point	Longitude	Point
1.Angola	1	-16.25	S	13.75	E
	2	-13.75	S	13.75	E
	3	-8.75	S	13.75	E
	4	-6.25	S	13.75	E
	5	-16.25	S	16.25	E
	6	-13.75	S	16.25	E
	7	-11.25	S	16.25	E
	8	-8.75	S	16.25	E
	9	-6.25	S	16.25	E
	10	-16.25	S	18.75	E
	11	-13.75	S	18.75	E
	12	-11.25	S	18.75	E
	13	-8.75	S	18.75	E
	14	-16.25	S	21.25	E
	15	-13.75	S	21.25	E
	16	-11.25	S	21.25	E
	17	-8.75	S	21.25	E
	18	-11.25	S	23.75	E
2.Benin	1	11.25	N	1.25	E
3.Botswana	1	-26.25	S	21.25	E
	2	-23.75	S	21.25	E
	3	-21.25	S	21.25	E
	4	-18.75	S	21.25	E
	5	-23.75	S	23.75	E
	6	-21.25	S	23.75	E
	7	-18.75	S	23.75	E
	8	-23.75	S	26.25	E
	9	-21.25	S	26.25	E
4.Burkina Faso	1	11.25	N	3.75	W
	2	11.25	N	1.25	W
	3	13.75	N	1.25	W
5.Burundi	1	-3.75	S	28.75	E
	2	-3.75	S	31.25	E
6. Cameroon	1	3.75	N	11.25	E
	2	6.25	N	11.25	E
	3	3.75	N	13.75	E
	4	6.25	N	13.75	E
	5	8.75	N	13.75	E
7.Central African Republic	1	3.75	N	16.25	E
	2	6.25	N	16.25	E
	3	6.25	N	18.75	E

	4	6.25	N	21.25	E
	5	8.75	N	21.25	E
	6	6.25	N	23.75	E
	7	6.25	N	26.25	E
8.Chad	1	13.75	N	13.75	E
	2	8.75	N	16.25	E
	3	11.25	N	16.25	E
	4	13.75	N	16.25	E
	5	16.25	N	16.25	E
	6	18.75	N	16.25	E
	7	21.25	N	16.25	E
	8	8.75	N	18.75	E
	9	11.25	N	18.75	E
	10	13.75	N	18.75	E
	11	16.25	N	18.75	E
	12	18.75	N	18.75	E
	13	21.25	N	18.75	E
	14	11.25	N	21.25	E
	15	13.75	N	21.25	E
	16	16.25	N	21.25	E
	17	18.75	N	21.25	E
	18	16.25	N	23.75	E
	19	18.75	N	23.75	E
9.Congo, Brazzaville	1	-3.75	S	11.25	E
	2	-3.75	S	13.75	E
	3	-1.25	S	16.25	E
	4	1.25	N	16.25	E
10.Congo, Kinshasa	1	-3.75	S	16.25	E
	2	-6.25	S	18.75	E
	3	-3.75	S	18.75	E
	4	-1.25	S	18.75	E
	5	1.25	N	18.75	E
	6	3.75	N	18.75	E
	7	-6.25	S	21.25	E
	8	-3.75	S	21.25	E
	9	-1.25	S	21.25	E
	10	1.25	N	21.25	E
	11	3.75	N	21.25	E
	12	-8.75	S	23.75	E
	13	-6.25	S	23.75	E
	14	-3.75	S	23.75	E
	15	-1.25	S	23.75	E
	16	1.25	N	23.75	E
	17	3.75	N	23.75	E
	18	-11.25	S	26.25	E
	19	-8.75	S	26.25	E
	20	-6.25	S	26.25	E
	21	-3.75	S	26.25	E

	22	-1.25	S	26.25	E
	23	1.25	N	26.25	E
	24	3.75	N	26.25	E
	25	-8.75	S	28.75	E
	26	-6.25	S	28.75	E
10.Congo, Kinshasa (cont	27	-3.75	S	28.75	E
	28	-1.25	S	28.75	E
	29	1.25	N	28.75	E
	30	3.75	N	28.75	E
11.Cote d'Ivoire	1	6.25	N	6.25	W
	2	8.75	N	6.25	W
	3	6.25	N	3.75	W
	4	8.75	N	3.75	W
12.Djibouti	1	11.25	N	41.25	E
	2	11.25	N	43.75	E
13.Equatorial Guinea	1	3.75	N	8.75	E
	2	1.25	N	11.25	E
14.Eritrea	1	16.25	N	38.75	E
	2	13.75	N	41.25	E
15.Ethiopia, post 1993	1	6.25	N	36.25	E
	2	8.75	N	36.25	E
	3	11.25	N	36.25	E
	4	3.75	N	38.75	E
	5	6.25	N	38.75	E
	6	8.75	N	38.75	E
	7	11.25	N	38.75	E
	8	13.75	N	38.75	E
	9	6.25	N	41.25	E
	10	8.75	N	41.25	E
	11	11.25	N	41.25	E
	12	6.25	N	43.75	E
	13	8.75	N	43.75	E
15. Ethiopia, pre 1993	1	16.25	N	38.75	E
	2	13.75	N	41.25	E
	3	6.25	N	36.25	E
	4	8.75	N	36.25	E
	5	11.25	N	36.25	E
	6	3.75	N	38.75	E
	7	6.25	N	38.75	E
	8	8.75	N	38.75	E
	9	11.25	N	38.75	E
	10	13.75	N	38.75	E
	11	6.25	N	41.25	E
	12	8.75	N	41.25	E
	13	11.25	N	41.25	E
	14	6.25	N	43.75	E
	15	8.75	N	43.75	E

16.Gabon	1	-1.25	S	11.25	E
	2	-1.25	S	13.75	E
	3	1.25	N	13.75	E
17.Gambia	1	13.75	N	16.25	W
	2	13.75	N	13.75	W
18. Ghana	1	6.25	N	1.25	W
	2	8.75	N	1.25	W
19. Guinea	1	11.25	N	13.75	W
	2	11.25	N	11.25	W
	3	8.75	N	8.75	W
	4	11.25	N	8.75	W
20. Guinea-Bissau	1	11.25	N	16.25	W
21. Kenya	1	-1.25	S	36.25	E
	2	1.25	N	36.25	E
	3	3.75	N	36.25	E
	4	-3.75	S	38.75	E
	5	-1.25	S	38.75	E
	6	1.25	N	38.75	E
	7	-1.25	S	41.25	E
	8	3.75	N	41.25	E
22.Lesotho	1	-28.75	S	28.75	E
23.Liberia	1	6.25	N	351.25	E
24.Madagascar	1	-23.75	S	43.75	E
	2	-23.75	S	46.25	E
	3	-21.25	S	46.25	E
	4	-18.75	S	46.25	E
	5	-16.25	S	46.25	E
	6	-18.75	S	48.75	E
	7	-16.25	S	48.75	E
	8	-13.75	S	48.75	E
25.Malawi	1	-13.75	S	33.75	E
	2	-11.25	S	33.75	E
26.Mali	1	16.25	N	1.25	E
	2	18.75	N	1.25	E
	3	16.25	N	3.75	E
	4	18.75	N	3.75	E
	5	13.75	N	11.25	W
	6	13.75	N	8.75	W
	7	11.25	N	6.25	W
	8	13.75	N	6.25	W
	9	23.75	N	6.25	W
	10	13.75	N	3.75	W
	11	16.25	N	3.75	W
	12	18.75	N	3.75	W
	13	21.25	N	3.75	W
	14	23.75	N	3.75	W
	15	16.25	N	1.25	W

	16	18.75	N	1.25	W
	17	21.25	N	1.25	W
27.Mauritania	1	21.25	N	16.25	W
	2	16.25	N	13.75	W
	3	18.75	N	13.75	W
	4	21.25	N	13.75	W
	5	16.25	N	11.25	W
	6	18.75	N	11.25	W
	7	21.25	N	11.25	W
27.Mauritania (cont	8	23.751.25	W		
	9	16.25	N	8.75	W
	10	18.75	N	8.75	W
	11	21.25	N	8.75	W
	12	23.75	N	8.75	W
	13	16.25	N	6.25	W
	14	18.75	N	6.25	W
	15	21.25	N	6.25	W
28.Mozambique	1	-23.75	S	33.75	E
	2	-21.25	S	33.75	E
	3	-18.75	S	33.75	E
	4	-16.25	S	33.75	E
	5	-18.75	S	36.25	E
	6	-16.25	S	36.25	E
	7	-13.75	S	36.25	E
	8	-16.25	S	38.75	E
	9	-13.75	S	38.75	E
	10	-11.25	S	38.75	E
29.Namibia	1	-21.25	S	13.75	E
	2	-18.75	S	13.75	E
	3	-26.25	S	16.25	E
	4	-23.75	S	16.25	E
	5	-21.25	S	16.25	E
	6	-18.75	S	16.25	E
	7	-28.75	S	18.75	E
	8	-26.25	S	18.75	E
	9	-23.75	S	18.75	E
	10	-21.25	S	18.75	E
	11	-18.75	S	18.75	E
30.Niger	1	13.75	N	1.25	E
	2	13.75	N	3.75	E
	3	13.75	N	6.25	E
	4	16.25	N	6.25	E
	5	18.75	N	6.25	E
	6	13.75	N	8.75	E
	7	16.25	N	8.75	E
	8	18.75	N	8.75	E
	9	21.25	N	8.75	E
	10	13.75	N	11.25	E

	11	16.25	N	11.25	E
	12	18.75	N	11.25	E
	13	21.25	N	11.25	E
	14	16.25	N	13.75	E
	15	18.75	N	13.75	E
	16	21.25	N	13.75	E
31.Nigeria	1	8.75	N	3.75	E
	2	11.25	N	3.75	E
	3	6.25	N	6.25	E
	4	8.75	N	6.25	E
31.Nigeria (cont	5	11.25	N	6.25	E
	6	6.25	N	8.75	E
	7	8.75	N	8.75	E
	8	11.25	N	8.75	E
	9	8.75	N	11.25	E
	10	11.25	N	11.25	E
	11	11.25	N	13.75	E
32.Rwanda	1	-1.25	S	28.75	E
	2	-1.25	S	31.25	E
33.Senegal	1	13.75	N	16.25	W
	2	16.25	N	16.25	W
	3	13.75	N	13.75	W
34.Sierra Leone	1	8.75	N	11.25	W
35.Somalia	1	1.25	N	41.25	E
	2	1.25	N	43.75	E
	3	3.75	N	43.75	E
	4	3.75	N	46.25	E
	5	6.25	N	46.25	E
	6	8.75	N	46.25	E
	7	6.25	N	48.75	E
	8	8.75	N	48.75	E
	9	11.25	N	48.75	E
36. South Africa	1	-33.75	S	18.75	E
	2	-31.25	S	18.75	E
	3	-33.75	S	21.25	E
	4	-31.25	S	21.25	E
	5	-28.75	S	21.25	E
	6	-33.75	S	23.75	E
	7	-31.25	S	23.75	E
	8	-28.75	S	23.75	E
	9	-26.25	S	23.75	E
	10	-33.75	S	26.25	E
	11	-31.25	S	26.25	E
	12	-28.75	S	26.25	E
	13	-26.25	S	26.25	E
	14	-31.25	S	28.75	E
	15	-26.25	S	28.75	E
	16	-23.75	S	28.75	E

	17	-28.75	S	31.25	E
	18	-23.75	S	31.25	E
37.Sudan	1	8.75	N	23.75	E
	2	11.25	N	23.75	E
	3	13.75	N	23.75	E
	4	8.75	N	26.25	E
	5	11.25	N	26.25	E
	6	13.75	N	26.25	E
	7	16.25	N	26.25	E
	8	18.75	N	26.25	E
	9	21.25	N	26.25	E
37.Sudan (cont	10	6.25	N	28.75	E
	11	8.75	N	28.75	E
	12	11.25	N	28.75	E
	13	13.75	N	28.75	E
	14	16.25	N	28.75	E
	15	18.75	N	28.75	E
	16	21.25	N	28.75	E
	17	6.25	N	31.25	E
	18	8.75	N	31.25	E
	19	11.25	N	31.25	E
	20	13.75	N	31.25	E
	21	16.25	N	31.25	E
	22	18.75	N	31.25	E
	23	21.25	N	31.25	E
	24	6.25	N	33.75	E
	25	8.75	N	33.75	E
	26	11.25	N	33.75	E
	27	13.75	N	33.75	E
	28	16.25	N	33.75	E
	29	18.75	N	33.75	E
	30	21.25	N	33.75	E
	31	13.75	N	36.25	E
	32	16.25	N	36.25	E
	33	18.75	N	36.25	E
	34	21.25	N	36.25	E
38.Swaziland	1	-26.25	S	31.25	E
39.Tanzania	1	-6.25	S	31.25	E
	2	-3.75	S	31.25	E
	3	-1.25	S	31.25	E
	4	-8.75	S	33.75	E
	5	-6.25	S	33.75	E
	6	-3.75	S	33.75	E
	7	-1.25	S	33.75	E
	8	-11.25	S	36.25	E
	9	-8.75	S	36.25	E
	10	-6.25	S	36.25	E
	11	-3.75	S	36.25	E

	12	-8.75	S	38.75	E
	13	-6.25	S	38.75	E
40.Togo	1	6.25	N	1.25	E
	2	8.75	N	1.25	E
41.Uganda	1	1.25	N	31.25	E
	2	3.75	N	31.25	E
	3	1.25	N	33.75	E
	4	-1.25	S	31.25	E
	6	-1.25	S	29.75	E
	5	3.75	N	33.75	E
42.Zambia	1	-16.25	S	23.75	E
	2	-13.75	S	23.75	E
	3	-16.25	S	26.25	E
	4	-13.75	S	26.25	E
42.Zambia (cont	5	-16.25	S	28.75	E
	6	-13.75	S	28.75	E
	7	-11.25	S	28.75	E
	8	-13.75	S	31.25	E
	9	-11.25	S	31.25	E
	10	-8.75	S	31.25	E
43.Zimbabwe	1	-18.75	S	26.25	E
	2	-21.25	S	28.75	E
	3	-18.75	S	28.75	E
	4	-21.25	S	31.25	E
	5	-18.75	S	31.25	E
	6	-16.25	S	31.25	E
MENA' countries					
44.Tunisia	1	33.75	N	8.75	E
	2	36.25	N	8.75	E
45.Morocco	1	26.25	N	8.75	W
	2	26.25	N	11.25	W
	3	28.75	N	8.75	W
	4	31.25	N	6.25	W
	5	31.25	N	8.75	W
	6	33.75	N	3.75	W
	7	33.75	N	6.25	W
46.Algeria	1	21.25	N	1.25	E
	2	21.25	N	3.75	E
	3	21.25	N	6.25	E
	4	23.75	N	1.25	E
	5	23.75	N	3.75	E
	6	23.75	N	6.25	E
	7	23.75	N	8.75	E
	8	23.75	N	11.25	E
	9	23.75	N	1.25	W
	10	26.25	N	1.25	E
	11	26.25	N	3.75	E
	12	26.25	N	6.25	E

	13	26.25	N	8.75	E
	14	26.25	N	1.25	W
	15	26.25	N	3.75	W
	16	26.25	N	6.25	W
	17	28.75	N	1.25	W
	18	28.75	N	1.25	E
	19	28.75	N	3.75	E
	20	28.75	N	6.25	E
	21	28.75	N	6.25	W
	22	28.75	N	8.75	E
	23	28.75	N	3.75	W
	24	31.25	N	1.25	W
	25	31.25	N	1.25	E
	26	31.25	N	3.75	E
	27	31.25	N	3.75	W
	28	31.25	N	6.25	E
	29	31.25	N	8.75	E
	30	33.75	N	1.25	W
	31	33.75	N	1.25	E
	32	33.75	N	3.75	E
	33	33.75	N	6.25	E
	34	36.25	N	1.25	E
	35	36.25	N	3.75	E
	36	36.25	N	6.25	E
47.Yemen	1	13.75	N	43.75	E
	2	13.75	N	46.25	E
	3	16.25	N	43.75	E
	4	16.25	N	46.25	E
	5	16.25	N	48.75	E
	6	16.25	N	51.25	E
	7	18.75	N	51.25	E
48.Oman	1	18.75	N	53.75	E
	2	18.75	N	56.25	E
	3	21.25	N	58.75	E
	4	21.25	N	56.25	E
	5	23.75	N	56.25	E
	6	26.25	N	56.25	E
49.Bahrain	1	26.25	N	51.25	E
50.United Arab Emirates	1	23.75	N	53.75	E
51.Kuwait	1	28.75	N	48.75	E
52.Qatar	1	26.25	N	51.25	E
53.Saudi Arabia	1	21.25	N	51.25	E
	2	21.25	N	48.75	E
	3	21.25	N	46.25	E
	4	21.25	N	43.75	E
	5	21.25	N	41.25	E
	6	21.25	N	53.75	E
	7	23.75	N	38.75	E

	8	23.75	N	41.25	E
	9	23.75	N	43.75	E
	10	23.75	N	46.25	E
	11	23.75	N	48.75	E
	12	23.75	N	51.25	E
	13	26.25	N	43.75	E
	14	26.25	N	41.25	E
	15	26.25	N	38.75	E
	16	26.25	N	48.75	E
	17	26.25	N	46.25	E
	18	28.75	N	36.25	E
	19	28.75	N	38.75	E
	20	28.75	N	41.25	E
	21	28.75	N	46.25	E
	22	28.75	N	43.75	E
	23	31.25	N	38.75	E
	24	31.25	N	41.25	E
54.Israel	1	31.25	N	33.75	E
55.Jordan	1	31.25	N	36.25	E
56.Egypt	1	26.25	N	26.25	E
	2	26.25	N	33.75	E
	3	31.25	N	31.25	E
	4	28.75	N	31.25	E
	5	26.25	N	31.25	E
	6	23.75	N	31.25	E
	7	23.75	N	33.75	E
	8	28.75	N	33.75	E
	9	23.75	N	28.75	E
	10	23.75	N	26.25	E
	11	26.25	N	28.75	E
	12	28.75	N	28.75	E
	13	28.75	N	26.25	E
	14	31.25	N	26.25	E
	15	31.25	N	33.75	E
57.Lebanon	1	33.75	N	36.25	E
58.Turkey	1	36.25	N	33.75	E
	2	36.25	N	36.25	E
	3	38.75	N	43.75	E
	4	38.75	N	28.75	E
	5	38.75	N	31.25	E
	6	38.75	N	33.75	E
	7	38.75	N	36.25	E
	8	38.75	N	38.75	E
	9	38.75	N	41.25	E
	10	41.25	N	41.25	E
	11	41.25	N	36.25	E
	12	41.25	N	33.75	E
	13	41.25	N	28.75	E

59.Syria	1	33.75	N	36.25	E
	2	33.75	N	38.75	E
	3	36.25	N	38.75	E
	4	36.25	N	41.25	E
60.Iraq	1	31.25	N	43.75	E
	2	31.25	N	46.25	E
	3	33.75	N	41.25	E
	4	33.75	N	43.75	E
	5	36.25	N	43.75	E
61.Iran	1	26.25	N	58.75	E
	2	26.25	N	61.25	E
	3	28.75	N	51.25	E
	4	28.75	N	53.75	E
	5	28.75	N	56.25	E
	6	28.75	N	58.75	E
	7	28.75	N	61.25	E
	8	31.25	N	48.75	E
	9	31.25	N	51.25	E
	10	31.25	N	53.75	E
	11	31.25	N	56.25	E
	12	31.25	N	58.75	E
	13	31.25	N	61.25	E
	14	33.75	N	46.25	E
	15	33.75	N	48.75	E
	16	33.75	N	51.25	E
	17	33.75	N	53.75	E
	18	33.75	N	56.25	E
	19	33.75	N	58.75	E
	20	36.25	N	46.25	E
	21	36.25	N	48.75	E
	22	36.25	N	51.25	E
	23	36.25	N	53.75	E
	24	36.25	N	56.25	E
	25	36.25	N	58.75	E
	26	38.75	N	46.25	E

[9].

[9]For SSA' sample, it is mentioned by MSS: No degree grid node fell within the national boundaries for five small African countries–Burundi, Djibouti, Gambia, Guinea-Bissau, and Rwanda, so in these cases they assigned rainfall measures from the node nearest to their borders. We do so for MENA' sample, countries where no degree grid node fell within their boundaries are: Lebanon, Bahrain, Kuwait, Israel, and Qatar