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RESEARCH ARTICLE

The relationship between climate change and political instability: the case of MENA countries (1985:01–2016:12)

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Abstract

The aim of this study is to examine the relationship between climate change and political instability in the MENA region. To this extent, 18 Middle East and North African (MENA) countries are analyzed covering the period 1985:01–2016:12 with monthly data. In econometric analysis, at first cross-sectional dependency analysis is applied, and existence of cross-sectional dependency among countries is found. Therefore, CADF-second generation panel unit root test applied, and finally, Dumitrescu and Hurlin (2012) panel causality test that consider the cross-sectional dependency are utilized. For empirical analysis, temperature and precipitation data representing climate change, political instability, and conflict data are employed. According to the findings, there is a causal relationship from climate change to political instability in 16 countries and to conflict in 15 countries. In addition to this, at least one causal relationship is determined from climate change to political instability or conflict in all MENA countries. Therefore, empirical results support the assumption that climate change acts as a threat multiplier in MENA countries since it triggers, accelerates, and deepens the current instabilities.

Keywords Climate change · Political instability · Environmental economics · Panel causality · MENA · Conflict

Introduction

Although there is no consensus on the definition of political instability in the literature, there are different definitions in different studies. Researchers generally used different parameters to measure the variable of political instability. Hurwitz (1973), who put forward one of the pioneering research on the theoretical background of political instability, examined this issue under different headings and suggested that political instability may occur in countries where five cases are not available. The five cases are listed as follows: (i) the absence of violence, (ii) the length of government office, (iii) the existence of a legitimate constitutional regime, (iv) the absence of structural change, and (v) the sophisticated social character. In addition to these criteria, there are also researchers who include different indicators to the concept of political instability such as revolutions, coups, and political assassinations (Barro 1991); tendencies of government change through constitutional or unconstitutional methods (Alesina et al. 1996; Cukierman et al. 1992); social unrest phenomena, changes of policy makers, fragmentation of decision-making process, and election uncertainties (Carmignani 2003); demonstrations against government policies, rebellions using physical force (Banks 2005), polarization (Beck et al. 2001), civil war (Gleditsch et al. 2002), corruption (ICRG, 2016), and regime changes (Marshall et al. 2002). Political instability, however, may occur not only in democratic governments but also in autocratic governments (Şanlısoy and Kök 2010). As a result of all these developments, political instability is thought to change the behavior of the economic, monetary, and fiscal authorities and thus, be the determinant of economic decisions and outputs (Gurgul and Lach 2012; (Chawdhury 2016; Arslan 2011).

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Economic and political problems directly lead to political instability. However, there are also important factors that indirectly affect political instability. In this study, one of the most important factors indirectly causing political instability is thought to be climate change. Catastrophic weather events, damage to food and water resources by changing climate, new infectious disease outbreaks, and health problems due to ecosystem changes are all related to global warming and pose various risks (Huntjens and Nachbar 2015). Climate change does not only affect health but also affcets income, migration, and political instability. Climate change threatens human security through (i) damaging to livelihoods; (ii) compromising culture and identity; (iii) increasing migration (forced migration); (iv) and reducing the ability of states to provide the necessary conditions for human security (IPCC 2014a, 2014b, 2014c).

Unfortunately, it is foreseen that most of the damages caused by climate change will be felt by poor countries (Mendelsohn et al. 2006; Tol 2005; Smith and Vivenkananda 2007). It is mainly due to the lack of infrastructural and technological capacity of the poor countries which are necessary to eliminate the destructive effects of climate change. For example, in the Middle East and North Africa (MENA) region, many people will migrate in the future due to problems caused by climate change; however, poor people are expected to stay (World Bank 2014) because they cannot afford to migrate as they have unsufficient resources to finance such migration. Water scarcity in the MENA region increases poverty due to the strong dependence of rain-fed agriculture on water, and political instability in the region creates an additional fragility that has been getting stronger (Link et al. 2015). In this context, climate change acts as a "threat multiplier in the MENA region by putting more pressure on limited resources and reinforcing pre-existing threats such as political instability, poverty and unemployment" (Price 2017), but it is inevitable that other regions also will be affected. For example, the number of climate refugees are highest in sub-Saharan Africa, however there are also different countries at risk. Some of these countries are Yemen, China, Louisiana, Tuvalu, Kiribati, and Bangladesh (Durkova et al. 2012). Table 1 indicates the process of political instability related to climate change.

Forsyth and Schomerus (2013) state that there are direct, indirect, and controversial approaches from climate change to political instability, and they explain the linear process to political instability in Table 1. Accordingly, climate events such as the rise of sea level, increase in CO_2, melting of glaciers, and increase in temperatures have an impact on natural resources. These effects can be listed as degrading the ecosystem such as the decrease of biological diversity, the decrease of water resources, and the inefficiency of the soil. The impact on natural resources leads to the restriction of important human needs such as water, food, energy, education, and health. Decreasing the incomes of individuals caused by climate change may lead to social unrest phenomena (Schmidhuber and Tubiello, 2007; FAO 2012; Femia and Werrell 2013; Mhanna 2013; Gleick 2014). Indicators of political instability, such as poverty, demonstrations and riots, environmental conflicts, terrorism, and migration, may emerge especially if problems occurring in sectors such as water, agriculture, forestry, and fisheries persist (Barrett 2013). As can be seen, although natural events caused by climate change do not directly cause indicators of political instability such as conflict, terrorism, and violence, these developments play an important role by triggering the beginning of the process leading to political instability.

The CNA Corporation (2007) reports that climate change acts as a threat multiplier for political instability in some of the world's unstable regions. According to the estimates of the report, climate change will seriously aggravate the current marginal living standards in many Asian, African, and Middle Eastern countries, leading to extensive political instability. The economic and environmental conditions in these regions are already fragile, and factors such as reduced food production, increased diseases, reduced access to clean water resources, and increased population forced to migrate will be added to this fragility. It is underlined in the report that climate change has the potential to create natural and human catastrophes far beyond what is seen today, and the consequences will bring social demands that exceed the capacity of governments to cope, and this situtation will increase political instability. The World Economic Forum (2017) noted that in a world of increasing environmental problems, the complex food system has become more vulnerable to sudden supply shocks. Accordingly, issues such as extreme weather changes and political instability can create simultaneous problems in the main food production regions and trigger global tensions and increase the prices. This risk of systematic deterioration has the potential to increase vulnerabilities around the world, including the reduction of agricultural product diversity, conflicts at access to water, and geopolitical tensions.

In many studies, it is considered that climate change has an accelerating and deepening effect by triggering some social events (Scheffran et al. 2012; De Châtel 2014; Maia 2018). For instance, climate change has an indirect effect on the emergence of protests and conflicts in some countries where Arab Spring events occur (Johnstone and Mazo 2011). This impact is thought to exacerbate current political instability and social unrest. According to Selby et al. (2017), this view is explained for Syria human crises as follows: (i) human-induced climate change is a factor that causes extreme drought in Syria before the civil war; (ii) this drought has led to large-scale immigration; (iii) and it has been one of the reasons that pushed the Syrian people into war by stimulating socioeconomic tensions.

Table 1 Relationship between climate change and some political instability indicators

Climate change	Natural resources	Human needs	Societal Instability
Temperature	Soil	Water	Demonstrations
CO_2 concentration	Water	Food	Riots
Solar radiation	Ecosystems	Energy	Migration
Wind, clouds	Forest	Health	Poverty
Weather extremes	Fishery	Jobs/income	Lack of legitimacy
Ocean currents	Biodiversity	Transportation	Weak institutions
Ice melting	Oceans/coasts	Education	Crime/urban violence
Sea-level rise	Glacier/ice	Lifestyle	Civil unrest
		Community	Coups d'état
			Armed rebellions
			Terrorism
			Ethnic/racial conflict
			Environmental conflict
STRESS	**IMPACT**		**RESPONSE**

Resource: Forsyth and Schomerus 2013

This study is thought to contribute to the literature as it is one of the first studies to empirically examine the causal relationship from climate change to political instability. The aim of this study is to examine empirically whether climate change plays a role in the emergence of political instability in MENA countries. The structure of the paper is as follows: Theoretical information about the relationship between political instability and climate change is given in the introduction and literature survey related to the studies dealing with this relationship is presented in the second part. In the third part, model and data are discussed and then in Section 4, empirical findings are depicted. In the conclusion, empirical findings are discussed and some policy implications are suggested.

Literature survey

There are few studies explaining the current social events, violence, and conflicts with climate change in the literature. The results of some studies on political instability in the MENA region show that climate change in the region accelerates social unrest and violence. Maia (2018) mentioned the mechanisms that affect society by bringing together the ISIS climate change. Accordingly, as in other terrorist organizations, ISIS has identified important strategies through recruitment groups in Iraq. According to the paper, the effects of temperature and droughts in Iraq have been felt by the public, and in 2010, there was a vicious drought (5 times in the last 7 years). In 2012, severe winds caused crops to be destroyed in Kirkuk, Iraq, and the communities in the region both suffered a break in the food chain and faced significant losses in their income. Thus, hunger and unemployment emerged in the region. Damaged families were particularly targeted by ISIS. Knowing that the agricultural sector was affected the most, the ISIS controlled the agricultural offices, gave food baskets to people, and assured the people that their families would not suffer if they participate in the terorist organization. Kelley et al. (2015) stated that before the Syrian uprising that began in 2011, the Fertile Crescent region experienced the most severe drought. According to the researchers, for Syria, which has poor governance and unsustainable agricultural and environmental policies, drought has had a catalytic effect and contributed to political unrest. De Châtel (2014) supports this phenomenon in his study. According to De Chatel (2014), drought between 2006 and 2010 triggered the 2011 uprising in Syria. The rapid economic liberalization, 50 years resource mismanagement, the cancellation of subsidies and the government's failure to solve the environmental and humanitarian crisis are the main reasons for the events. Kelley et al. (2015) stated that the entire Middle East has been facing a warmer temperature due to climate change, and that will affect water resources and agriculture and possibly increase the risk of conflict further in the region. Aribigbola et al. (2013) assert that climate change has trigggered political instability indicators such as terrorism and conflict in many African countries due to the natural disasters that have broken food chain. According to the study, there are many families forced to migrate to sustain food or employment. Thus, in the long term, this situtation will create ethnic tension, food scarcity, and high prices. Burke et al. (2009) found a strong historical link between civil war and warmth in Africa. Accordingly, they stated that hot years significantly increased the probability of war. Biello (2011) stated that the rise in food prices in Egypt accelerated the uprisings in the country and emphasized that climate change is one of the factors causing food prices to rise. Sternberg (2012) supported this claim and argued that the winter drought in China is related to global wheat prices. Due to the winter drought in China, world wheat supply has decreased, and wheat scarcity has occurred in Egypt, the world's largest wheat importer, and food prices have risen dramatically. The rise in food prices soon led to the emergence of demonstrations of poverty and political discontent. Johnstone and Mazo (2011) laid emphasis on the relationship between food prices and unrest. They revealed that events seen in Algeria, Egypt, Jordan, Tunisa, and Yemen are related to food prices. As a matter of fact, they claimed that high food prices are one of the reasons that pushed people onto the streets in those countries. Thus, the Arab Spring demonstrations became widespread. The negative effects of climate change are not limited to MENA countries. For example, Fahad and Wang (2019) affirmed that Pakistan is one of the most vulnerable countries especially in Southeast Asia experiencing floods and droughts as a result of climate change. According to the study, extreme weather conditions have negative impacts on the agriculture sector, groundwater, and poverty. Therefore, effective adaptation strategies should be applied in the country.

Some reports also draw attention on climate-related events. According to the report published by UNHCR (2019), approximately 2 million people were displaced in northeastern Nigeria due to the climate-based conflicts, and more than 540,000 people moved to Cameroon, Chad, and Niger. Similarly, Dupont (2008) estimated that in the developing countries, people will change their places in response to a deteriorating environment. These migrations will increase with socioeconomic events caused by ecological stress, political instability, military conflict, and adverse climate effects. Waha et al. (2017) stated that 70% of the agriculture sector in the MENA region is fed by rain, and changing climate conditions have a significant impact on this sector. This is critical for the economies of the country, as the highest employment is in the agricultural sector in many Arab countries. According to the researchers, the lost revenue of farmers due to decreased agricultural productivity will contribute to the migration flows to urban areas. This situation will bring different economic, political and sociological problems. Verisk Maplecroft Analytics (2014) examined 198 countries across 26 issues on their sensitivity of populations, physical exposure, and governmental capacity to adapt to climate change over the next 30 years. There are ten countries with the highest level of risk. These countries are Bangladesh, Sierra Leone, South Sudan, Nigeria, Chad, Haiti, Ethiopia, Philippines, Central African Republic, and Eritrea. The growth of the economies in the extreme risk category include Cambodia, India, Myanmar, Pakistan, and Mozambique. Each of these countries heavily relies on agriculture for revenue (65% employed in the sector), and a climatic threat to their agriculture sector incites instability, which can lead to political instability. For example, Nigeria is one of the most affected country due to the emergence of Boko Haram in some regions. According to the report, violence in the region may be related with the socioeconomic conditions affected by climatic events. Finally, the report underlined that the Arab Spring was also found to be initiated by food price volatility and food insecurity, especially in Egypt and Syria. These examples indicate that climate change plays an important role in some social events, demonstrations, and terrorism activites by acting as a threat multiplier.

Considering the opposite direction of the relationship above, there are some studies focusing on the negative impacts of political instability on the environment. Fredriksson and Svensson (2003) found that there was an interaction between political instability and corruption; one of its indicators argued that this interaction could be effective in determining and implementing economic policies. This result is important, considering that economic policies directly and indirectly affect environmental policies. Zugravu et al. (2008) investigated whether economic transformation in transition countries contributed to global emission reduction. For this purpose, they created a model for the period 1997–2003 by using supply-demand method. The results reveal that political instability and corruption have a negative effect on the rigidity of environmental laws in transition countries and emerging market economies, but this effect is weak in industrialized countries. In other words, political instability and corruption leads to the bend or non-implementation of rules stipulating the implementation of environmental standards. In addition, they stated that institutional factors are important for pollution reduction in transition economies according to their future forecasts. Gani (2012) examined the relationship between five different governance indicators (political instability, government efficiency, quality of regulation, rule of law, and corruption) and CO_2 emissions in developing countries. For this purpose, using the panel data analysis, they included 99 countries in the model for the period 1996–2009. The results show that political stability, the rule of law and corruption control have a negative and statistically significant relationship with CO_2 emissions per capita. In this context, it is seen that the environmental deterioration decreases if there is political stability, the rule of law and fighting against corruption in countries. Halkos and Tzeremes (2013) applied nonparametric estimators to examine the relationship between CO_2 emissions and governance indicators of countries. For this purpose, they used data for G-20 countries for the period 1996–2010. Six governance indicators (lack of political stability and violence, freedom of expression and accountability, government effectiveness, regulatory quality, rule of law, and control of corruption) were included in their analysis. The findings revealed a non-monotonic relationship between CO_2 emissions and governance indicators. However, the relationship between CO_2 emissions and governance is not linear, and it is stated that the high governance quality of the countries will not always lead to a decrease in CO_2 emission levels. Sekrafi and Sghaier (2016) examined the effects of political instability, corruption, environmental quality, and energy consumption on economic growth in the MENA countries for the period 1984–2020 using both static and dynamic panel data approaches. Empirical results show that increased corruption directly affects economic growth, environmental quality, and energy consumption. Another empirical finding is that economic growth negatively impacts environmental degradation and political instability in the MENA region.

Methods and data

In this study, the relationship between climate change (temperature and precipitation changes representing climate change) and political instability and conflict in MENA countries during the period of 1985:01–2016:12 is examined by econometric analysis. In this context, Table 2 contains the 18 MENA countries used in the analysis and provides explanations of the variables. The data for the empirical analysis were obtained from World Bank Climate Change Portal (2018) and ICRG (2016).

In the analysis that is part of this study, at first, cross-sectional dependency analysis, CADF-second generation panel unit root test; and, finally, Dumitrescu and Hurlin (2012) panel causality tests are utilized. Both temperature and precipitation data are analyzed separately with political instability and conflict. If a causal relationship is detected from one of the variables (temperature and precipitation) to political instability and conflict, it means that there is a weak relationship between the variables. However, if a relationship is detected in both variables, it shows the strong relationship.

The CADF (Cross-sectional Augmented Dickey Fuller) unit root test developed by Pesaran (2007) is used in this study to test the stationarity.The CADF test statistic values are calculated for all units forming the panel firstly. Then, the arithmetic average of these tests is taken, and CIPS (Cross-sectionally Augmented IPS) statistic values are obtained for the whole panel. The CADF test results perform a stationarity test for each country that form the panel, while the CIPS test performs a stationarity test for the whole panel. The calculation of CADF and CIPS test statistical values are shown in (Eqs. 1, 2, 3, 4, 5, 6 and 7):

$$t(N,T) = \frac{\Delta y'_i \overline{M}_i y_{i-1}}{\sigma^2 \left(\Delta y'_{i-1} \overline{M}_i, \ \ \Delta y_{i-1} \right)^{1/2}} \tag{1}$$

$$\overline{\mathrm{M}} = \left(\tau, \Delta \mathrm{y}, \overline{\mathrm{y}}_{\mathrm{t-1}} \right) \tag{2}$$

$$\tau = (1, 1, \ldots)' \tag{3}$$

$$\Delta \mathrm{y} = \left(\Delta \overline{\mathrm{y}}_1, \Delta \overline{\mathrm{y}}_2, \ldots \Delta \overline{\mathrm{y}}_{\mathrm{t}} \right)' \tag{4}$$

$$\overline{\mathrm{y}}_{\mathrm{t-1}} = \left(\overline{\mathrm{y}}_0, \overline{\mathrm{y}}_1, \overline{\mathrm{y}}_{\mathrm{t-1}} \right)' \tag{5}$$

$$\sigma^2 = \frac{\Delta \mathrm{y}'_{\mathrm{i}} \overline{\mathrm{M}}_{\mathrm{i}}, \ \ \Delta \mathrm{y}_{\mathrm{i}}}{\mathrm{T-4}} \tag{6}$$

$$\mathrm{CIPS} = \mathrm{N}^{-1} \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{t(N,T)} \tag{7}$$

The cross-sectional dependence is based on the assumption that a shock occurring in any of the units forming the panel affects the other units. Globalization has reached a certain stage, and this process has been continuing rapidly. Many countries establish economic relations regardless of geography and work on systems based on mutual trade. Therefore, an economic shock in one country has the capacity to influence other countries directly and indirectly. In this context, in panel data analysis, the results obtained from the tests performed with the exception of cross-section dependence will be deviant and unreliable. Therefore, it is necessary to test the presence of cross-sectional dependence among the variables before the analysis and apply the analysis based on the results (Menyah et al. 2014).

In empirical analysis, causality tests should be applied to reveal the direction of the relationship between variables. Therefore, in this part of the empirical analysis, panel bootstrap causality test based on individual Wald statistics developed by Dumitrescu and Hurlin (2012) was used. In Dumitrescu and Hurlin (2012) test, two series which are stationary are analyzed. The causality analysis also takes into

Table 2 MENA countries included to the analysis and explanations

Bahrain	Israel	Tunisia
United Arab Emirates (UAE)	Qatar	Oman
Algeria	Kuwait	Jordan
Morocco	Libya	Sudan
Iraq	Lebanon	Syria
Iran	Egypt	Saudi Arabia
Data	*Unit*	*Data source*
Mean temperature	Celsius	World Bank Climate Change Knowledge Portal
Mean precipitation	Milimeter	World Bank Climate Change Knowledge Portal
Conflict	Index (0–12)	ICRG
Political instability	Index (0–100)	ICRG

Table 3 Cross-section dependence test results

Variables	LM	CD_{LM}	LM_{adj}	CD
Precipitation	11,031.24[a] (0.00)	621.86[a] (0.00)	621.84[a] (0.00)	64.52[a] (0.00)
Temperature	45,489.21[a] (0.00)	2591.74[a] (0.00)	2591.71[a] (0.00)	206.33[a] (0.00)
Political instability	29,995.46[a] (0.00)	1705.98[a] (0.00)	1705.91[a] (0.00)	143.59[a] (0.00)
Conflict	24,538.02[a] (0.00)	1393.99[a] (0.00)	1393.95[a] (0.00)	115.53[a] (0.00)

[a] Shows statistical significancy at 1% significance level. Values in parentheses are the probability value

account heterogeneity. Therefore, if the series used in the analysis are not stationary, the first differences should be taken, and stationary variables should be used. In Dumitrescu and Hurlin (2012) test, a linear model in (Eq. 14) is taken into consideration:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} \quad (8)$$

In (Eq. 8), "αi" and "δi" parameters are assumed that the individual effects are constant in the time dimension. The Dumitrescu and Hurlin (2012) test is based on the assumption that the panel is stationary, and the lagging sequence of "K" is the same for each section forming the panel. However, this method allows autoregressive parameters, and the slopes of the regression coefficients vary between the groups. Another advantage of this test is that the time dimension "T" may be applied in case of the section dimension; "N" is larger or smaller.

Dumitrescu and Hurlin (2012) define null hypothesis and alternative hypothesis based on panel causality analysis as in (Eqs. 9, 10, and 11):

$$H_0 = \beta_i = 0 \ \Lambda i = 1, \ldots, N \quad (9)$$

There is no causality from x to y for all sections.

$$H_1 : \beta_i = 0 \ \Lambda i = 1, \ldots, N_1 \quad (10)$$

$$\beta_i \neq 0 \ \Lambda i = N_1 + 1, N_1 + 2, \ldots, N$$

There is a causality relationship from x to y for some sections. (11)

Table 4 CADF unit root test results

	CADF (CIPS statistics)	
Variables	Level	First difference
Precipitation	−2.19	−8.32[a]
Temperature	−8.77[a]	−10.92[a]
Political instability	−10,61[a]	−14.79[a]
Conflict	−9.03[a]	−14.63[a]

[a] Indicates statistical significance at 1% significance level. Critical values of 1, 5, and 10% statistical significance level for CADF test are −3.25, −2.60, and −2.26, respectively. The critical values of CADF are obtained from Table 1 a of Pesaran (2007: 274)

In the panel causality test of Dumitrescu and Hurlin (2012), individual Wald statistics are calculated for each section in order to test the null hypothesis. Then, as shown in (Eq. 12), the Wald statistics ($W_{N,T}^{Hnc}$) which are valid for the panel are obtained by taking the average of individual Wald statistics.

$$W_{N,T}^{Hnc} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \quad (12)$$

Dumitrescu and Hurlin (2012) use the test statistics "$Z_{N,T}^{Hnc}$ " when the time dimension is larger than the cross-sectional dimension ($T > N$), but when the time dimension is smaller than the cross-sectional dimension ($T < N$), they recommend using "Z_N^{Hnc} " test statistics.

Standardized test statistics are shown in Eqs. (13, 14, 15):

$$\text{If } T > N, \quad (13)$$

$$Z_{N,T}^{Hnc} = \sqrt{\frac{N}{2K}} \left(W_{N,T}^{Hnc} - K \right) \rightarrow N(0, 1) \quad (14)$$

$$T < N \text{ ise,}$$

$$Z_N^{Hnc} = \frac{\sqrt{N} \left(W_{N,T}^{HNC} - N^{-1} \sum_{i=1}^{N} E\left(W_{i,T}\right) \right)}{\sqrt{1/N \sum_{i=1}^{N} VAR\left(W_{i,T}\right)}} \quad (15)$$

The advantages of Dumitrescu and Hurlin (2012) method are (i) it can take into account both cross-sectional dependence and heterogeneity among the countries forming the panel, (ii) can be used even when the time dimension is greater than or smaller than the cross-sectional dimension (*N*), and (iii) can produce effective results in unbalanced panel data (Dumitrescu and Hurlin 2012). Another advantage of Dumitrescu and Hurlin test is that it allows analyzing in the absence of cointegration relationship between variables (Alper and Oransay 2015).

Empirical findings

Findings of the panel cross-section dependence, the panel unit root and panel causality test obtained by empirical analysis are reported in the following tables.

Table 3 shows cross-sectional dependence test results among the countries. Four alternative test statistics for all

Table 5 Unit root test results by country

Countries	Precipitation		Temperature		Political instability		Conflict	
	CADF	ρ	CADF	ρ	CADF	ρ	CADF	ρ
Algeria	− 12,442	1	−10,331	5	−1656	1	−3230	1
Bahrain	− 12,415	1	−8142	4	−1948	1	−3470	1
Egypt	− 13,405	1	−10,347	2	−3086	1	−1252	1
Iran	− 8865	2	−10,584	3	−0,400	1	−3361	1
Iraq	− 7385	1	−6806	4	−0,703	1	−2616	1
Jordan	− 9487	1	−11,170	2	−3434	1	−2426	1
Kuwait	− 11,127	1	−8248	4	−3331	1	−2824	1
Lebanon	− 8871	1	−12,864	1	−1708	1	−2027	1
Libya	− 11,148	1	−12,344	2	−2816	1	−1269	1
Morocco	− 10,534	1	−10,351	4	−2696	1	−2125	1
Oman	− 13,589	1	−6740	5	−2551	1	−2116	1
Qatar	− 12,347	1	−7882	4	−2348	1	−2609	1
Saudi Arabia	− 14,046	1	−8250	4	−4998	1	−2800	1
Israel	− 10,132	1	−10,889	1	−2400	1	−2666	1
Sudan	− 9316	1	−6144	9	−1795	1	−2584	1
Syria	− 9680	1	−3324	4	−3022	1	−2360	1
Tunisia	− 10,988	1	−3740	6	−2540	1	−2382	1
United Arab Emirates	− 12,215	1	−7734	4	−3759		−2256	1
PANEL CIPS	*− 10,999*		*− 8660*		*− 2511*		− 2465	

variables reject the null hypothesis “no cross-sectional dependence at 1% statistical significance level.” This result means that a shock in any of the MENA countries may also affect other countries. Therefore, in order to reach reliable findings, it is necessary to use panel unit root and panel causality methods (second generation panel data analyzes) which take account of cross-sectional dependence for these countries. In Table 4, the second-generation unit root test (CADF) findings are reported for the whole panel.

According to the CADF unit root test results, all variables except the pericipitation are stationary in the level values. When the first differences of the series are taken, it is seen that all variables are stationary. The integrated degree of all variables used in the analysis is I [1]. In Table 5, the CADF unit root test findings are reported for each country in the panel.

After the cross-sectional dependence and unit root tests, Dumitrescu and Hurlin (2012) panel causality test was applied to determine the direction of the relationship between the variables. The panel causality test was first applied to each country individually to determine the causal relationship between temperature, precipitation, political instability, and conflict. After obtaining the causality results of Dumitrescu and Hurlin (2012) belonging to each country, Panel Granger causality test was applied to the whole panel and reported below the table.

Table 6 shows Dumitrescu and Hurlin panel causality test results. The findings may be summarizied as follows.

Hypothesis 1: All countries except for Algeria, Egypt, and Tunisia have a causal relationship from temperature changes to political instability; however, for the whole panel, changes in temperature are not a cause of political instability.

Hypothesis 2: Only Jordan, Egypt, and Israel have a causal relationship from precipitation changes to political instability, and for the whole panel, there is a causal relationship from changes in precipitation to political instability.

Hypothesis 3: In all countries except for Egypt, Jordan, Morocco, Oman, Saudi Arabia, and Tunisia, a causal relationship is determined from temperature changes to conflicts; however, results for the whole panel reveal that there is no causal relationship from temperatures to conflicts.

Hypothesis 4: Only Tunisia, Egypt and Jordan have a causal relationship from changes in rainfall to conflicts. For the whole panel, there is a causal relationship from changes in precipitation to conflicts.

In the empirical analysis, in order to test the existence of a causality relationship from climate change to political instability, the indicator of conflict was also tested. The reason for this is to strengthen the reliability and consistency of the results. For the same purpose, two different variables, both temperature changes and precipitation changes, were used to represent climate change. Thus, the relationships between climate change and political instability variables were tested separately, and the findings were interpreted as strong or weak relationships. As it is seen in Table 7, except for Moroco, Oman,

Table 6 Dumitrescu ve Hurlin panel causality test results

	Hypothesis 1		Hypothesis 2		Hypothesis 3		Hypothesis 4	
	H_0: Changes in temperature are not the cause of political instability.		*H_0: Changes in precipitation are not the cause of political instability.*		*H_0: Changes in temperature are not the cause of conflicts.*		*H_0: Changes in precipitation are not the cause of conflicts.*	
Countries	*Wald stat.*	*Prob.*	*Wald stat.*	*Prob.*	*Wald stat.*	*Prob.*	*Wald stat.*	*Prob.*
Algeria	10.67	0.22	9.08	0.34	14.89***	0.06	3.31	0.91
Bahrain	37.29*	0.00	3.87	0.87	17.28**	0.03	3.98	0.86
Egypt	11.98	0.15	17.78**	0.02	13.03	0.11	16.33**	0.04
Iran	17.82**	0.02	6.48	0.59	21.14*	0.01	12.41	0.13
Iraq	36.11*	0.00	6.69	0.57	24.37*	0.00	5.37	0.72
Jordan	32.10*	0.00	29.89*	0.00	8.52	0.38	18.49**	0.02
Kuwait	43.00*	0.00	10.84	0.21	24.00*	0.00	10.42	0.24
Lebanon	36.43*	0.00	9.99	0.27	27.09*	0.00	9.62	0.29
Libya	32.32*	0.00	7.32	0.50	25.98*	0.00	5.72	0.68
Morocco	33.81*	0.00	6.73	0.57	11.30	0.19	2.91	0.94
Oman	52.18*	0.00	10.39	0.24	12.54	0.13	2.02	0.98
Qatar	65.89*	0.00	12.73	0.12	25.85*	0.00	1.65	0.99
Saudi Arabia	30.94*	0.00	5.70	0.68	8.35	0.40	4.83	0.78
Israel	23.18*	0.00	15.83**	0.04	20.97*	0.01	10.80	0.21
Sudan	62.77*	0.00	8.90	0.35	65.11*	0.00	8.49	0.39
Syria	21.41*	0.01	13.72***	0.09	18.20**	0.02	8.98	0.34
Tunisia	6.15	0.63	10.99	0.20	4.11	0.85	16.22**	0.04
United Arab Emirates	90.47*	0.00	9.70	0.29	41.77*	0.00	7.13	0.52
Panel (*MENA*)	*− 1.40*	*0.15*	*3.10**	*0.00*	*− 1.15*	*0.21*	*− 1.65****	*0.10*

*, **, and *** show significance at 1%, 5%, and 10% significance levels, respectively. It means that Wald statistics are significant, and the null hypothesis is required to be rejected

and Saudi Arabia, there is a weak causality relationship from climate change to conflict in 15 MENA countries. In addition, only in two countries (Algeria and Tunisia) that there is no causality relationship from climate change to political instability. In other words, in all countries in the MENA region, at least one causal relationship has been determined from climate change to political instability or conflict. Therefore, empirical results reveal that climate change can be cited as a reason for explaining the political instability in the MENA region. As we do not claim that there is a direct relationship between the variables, having a weak relationship also meets our expectations.

Table 7 Summary of findings

	Political instability	Conflict
Algeria	X	→
Bahrain	→	→
Egypt	→	→
Iran	→	→
Iraq	→	→
Jordan	➡	→
Kuwait	→	→
Lebanon	→	→
Libya	→	→
Morocco	→	X
Oman	→	X
Qatar	→	→
Saudi Arabia	→	X
Israel	➡	→
Sudan	→	→
Syria	➡	→
Tunisia	X	→
United Arab Emirates	→	→
Panel (*MENA*)	→	→

Conclusion

In this study, the relationship between climate change and political instability in 18 MENA countries was investigated empirically. Dumitrescu and Hurlin (2012) panel causality test results indicate that there is a causal relationships from climate change to political instability (16 countries) and to conflict (15 countries) in the MENA region. Therefore, the thesis supports the hypothesis that climate change in MENA region acts as a threat multiplier for the emergence of political instability. In particular, the determination of causality in many countries affected by the Arab Spring events supports the thesis of this study. Nonetheless, the causality relationship in countries like Qatar, UAE, Kuwait, Saudi Arabia, and Bahrain is contrary to expectations as they are relatively stable and wealthier than other countries. However, it can be explained by the fact that a shock in the region has a spillover effect on the other countries as well. Findings obtained from empirical analysis are supported by the studies conducted by Sternberg (2012); Selby et al. (2017); Maia (2018); Price (2017); Durkova et al. (2012); Kelley et al. (2015); Burke et al. (2009); Biello (2011); Waha et al. (2017); and Forsyth and Schomerus (2013) (The CNA Corporation 2007; World Economic Forum 2017; UNHCR, 2015).

The MENA region has long been experiencing instability due to the devastating effects of both climate change and political instability. Agricultural resources in the MENA region are largely water-dependent (Martens 2017; Shetty 2006), and recent droughts have led to significant reductions in the income of people who live in the region and earn the livelihood from the agricultural sector (Adoho and Wodon 2014). One of the indicators of social unrest is the loss of personal income (Keidel 2005). In many countries in the region, the problem of unemployment continues, and people who migrate cannot be employed quickly. This situation causes unrest in society. For this reason, it is possible for some individuals to participate in demonstrations, protests, and even violence in the region from time to time. Because these people are restless unless their income losses are compensated, and their employment is provided, and finally, they are more vulnerable to the propaganda of terrorist organizations unless sustainable living conditions are provided. According to World Bank (2019), agriculture sector has a significant share in GDP in MENA countries especially where Arab Spring is experienced (Libya: 37.1% for 2017, Sudan: 30.5%, Syria: 19.5%, Algeria: 12%, 3; Egypt: 11.5%; Tunisia: 9.5%; Yemen: 6.02%). Therefore, income losses in the agricultural sector in the region can bring social problems in addition to economic problems. Due to droughts, agriculture failure and conflicts, serious migrations occurred in the MENA region. Considering the migration data of the countries, immigration in these countries seems to be at a very serious level. According to Pew Research Center (2019) data, 2017 migration numbers are as follows: Libya, 160 thousand; Sudan, 1.95 million; Syria, 6.86 million; Algeria, 1.79 million; Egypt, 3.41 million; Tunisia, 770 thousand; Yemen, 1.19 million people. In addition to that, it is foreseen that many people will continue to migrate in the MENA region (World Bank 2014).

Climate change is expected to have devastating effects on MENA countries such as drought and agriculture failure. However, the negative impacts that will take place on these countries as a result of climate change have been caused not only by the actions of the MENA countries but also by the worldwide greenhouse emissions. In fact, the share of MENA countries in global emissions is very limited. Therefore, mitigating the devastating effects of climate change in the region depends mostly on global environmental and energy policies rather than regional policies. In this context, the INDC mechanism in the Paris Agreement signed by 196 countries should work effectively, and countries should fulfill their emission reduction commitments. Moreover, it is fair to argue that such vulnerable countries should mainly focus on climate-related adaptation strategies, and such programs should be supported and financed by developed countries.

In this study, it is not argued that climate change directly causes political instability, but it is propounded that there is an interaction mechanism between these indicators. It is thought that climate change acts as a threat multiplier and affects individuals economically and socially. It accelerates and deepens problems, especially in regions where political instability has already started. In order to reduce instability in the region and prevent incidents of violence, conflict, and terrorism, it is necessary to reduce the vulnerability of people who suffered from climate change. For this purpose, individuals working in the agricultural sector should be supported financially, and their production should be encouraged. In order to reduce the damages that may occur in the agricultural sector, incentive mechanisms should be established and policies should be developed to prevent possible migration events. However, in case the emergence of migration, short, medium, and long-term strategies should be developed to increase the adaptation of migrants to the places they migrate. Finally, in this study, MENA countries, where socioeconomic problems caused by climate change have become evident, have been examined, but it should be reminded that other regions (e.g., the Mediterranean countries) with agriculture-based economies are also at risk.

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