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RESEARCH ARTICLE

Temperatures, conflict and forced migration in West Asia and North Africa

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ABSTRACT The region of West Asia and North Africa has not only been termed a "hotspot" region for the adverse impact of climate change in light of extreme temperature increases. Several countries have also experienced protracted humanitarian crises and civil wars in the last two decades, such as those in Syria, Yemen and Libya. The vulnerability of these populations makes advancing our understanding of how climate change may impact migration patterns in the region a matter of urgency. This study examines whether extreme temperatures influence bilateral forced migration between countries within West Asia and North Africa through their potential to increase armed conflict. The findings suggest that extreme temperatures in two consecutive years, defined as the upper 10% of the country-specific annual mean temperature distribution, cumulatively increase the probability of armed conflict by 42.5% in the following year ($p = 0.07$). Armed conflict is strongly associated with an increase in asylum flows, by 45.8 percentage points ($p = 0.00$), and there is a weak indication that conflict mediates the relationship between extreme heat and asylum flows. This explorative study is the first to apply a regional displacement perspective to the climate-conflict-migration nexus in West Asia and North Africa. The results underline the importance of taking contextual factors into account in the analysis of environmental migration.

KEYWORDS Climate change • Conflict • Forced migration • MENA

Introduction

Climatic irregularities may increase migration flows, particularly in contexts where individuals are vulnerable to climatic shocks. One of the indirect channels through which environmental change may impact migration is through its potential to increase conflict as a driver of migration (Abel et al., 2019). Especially prone to forced migration in relation to climatic variability are regions that (1) are highly affected by the impact of global warming, and (2) have experienced high levels of violent conflict in the past. In these contexts,

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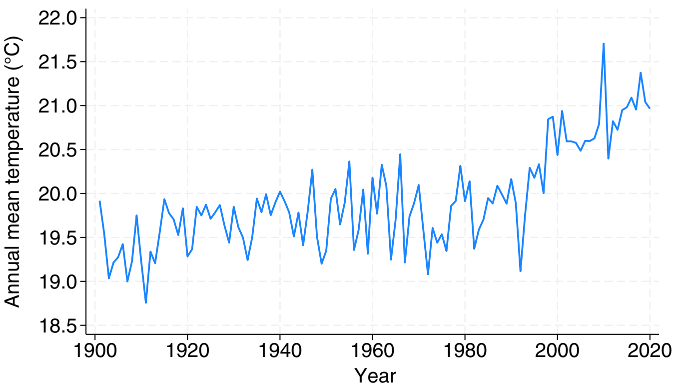
climatic irregularities might aggravate grievances and security concerns by exacerbating divides between population groups.

This study is, to the best of my knowledge, the first to investigate the climate-conflict-migration nexus from a regional displacement perspective, looking at the bilateral asylum flows that occur between countries *within* the West Asia and North Africa region (WANA). I investigate the impact of extreme temperatures on forced bilateral migration between 29 countries in West Asia and North Africa through armed conflict using UNHCR (2021) data on asylum applications for the years 2000–2019. I use a fixed effects modelling strategy in a mediation analysis to draw on the within-origin country variation of temperatures across years, and to account for annual shocks and time-invariant characteristics of the origin country, the host country and the origin-host country pair.

The region of West Asia and North Africa might be particularly vulnerable to environmental migration in the context of armed conflict (Abel et al., 2019; Hoffmann et al., 2020). WANA is among the geographic regions forecasted to be most strongly affected by temperature extremes, according to the IPCC's Sixth Assessment Report (Hoegh-Guldberg et al., 2018, p. 177). Figure 1 below shows the annual mean temperature in degrees Celsius for countries in West Asia and North Africa in the 1901–2020 period. In addition to rising temperatures, several countries in West Asia and North Africa have experienced outbreaks of violent conflict in the last two decades. Some of these conflicts, such as those in Syria, Yemen and Libya, have driven mass displacement and resulted in long-lasting civil wars and protracted humanitarian crises. The region accounts for 38 million international migrants. Six million people have been displaced from the

Figure 1 Annual mean temperature in degrees Celsius for countries in West Asia and North Africa in the 1901–2020 period.



Data source: Climate Change Knowledge Portal (World Bank Group, 2021)
Note: Countries include Afghanistan, Algeria, Armenia, Azerbaijan, Bahrain, Cyprus, Egypt, Georgia, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, Yemen.

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Arab Republic of Syria alone, which makes Syria the country for which the largest number of refugees and asylum-seekers worldwide is recorded (UNDESA, 2020, p. 17; IOM, 2019, p. 3), followed by the State of Palestine (UNHCR 2020, p. 2). Conflicts and disasters have also led to high levels of internal displacement in the last decade, particularly in Syria, where 17 million people were displaced between 2010 and 2019, and in Iraq and Yemen (IDMC 2021, p. 3).

The environment is rarely the sole driver of migration, and the link between environmental change and migration is highly dependent on contextual factors (Borderon et al., 2019; Obokata et al., 2014; Black et al., 2011). The risk of armed conflict is higher in contexts where populations depend on agricultural production (Caruso et al., 2016; Maystadt et al., 2015; Maystadt and Ecker, 2014; Miguel et al., 2004). This risk is particularly acute in places where drought, water scarcity, floods and temperature extremes affect sources of food, water and income, potentially exacerbating inequalities between socioeconomic and ethnic groups (Ide et al., 2020; Schleussner et al., 2016; Daoudy, 2020).

These contextual factors are, however, region-specific. The heterogeneity of countries and larger regions is often ignored in study designs that use global samples across regions, even though the differences are often large, and can be incorporated in the modelling structure to a limited extent only. This challenge has led to inconsistent results, for example regarding a "trapping-in" effect of migrants in poverty (Cattaneo and Peri, 2016; Gröschl and Steinwachs, 2017; Gray, 2011; Gray and Mueller, 2012).

This challenge can be addressed by focusing the analysis on regional migration patterns, because flows follow "migration corridors" that are shaped by historic, geographic, demographic, economic and other region-specific factors (UNDESA, 2020, p. 2). In West Asia and North Africa, more than 50% of migrants who left their country of origin reside in a country within the region (UNDESA, 2020, p. 21). This underlines the importance of considering migration regionally. Abel et al. (2019) found that drought may influence asylum migration through armed conflict, albeit only in countries affected by the Arab uprising. Could this effect be driven by asylum migration within the region?

This study applies a regional perspective to displacement across countries in West Asia and North Africa. It aims to investigate the effect of extremely hot annual mean temperatures on asylum migration through armed conflict as a mediator, drawing on a range of data sources. The findings suggest that two consecutive years with extremely hot temperatures increases the probability of armed conflict occurring in the following year by 42.5% ($p = 0.07$, standard errors are large). Conflict is also strongly associated with an increase in asylum applications, by 45.8 percentage points ($p = 0.000$). There is a weak indication that conflict mediates the relationship between extreme heat and asylum migration, although the estimated effects of extremely hot years are not statistically significant, and the analysis is only explorative. The results demonstrate that regional migration patterns can differ from the climate-migration relationships identified in studies with global samples, underlining the value of using regional samples and the importance of considering contextual factors of migration in the modelling strategy.

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Literature review

The environment as a driver of migration

Drivers of migration are embedded in a complex situational context, potentially interacting with other drivers to affect migration decisions. A commonly used framework in the study of environmental migration is Black et al.'s (2011) theoretical framework on the drivers of migration. These drivers can be political, demographic, economic, social and environmental, and operate in combination on the level of individual agency, personal and household characteristics and other barriers and facilitators on the micro and the meso level in shaping migration outcomes.

A shift in the theoretical underpinnings of the research on environmental migration has occurred, which was described by Hunter et al. (2015, p. 9) as follows:

> "[. . .] environmental factors interact with a complex array of contextual factors as well as individual- and household-level characteristics to ultimately shape migration decision making. Given this, rather than asking whether drought causes migration, for example, researchers are beginning to ask, In what combinations of contexts does drought increase or decrease migration?" (ibid.)

Based on Black et al.'s framework (2011), extreme heat can be conceptualised as an environmental driver of migration that may increase the hazardousness of the environment for people, and affect whether they have sufficient and reliable access to ecosystem services (e.g. in terms of land productivity (Cattaneo and Peri, 2016; Falco et al., 2019), habitability, food, energy and water security). Extreme heat may also impact other macro-level drivers, such as economic factors, by threatening people's incomes and livelihoods.

In such contexts, discontent with the political system and its response to environmental stress, conflicts over scarce resources and inequalities between social groups may arise or become aggravated. These challenges may put tremendous pressure on social and political institutions, and can induce, exacerbate or maintain violence as a driver of migration. In this study, I investigate whether extreme heat increases migration through armed conflict as a mediator. At the same time, I acknowledge that heat can increase migration through other drivers as well, such as those that impact the habitability of the area, agricultural yields, wages, employment stability and livelihoods. I hypothesise that part of the effect of temperatures on asylum migration might function through armed conflict.

Several systemic reviews on this topic have argued that no universal conclusions can be drawn. A growing body of literature has pointed out that some social groups may not be able to leave their homes due to a lack of resources, and thus become "trapped" (Cattaneo and Peri, 2016; Gröschl and Steinwachs, 2017; Gray, 2011; Gray and Mueller, 2012). Borderon et al. (2019) emphasised interactions on the micro, meso and macro levels that are highly context-specific, while Obokata et al. (2014) concluded that there is strong evidence of complex interactions between environmental and non-environmental factors. These authors also noted that quantitative studies are always susceptible to omitted variable bias.

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In summary, the existing literature indicates that migration outcomes are highly context-dependent.

Conflict may mediate the environment-migration relationship

This study seeks to investigate whether armed conflict provides an indirect channel in the often-hypothesised positive relationship between climate change and migration. Studies that examine this triple nexus of climate change, conflict and migration simultaneously are rare. One recent study by Abel et al. (2019) aimed to draw causal inferences from drought to armed conflict, and then from armed conflict to migration. By applying a sample selection approach using bilateral asylum-seeking data for more than 150 countries, they found statistically significant effects only for countries in Western Asia and Northern Africa in the 2010–2012 period. The authors argued that drought severity induced forced cross-border migration only in countries that underwent political transformation during the Arab uprisings, and attributed this effect to contextual factors.

Some studies have considered conflict as a confounder when testing the relationship between environmental change and migration in regression analyses. Hoffmann et al. (2020) conducted several meta-regressions using 30 country-level studies that estimated the effect of environmental change on migration. Indeed, they found that studies that control for income and conflict report smaller average effects of climate variability on migration. These results support the notion that armed conflict might function as a mediating factor in environmental migration (see Coniglio and Pesce, 2015; Falco et al. 2019).

Climatic anomalies may increase conflict

Empirical evidence on the link between climatic anomalies and conflict comes from studies covering various timescales and regional contexts, especially low- and middle-income settings. Burke et al. (2015) conducted an analysis of 55 econometric studies[1] that aimed to derive causal inferences from climate variation to conflict using identification in time series. They concluded that an increase in temperature by one standard deviation increases intergroup conflict, including political and collective violence, by more than 11%. In another meta-analysis, Hsiang et al. (2013) reviewed 60 quantitative experimental and natural experiment studies from a range of disciplines on the influence of climate variations on conflict across all regions of the world, ranging from the BC period to the present. In line with the previously mentioned review, they found that deviations from normal precipitation and temperature levels systematically increase conflict risk, and that the impact is often substantial: their median estimate for the frequency of intra-group conflict was 14% for an increase in temperatures or extreme rainfall by one standard deviation.

1 See, for example, (Maystadt et al., 2015) on the conflict in North and South Sudan, and Baysan et al. (2019) on the importance of non-economic psychological and physiological individual factors in mitigating the effects of temperatures on violence.

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There may be different factors that render populations more vulnerable to the emergence of conflict. Studies have shown that a country's dependence on agricultural production makes conflict more likely because yield reductions may induce crop and water scarcity (Caruso et al., 2016; Maystadt et al., 2015) and livestock market price fluctuations (Maystadt and Ecker, 2014), and can hamper economic growth (Miguel et al., 2004).

Conflict is a strong predictor of migration

There is a significant strand of the literature that seeks to understand how conflict may induce migration. Such studies have provided ample empirical evidence that violent conflict can be a strong predictor of internal and cross-border migration. For example, Sesay (2004) found that conflict is a major determinant of refugee flows. Through a pooled time-series analysis for the 1971–1990 period, Schmeidl (1997) examined the relationship between refugee flows and genocide, politicide, civil war and interstate war. She concluded that these measures of generalised violence are all predictors of migration, and that they are, indeed, stronger predictors of migration than civil rights violations. Both studies attributed greater importance to conflict than to economic hardship in the origin country in explaining forced migration. Moore and Shellman (2007) also found that civil war is a stronger predictor of migration than wage levels in the destination country. Here, armed conflict is conceptualised as a potential mediator in the temperature-asylum migration relationship based on findings on armed conflict as a driver of migration.

Contribution

The paper aims to make a contribution in several ways. First, there is a gap in the literature on the environment-conflict-migration nexus that may be of relevance for understanding how environmental drivers affect migration. This study investigates whether armed conflict can be considered as a mediator in the temperature-asylum migration relationship. While Abel et al. (2019) found such a link only for countries that underwent the Arab uprisings, they did not include origin-destination fixed effects that could control for all time-constant observed and unobserved characteristics of the origin country-host country pair. This might have biased the results if there were important omitted variables that influenced the temperature-migration relationship. The analysis here includes such a fixed effect, and aims to control for time-variant variables similar to those in Abel et al. (ibid.). In addition, there is a gap in the literature on the question of whether the asylum flows caused by climatic irregularities are global, or mainly occur between countries within the West Asia/North Africa region. For this reason, this study focuses on asylum flows between 29 countries in the WANA region. This approach emphasises the importance of migration within West Asian and North African states, which is shaped by various unique migration corridors.

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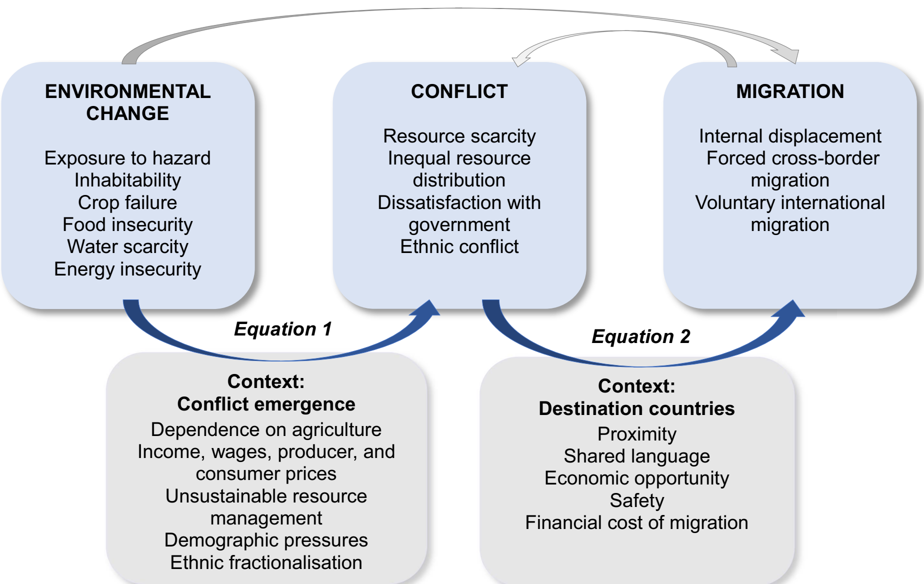
Conceptual model

The review of the existing empirical findings leads me to draw the following conclusions: first, only a few previous studies have investigated the climate-conflict-migration nexus comprehensively; second, the literature suggests that there is an *indirect* effect of climatic irregularities on migration flows through conflict; and, third, context-specific factors strongly influence environmental migration flows. This makes a further investigation of within-region migration meaningful, as it could help to isolate contextual factors and provide insight into specific migration types.

The conceptualisation for the model in this study is depicted in Figure 2. Environmental changes, such as extreme temperatures and rainfall, drought and extreme weather events like floods, but also desertification and sea level rise, can directly affect human life through exposure to hazards and changes in the availability of ecosystem services. These effects can, in turn, reduce food, water and energy security, and lead to crop failures and the inhabitability of land (Black et al., 2011).

Conflict can arise over scarce resources and their distribution, aggravating divides between population groups. In such cases, people may direct their grievances at public institutions and articulate dissatisfaction with ruling authorities. As the review of the research findings has shown, the onset of conflict in relation to climatic variability is contingent upon contextual factors. These factors include a country's dependence on

Figure 2 Conceptualization of the relationship between environmental change, conflict and migration.



Source: Own

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agricultural productivity for securing livelihoods, stable income and wage levels, employment and the country's management of natural resources. Fluctuations in agricultural output may increase economic pressures on individuals employed in the sector, and lead to income losses. They can also result in an increase in living costs for the general population by affecting producer and consumer prices. Armed conflict may be more likely to emerge in scenarios where existing tensions between ethnic groups are aggravated, and where demographic pressures, such as a large population of young people facing high unemployment levels, heighten the conflict potential in an environment where grievances can be voiced.

Through this mechanism, climatic variability may affect migration indirectly, with armed conflict acting as a mediator. These migration patterns are likely to build on established, region-specific corridors, and the direction of migration flows is influenced by the costs of mobility. Outflows are more likely to occur to countries that have a common language, are closer in distance, and offer safety as well as economic opportunities to migrants. The conceptualisation shows how extreme heat, conflict and migration may be linked, with conflict being an important determinant of migration that might arise in response to environmental stress.

Data and Measurements

Migration data

This study investigates the relationship between temperature irregularities, conflict and forced migration flows in West Asia and North Africa. For the main dependent variable, forced migration flows between WANA countries, I use data on asylum applications by the United Nations High Commissioner for Refugees (UNHCR, 2021).

For three main reasons, this study examines *forced bilateral* migration flows between WANA countries using asylum application data. (1) Conceptually, *forced* migration can be linked more closely to conflict than forms of *voluntary* migration. Asylum migration and asylum applications are often motivated by the prospect of being granted asylum, which means receiving internationally recognised refugee status. According to the UNHCR (n.d.), a refugee is "someone who has been forced to flee his or her country because of persecution, war or violence." Armed conflict is, therefore, one of the most characteristic drivers of asylum migration, allowing me to make a clearer conceptual link between conflict and forced migration. In terms of data availability, (2) the UNHCR (2021) provides *forced* migration data from asylum applications, but there are far less data available on *voluntary* migration for WANA countries than for countries in the Global North, e.g. European Union member states. Additionally, regarding the level of flows, (3) I choose to model *bilateral* displacement flows between countries as opposed to *internal* displacement flows on the subnational level. Modelling internal displacement on the subnational level may require detailed data on subnational units and subnational unit pairs. For WANA countries, information is more readily available on the country level. I merge data from a multitude of sources to capture country-level and origin-destination country pair characteristics, as described in the section on control variables.

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The UNHCR (2021) asylum application data provide the number of asylum applications made in a destination country *j* by citizens of the origin country *i* in a given year *t*, given that there was at least one asylum application. The analysis covers asylum applications made in the 29 abovementioned WANA countries in years 2000 to 2019 by individuals from any other WANA country. This limits the analysis to migratory flows within the broader region.

The outcome is measured as the log-transformed annual number of asylum applications made in the destination country *j* by citizens of the origin country *i* in year *t*. The units of analysis are the country pairs *i*-*j*, constituted by the origin *i* and destination country *j*. There are 812 country pairs (29 origin × 28 destinations), each contributing 20 observations (one for each year of the 2000–2019 study period). Country pairs include each unique combination, for example both:

Afghanistan – Bahrain, 2000: Asylum applications made in Afghanistan by Bahraini citizens in the year 2000

Bahrain – Afghanistan, 2000: Asylum applications made in Bahrain by Afghani citizens in the year 2000

Conflict data

The study investigates conflict as a mediator in the relationship between heat and forced migration. In the context of this study, conflict is understood as armed conflict that is either state-based or non-state-based, and that results in battle deaths. The Uppsala Conflict Data Program (UCDP) defines battle-related deaths by referring to "the use of armed force between warring parties in a conflict dyad, be it state-based or non-state, resulting in deaths" (UCDP n.d.). This category includes both military and civilian deaths through battlefield fighting, guerrilla activities and bombardments of military units, cities, villages etc. The UCDP (ibid.) clarifies that the "targets are usually the military itself and its installations, or state institutions and state representatives, but there is often substantial collateral damage in the form of civilians killed in crossfire, indiscriminate bombings etc. All deaths – military as well as civilian – incurred in such situations, are counted as battle-related deaths."

The definition therefore includes deaths perpetrated by both state-based and non-state-based warring parties on either side of a conflict, but includes deaths during protests only in so far as these are battle-related deaths, e.g. deaths through fighting, bombardment or similar violent activities. Protests and riots can be seen as other forms of conflict through which political discontent is voiced in the context of environmental and economic crises. While these events may be conceptually important dimensions of climate-related conflict, I aim to conceptualise conflict here as violent action that contributes to the hazardousness and instability of an individual's environment. This allows for a closer conceptual link between conflict and asylum migration than would be possible if non-violent forms of conflict were included. In addition, the above definition also captures conflicts between two non-state warring parties, which may be relevant in the context of climatic irregularities that affect resource availability and distribution.

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The UCDP Battle-Related Deaths Dataset is widely used in conflict research. Version 20.1 provides information on conflicts in the countries of interest until the year 2019, along with a best estimate for the number of battle-related deaths that I use to construct the conflict variable. The data collectors check the independence and transparency of information from local and international news reports, research reports and official documents published by public and private organisations, including NGOs, the government and the warring parties (Pettersson and Öberg, 2020, p. 11; UCDP, n.d.). A moderate approach is taken, and figures are only included when independent verification is possible (ibid.). Conflicts are only included in the dataset if at least 25 battle-related deaths were reported in the country where the conflict took place in the calendar year.

The conflict variable takes the value of (1) for countries in which at least 25 battle-related deaths per annum were reported, and the value of (0) otherwise. I rely on the UCDP with one adjustment for Palestine: the UCDP does not record battle-related deaths for the Palestinian Occupied Territories – or for Gibraltar and Western Sahara – likely because of a lack of official recognition by many countries of Palestine as a state. However, I include these three entities as states in the origin-destination (migration) country pairs because the UNHCR reports asylum application data for Palestine. Battle deaths in the Palestinian Occupied Territories have been reported regularly by multiple sources; for example, these deaths have been documented in detail since the Second Intifada in 2000 by the International Middle East Media Center. Therefore, I set the conflict variable for the Palestinian Occupied Territories to (1).

Temperature data

The temperature data are based on the Climate Change Knowledge Portal's country-level dataset, with gridded observations on monthly mean temperatures by Harris et al. (2020) provided by the University of East Anglia's Climatic Research Unit in cooperation with the National Center for Atmospheric Research of the University Corporation for Atmospheric Research (World Bank Group, 2021). In this study, annual mean temperatures in an origin country are classified as extreme if they fall within the upper 10% of the 20-year distribution of annual mean temperatures in the country during the reference period from 2000 to 2019.

Control variables

First, to estimate the effects of extreme heat on conflict probability, I establish that conflict can be a suitable mediator. Second, I investigate the impact of extreme heat on migration through conflict using a mediation analysis. In these two parts of the analysis, I use different but overlapping sets of control variables. Table 1 provides an overview of the variables used for each estimation, and their data sources.

To estimate the effect of extreme temperatures on conflict probability, I use a model with controls for the country's GDP per capita, economic dependence on agriculture, degree of autocracy/democracy, population size and degree of ethnic fractionalisation.

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Table 1 Overview of variables used in the analysis, their data source and measurement

Variable	Data source and dataset/version	Measurement	Inclusion in regression of conflict and/or migration
Conflict	Uppsala Conflict Data Program: UCDP Battle-Related Deaths Dataset version 20.1 (Petterson and Öberg, 2020)	Binary variable that takes the value of (1) if at least 25 battle-related deaths were recorded in the origin country in year *t*, and the value of (0) otherwise	Conflict (outcome), migration
Temperature deviation	Climate Change Knowledge Portal of the World Bank Group: Mean Temperature datasets (World Bank Group, 2021)	Binary variable that takes the value of (1) if the annual mean temperature falls within the top 10% of the origin country-specific annual mean temperature distribution in the 2000–2019 reference period	Conflict (for origin country), migration
GDP per capita (origin), GDP per capita (destination)	Feenstra et al. (2015): Penn World Table version 10.0; World Bank Development Indicators Databank (The World Bank, 2021) for missing data	Logarithm of the real GDP per capita of the origin/destination country *j* at constant 2017 national prices in millions of USD in year $t-1$	Conflict (for origin country), migration
Dependence on agriculture	World Bank Development Indicators Databank (The World Bank, 2021)	Agriculture, forestry and fishery of the origin country *i*, value added, in percent of GDP, in year $t-1$	Conflict (for origin country)
Political regime (origin), Political regime (destination)	Center for Systemic Peace: Polity5 Annual Time Series, 1946–2018 (Marshall and Gurr, 2020)	Polity-2 index for the democratisation of the origin/destination country *i* in year $t-1$, ranges from (−10) strongly autocratic to (+10) strongly democratic	Conflict (for origin country), migration
Ethnic fractionalisation	Geographical Research on War, Unified Platform by the ETH Zürich and partners: Ethnic Dimensions data (Group level data) (Girardin et al., 2015)	García-Montalvo index for the ethnic fractionalisation of the origin country *i* at time $t-1$	Conflict (for origin country)
Population size (origin), Population size (destination)	Feenstra et al. (2015): Penn World Table version 10.0	Log-transformed size of population in year $t-1$	Conflict (for origin country), migration

(table continues)

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Table 1 (*continued*)

Variable	Data source and dataset/version	Measurement	Inclusion in regression of conflict and/or migration
Asylum applications	Refugee Data Finder by United Nations High Commissioner for Refugees: Asylum applications (UNHCR, 2021)	Logarithm of the number of asylum applications made from origin country *i* to destination country *j* in year *t*	Migration (outcome)
Distance	Centre d'Études Prospectives et d'Informations Internationales: dist_cepii dataset (He, 2020)	Geodesic distance between the capitals of country *i* and country *j* in km	Migration
Common language	Centre d'Études Prospectives et d'Informations Internationales: dist_cepii dataset (He, 2020)	Binary variable that takes the value of (1) if origin *i* and destination *j* share an official language, and the value of (0) otherwise	Migration
Diaspora	United Nations Department of Economic and Social Affairs: International Migrant Stock by Destination and Origin 2019 (UNDESA, 2019)	Logarithm of the number of emigrants from the origin country *i* resident in the destination country *j* in year $t-1$	Migration

In the estimation of the effect of temperatures and conflict on asylum applications, I use the same GDP, autocracy/democracy and population size controls. While the conflict estimation includes these controls measured for the origin country, the migration estimation includes them measured for the destination country as well. In addition, I include controls for the distance between the origin and the destination country; whether the countries share an official language; and the size of the diaspora community, as measured by the number of citizens of the origin country living in the destination country.

Below, a further description of the variables and the rationale for their inclusion in the analysis are offered.

GDP per capita (conflict control, migration control)

The conflict equation includes a GDP per capita control variable to account for differentials in the impact of temperature fluctuations by the performance of an economy, as research has shown that temperatures have adverse effects on poor countries in particular (Dell et al., 2012), and may impair economic growth (ibid.; Miguel et al., 2004). Moreover, low development, in combination with other risk factors such as ethnic exclusion, was shown to increase conflict probability by Ide et al. (2020).

In migration models, GDP per capita is a standard component (see e.g. Backhaus et al., 2015; Beine and Parsons, 2015; Coniglio and Pesce, 2015; Moore and Shellman, 2007). Research on conflict migration has shown that migration flows vary based on the

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economic performance of the origin and the host countries (Schmeidl, 1997; Sesay, 2004; Moore and Shellman, 2007). Some studies have found that outmigration in response to increases in temperature anomalies occur only in middle-income countries (Cattaneo and Peri, 2016). Poor countries are disproportionately affected by temperature fluctuations (Dell et al., 2012), partially because of their higher dependence on agricultural production and the threats to economic growth related to this dependence (ibid.; Miguel et al., 2004). However, studies have also pointed to immobility in poor countries, noting that individuals might be "trapped" (ibid.; Gröschl and Steinwachs, 2017; Gray, 2011; Gray and Mueller, 2012). Thus, in countries with high levels of vulnerability to climatic events, some socioeconomic groups may lack the resources to migrate. In WANA, employment opportunities in strong economies, such as in the Gulf countries, have led to the establishment of persistent labour migration corridors. These corridors facilitate migration from poorer countries, and may be a major factor in channelling forced migration, particularly given the relatively lower costs associated with staying within the broader geographic and cultural region.

To capture some of this variation in the economic performance of the host and the origin countries, I use data for real GDP per capita from the Penn World Table, version 10 (Feenstra et al., 2015). The data are based on constant 2017 national prices, which allows for comparisons across countries as well as over time. Missing data for Afghanistan and Libya are interpolated with data from the World Bank's World Development Indicators (The World Bank, 2021), held constant at 2017 international US dollars. For Gibraltar and Western Sahara, no reliable data source for interpolation could be identified. For the analysis, GDP is log-transformed and measured at both the origin and the destination country in year $t-1$.

Political regime (conflict control, migration control)

The political regime type is considered an important contextual variable for conflict emergencies more broadly, and for climate-related conflicts more specifically. For example, Daoudy (2020) argued that state policies and institutions determine the governance structures that are in place to deal with resource scarcity and crop failure, and she illustrates how exclusionary policies in authoritarian regimes can affect vulnerable population groups disproportionately when they are faced with environmental stress. Olper and Raimondi (2013) showed that in autocratic regimes, the agricultural sector is taxed more heavily, potentially increasing the risk of the emergence of conflict. In origin-destination models of migration, the political regime type might also be of interest, as migrants tend to relocate to countries that are more democratic (Abel et al., 2019).

I utilise data from the Polity5 Annual Time Series 1946–2018 dataset maintained by the Center for Systemic Peace (Marshall and Gurr, 2020). I use the two ordinal measures for the institutionalisation of democracy and autocracy, which draw on the combination of a range of characteristics of the democratic/autocratic institutions and the state under investigation. Both variables are constructed as an additive 11-point scale from zero to 10. While there is also a combined measure of the two variables for autocratic and democratic institutionalisation in the polity-2 index, this index has been heavily criticised in the literature.

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The inclusion of the two separately constructed variables allows for a more comprehensive conceptualisation of political regime characteristics. I use the Polity5 data to ensure that my results are comparable with those of Abel et al. (2019).

Ethnic fractionalisation (conflict control)

Ethnic fractionalisation per se does not seem to be a determinant of conflict (Miguel et al., 2004). However, Daoudy (2020) has demonstrated in a compelling multidimensional study of the Syrian uprisings how ethnic fractionalisation can increase vulnerability under environmental pressure – like consecutive droughts – when unsustainable, ideologically exclusive policies exacerbate inequalities between groups. This observation is in line with Ide et al. (2020), who showed that high levels of ethnic exclusion increase the risk of conflict following natural disasters in certain contexts; and with Schleussner et al. (2016), who underlined the role of ethnic divides in climate-related conflicts.

I use data from the Ethnic Dimensions (Group level) dataset maintained by the Geographical Research on War, Unified Platform (Girardin et al., 2015) to compute a García Montalvo index[2] (Montalvo and Reynal-Querol, 2002) for the degree of ethnic fractionalisation in a country at year $t-1$ as $4\sum_{i=1}^{N} \pi_i^{2}(1-\pi_i)$ where N is the number of ethnic groups and π is the proportion of people belonging to an ethnic group. When a conventional fractionalisation index was used for the models instead, calculated as $1-\sum_{i=1}^{N} \pi_i^{2}$, the results were not substantively different[3].

Dependence on agriculture (conflict control)

Research has suggested that agricultural production is among the main channels through which climatic irregularities may induce conflict. Heavy reliance on agricultural output increases the vulnerability of dependent population groups (von Uexkull, 2014, von Uexkull et al., 2016). Fluctuations in agricultural output can affect livelihoods through rising consumer and producer prices and income and employment losses, which may, in turn, lead to conflicts over scarce resources and inequal resource distribution. In the analysis, a control for the country's *dependence on agriculture* is included. It measures the contribution of the agriculture, forestry and fishing sector to the country's GDP in year $t-1$ based on data from the World Bank Indicators (The World Bank, 2021).

Population size (conflict control, migration control)

Research has shown that population size can matter for the relationship between the environment and the potential for conflict. Ide et al.'s multi-method study found that

2 The García Montalvo index used here aims to overcome some of the shortcomings of the initially popular because easy to compute ELF (Bossert et al., 2011).

3 A conventional ethnolinguistic fragmentation index (ELF), proposed by Taylor et al. (1972), is one minus the Herfindahl index of ethnolinguistic group shares. The García Montalvo index used here aims to overcome some of the shortcomings of the initially popular because easy to compute ELF (Bossert et al., 2011).

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the risk of conflict is higher for contexts with high population, low development and high ethnic exclusion levels. In the context of migration, the literature suggests that individuals tend to relocate to more populous areas (Czaika and Kis-Katos, 2009; Lozano-Gracia et al., 2010). Therefore, I include controls for the log-transformed population size of the origin and the destination country in year $t-1$ in the migration models. Like the GDP data, these data are from the Penn World Table compiled by Feenstra et al. (2015).

Diaspora (migration control)

Having historical, cultural and economic ties can facilitate migration between countries, especially when they share an official language and have an existing diaspora. The size of the already existing community of natives at the destination is a widely incorporated predictor in migration gravity models (Backhaus et al., 2015; Beine and Parsons, 2015; Coniglio and Pesce, 2015; Moore and Shellman, 2007). To control for the size of the *diaspora* community at the destination country j, I use the log-transformed number of natives from the origin country i residing at the destination country j prior to the year of migration. For this purpose, I draw on UNDESA (2019) International Migrant Stock data, which are published for all countries of the world on a five-year basis. Using the estimates from the years 1995, 2000, 2005, 2010 and 2015, I carry the last observation forward to fill in missing values for years without published data.

Potential time-constant controls

Two further variables may be of interest, and are widely used in gravity models to predict migratory flows (Backhaus et al., 2015; Beine and Parsons, 2015; Coniglio and Pesce, 2015; Moore and Shellman, 2007). First, smaller distances between countries are associated with lower emigration costs, making immigration more likely (Backhaus et al., 2015; Beine and Parsons, 2015; Coniglio and Pesce, 2015; Moore and Shellman, 2007; Abel et al. 2019). Second, as was alluded to above in the discussion on historical and cultural ties, migration barriers may be lower when countries share an official language. Therefore, I downloaded data on distance (geodesic, measured in km between the two capitals) and shared official language from the "dist_cepii" dataset by the Centre d'Études Prospectives et d'Informations Internationales (He, 2020), which holds such dyadic information for gravity models in econometrics.

However, the data I acquired show that the distance and the shared language variables are time-constant – i.e. there is no within origin-destination pair variation during the observation period. This means these variables would be dropped in the origin-destination fixed effects specification for the estimation of asylum flows, as they do not contribute any information to the identification. They are, however, included in the random effects specification for the asylum flow regressions, which I present for comparison with similar results.

Table 2 provides an overview of the descriptive statistics.

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Table 2 Descriptive statistics of variables used in the analysis, $N = 16{,}240$

	Count	% of Total	Mean (SD)	Min – Max
Dependent variables				
Asylum applications	16,240		97.03 (2332.21)	0 – 245,854
Asylum applications (log)	16,240		0.55 (1.49)	0 – 12.41
Conflict	15,680			
≥ 25 battle-related deaths	9,632	61.43%		
< 25 battle-related deaths	6,048	38.57%		
Independent variables				
Temperature variables				
Extremely hot year (*t*)	14,560			
Lower 90%	13,104	90.00%		
Upper 10%	1,456	10.00%		
Extremely hot year ($t-1$)	14,560			
Lower 90%	13,132	90.19%[1]		
Upper 10%	1,428	9.81%[1]		
Extremely hot year ($t-2$)	13,832			
Lower 90%	12,908	89.68%[1]		
Upper 10%	924	10.32%[1]		
Control variables				
Variables for origin and destination country				
GDP per capita	15,036		23,339.04 (26,319.43)	1,189.79 – 120,747.90
GDP per capita (log)	15,036		9.53 (1.03)	7.08 – 11.70
Agriculture, fishery forestry in % of GDP	13,832		8.57 (8.24)	0.09 – 41.25
Population size	15,680		18.87 (22.78)	0.03 – 98.42
Population size (log)	15,680		2.04 (1.65)	−3.49 – 4.59
Democratisation index	13,832		2.13 (3.08)	0 – 10
Autocracy index	13,832		4.52 (3.37)	0 – 10
Ethnic fractionalisation (García-Montalvo index)	14,560		0.54 (0.27)	0.05 – 0.95
Dyadic variables				
Distance between capitals (km)	16,240		2,677.80 (1,767.11)	55.31 – 8455.04
Common official language	16,240			
Common language	8,440	51.97%		
No common language	7,800	48.03%		

(table continues)

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Table 2 (*continued*)

	Count	% of Total	Mean (SD)	Min – Max
Size of diaspora community from origin *i* at destination country *j*	16,240		291.38 (433.92)	0 – 1,414
Size of diaspora community from origin *i* at destination country *j* (log)	16,240		2.58 (3.15)	0 – 7.25

[1]Extremely hot year defined as a year falling within the top 10% of the origin country-specific annual mean temperature distribution in 2000–2019. Temperatures measured in year t (year of asylum migration) and one-year and two-year lags ($t-1$ and $t-2$). Percentages based on the country-specific distribution of annual mean temperatures calculated without missing values.
For variables in which the log-transformed distribution is shown, the log-transformed variable is used in the analyses. All control variables are measured at time $t-1$ (one-year lag).

Analytic strategy

I estimate the effect of temperatures on asylum migration through armed conflict in two steps: first, I investigate whether temperatures affect the probability of armed conflict in the origin country in order to test whether conflict can serve as a potential mediator; and, second, I model migration flows to examine how temperatures and conflict are associated with asylum applications between origin-destination pairs. This part is conducted as a mediation analysis of the effect of temperatures on asylum migration with armed conflict as the mediator.

Equation (1) is a linear probability model for conflict occurrence in the origin country, formally:

$$c_{i,t} = \sum_{l=0}^{2} \beta T_{i,t-l} + \alpha_i + \gamma_t + \Phi Z_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

where $c_{i,t}$ is conflict occurrence in origin country i in year t. The summation contains our variables of interest: $T_{i,t-l}$ is the extreme annual mean temperature (binary variable with the value of (1) for the upper 10% of years of the country's mean temperature distribution), included for the contemporaneous year and its first and second annual lag l. α_i and γ_t are origin country and year fixed effects. They control for unmeasured, time-invariant characteristics and annual fluctuations on the country level. This specification helps to address the challenge of the enormous heterogeneity of the 29 WANA countries. $Z_{i,t-1}$ is a set of control variables for the origin country with a one-year time lag. The controls include the country's degree of ethnic fractionalisation; GDP per capita; dependence on agricultural production as the agricultural, fishery and forestry sector in percentage of GDP; and the degree of autocratic and democratic institutionalisation. Standard errors are clustered at the origin country level.

Equation (2) describes the tobit model, a censored regression model, employed to estimate migration flows. Tobit models, which were originally proposed by James Tobin (1958) to model household expenditures for data where many observations take the value of

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zero, estimate a linear relationship between the outcome variable and the independent variable(s). The model assumes that there is a latent outcome variable Y^* that is continuous. However, this latent variable is not observed over its entire range. Instead, there is an observed continuous outcome variable that is left- or right-censored and non-negative. The tobit model accounts for this censoring, deciding whether the observed value is at the censoring point or beyond it (i.e. in our case, whether there were any asylum applications from the origin to the destination country), and then applies a maximum likelihood (MLE) function.

In our data, the number of recorded asylum applications for the country pairs ranges from zero to 245,854. For a large share of country pairs, no asylum applications are observed from an origin i to a destination j in a given year t. Therefore, there are many observations in which the number of asylum applications, which underlies the outcome variable, is zero (i.e. left-censored). Their information is not lost, as these observations are still included in the data.

This pattern is not unusual for country-level migration flow data. Left-censoring in asylum applications between WANA countries may be explained by several circumstances. 1) There might be logistical, legal, financial and other barriers to migration that make successful migration from the origin to the host country costly, risky, dangerous or infeasible. In this case, immigration to the host country may be *desirable*, but it is suppressed by practical circumstances. 2) Individuals might immigrate to the host country with the intention to seek asylum, but fail to apply for asylum upon arrival (e.g. because they learn about the unlikeliness of a successful outcome, logistical barriers, or a different and better route to legal or undocumented immigration), or their application is not recorded. In the latter case, (asylum) migration actually *takes place*, but it is suppressed to the observed value of zero.[4]

A tobit model assumes there is a latent variable, and the dependent variable is observed when the latent variable exceeds an underlying threshold. To investigate temperature impacts on migration, I estimate equation (2) as

$$Y_{ij,t} = \begin{cases} \sum_{l=0}^{2} \beta T_{i,t-l} + \alpha_{ij} + \gamma_t + \Phi O_{i,t} + \Lambda D_{j,t} + \Omega P_{ij,t} + \varepsilon_{ij,t} & \text{if } Y^*_{ij,t} > 0 \\ 0 & \text{if } Y^*_{ij,t} = 0 \end{cases} \tag{2}$$

where $Y_{ij,t}$ is the log-transformed number of asylum applications from origin i to a destination j in year t. The observed dependent variable $Y_{ij,t}$ is equal to the assumed latent variable $Y^*_{ij,t}$, if there is at least one asylum application made from origin i to a destination j at t; otherwise the observed outcome is zero. The summation of $T_{i,t-l}$ is the annual temperature along with its one- and two-year lags. α_{ij} is a country pair fixed effect. The model is estimated with robust standard errors. In an alternative specification, I also employ a country pair random effect with bootstrap standard errors. γ_t is a year fixed effect. $O_{i,t}$, $D_{j,t}$ and $P_{ij,t}$ are vectors for origin, destination and dyadic country pair-specific covariates, as described in the previous section.

4 Zero asylum applications may also result from host country-specific characteristics, such as poor livelihood prospects, that make *immigration* relatively less desirable.

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Results

Effects of extreme temperatures on conflict

Table 3 shows the results for a linear probability model (model (1)) estimating the probability of *conflict* in the origin country, defined as the occurrence of at least 25 battle-related deaths per year. The model is estimated using 427 observations. Note that these observations come from the unique observations for each of the 26 origin countries (16.4 observations per origin on average), not from the country pairs that are used for migration estimation in the second equation.

The binary variables for the extreme temperature years take the value of (1) if the country's annual mean temperature is in the upper 10% of the country's mean temperature distribution across the 2000–2019 period. Therefore, the effect estimates are to be interpreted as the effect of an extremely hot year in comparison to the effect of a year with an annual mean temperature below the 90th percentile of the country-specific temperature distribution. As shown in Figure 3, the effect of extreme temperatures in the same year as the conflict occurred is not statistically significant. The one-year lag of

Table 3 Linear probability fixed effects models for the effects of extremely hot years on conflict occurrence, measured as at least 25 battle-related deaths, in 29 WANA countries in 2000–2019, estimated with country and year fixed effects

	Model (1)		
	Conflict on temperatures and additional covariates		
	Coeff	**Bootstrap SE**	***P*-value**
Extremely hot years (*t*)	0.052	(0.065)	0.429
Extremely hot years ($t-1$)	0.137*	(0.076)	0.084
Extremely hot years ($t-2$)	0.124*	(0.066)	0.072
Number of observations		427	
Groups		26	
Obs. per group (min, max, average)		5, 19, 16.4	
Wald Chi^2 (df)		55.11 (27)	
Prob > Chi^2		0.0011	
R-squared (overall)		0.0612	

Extremely hot year defined as a year falling within the top 10% of the origin country-specific annual mean temperature distribution in 2000–2019 in year *t* (year of asylum migration) and one-year and two-year lags ($t-1$ and $t-2$).
Model includes country and year FE. Coefficients bootstrapped. Controls for the country's GDP; the share of the agricultural, forestry and fishery sector in % of GDP; population size; institutionalised democratisation; degree of autocracy; and a García-Montalvo ethnic fractionalisation index.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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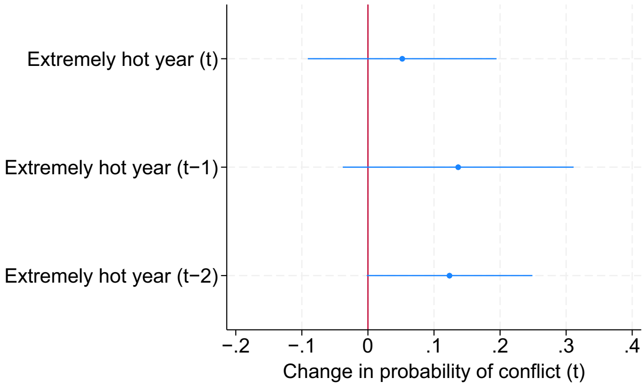
Figure 3 Coefficients for the estimated effects of extremely hot annual mean temperatures in year of asylum application (t) and previous two years ($t-1$, $t-2$) on conflict occurrence from a fixed effect regression model (model 1), plotted with 95% confidence intervals.



Data sources: UCDP (Petterson and Öberg, 2020), Climate Change Knowledge Portal (World Bank Group, 2021)
Note: Conflict occurrence defined as at least 25 battle-related deaths in a country in a given year t, based on data from the Uppsala Conflict Data Program (Petterson and Öberg, 2020). Extremely hot year defined as a year falling within the top 10% of the origin country-specific annual mean temperature distribution in 2000–2019 in year t (year of asylum migration) and one-year and two-year lags ($t-1$ and $t-2$). Modelled with country and year fixed effects. Standard errors clustered at the country level. Controls for the country's GDP; the share of the agricultural, forestry and fishery sector in % of GDP; population size; institutionalized democratization; degree of autocracy; and a García-Montalvo ethnic fractionalisation index (see section Control variables).

extreme temperatures is estimated at a beta of 0.14 with a p-value of 0.084, corresponding to a 0.14 percentage point increase in conflict probability. This corresponds to a 22.3% increase in the probability of armed conflict when the mean temperature in a given year is above the 90th percentile threshold of the country's long-term temperature distribution. In addition, the effect of hot temperatures measured at a two-year time lag indicates that the probability of conflict increases by 12.4 percentage points, or 20.2% ($p = 0.066$), in hot years.[5]

Since the one- and two-year lags are both estimated at marginal statistical significance, I compute a Wald test for the two variables to test whether the coefficients are equal to zero independently of each other. The test yields a p-value of 0.07. This is not a clear indication of whether extreme temperatures in the previous two consecutive years explain the variation in the occurrence of conflict. The cumulative effect of extreme temperatures in the two years prior to the emergence of conflict would result in a 42.5% increase in the probability of conflict. This effect is rather large given how large the standard errors are, and given that the sample size is small and the regression specification is conservative, controlling for

5 Coefficients in Table 3 are converted from percentage point changes into percent changes by dividing the coefficient by the mean of the dependent variable (the mean of the binary armed conflict variable is 61.43%, see Table 2 for descriptive statistics).

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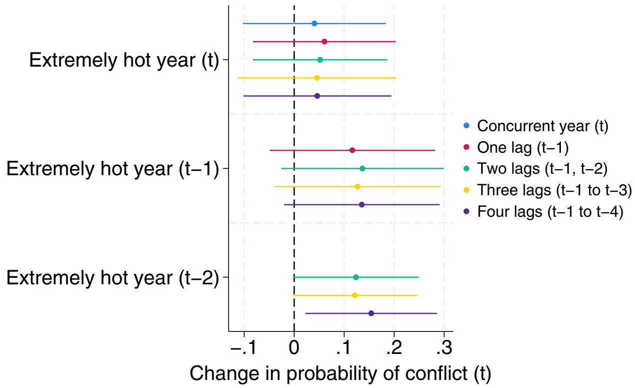
Figure 4 Coefficients for the effects of extremely hot annual mean temperatures measured at different time lags (year of asylum application *t* up to four-year lag *t* – 4) on conflict occurrence from fixed effect regression models, plotted with 95% confidence intervals.



Data sources: UCDP (Petterson and Öberg, 2020), Climate Change Knowledge Portal (World Bank Group, 2021)
Note: Extremely hot year defined as a year falling within the top 10% of the origin country-specific annual mean temperature distribution in 2000–2019 in year *t* (year of asylum migration) and one-year and two-year lags (*t* – 1 and *t* – 2). All models include country and year fixed effects. Standard errors clustered at the country level. Controls for the country's GDP; the share of the agricultural, forestry and fishery sector in % of GDP; population size; institutionalized democratization, degree of autocracy; and a García-Montalvo ethnic fractionalisation index (see section Control variables).

all unobserved time-constant origin country-specific characteristics and some observed time-variant characteristics, and using annual mean temperatures instead of maximum temperatures with bootstrapped coefficients.

The estimates are not impacted by autocorrelation of the temperature measurements in the time series, and the effects are stable across models with differing numbers of temperature variables and their lags (see Figure 4). The results suggest there is an indication that extreme temperatures may induce conflict in the 29 WANA countries. In the next section, I investigate whether extreme temperatures are also linked with migration, and whether this effect of temperatures on migration might function through conflict.

Effects of extreme temperatures and conflict on asylum applications

Table 4 presents results for a set of tobit models to explore the effect of extreme temperatures on the outcome of asylum migration, and to investigate whether conflict might be a mediator in this relationship.

First, model (2) regresses the migration outcome on conflict to establish whether conflict is a relevant predictor of asylum flows. Second, model (3) regresses the migration outcome only on the temperature variables to examine the (total) effect of heat on migration. Model (4) regresses the migration outcome on the temperature variables as in the previous

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model, but additionally includes the conflict control to test whether conflict functions as a mediator in the heat-migration relationship.

All models control for the distance between capitals, and for whether the origin and the destination country share an official language (these two dyadic variables are unnecessary in the Panel (A) set of models with country pair fixed effects, as they are time-constant within country pairs), the size of the diaspora community of citizens from the origin country in the destination country, GDP per capita, population size, and democratic and autocratic

Table 4 Left-censored tobit models for the impacts of extremely hot years and conflict occurrence on migration flows, measured as the log-transformed number of asylum applications between 29 WANA countries in 2000–2019. Year fixed effects and origin-destination pair random or fixed effects

	Model (2)		**Model (3)**		**Model (4)**	
	Asylum applications on conflict		**Asylum applications on temperatures**		**Asylum applications on conflict, temperatures**	
	Coeff	**SE**	**Coeff**	**SE**	**Coeff**	**SE**
Panel (A) (Origin-destination fixed effects)						
Conflict	0.458***	(0.116)	–	–	0.478***	(0.165)
Extremely hot years (*t*)	–	–	0.101	(0.166)	0.089	(0.193)
Extremely hot years (*t* – 1)	–	–	0.068	(0.191)	−0.007	(0.171)
Extremely hot years (*t* – 2)	–	–	−0.172	(0.171)	−0.194	(0.116)
Number of observations		11,630		11,078		11,078
Number of groups		650		650		650
Uncensored – left-censored		1,960 – 9,670		1,897 – 9,181		1,897 – 9,181
Log pseudolikelihood		−5,521.899		−5,298.244		−5,290.352
Pseudo R^2		0.421		0.423		0.424
Panel (B) (Origin-destination random effects)						
Conflict	0.576***	(0.160)	–	–	0.592***	(0.153)
Extremely hot years (*t*)	–	–	0.100	(0.166)	0.083	(0.184)
Extremely hot years (*t* – 1)	–	–	0.086	(0.187)	0.002	(0.200)
Extremely hot years (*t* – 2)	–	–	−0.189	(0.161)	−0.213	(0.166)
Number of observations		11,630		11,078		11,078
Number of groups		650		650		650
Obs. per group (min, avg, max)		5, 17.9, 20		5, 17.0, 19		5, 17.0, 19.0
Uncensored – left-censored		1,960 – 9,670		1,897 – 9,181		1,897 – 9,181
Wald chi^2 (df)		556.86 (31)		622.06 (32)		587.91 (33)
Prob > chi^2		0.000		0.0000		0.0000

(table continues)

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Table 4 (*continued*)

	Model (2)		Model (3)		Model (4)	
	Asylum applications on conflict		Asylum applications on temperatures		Asylum applications on conflict, temperatures	
	Coeff	SE	Coeff	SE	Coeff	SE
LR-test of $\sigma_u = 0$ (df)		2,728.12		2,705.70 (1)		2,634.96 (1)
Prob ≥ chibar^2		0.000		0.000		0.000

Outcome is the log-transformed number of asylum applications made by migrants from the origin country at the destination/host country per year and based on UNHCR (2021) data. Extremely hot year defined as a year falling within the top 10% of the origin country-specific annual mean temperature distribution in 2000–2019 in year t (year of asylum migration) and one-year and two-year lags ($t-1$ and $t-2$).
All models are estimated with year fixed effects and additional country pair fixed effects (Panel (A)) or additional country pair random effects (Panel (B)). Standard errors are robust in Panel (A) models, and are bootstrapped in Panel (B) models. Controls for the distance between capitals, whether the origin and the destination country share an official language, and the size of the diaspora community of citizens from the origin country in the destination country. Additional controls for both the origin and the destination country include the GDP per capita, population size and democratic and autocratic institutionalisation.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

institutionalisation in both the origin and the destination country. All three model specifications are estimated with a year fixed effect. In addition to the year fixed effect, the models also include a country pair fixed effect, see Panel (A); and, alternatively, a country pair random effect, see Panel (B).

Migration flows are measured as the log of the UNHCR-reported number of asylum applications between country pairs in year t, and left-censoring occurs at zero.

As the outcome of asylum applications is log-transformed, the coefficients for binary predictors (such as the conflict and temperature variables) are interpreted as the percent change in the outcome for a category switch in the binary predictor.[6]

Across the models, the effect estimate for conflict is positive and strongly statistically significant, pointing to increases in asylum flow applications from citizens of countries where there is violent conflict. This effect is stable across the different specifications with country pair fixed effects (Panel (A)) and country pair random effects (Panel (B)). The model with country pair fixed effects (model (2), Panel (B)) estimates an increase in asylum applications of 45.8 percentage points ($p = 0.000$) when 25 or more annual battle deaths are recorded in the origin country. These results suggest that conflict is strongly associated with large increases in outmigration.

After testing whether extreme temperatures are associated with increases in conflict, and whether conflict as a potential mediator is associated with asylum flow increases,

6 For an accessible overview of the interpretation of regression models with log-transformed variables, see UCLA Statistical Methods and Data Analytics: https://stats.oarc.ucla.edu/other/mult-pkg/faq/general/faqhow-do-i-interpret-a-regression-model-when-some-variables-are-log-transformed/

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I investigate the relationship between extreme temperatures and asylum flows in model (3). This specification models the total effect of heat on the migration outcome without controlling for the mediator. The results show that the estimates of extremely hot temperatures in the year of migration and in the year prior to migration are positive, suggesting a 10.1 percentage point (concurrent year) and a 6.8 percentage point (one-year lag) increase in migration. For the two-year lag ($t-2$), hot temperatures yield a negative effect estimate of −0.172. However, none of the estimates is statistically significant and the standard errors are large.

Finally, in model (4), where conflict is now included as the mediating variable, the coefficient size of the temperature estimates for the concurrent year and the one-year lag (t and $t-1$) is decreased in comparison to model (3) without the mediator. If temperatures affected asylum flows through conflict, we would expect the temperature coefficients to decrease once the conflict effect on migration is controlled for. In model (4), the coefficient for heat in the year of migration (t) decreases from a change of 10.1 to 8.9 percentage points, and the coefficient for the year prior to migration ($t-1$) decreases from a change of 6.8 to −0.7 percentage points (see Figure 5). The same pattern is apparent in the random effects models (Panel (B)). As the estimated association between temperatures and migration is indeed smaller for the concurrent and one-year lagged measures for extreme heat once the mediator is added to the estimation, this could be regarded as an indication that conflict mediates the heat-migration relationship. However, as the temperature coefficients are neither statistically significant nor statistically different from each other, the results from this exploratory analysis should be interpreted with caution.

To explore a simpler alternative specification, I also estimate "naïve" OLS regressions instead of the tobit models. The tobit models in Table 4 use the observations in which there were zero asylum applications recorded between an origin-destination pair at year t, and the estimation accounts for this left-censoring in the data. In the simpler OLS regressions, I regress the same outcome of asylum applications on the same predictors as those included above in Table 4. But instead of using the whole sample, I restrict the sample to observations in which at least one asylum application was made from the origin at the destination in year t. By using information only on the non-zero asylum applications, this model focuses on a subset of country pairs and years in which at least one asylum application was recorded. Therefore, the results cannot be representative for the whole sample of WANA countries under study, because they selectively ignore country pair differences that are likely caused by migration barriers and preferences. The results show that across those models as well, conflict is clearly associated with increases in asylum applications, while estimates for the years of extreme average temperatures decrease once the mediator is included, but are not statistically significant.

To summarise, the results show that in the 29 WANA countries under study, extremely hot years (defined as years in which the annual mean temperature is above the 90^{th} percentile of the country-specific 20-year mean temperature distribution from 2000 to 2019) are associated with conflict increases; conflict is strongly associated with increases in asylum applications; and there is a weak indication that conflict is a mediator in the heat-migration relationship, though the temperature effects estimated here are not statistically significant, and the analysis is only explorative.

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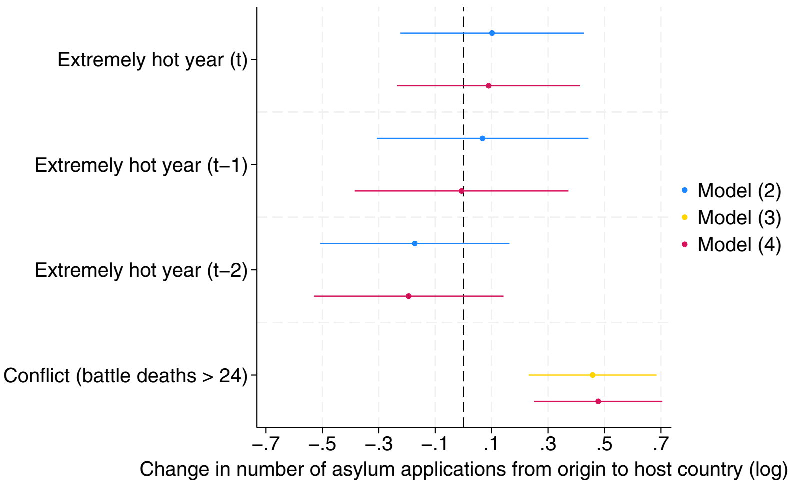
Figure 5 Coefficients for the effects of extremely hot annual mean temperatures in the year of asylum application (t) and the previous two years ($t-1$, $t-2$) and conflict occurrence on the number of asylum applications (log) from fixed effect regression models (models (2), (3), (4)), plotted with 95% confidence intervals.



Data sources: UNHCR (2021), Climate Change Knowledge Portal (World Bank Group, 2021), UCDP (Petterson and Öberg, 2020)

Note: Extremely hot year defined as a year falling within the top 10% of the origin country-specific annual mean temperature distribution in 2000–2019 in year t (year of asylum migration) and one-year and two-year lags ($t-1$ and $t-2$). All models include country pair (origin country–destination country) and year fixed effects. Coefficients clustered at the country pair level. Controls for the distance between capitals, whether the origin and the destination country share an official language and the size of the diaspora community of citizens from the origin country in the destination country. Additional controls for both the origin and the destination country include the GDP per capita, population size and democratic and autocratic institutionalization (see section Control variables).

Limitations

The focus of the analysis is on establishing a causal pathway from extreme heat to asylum migration that functions through conflict in the origin country. To this end, the first part of the analysis estimates the effect of extremely hot years on the probability of conflict using a within-country fixed effects regression that also includes a year fixed effect. This means that unmeasured, time-invariant characteristics of the origin country and annual fluctuations on the country level are controlled for. This allows me to exploit the quasi-random temperature fluctuations that occur across years at the same place for causal inference. A limitation of this approach is that time-varying country-level and subnational-level characteristics are not controlled for, beyond the controls included for GDP per capita, dependence on agriculture, population size, ethnic fractionalisation and political regime type. While fixed effects approaches are the standard approaches used in climate and population studies to isolate within-unit variation of the independent variable, caution is still warranted when considering a causal interpretation of the results. In addition, the fixed effects results might be biased towards observations in which there is a change in otherwise mostly time-constant controls (ethnic fractionalisation, democratic and autocratic institutionalisation).

The same potential issues arise in the second part of the analysis. Here, the estimation for the effect of temperatures on asylum applications made by citizens of the origin country in the host country includes an origin-host fixed effect and a year fixed effect, controlling only for observed and unobserved time-constant characteristics of country pairs and annual shocks. In addition, the relationship between conflict and migration may not be causal. Thus, these findings should be regarded as more explorative than those from the first part of the temperature-conflict analysis. The strong association found between conflict as the mediator and asylum applications is in line with observations from the previous literature (Moore and Shellman, 2007; Sesay, 2004; Schmeidl 1997). Reverse causality from asylum applications to conflict is controlled for, as conflict is measured with a one-year time lag. However, there could be concerns regarding the causal effect of conflict on migration, as the exogenous variation of conflict is not isolated. As conflict is treated as the mediating variable, it is by definition endogenous to asylum applications. However, there may be additional confounders that cause the strong association between conflict and asylum applications beyond temperature variability. While the analysis controls for potential confounders for the relationship between conflict and asylum applications – including GDP per capita, political regime type, population size, distance between countries, shared official language and the diaspora community – it cannot be ruled out that there are unobserved sources of the association between conflict and asylum applications.

Some limitations arise from the limited availability of traditional sources of data that can be used to measure migration flows comprehensively. For this reason, bilateral, annual asylum flows are examined in this study. However, subnational, interannual flows may be of particular interest in climate migration research, because they can reflect seasonal migration patterns that are linked with climatic variabilities. By relying on the annual aggregation of temperature data on the country level, the approach used here does not incorporate the timing and the locality of climatic shocks, although extreme temperatures might be particularly detrimental if they occur during the growing season and affect agricultural productivity in communities that depend on ecosystem services.

Furthermore, the asylum application data provided by UNHCR do not provide information on the demographic characteristics of asylum seekers beyond their origin country. The literature shows that climate-migration links may be highly varied across different population groups (Abu et al., 2014; Ocello et al., 2015), and points to a "trapping in" effect for poorer individuals (Cattaneo and Peri, 2016; Gröschl and Steinwachs, 2017; Gray 2011; Gray and Mueller, 2012). The analysis presented here is only able to make inferences on the country level, although these patterns are ultimately shaped by the heterogenous migration behaviour of social groups on the subnational level. Furthermore, even if forced migration occurs, there may be different unobserved reasons why migrants do or do not eventually apply for asylum in order to be granted refugee status – though this would lead to an underestimation of the temperature effects.

While I use the annual mean temperature rather than the maximum temperature to choose a more conservative specification, another limitation concerns the inclusion of other environmental indicators. The lack of inclusion of rainfall data and other

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environmental indicators in this study may raise concerns that the question of whether the relationship between temperatures and asylum migration might be driven by other climatic factors is not addressed. One challenge that arises when measuring any environmental exposure, but especially when controlling for precipitation in the context of this study, is that rainfall may vary significantly throughout the year. But this intra-year distribution is particularly important, as it may impact agricultural seasons differentially. Such variation is difficult to capture sufficiently in an annual measure (as asylum flows are only reported annually).

The inclusion of precipitation data is particularly relevant in contexts where rainfed agriculture is predominantly practiced. The large majority of the countries included in this study have very arid climates with little rainfall. In this region, agricultural production relies almost exclusively on irrigation systems that are more resilient to aridity than rainfed agriculture. Nevertheless, there is a valid concern that a lack of rainfall – or, more specifically, drought, especially if it is prolonged – could affect water availability, and might make the approach of using only temperature data inadequate. It is very likely that only some of this variation is captured in the temperature measurement used. Future studies should aim to reflect climatic nuances more precisely by including additional climatic indicators in the analysis.

Regarding the temperature measurement, there are differences between countries in terms of how drastic the temperature difference is between years with temperatures above and below the 90^{th} percentile threshold. However, these differences are likely to bias the results downwards based on the observations in which the temperatures are less "extreme" than they are in others. The underlying temperature effect for these observations would accordingly be smaller, which should be reflected in the results.

Another concern may be related to the construction of a binary measure for armed conflict as opposed to the use of a continuous measure. However, creating a continuous measure would be challenging, as the UCDP data are structured based on conflict dyads. The data provided are based on conflict observations, and for each conflict ID, a number of battle deaths is reported per annum (I use the best estimate, as opposed to the minimum or maximum estimate). The location of the fatalities is extracted based on the variable for the battle location. But for some conflict-year observations, multiple countries are given as the battle location. In such cases, it is impossible to disentangle how many of the stated battle deaths are uniquely attributable to each of the battle location countries listed, and a unique attribution to either country might be grossly inaccurate, particularly in cases in which a large number of battle deaths is reported. This issue affects about one-fifth of the cases in the final dataset used for the analysis. As it is not possible to investigate whether an attribution of battle deaths to either of the multiple countries listed would be a (potentially severe) underestimation or overestimation that induces bias, I use a binary specification for the armed conflict variable.

Lastly, the heterogeneity of the WANA countries remains a challenge for the conceptualisation and operationalisation of the bilateral migration predictors. I try to address the heterogeneity that could cause variation in the temperature-conflict relationship by employing a within-country analysis, and, analogously, a within-origin-destination pair analysis in the temperature-migration estimation. While heterogeneity is reduced by using

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a regional sample rather than a global sample, there is scope to examine more explicitly relevant subnational- and country-level differences, as well as broader regional differences.

Heterogeneity in conflict risk could also be explored by testing interactions between the environmental variables and the available time-variant controls. I tested interactions between the temperature variables (at year t, $t-1$, $t-2$) and the control variables (GDP per capita, agricultural dependence, ethnic fractionalisation, population size, democratic and autocratic institutionalisation), and found that none of the interaction terms is statistically significant. The only exception is that there seems to be an increase in the probability of conflict for the hot years (at year $t-1$) in countries with higher levels of ethnic fractionalisation. However, upon inclusion of the other time-variant control variables, this effect disappears. The sample size of the regression with less than 500 origin country-year observations is too small to arrive at sufficiently small standard errors and statistically meaningful results with the interaction terms tested.

Conclusion

There are few existing studies on migration within West Asia and North Africa (WANA). This lack of research is surprising, given the prevalence of forced and voluntary migration in the region, the immense and increasing pressures of climate change that these states and their populations are facing, and the existence of long-lasting civil conflicts and political instability in some of the region's countries. This study investigates regional, forced bilateral migration between countries of West Asia and North Africa to better understand the link between climatic irregularities, conflict and migration. I merge data from a range of sources that reflect both the vulnerabilities of the origin country to climate-related conflict, as well as origin-destination relationships. I estimate the relationship between extreme temperatures in the origin country and conflict probability and asylum flow sizes. The fixed effects model specifications control for time-invariant origin country and origin-destination pair specificities. This isolation of within-origin temperature variation makes the temperature fluctuations across the years quasi-random.

The study yields two main results. First, there are some indications that temperatures are linked with an increased probability of conflict in WANA in 2000–2019. Extremely hot years, defined here as years that fall within the hottest 10% of the country-specific annual mean temperature distribution over the period of observation, are associated with a sizeable increase in conflict probability. The estimation suggests that two consecutive years of extremely hot temperatures increases the probability that a conflict will occur in the following year by 42.5%. However, this effect is only marginally statistically significant ($p = 0.07$), as the sample under study is small and a fairly conservative model specification is chosen. This result is in line with the findings of the existing literature for a range of contexts on the relationship between climatic irregularities and the emergence of violent conflict (see Burke et al., 2015; Hsiang et al., 2013; and others). However, this finding stands out, given that traditional data sources provide only a limited sample size to investigate regional, bilateral migration, and given the model restrictions introduced by the country and year fixed effects and the clustered standard errors at the country level.

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Second, although extreme heat appears to be linked with armed conflict occurrence, and the occurrence of conflict in the origin country is shown to be strongly associated with an increase in asylum flows, by 45.8 percentage points ($p = 0.000$), this study finds only a weak indication that conflict might mediate the relationship between extreme heat and asylum flows in the sample under study. The mediation analysis shows that the temperature coefficients indeed decrease after the conflict measure is included as the mediator in the model. However, the temperature coefficients do not reveal a clear effect on asylum migration, as they are not statistically significant. It should be kept in mind that the analysis is only explorative.

Other climate migration studies have found that conflict might mediate the temperature-migration relationship (Abel et al., 2019; Hoffmann et al., 2020; Coniglio and Pesce, 2015; Falco et al. 2019). There are several potential reasons for these different findings, most importantly, differences in the studies' modelling strategies and regional focuses. Abel et al. (2019) had a similar research interest, but used global data that included extra-regional migration flows from West Asian and North African countries into countries outside the region, and did not include country fixed effects in their staged modelling strategy. This study, by contrast, controls for origin-destination pair characteristics that are constant over time.

This study on forced migration within the WANA region also demonstrates two important points. First, "zooming in" to the regional level can provide information on expected bilateral migration patterns within a subregion of the globe. These intraregional flows are of tremendous importance in the context of climate migration, as migrants often relocate to adjacent countries for various reasons, including because of the information advantages and relatively lower costs. For this purpose, fixed effects modelling can account for place specificities, particularly regarding migration corridors between countries that have developed historically due to cultural, demographic, economic and other factors.

Second, examining regional bilateral migration flows can reveal patterns that differ from those found in analyses that use global samples. Lower-level analyses can illuminate links between specific migration types and the regional context determined by time and place. Many determinants of climate and conflict migration are context-specific, such as a populations' ethnic fractionalisation and local communities' dependence on agriculture. These determinants interact to shape environment-conflict and migration relationships in a complex interplay. Analyses on lower spatial levels are therefore useful.

There is an urgent need to identify the factors that make WANA countries vulnerable to climate-related conflicts. Spatially referenced, high-resolution environmental and conflict data on different types of conflict offer possibilities for further investigating patterns by incorporating the local and seasonal vulnerabilities of populations. In addition, non-traditional data sources, such as spatially referenced mobile phone and social media data, may provide an opportunity to explore mobility and migration flows that are unrecorded by national and supranational authorities. In addition, an exploration of growing season-adjusted, subnationally derived exposures may yield further insights. While the results of this study provide no strong evidence on the short-term relationship between temperatures and forced migration, the long-term pressures of climate-related conflict remain unexplored. Beyond the WANA region, further studies may assess the importance of migration

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across countries within a geographic (or political) region in relation to climatic variability and shocks.

The existing violent conflicts in several West Asian and North African countries, and the risk of new conflicts emerging in regimes where citizens have faced several uprisings in the last decade, make understanding how environmental change impacts conflict in the region a relevant objective. This issue is of interest for public authorities as well as non-governmental organisations concerned with peacebuilding and reducing social inequalities in the context of climatic changes, but also for funders of humanitarian programs and policymakers on the national and the international level who aim to adopt effective mitigation strategies for vulnerable population groups.

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