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Large weather and conflict effects on internal displacement in Somalia with little evidence of feedback onto conflict

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ABSTRACT

Extreme weather and conflict may drive forced displacement. However, their individual contribution to displacement is not fully understood due to challenges around isolating individual channels of causality. Here, we use novel disaggregated data on internal displacement in all of Somalia's subregions from 2016 to 2018 broken down by reported reason of displacement and combine it with weather and conflict data. This allows us to isolate the effects of extreme weather and conflict on forced displacement, as well as the effects of displacement on conflict itself. We find large non-linear effects of weather on displacement where an increase in temperature anomalies from 1 °C to 2 °C (to approx. 1.5 standard deviations, SD) leads to a tenfold increase in displaced people, and a reduction in precipitation from 50 mm to 0 mm (approx. 1.5SD) leads to around a fourfold increase in displacement. We find significant effects of conflict events on displacement (which are masked when the data is aggregated) with a 1.5 standard deviation increase in conflict events increasing displacement 50-fold. We further show that displacement itself has little detectable effect on the occurrence of conflict events.

1. Introduction

Extreme weather (potentially exacerbated by a changing climate) and conflict may drive population displacement within countries. In order to allocate aid and resources to displaced people optimally, the causal drivers of displacement need to be understood. While the impacts of a changing climate and conflict on communities have been well documented in other fields, the quantification of weather/climate effects on displacement has been severely limited by highly aggregated data and the difficulty of disentangling multiple causes. Systematic evidence is urgently needed in regions most impacted by this multi-faceted security issue (Guldberg et al., 2018; IPCC, 2019)). African drylands are projected to be among the worst hit regions from more intense and frequent extreme weather events. The impacts can result in cascading risks affecting populations through multiple, interconnected challenges, including through their effects on agricultural production, food and water security, employment, and conflict (IPCC, 2018; Thalheimer et al., 2021).

The consequences are already felt today by those most vulnerable to a warming climate, among others, internally displaced populations (IDPs) (Benonnier et al., 2021; Hoffmann et al., 2020; IPCC, 2018; Xu et al., 2020). Estimates indicate that in 2021 alone, over 23 million new displacements occurred due to weather and climate-related events with many of the internally displaced populations in African drylands (Internal Displacement Monitoring Centre, 2022). Only recently, researchers have engaged in modelling the outcomes of climate-related human mobility with the evidence remaining limited and fragmented (Koubi, 2019; von Uexkull and Buhaug, 2021) with vulnerability to weather and climate shocks thought to be of growing importance (Buhaug and von Uexkull, 2021). Recent and ongoing humanitarian crises in the Horn of Africa demonstrate that among many possible vulnerability stressors, drought and violent conflict are the two leading concerns (Anderson et al., 2021). The compounding effects of these two factors represents a grave challenge to human mobility in a warming world.

Here, we quantify the interaction of extreme weather, conflict, and displacement using novel data on all of Somalia's 18 regions between 2016 and 2018. We draw on subnational spatio-temporal data on

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internal displacement broken down by reported reasons for displacement in Somalia, carefully isolating each channel of causality (see Supplementary Material SPM 1 for additional details on the Somalian context). We show that extreme weather in the form of droughts and high temperatures significantly increase internal displacement. We further show that increases in armed conflict leads to large internal displacement, which however, is masked when using displacement data aggregated over weather and conflict-driven displacement. Unlike previous studies, we find little evidence of displacement itself affecting the number of occurring conflict events.

We contribute to two strands of the climate change and conflict impact literature: First, our work relates to studies regarding the thematic stream of human mobility and other sensitivities and responses to climate change (e.g., Hoegh-Guldberg et al., 2019; Oakes et al., 2019; Xu et al., 2020) and more specifically, to studies on the emerging field of climate mobility (Benveniste et al., 2020; Boas et al., 2019; Hoffmann et al., 2021). Second, we expand on empirical evidence on the interaction of multicausal drivers of human mobility (Black et al., 2011), such as weather and climate-related events as an environmental driver and conflict as a political driver.

Existing studies come to ambiguous conclusions regarding the role of weather/climate and conflict shocks as determinants of mobility. One study framed climate mobilities as a security issue (Baldwin et al., 2014, p. 125). Climate and conflict shocks have been shown as a potential to trigger migration cascades with implication for international security (Abel et al., 2019; Missirian and Schlenker, 2017). In this connection, the 2015 Syrian refugee crisis is a notable example (Linke and Ruether, 2021). The recent academic discourse has become cautious about such contextualization given the limited and mixed evidence (Boas et al., 2019; Vinke et al., 2020). For example, while Ash and Obradovich (2020) and Kelley et al. (2015) find a positive association between climate migration and violence in Syria, flood-related displacement in Bangladesh did not lead to protests (Petrova, 2021). In the context of poor governance and political fragility, weather and climate-related events can create and maintain conflict over scarce resources (Cattaneo et al., 2019; Missirian and Schlenker, 2017) and thus potentially increase the likelihood of conflict. Taken together, whether climate mobility increases violence at the destination is highly contextual (Ide and Scheffran, 2014; Koubi, 2019). We expand this strand of literature by assessing effects of internal displacement from extreme weather and conflict shocks. Compared to existing studies, our setting allows us to uniquely disentangle the effects of weather and conflict on displacement and subsequently quantify their impacts. Such enhanced empirical evidence is relevant for a better understanding of interaction pathways of extreme weather and conflict-related human mobility, and ultimately for an evidence-based design of preventive security policy such as climate policy that are implemented or funded at the local level, and thus support effective anticipatory humanitarian action.

2. Data, measurement, and methods

2.1. Displacement data and patterns

We combine spatio-temporal data on internal displacement, extreme weather, and violent conflict from all of Somalia's 18 regions at a monthly frequency over 2016–2018. We measure displacement using novel Protection and Return Monitoring Network (PRMN) survey data on internal displacement in Somalia, collected by the United Nations High Commissioner for Refugees (UNHCR, 2022). Each month, PRMN/UNHCR collects survey results at various points across Somalia's 18 administrative regions (administrative level 1). The sample was representative for the displacement at the origin and destination region of 2.193 million people from January 2016 to September 2018. Primary reasons for monthly internal displacement (see Fig. 2) were originally reported in four categories (drought, flood, conflict, and other). PRMN/UNHCR capture this detailed information at the regional level by conducting interviews with IDP heads of household. This is done primarily at points of arrival (i.e., destination) or by interviewing key informants at IDP settlements, transit centers, and other strategic locations and detailed information on the survey can be found in (UNHCR Somalia,

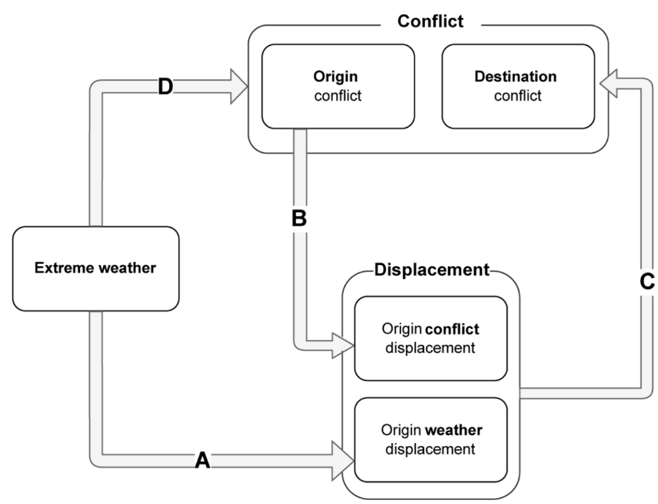

Fig. 2. Conceptual framework illustrating the range of possible interaction pathways between extreme weather, displacement, and conflict, where we observe both in and out migration in each region, as well as conflict and climate at both the origin and destination of IDPs.

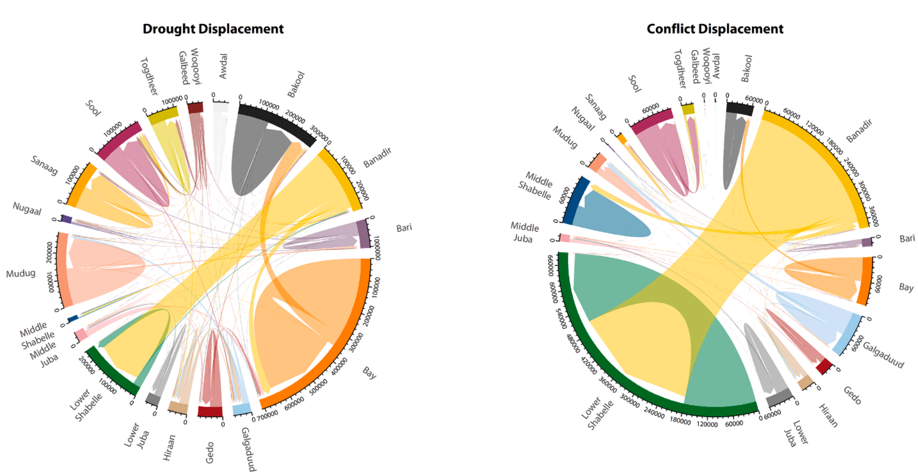

Fig. 1. Regional distribution of internal displacement, including within-region flows between 2016 and 2018 across Somalia. The circos plot on the left shows IDPs who reported drought as their primary reason for displacement and on the right conflict as the main driver. Notes: We show drought and conflict displacement separately to illustrate two key aspects: 1) most displacement occurs in southern Somalia and 2) high levels of within-region displacement occur independent of the displacement reason reported. Displacement due to conflict (over 0.6 million) remains a persisting factor in the southern regions. Drought is reported to displace more people in this period (over 1.2 million), largely affecting the southern regions of Bay, Bakool and Lower Shabelle.

2017). Visual inspection of the displacement data (Fig. 1) shows the importance of both conflict-driven and drought-driven displacement and that much of the displacement manifests itself as movement within each region. Our data thus allows us to uniquely quantify within-region movements as we record both the origin and destination of each IDP. We combine the subnational displacement data with high-resolution observations of extreme weather proxied by monthly temperatures and precipitation.

2.2. Extreme weather data and processing

Extreme weather is measured by regional monthly temperature and absolute precipitation anomalies over the period 2016–2018 with a climatology baseline of 1981–2010. Mean temperature anomalies were obtained from the Berkeley Earth dataset (Rohde et al., 2013), which offers a gridded temperature product. Berkeley Earth also provides a daily gridded homogenized temperature anomaly field. Each daily time series is transformed into a series of temperature anomalies by subtracting the corresponding monthly average (with respect to 1951–1980) from each daily observation at the same station. The temperature anomaly field is available from 1880 at a 1.00°x1.00° spatial resolution which we map to each of Somalia's 18 regions and average over each month to match the displacement data.

We use satellite-derived precipitation observations from the Climate Hazards Groups Infrared Precipitation with Stations dataset (CHIRPS), the best practice dataset for drought monitoring in the East Africa region (Dinku et al., 2018; Funk et al., 2016). We compute absolute precipitation anomalies relative to their long-term regional averages. To construct precipitation anomalies for the same base period as the Berkeley dataset, i.e., 1951–1981, we use the Fifth generation of the European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis data (ERA5) for monthly regional averages in this period (Hersbach et al., 2020). The use of ERA5 precipitation data allows us to recalibrate and expand the CHIRPS observed precipitation time series to match the anomalies computed for temperatures. We use the precipitation anomalies combined with temperature as an indicator for drought, a validated approach performed in numerous drought attribution studies for eastern Africa (Harrington et al., 2022; Otto et al., 2018; Philip et al., 2017).

2.3. Conflict data and processing

To allow us to quantify the effect of conflict onto internal displacement, we obtain data on the frequency of conflict events and fatalities (see Supplementary Material SPM 2) recorded through the Armed Conflict Location and Event Data Project (ACLED) database (Raleigh et al., 2010). Conflict events are defined as the number of recorded data on violent conflict in the ACLED database, including human-coded and media-based data points. A datapoint counts as a conflict event, which includes battles or attacks on civilians as a proxy for violence. As a robustness check, we also consider conflict fatalities in each region to approximate the intensity (rather than frequency) of conflict.

The final dataset of displacement, extreme weather, and conflict spans a total of 568 month-region observations covering all of Somalia's 18 regions for more than two years of 2016/17 drought. We provide the summary statistics in Table SPM 2.1.

2.4. Interaction pathways

2.4.1. Conceptual approach

The interaction between extreme weather, conflict, and internal displacement can be multi-directional and result in displacement through different pathways. We illustrate these interaction pathways in Fig. 2 which subsequently guides our empirical identification strategy. Extreme weather may directly drive displacement (e.g., due to droughts) shown as channel A in Fig. 2, or indirectly by leading to increased conflict (e.g., due to resource scarcity) shown as channel D and subsequent conflict-driven displacement in channel B. Conflict at the origin region may drive displacement (e.g., fleeing from a warzone, channel B), but conflict may itself be driven by in-migration at the destination (e.g., mixing of ethnic groups/ intra clan rivalry/resource scarcity, channel C). We rely on a set of identifying assumptions to isolate these pathways. First, we assume that IDPs truthfully declare the primary reason for displacement at each UNHCR checkpoint, as indicated in the PRMN data collection methodology (UNHCR Somalia, 2017). As the UN surveys on displacement are anonymous and released with a substantial lag, there is no obvious reason for IDPs not to truthfully report their reason at each checkpoint. Second, we assume that IDPs from the origin region do not affect the occurrence of conflict at the origin region. Although the degree to which people are forced to leave due to conflicts might differ, the literature does not suggest that out-migration itself causes conflict at the origin. This is in line with assumptions in the literature (e.g., Borderon et al., 2019; Collier and Hoeffler, 2005; Ide and Scheffran, 2014) and we thus consider our assumptions reasonable.

By analyzing how each of the pathways – extreme weather, conflict, and displacement – interact between within-country origin and destination regions, we shed light on three interaction pathways: i) weather effects on displacement, ii) conflict effects on displacement, and iii) displacement effects on conflict. Examining this nexus is crucial for the design of climate and security policy measures that can strengthen resilience to weather and conflict shocks, particularly among displaced populations, which are among the most vulnerable. In this context, we argue that formulating effective policy responses to the climate crisis requires an understanding of the interaction between the multi-causal drivers of human mobility at the local level. Moreover, we contribute some of the first empirical analyses of disentangling extreme weather and conflict effects on displacement outcomes using bi-directional data at subnational scale.

2.4.2. Model specification and interaction pathways

We model four channels through which extreme weather and conflict directly or indirectly could interact (channels A–D in Fig. 2) using well-established two-way fixed effect (TWFEs) panel estimators while allowing for non-linearities and dynamic effects over time and controlling for region and year-month (i.e., time) fixed effects. We provide the exact specification of each of the eight models in Table 1. We provide all model results in Tables SPM 2.2 – 2.4 and their marginal effects are contained in Table SPM 2.5.

First, to quantify the net effect of weather shocks on IDPs (weather channel A + conflict and weather channels [B + D]), we model the total displacement out of each region as a function of weather conditions at the origin (Model 1). Second, we identify the sole-extreme weather effect (channel A) by estimating the same model using the subset of drought-reported displacement (Model 2). This identifies channel A by only focusing on IDPs reporting drought to be the reason for displacement (see Fig. 2). Third, we identify the effect of conflict on displacement (channel B) by modelling displacement (total and conflict-reported - Models 3 and 4) as a function of conflict at the origin. Fourth, we isolate the effect of displacement on conflict by modelling conflict at the destination as a function of in-migration of IDPs (channel C) with and without controlling for weather (Models 5). We discuss potential endogeneity in our conflict models due to spillovers (neighboring conflict may appear to be caused by IDPs) and reverse causality (IDPs potentially choosing low conflict areas) in section 3.3.

The interactions between extreme weather, conflict, and displacement may be non-linear and may take place with a temporal lag. To capture lagged effects, we therefore model the relationships using distributed lags up to 4 months (and evaluate models with up to 8 lags as well to test their sensitivity in the Supplementary Material, see Figures SPM 3.1.6–3.1.7). To allow for potential non-linearities (for example, an additional degree Celsius of warming may have different impacts going from 1 °C to 2 °C, relative to 2 °C to 3 °C), we specify our

Table 1
Model Specifications.

No.	Identified Channel of Effects	Model Specification	Results
1	Weather on total displacement (A + B + D).	$log(TotDispl)_{i,t} = \alpha_i + \lambda_t + T_{i,t}\beta_{Temp} + P_{i,t}\beta_{Precip} + \epsilon_{i,t}$	Fig. 3
2	Weather on drought-reported displacement (A)	$log(DroughtDispl)_{i,t} = \alpha_i + \lambda_t + T_{i,t}\beta_{Temp} + P_{i,t}\beta_{Precip} + \epsilon_{i,t}$	Fig. 4
3.1	Conflict on total displacement (B)	$log(TotDispl)_{i,t} = \alpha_i + \lambda_t + C_{i,t}\beta_{Confl} + \epsilon_{i,t}$	Supplementary Material SPM 2
3.2	With weather controls:	$log(TotDispl)_{i,t} = \alpha_i + \lambda_t + C_{i,t}\beta_{Confl} + T_{i,t}\beta_{Temp} + P_{i,t}\beta_{Precip} + \epsilon_{i,t}$	
4.1	Conflict on conflict-reported displacement (B)	$log(ConfDispl)_{i,t} = \alpha_i + \lambda_t + C_{i,t}\beta_{Confl} + \epsilon_{i,t}$	Fig. 5
4.2	With weather controls:	$log(ConfDispl)_{i,t} = \alpha_i + \lambda_t + C_{i,t}\beta_{Confl} + T_{i,t}\beta_{Temp} + P_{i,t}\beta_{Precip} + \epsilon_{i,t}$	
5.1	Arriving displacement on conflict (C):	$log(Confl + 1)_{i,t} = \alpha_i + \lambda_t + AD_{i,t}\beta_{AD} + \epsilon_{i,t}$	Fig. 6
5.2	With weather controls:	$log(Confl + 1)_{i,t} = \alpha_i + \lambda_t + AD_{i,t}\beta_{AD} + T_{i,t}\beta_{Temp} + P_{i,t}\beta_{Precip} + \epsilon_{i,t}$	

Variable definitions: *TotDispl, DroughtDispl, ConflDispl*: number of departing IDPs from region *i* aggregated (Total) and due to reported droughts or *conflict*.
$T_{i,t} = (Temp_{i,t}, \cdots, Temp_{i,t-s}Temp^2_{i,t}, \cdots, Temp^2_{i,t-s})$: monthly temperature anomalies up to *s* lags.
$P_{i,t} = (Precip_{i,t}, \cdots, Precip_{i,t-s}Precip^2_{i,t}, \cdots, Precip^2_{i,t-s})$: monthly precipitation anomalies up to *s* lags.
$C_{i,t} = (Confl_{i,t}, \cdots, Confl_{i,t-s}, Confl^2_{i,t}, \cdots, Confl^2_{i,t-s})$: conflict events up to *s* lags.
$AD_{i,t} = (ArrivDispl_{i,t}, \cdots, ArrivDispl_{i,t-s}, ArrivDispl^2_{i,t}, \cdots, ArrivDispl^2_{i,t-s})$: number of IDPs arriving in region *i*.
for up to s monthly lags, where we set s = 4 (with varying lag-lengths as robustness check in the Supplementary Material SPM 3). Region fixed effects are given by α_i and month-year fixed effects are given by λ_t. Standard errors are clustered at the region level.

models using second-order polynomials. This allows for either increasing or decreasing marginal effects of weather, conflict, or displacement. To quantify the net effect of each possible driver of displacement, we look at the cumulative contribution of each variable summed over its lags. We compute the standard errors of the resulting net effects as the standard error of the sum of the temporally lagged coefficients using the estimated variances and covariances. To exemplify, for a model with a contemporaneous effect β_1 and lagged effect β_2, the net effect is given by $\beta_1 + \beta_2$, and the variance of the net effect can be computed as $var(\beta_1) + var(\beta 1) + 2\ cov(\beta_1, \beta_2)$. Complete results disaggregating the lagged terms are reported in the Supplementary material (see Tables SPM 2.1–2.5, and Supplementary Material SPM 3).

We model the impacts on the level of displacement for each region (rather than relative migration between regions) as this allows us to quantify the overall effect of weather/conflict on displacement and also permits us to model displacement *within* the same region. This is crucial given the large number of IDPs moving within their origin region (see Fig. 1). Table 1 shows the relevant equations used to estimate the effects for each channel.

In contrast to a recent study (Owain and Maslin, 2018), our research design allows us to explicitly disentangle effects through which weather shocks influence internal displacement and to estimate non-linear effects of extreme weather on displacement and conflict, and the effects of conflict on displacement, and *vice versa*. Beyond isolating individual interaction pathways, the level of disaggregation (by reason of displacement), this model also allows to study the degree to which aggregation of data masks underlying causes of internal displacement.

In the following section, we express our results and estimated effect sizes in terms of marginal effects (e.g., the impact of a 1 °C or 1.5SD change on displacement). To quantify the effect sizes (see Table 1 and Table SPM 2.1) we consider the percentage difference between the predicted values at a number of different points in the distribution of the relevant predictor variables, i.e., we consider the predicted value at 2 °C relative to the predicted value at 1 °C.

3. Results

3.1. The effects of extreme weather on displacement

We first investigate the effect of weather shocks on total displacement (summed over all reported reasons thus identifying channels A + [B + D] in Fig. 2; Model 1). We find significant non-linear effects of temperatures on displacement (χ^2 test for joint significance of contemporaneous and lagged temperature variables $p < 0.001$), where higher than usual temperatures lead to increased displacement (see Fig. 3 and Table SPM 2.2 for full estimation results). We estimate that an increase in temperature anomalies from 1 °C to 2 °C (an approx. 1.5SD increase) leads to around 2400 more IDPs or an approximate tenfold (1098 %) increase of the predicted IDPs for our reference region Bakool in May 2016. Other fixed effects predictions change the number of predicted IDPs – as for example certain months or regions experience high average displacement levels – but the relative mean marginal effects (i.e., percentage changes) are identical across fixed effects chosen (see Supplementary Material SPM 6 for a discussion and an illustration of this effect). Such large temperature anomalies in excess of + 1 °C occur frequently in Somalia (see histogram in Fig. 3) thus constituting a large factor in observed displacement.

Turning to lack of precipitation, a reduction of 50 mm (approx. 1.5SD change) from 100 mm to 50 mm in monthly rainfall is associated with an approximate doubling of predicted IDPs, while a further reduction in precipitation from 50 mm to 0 mm leads to another fourfold increase in predicted IDPs (χ^2 test for joint significance, $p < 0.001$).

Drought-impacted IDPs are the largest share of people affected by displacement according to the PRMN/UNHCR database. When we restrict the sample to drought-reported displacement to isolate channel A (Model 2), a similar net effect emerges (see Fig. 4 compared to

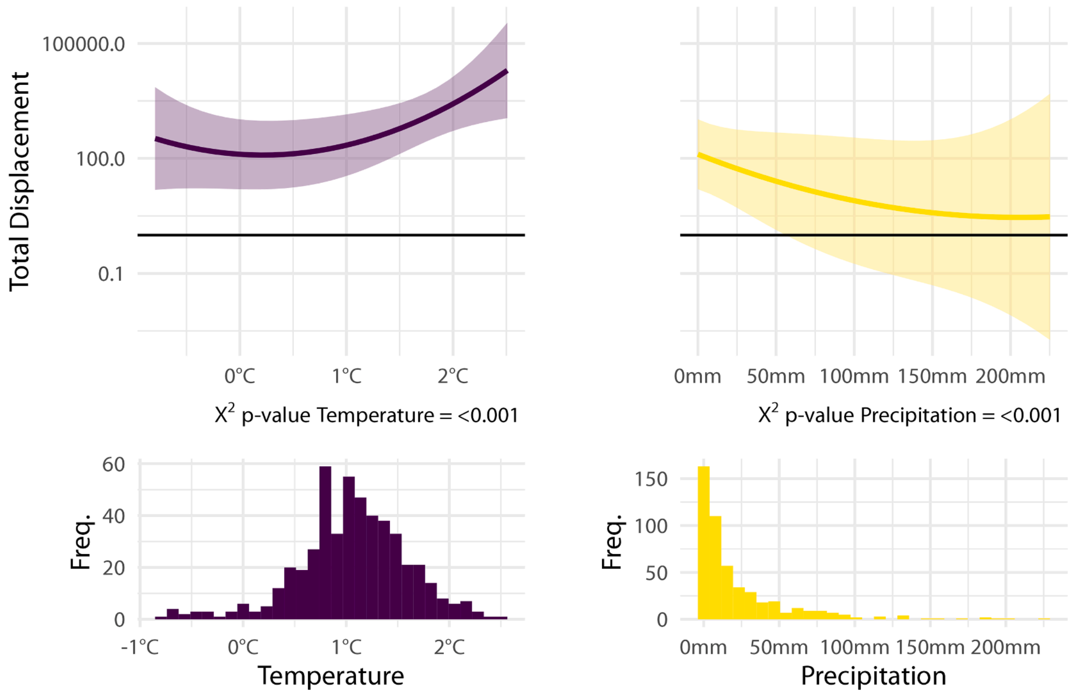

Fig. 3. Estimated cumulative non-linear effects of temperature (left) and precipitation anomalies (right) on total displacement from estimated Model 1. Bottom panels show the histogram of extreme weather over the sample period. Note: All following figures show effects using intercepts for Bakool region and May 2016. Any other region or date would simply result in an upwards or downwards shift but would not change the overall shape of the relationship (see Supplementary Material SPM 6 for an illustration of different fixed effect predictions).

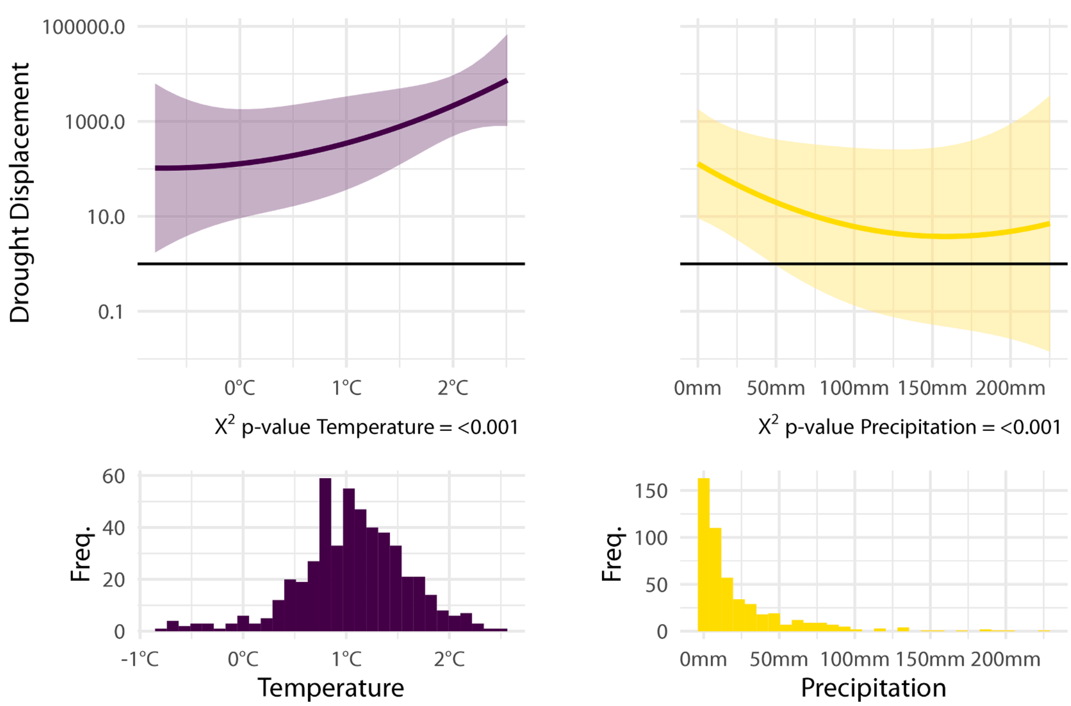

Fig. 4. Estimated cumulative non-linear effect of temperature anomalies (left) and precipitation anomalies (right) on drought-reported displacement from Model 2. Lower panel shows histogram of anomalies over the sample.

Fig. 3). This is perhaps unsurprising but provides evidence that the direct-extreme weather channel dominates any conflict-driven response that might have been instigated by climate (channels [B + D]). Drought-induced IDPs are more prone to perceive the adverse impacts of an extreme dry climate as a decision to move. Drought-reported displacement is even more responsive to precipitation shocks with a reduction from 50 mm of rain to 0 mm (no rainfall, approx. 1.5SD change) increasing the predicted number of IDPs about fivefold. The estimated effects are summarized in Figs. 3–4 and Table SPM 2.5.

These results are robust to using a linear model specification (where we also find positive temperature and negative precipitation effects see Supplementary Material SPM 3.2) as well as varying the lag length in the

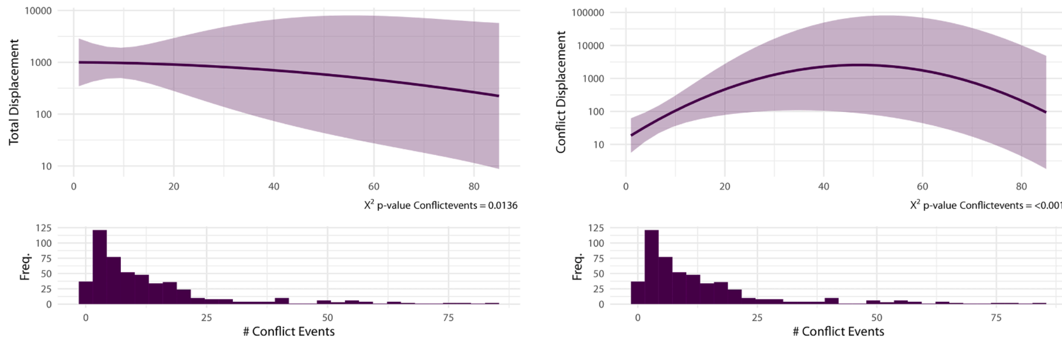

Fig. 5. Cumulative non-linear effect of conflict events on total displacement (Model 3.1, left) and conflict displacement (Model 4.1, right). Histogram of conflict events over the sample shown in lower panel. Estimation results for Models 3.2 and 4.2 controlling for weather are provided in Supplementary Material SPM 2.

estimated models (see Supplementary Material SPM 3.1). We note that the joint significance of the non-linear terms supports the choice of a non-linear model over a model with only linear terms.

3.2. The effects of conflict on displacement

Here we present the effects of conflict events on overall displacement (Models 3.1 and 3.2) as well as for the sub-sample of IDPs who self-reported to be displaced due to conflict (Models 4.1 and 4.2). Modelling the aggregate displacement response (summed over all self-reported categories including conflict and drought) as a function of conflict at the origin region (i.e., channel B in isolation, relating how many people leave a region to the number of conflict events in that region), we find no statistically significant effects of conflict on displacement (Fig. 5 left panel, χ^2 test for joint significance, $p = 0.013$ when not controlling for weather, and $p = 0.08$ when controlling for weather, see Supplementary Material SPM 2, Table SPM 2.3 and Figure SPM 2.1). However, this result is likely driven by data-aggregation and conflation of different reasons for displacement. In other words, the number of IDPs reporting to be displaced due to droughts masks the conflict signal. Due to this increased noise, there is low statistical power to detect effects of conflict on displacement (see also Supplementary SPM 7 for interaction models). Once we isolate the subset of IDPs who self-report to be displaced due to conflict, we find large and significant effects (Fig. 5 right panel, χ^2 test for joint significance, $p < 0.001$). Specifically, we estimate that an increase of 25 conflict events (an approx. 1.5SD increase in conflict events) compared to no conflict events in a month lead to a predicted 50-fold increase in the number of IDPs and at least double again when considering an increase from 25 to 50 conflict events. These results are robust to controlling for weather shocks, see Table SPM 2.3 and SPM 2.4. Notably, we find little evidence of interaction effects between precipitation and conflict (which are not statistically different from zero) on displacement (see SPM 7).

Contrasting total and conflict-reported displacement, these results also offer a cautious tale – testing for an effect of conflict on total displacement masks the conflict signal, suggesting that data aggregation can lead to a spurious conclusion that conflict has no effect on displacement (see Supplementary Material SPM 2). These results are again robust to using a model that only includes linear terms, though the statistical significance of the quadratic terms in the conflict-displacement models (4.1 & 4.2) strongly support our choice of a quadratic specification. The results are also robust to alternative measures of conflict. As a robustness check, instead of estimating the effect of the number of conflict events, we approximate the intensity of conflict using the number of conflict-induced fatalities. We repeat the estimation of models 3.1, 3.2, 4.1, and 4.2 using the fatality measure of conflict and plot the results in SPM section 2. The results show large and significant effects of conflict intensity (proxied by fatalities) on displacement.

3.3. Displacement effects on conflict

Here we investigate whether arriving IDPs contribute to conflict in their destination region, as arriving displacement might increase pressures on scarce resources such as food and drinking water (Models 5.1 and 5.2, channel C in Fig. 2). We estimate this pathway with and without controlling for weather shocks (models controlling for weather shocks are reported in Supplementary Material SPM 2). We find little indication of a significant effect of arriving displacement on the occurrence of conflict events at the destination (Fig. 6, χ^2 test for joint significance of conflict variables, $p = 0.13$). While the point estimate of the cumulative effect over all lags is positive, the effect is not statistically different from zero (see Supplementary Material SPM 2, Table SPM 2.4 and Figure SPM 2.2). We also find no statistically significant effect when considering a linear instead of non-linear model (see Supplementary Material SPM 3), however do find a statistically significant result when controlling for weather shocks and when using fatalities rather than conflict events (Model 5.2 and Figure SPM 5 panel G–H).

There are, however, two specific sources of potential endogeneity in

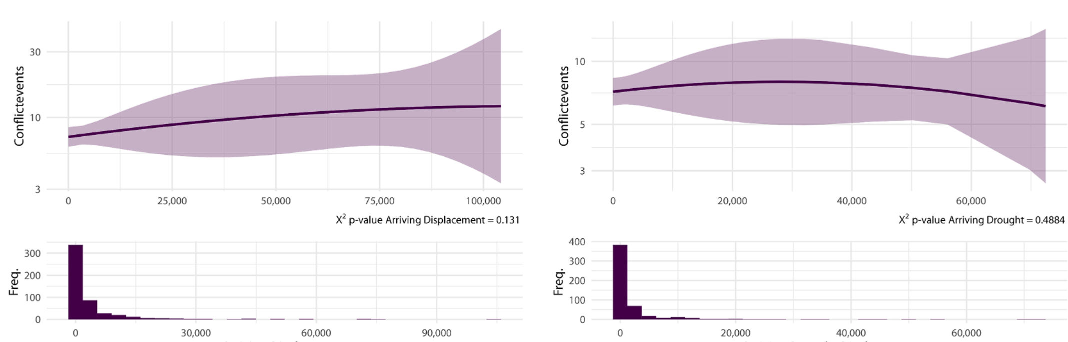

Fig. 6. Cumulative effect of arriving displaced people on the conflict events (Model 5.1 – left). Modified Model 5.1 with only drought displacement only including lags 2–4 is shown in the right panel). Lower panel shows the histograms of arriving IDPs over the sample.

our analysis of the effect of displacement on conflict. First, there may be conflict spillover effects where neighboring regions experience conflict at the same time, which might then be spuriously attributed to IDPs moving into a region. Second, there may be concerns around reverse causality, with IDPs choosing to move to low-conflict regions.

The first concern (spillover) would lead to an overestimation of the effect of displacement on conflict. Despite this potential upward bias in effects, we find no statistically significant effect of incoming IDPs on conflict (see Fig. 6). Nevertheless, as an additional robustness check, we also re-estimate the model using only in-migration driven by droughts. Studying the effects of incoming IDPs displaced due to weather on conflict at the destination could isolate the displacement effect more closely, reducing the neighbor spillovers through any conflict channels. Using only drought-induced in-migration, the results suggest an overall positive impact on conflict frequency, however, the results are likely distorted due to outlying observations. The estimated effect is close to zero (in fact the point estimate is negative) over most of the range of observed displacement (see histogram in Figure SPM 4.1) and only pulled upwards due to a small set of outlying observations which exhibit very high levels of displaced people (see Supplementary Material SPM 4).

While this specification might address concerns around spill over, there remains the second potential source of endogeneity: IDPs may choose to move to areas of low conflict, raising concerns around reverse-causality. We address this by repeating our analysis using two alternate model specifications. First, we consider dynamic models with only lagged in-migration (total and drought-driven) with lags of 2–4 months (see Fig. 6, right panel). This lagged specification can help isolate the effects of displacement on conflict as we now only consider whether displacement in the past affects conflict in the present. Second, we consider dynamic models controlling for lagged levels of conflict at the destination. Both sets of temporally lagged models confirm our earlier results. We again find no statistically significant effect of displacement on conflict at the destination. This holds for model specifications with and without controlling for weather (see Supplementary Material SPM 4).

4. Discussion

Carefully disentangling the interaction between extreme weather, conflict, and internal displacement, we have three main findings: First, there are large effects of temperatures and precipitation shocks on internal displacement. Our estimates suggest that a reduction from 50 mm of monthly precipitation to 0 mm leads to a fourfold increase in predicted IDPs. An increase in temperatures from 1 °C to 2 °C is associated with a tenfold increase in predicted IDPs, however, the response appears to be nonlinear, with a change from 0 °C to 1 °C only leading to close to a doubling (approx. 70 % increase) in predicted IDPs. This is in-agreement with recent evidence (Owain and Maslin, 2018) that suggests climate change might exacerbate displacement conditions in the Horn of Africa region. It is also in agreement with Pape and Wollburg (2019) who found that the 2016/17 drought increased poverty and hunger in rural areas across Somalia; these effects are even bigger when considering repeated drought shocks. The response to weather shocks, however, opens the door to policy responses – timely counter measures to droughts may be able to offset the negative impacts and thus not force people to migrate to move themselves out of harm's way, even when faced with multiple, simultaneously occurring (compounding) vulnerabilities.

Second, conflict is a strong driver of internal displacement. If conflict events increase from 0 to 25 (an approx. 1.5SD change) our results predict a 50-fold increase in the number IDPs and doubling again if conflict events increase again from 25 to 50. As conflict events occur frequently and often exceed 10–25 events per region, these effects are large and common. However, these effects are only detectable when using disaggregated data broken down by reason of displacement. When using aggregate data that combines weather and conflict driven displacement, no statistically significant effect of conflict is detectable. This offers a cautious tale for related studies assessing the link between conflict and displacement; aggregate displacement data may well mask displacement signals, potentially leading to the erroneous conclusion of conflict (or other drivers) having little effect on displacement.

Third, we find no statistically significant effect of incoming IDPs increasing conflict at their destination. Arriving IDPs do not appear to increase the probability of conflict at their destination, suggesting that concerns around migration-induced conflict (perhaps through migration-induced resource scarcity) may be unfounded.

Several streams within the climate mobility literature suggest a causal relationship between weather and climate-related events, conflict, and human mobility, showing that already vulnerable populations such as migrants and asylum seekers are often disproportionately affected by (or exposed to) extreme weather and conflict shocks (e.g., Abel et al., 2019; Boas et al., 2019; Mach et al., 2019). Especially relevant to our analysis is the work of Abel et al., (2019), who describe two potential interaction pathways for forced migration: First, weather shocks could contribute to conflict under certain conditions. Second, conflict can exacerbate the extreme weather effects on forced types of migration and compound with geopolitical stressors. Returning to our set of interactions between weather, conflict, and displacement outlined in Fig. 2, we can combine our estimates into a bigger picture and shed light on these hypotheses. We find significant weather effects on displacement (channels A + B + D) where, however, the net effect (allowing for a possible conflict channel) migration is comparable to the direct effect of weather on displacement, suggesting that the effect of weather on conflict (channel D) and subsequently displacement is small. Instead, displacement appears to be driven separately by two channels: a direct weather channel (channel A) and a direct channel of conflict increasing displacement (channel B) which is in-line with Abel et al. (2019). There is little evidence that displacement itself increases conflict (channel C).

Our findings also speak to the growing strand of climate impact literature on human responses to a changing climate. With regard to Somalia, several studies have examined the role of extreme weather and conflict on vulnerable populations (Anderson et al., 2021; Maystadt and Ecker, 2014; Owain and Maslin, 2018). These studies suggest that changes in weather and climate-related events adversely impact human mobility and exacerbate displacement situations in the region (Owain and Maslin, 2018) and conflict through indirect pathways of food security (Anderson et al., 2021; Maystadt and Ecker, 2014). However, these studies are based on national data and thus fall short of providing empirical evidence on a sub-national scale. We expand on this literature by providing one of the first empirical assessments of extreme weather and conflict shocks using granular, subnational-level data. A further contribution of this study is the use of a systematic and coherent empirical framework to show how weather shocks and conflict events are related to internal displacement outcomes and the role of arriving IDPs (i.e., interaction pathways). Drawing on a large national sample and using detailed subnational-level data, we provide for the first clearly identified empirical evidence that internal displacement is closely related to precipitation and temperature shocks, minimizing the capacity to absorb conflict shocks, at least in the Somalia context. As a caveat, we should emphasize that we have only information on the primary reason for displacement, but no data on additional reasons, such as forced eviction or food insecurity.

Overall, our results highlight the nuances of the interactions between extreme weather, conflict, and displacement, both along temporal and non-linear dynamics. The results further emphasize the need for granular disaggregated displacement and migration data for other regions affected by weather, climate, and conflict events. Detailed displacement information may tell a different story of the drivers of displacement when compared to aggregated measures available in many other regions. Adverse impacts of climate change could present compounding risks to already-vulnerable populations and hamper sustainable ways for human mobility and societal outcomes.

5. Conclusions

Drawing on a unique, disaggregated displacement dataset, comprising reported reasons of internal displacement in Somalia, we systematically assessed the interaction pathways of weather shocks and conflict on displacement, and the relationship of arriving IDPs on conflict outcomes. The study's main results can be summarized as follows: Weather shocks affect internal displacement outcomes with higher temperatures and lower precipitation leading to an increase in displacement. Conflict events lead to an immediate, large, displacement response. However, detection of this conflict signal is masked if only aggregate data is considered. Finally, we find no evidence of displacement itself increasing the occurrence of conflict at the destination of IDPs.

These findings are not just relevant for expanding the empirical evidence on extreme weather, conflict, displacement, but also for improving the design of climate policy as a preventive security policy. In Somalia, our findings indicate a need to strengthen policy interventions towards anticipatory humanitarian action – namely, measures before natural hazards materialize and tip over fragile resilience levels. The 2020 issue brief "Forecast-based financing and disaster displacement", developed by a joint steering committee consisting of experts from the fields of humanitarian aid and climate science (IFRC, 2020) identifies displacement stage-specific information and actions as a key to forecast-based financing and anticipatory action plans. However, they only hint at the importance of quantitative assessments for the efficacy to inform anticipatory humanitarian action in the displacement context. Structuring the empirical analysis around the interaction pathways of extreme weather, conflict, and displacement, in combination with the available respective data, can help to bring the most important dynamics into focus. Our results underline the importance of coupling the evidence of weather and conflict shocks on internal displacement at the local level to improve anticipatory action and ultimately, people's resilience to such shocks. These actions should aim in particular at the most effective areas for humanitarian intervention to avert risks of displacement in a changing climate. In this connection, the location of displacement and impact by weather shocks or conflict events can give crucial information to act quickly in terms of humanitarian assistance. Examples of such anticipatory humanitarian actions exist outside the displacement context in Somalia. The Famine Early Warning Systems Network, for example, provides early warning maps, a simple forecast mapping tool that aims to provide evidence-based information on humanitarian crises to help facilitate humanitarian funding and action (FEWS NET, 2022). Our analysis underscores the importance of empirical evidence for such initiatives. For the development of preventive security and policy plans, such empirical evidence should play an important role, as they are valuable to strengthen resilience. Ultimately, our analysis supports the promotion of peace and responds to local security challenges in a climate change vulnerable and conflict-affected country.

CRediT authorship contribution statement

Lisa Thalheimer: Conceptualization, Methodology, Software, Formal analysis, Data curation, Validation, Visualization, Project administration, Writing – original draft, Writing – review & editing. **Moritz P. Schwarz:** Methodology, Software, Formal analysis, Data curation, Visualization, Writing – original draft, Writing – review & editing. **Felix Pretis:** Conceptualization, Methodology, Software, Formal analysis, Project administration, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

All data are open-source and linked in the main text and Supplementary material.

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Appendix A. Supplementary data

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References

Abel, G.J., Brottrager, M., Cuaresma, J.C., Muttarak, R., 2019. Climate, conflict and forced migration. Glob. Environ. Change 54, 239–249.

Anderson, W., Taylor, C., McDermid, S., Ilboudo-Nébié, E., Seager, R., Schlenker, W., Cottier, F., de Sherbinin, A., Mendeloff, D., Markey, K., 2021. Violent conflict exacerbated drought-related food insecurity between 2009 and 2019 in sub-Saharan Africa. Nat. Food 2, 603–615. https://doi.org/10.1038/s43016-021-00327-4.

Ash, K., Obradovich, N., 2020. Climatic Stress, Internal Migration, and Syrian Civil War Onset. J. Confl. Resolut. 64, 3–31. https://doi.org/10.1177/0022002719864140.

Baldwin, A., Methmann, C., Rothe, D., 2014. Securitizing 'climate refugees': the futurology of climate-induced migration. Crit. Stud. Secur. 2, 121–130. https://doi.org/10.1080/21624887.2014.943570.

Benonnier, T., Millock, K., Taraz, V., 2021. Long-term migration trends and rising temperatures: the role of irrigation. J. Environ. Econ. Policy 0, 1–24. 4 doi:10.1080/21606544.2021.1993348.

Benveniste, H., Oppenheimer, M., Fleurbaey, M., 2020. Effect of border policy on exposure and vulnerability to climate change. Proc. Natl. Acad. Sci. 117, 26692–26702. https://doi.org/10.1073/pnas.2007597117.

Black, R., Adger, W.N., Arnell, N.W., Dercon, S., Geddes, A., Thomas, D., 2011. The effect of environmental change on human migration. Glob. Environ. Change, Migration Global Environ. Change – Rev. Drivers of Migration 21, S3–S11. https://doi.org/10.1016/j.gloenvcha.2011.10.001.

Boas, I., Farbotko, C., Adams, H., Sterly, H., Bush, S., van der Geest, K., Wiegel, H., Ashraf, H., Baldwin, A., Bettini, G., Blondin, S., de Bruijn, M., Durand-Delacre, D., Fröhlich, C., Gioli, G., Guaita, L., Hut, E., Jarawura, F.X., Lamers, M., Lietaer, S., Nash, S.L., Piguet, E., Rothe, D., Sakdapolrak, P., Smith, L., Tripathy Furlong, B., Turhan, E., Warner, J., Zickgraf, C., Black, R., Hulme, M., 2019. Climate migration myths. Nat. Clim. Change 9, 901–903. https://doi.org/10.1038/s41558-019-0633-3.

Borderon, M., Sakdapolrak, P., Muttarak, R., Kebede, E., Pagogna, R., Sporer, E., 2019. Migration influenced by environmental change in Africa: A systematic review of empirical evidence. Demogr. Res. 41, 491–544. https://doi.org/10.2307/26850658.

Buhaug, H., von Uexkull, N., 2021. Vicious Circles: Violence, Vulnerability, and Climate Change. Annu. Rev. Environ. Resour. 46, 545–568. https://doi.org/10.1146/annurev-environ-012220-014708.

Cattaneo, C., Beine, M., Fröhlich, C.J., Kniveton, D., Martinez-Zarzoso, I., Mastrorillo, M., Millock, K., Piguet, E., Schraven, B., 2019. Human Migration in the Era of Climate Change. Rev. Environ. Econ. Policy 13, 189–206. https://doi.org/10.1093/reep/rez008.

Collier, P., Hoeffler, A., 2005. Resource Rents, Governance, and Conflict. J. Confl. Resolut. 49, 625–633. https://doi.org/10.1177/0022002705277551.

Dinku, T., Funk, C., Peterson, P., Maidment, R., Tadesse, T., Gadain, H., Ceccato, P., 2018. Validation of the CHIRPS satellite rainfall estimates over eastern Africa. Q. J. R. Meteorol. Soc. 144, 292–312. https://doi.org/10.1002/qj.3244.

FEWS NET, 2022. Somalia | Famine Early Warning Systems Network [WWW Document]. URL https://fews.net/east-africa/somalia (accessed 1.26.22).

Funk, C., Harrison, L., Shukla, S., Korecha, D., Magadzire, T., Husak, G., Galu, G., Hoell, A., 2016. Assessing the Contributions of Local and East Pacific Warming to the 2015 Droughts in Ethiopia and Southern Africa. Bull. Am. Meteorol. Soc. 97, S75–S80. https://doi.org/10.1175/BAMS-D-16-0167.1.

Guldberg, O.H., Jacob, D., Taylor, M., Bindi, M., Brown, S., Camilloni, I., Zougmore, R., 2018. Chapter 3: Impacts of 1.5 C Global Warming on Natural and Human Systems. Glob. Warm. 15 C IPCC Spec. Rep. Impacts Glob. Warm. 15 C Pre-Ind. Levels Relat. Glob. Greenh. Gas Emiss. Pathw. Context Strength. Glob. Response Threat Clim. Change.

Harrington, L.J., Wolski, P., Pinto, I., Ramarosandratana, A.M., Barimalala, R., Vautard, R., Philip, S., Kew, S., Singh, R., Heinrich, D., Arrighi, J., Raju, E., Thalheimer, L., Razanakoto, T., van Aalst, M., Li, S., Bonnet, R., Yang, W., Otto, F.E. L., van Oldenborgh, G.J., 2022. Limited role of climate change in extreme low rainfall associated with southern Madagascar food insecurity, 2019-21. Environ. Res. Clim. https://doi.org/10.1088/2752-5295/aca695.

Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Muñoz-Sabater, J., Nicolas, J., Peubey, C., Radu, R., Schepers, D., Simmons, A., Soci, C., Abdalla, S., Abellan, X., Balsamo, G., Bechtold, P., Biavati, G., Bidlot, J., Bonavita, M., De Chiara, G., Dahlgren, P., Dee, D., Diamantakis, M., Dragani, R., Flemming, J., Forbes, R., Fuentes, M., Geer, A., Haimberger, L., Healy, S., Hogan, R.J., Hólm, E., Janisková, M., Keeley, S., Laloyaux, P., Lopez, P., Lupu, C., Radnoti, G., de Rosnay, P., Rozum, I., Vamborg, F., Villaume, S., Thépaut, J.-N., 2020. The ERA5 global reanalysis. Q. J. R. Meteorol. Soc. 146, 1999–2049. https://doi.org/10.1002/qj.3803.

Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bolaños, T.G., Bindi, M., Brown, S., Camilloni, I.A., Diedhiou, A., Djalante, R., Ebi, K., Engelbrecht, F., Guiot, J., Hijioka, Y., Mehrotra, S., Hope, C.W., Payne, A.J., Pörtner, H.-O., Seneviratne, S.I., Thomas, A., Warren, R., Zhou, G., 2019. The human imperative of stabilizing global climate change at 1.5°C. Science 365. https://doi.org/10.1126/science.aaw6974.

Hoffmann, R., Dimitrova, A., Muttarak, R., Crespo Cuaresma, J., Peisker, J., 2020. A meta-analysis of country-level studies on environmental change and migration. Nat. Clim. Change 1–9. https://doi.org/10.1038/s41558-020-0898-6.

Hoffmann, R., Šedová, B., Vinke, K., 2021. Improving the evidence base: A methodological review of the quantitative climate migration literature. Glob. Environ. Change 71, 102367. https://doi.org/10.1016/j.gloenvcha.2021.102367.

Ide, T., Scheffran, J., 2014. On climate, conflict and cumulation: suggestions for integrative cumulation of knowledge in the research on climate change and violent conflict. Glob. Change Peace Secur. 26, 263–279. https://doi.org/10.1080/14781158.2014.924917.

IFRC, 2020. Forecast-based Financing and disaster displacement: Acting early to reduce the humanitarian impacts of displacement.

Internal Displacement Monitoring Centre, 2022. Global Report on Internal Displacement 2022. Geneva.

IPCC, 2018. Global Warming of 1.5 °C. World Meteorological Organization, Geneva, Switzerland.

IPCC, 2019. Special Report on Climate Change and Land.

Kelley, C.P., Mohtadi, S., Cane, M.A., Seager, R., Kushnir, Y., 2015. Climate change in the Fertile Crescent and implications of the recent Syrian drought. Proc. Natl. Acad. Sci. 112, 3241–3246. https://doi.org/10.1073/pnas.1421533112.

Koubi, V., 2019. Climate Change and Conflict. Annu. Rev. Polit. Sci. 22, 343–360. https://doi.org/10.1146/annurev-polisci-050317-070830.

Linke, A.M., Ruether, B., 2021. Weather, wheat, and war: Security implications of climate variability for conflict in Syria. J. Peace Res. 58, 114–131. https://doi.org/10.1177/0022343320973070.

Mach, K.J., Kraan, C.M., Adger, W.N., Buhaug, H., Burke, M., Fearon, J.D., Field, C.B., Hendrix, C.S., Maystadt, J.-F., O'Loughlin, J., Roessler, P., Scheffran, J., Schultz, K. A., von Uexkull, N., 2019. Climate as a risk factor for armed conflict. Nature 571, 193–197. https://doi.org/10.1038/s41586-019-1300-6.

Maystadt, J.-F., Ecker, O., 2014. Extreme Weather and Civil War: Does Drought Fuel Conflict in Somalia through Livestock Price Shocks? Am. J. Agric. Econ. 96, 1157–1182. https://doi.org/10.1093/ajae/aau010.

Missirian, A., Schlenker, W., 2017. Asylum applications respond to temperature fluctuations. Science 358, 1610–1614. https://doi.org/10.1126/science.aao0432.

Oakes, R., Banerjee, S., Warner, K., 2019. Human mobility and adaptation to environmental change 253–269. doi:10.18356/2a8d511f-en.

Otto, F.E.L., Philip, S., Kew, S., Li, S., King, A., Cullen, H., 2018. Attributing high-impact extreme events across timescales—a case study of four different types of events. Clim. Change 149, 399–412. https://doi.org/10.1007/s10584-018-2258-3.

Owain, E.L., Maslin, M.A., 2018. Assessing the relative contribution of economic, political and environmental factors on past conflict and the displacement of people in East Africa. Palgrave Commun. 4, 1–9. https://doi.org/10.1057/s41599-018-0096-6.

Pape, U., Wollburg, P., 2019. Impact of Drought on Poverty in Somalia.

Petrova, K., 2021. Natural hazards, internal migration and protests in Bangladesh. J. Peace Res. 58, 33–49. https://doi.org/10.1177/0022343320973741.

Philip, S., Kew, S.F., van Oldenborgh, G.J., Otto, F.E.L., O'Keefe, S., Haustein, K., King, A., Zegeye, A., Eshetu, Z., Hailemariam, K., Singh, R., Jjemba, E., Funk, C., Cullen, H., 2017. Attribution Analysis of the Ethiopian Drought of 2015. J. Clim. 31, 2465–2486. https://doi.org/10.1175/JCLI-D-17-0274.1.

Raleigh, C., Linke, A., Hegre, H., Karlsen, J., 2010. Introducing ACLED: An Armed Conflict Location and Event Dataset: Special Data Feature. J. Peace Res. 47, 651–660. https://doi.org/10.1177/0022343310378914.

Rohde, R., Muller, R., Jacobsen, R., Perlmutter, S., Mosher, S., 2013. Berkeley Earth Temperature Averaging Process. Geoinformatics Geostat. Overv. 01 https://doi.org/10.4172/2327-4581.1000103.

Thalheimer, L., Williams, D.S., van der Geest, K., Otto, F.E.L., 2021. Advancing the Evidence Base of Future Warming Impacts on Human Mobility in African Drylands. Earths Future 9, e2020. https://doi.org/10.1029/2020EF001958.

UNHCR Somalia, 2017. Protection & Return Monitoring Network (PRMN) - Notes on methodology.

UNHCR, 2022. UNHCR Somalia - Interactive Internal Displacements Visualisation [WWW Document]. UNHCR Somal. Intern. Displac. URL https://unhcr.github.io/dataviz-somalia-prmn/index.html (accessed 2.8.22).

Vinke, K., Bergmann, J., Blocher, J., Upadhyay, H., Hoffmann, R., 2020. Migration as Adaptation? Migr. Stud. 8, 626–634. https://doi.org/10.1093/migration/mnaa029.

von Uexkull, N., Buhaug, H., 2021. Security implications of climate change: A decade of scientific progress. J. Peace Res. 58, 3–17. https://doi.org/10.1177/0022343320984210.

Xu, C., Kohler, T.A., Lenton, T.M., Svenning, J.-C., Scheffer, M., 2020. Future of the human climate niche. Proc. Natl. Acad. Sci. 117, 11350–11355. https://doi.org/10.1073/pnas.1910114117.