

Climate change and the Syrian civil war revisited



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ABSTRACT

For proponents of the view that anthropogenic climate change will become a 'threat multiplier' for instability in the decades ahead, the Syrian civil war has become a recurring reference point, providing apparently compelling evidence that such conflict effects are already with us. According to this view, human-induced climatic change was a contributory factor in the extreme drought experienced within Syria prior to its civil war; this drought in turn led to large-scale migration; and this migration in turn exacerbated the socio-economic stresses that underpinned Syria's descent into war. This article provides a systematic interrogation of these claims, and finds little merit to them. Amongst other things it shows that there is no clear and reliable evidence that anthropogenic climate change was a factor in Syria's pre-civil war drought; that this drought did not cause anywhere near the scale of migration that is often alleged; and that there exists no solid evidence that drought migration pressures in Syria contributed to civil war onset. The Syria case, the article finds, does not support 'threat multiplier' views of the impacts of climate change; to the contrary, we conclude, policymakers, commentators and scholars alike should exercise far greater caution when drawing such linkages or when securitising climate change.

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1. Introduction

In the view of many Western policymakers and commentators, the Syrian civil war was caused, in part, by anthropogenic climate change. Former US President Barack Obama claimed that climate change-related drought 'helped fuel the early unrest in Syria, which descended into civil war' (Obama, 2015); former Secretary of State John Kerry argued that 'it's not a coincidence that immediately prior to the civil war in Syria, the country experienced its worst drought on record' (Kerry, 2015); erstwhile Democratic presidential candidates Martin O'Malley and Bernie Sanders have claimed similarly (Democracy Now!, 2015; Schulman, 2015); and in the UK, Prince Charles has maintained that 'there is very good evidence indeed that one of the major reasons for this horror in Syria was a drought that lasted for five or six years' (Mills, 2015). International organisations (e.g. the World Bank: Verme et al., 2016: p. 33),

leading NGOs (e.g. Friends of the Earth: Bennett, 2015), official governmental and intergovernmental reports (e.g. Adelphi et al., 2015; King et al., 2015), defence think tanks (e.g. CNA Military Advisory Board, 2014: pp. 13–14), academics (e.g. Cole, 2015; Malm, 2016), activists (e.g. Brand, 2015) and commentators of various political persuasions (e.g. Box & Klein, 2015; Friedman, 2012, 2013) – all have argued similarly.

For its advocates, this Syria-climate change thesis is powerful not so much for its own sake, but because it illustrates the chaos that may ensue as greenhouse gas emissions rise. Climate change, runs the common policy refrain, is a 'threat multiplier' (CNA Military Advisory Board, 2007: p. 44) which will cause 'more drought, more famine, more mass displacement – all of which will fuel more conflict for decades' (Obama, 2009). The Syria case appears to confirm this, showing that the conflict effects of climate change are already with us, and lending extra credibility to warnings of future climate-driven instability. The Syria example, in turn, has potentially important policy implications, especially for the ways in which political, military and development institutions might prepare for and adapt to the changing global climate. The Syria-climate change link has been widely invoked, for example, in

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discussions about Europe's migrant and refugee crisis, with European Commission President Jean-Claude Juncker (2015) identifying climate change as one of the 'root causes' of the new migration, others suggesting that those displaced Syrians arriving in Europe are 'climate migrants' and 'climate refugees' (e.g. Baker, 2015; Dinshaw, 2015b), and still others arguing that the numbers currently arriving in Europe will inevitably rise as the planet warms (e.g. Hockenos, 2015; O'Hagan, 2015).

For all this, there is good reason for caution about the Syria-climate change thesis. Until a few years ago, the 2003–05 war in Darfur was widely identified by Western commentators and policymakers as climate change-related – and even as the 'first climate war' (e.g. Mazo, 2010: pp. 73–86; Welzer, 2012: pp. 61–5) – with UN Secretary General Ban Ki Moon going so far as to claim that 'the Darfur conflict began as an ecological crisis, arising in part from climate change' (Ki Moon, 2007). But such claims have since been discredited, with critics finding among other things that Darfur's war neither occurred during nor was directly preceded by drought (Kevane & Gray, 2008); that there existed no solid evidence linking the Sahelian drought to anthropogenic climate change, in fact possibly the opposite (Dong & Sutton, 2015); and that claims like those of the UN Secretary General misrepresented the political and economic causes, and the essentially counter-insurgency character, of the Darfur war (Verhoeven, 2011; Selby and Hoffmann, 2014a). More broadly, there is no consensus within the growing field of climate–conflict studies on whether violence and civil conflict are in any way related to climatic variables. Although some studies have identified such linkages (e.g. Hendrix & Salehyan, 2012; Hsiang et al., 2011), others have concluded to the contrary (e.g. Buhaug, 2010; Theisen et al., 2011/12) – as scientific reviews of the field have repeatedly shown (see esp. Field et al., 2014: ch. 12; Gleditsch & Nordås, 2014; also Selby, 2014). Historically, moreover, public and policy discourse on the security and geopolitical implications of climate change has been well ahead of, and often at variance with, the available scientific evidence (Nordås & Gleditsch, 2007; Selby and Hoffmann, 2014b). Given this background, it cannot be just assumed that the Syria-climate conflict story is valid: further critical scrutiny is required.

This paper seeks to provide this, offering a systematic interrogation of the claimed links between anthropogenic climate change and the Syrian civil war. We start by summarising the evidence for this thesis before turning, in the main body of the article, to the three principal sub-theses which inform it: that anthropogenic emissions of greenhouse gases contributed to Syria's drought; that this drought led to large-scale migration; and that this drought-related migration was an important factor in Syria's early unrest. Each of these sub-theses we find to be seriously flawed; and on this basis we conclude that there exists no convincing evidence that climate change contributed to the onset of Syria's civil war and that, unless new evidence emerges, the Syria case does not support 'threat multiplier' views of the impacts of climate change.

2. The Syria-climate conflict thesis

Three separate studies provide the underpinning evidence for the Syria-climate conflict thesis: (1) a two page briefing document by Francesco Femia and Caitlin Werrell of the Center for Climate and Security in Washington DC (Femia & Werrell, 2012) which, despite its brevity, was the primary reference point for proponents of the thesis up until 2015 (see e.g. Friedman, 2012; Quinn & Roche, 2014); this briefing has subsequently been extended and published in peer-reviewed form (Werrell et al., 2015); (2) a peer-reviewed article by Peter Gleick, one of the foremost scholars of water issues worldwide (Gleick, 2014); and (3) a further peer-reviewed article by Colin Kelley and colleagues, mostly earth scientists at

the universities of California and Columbia (Kelley et al., 2015). All three studies cover similar territory, and turn to many of the same sources. The latter study stands out, however, in having been published in the *Proceedings of the National Academy of Sciences*, and in being the only one of the three studies to deploy climate modelling. Its finding that climate change is 'implicated' in the onset of Syria's civil war was immediately and extensively reported, in outlets ranging from *Nature* (Zastrow, 2015) to the *Daily Mail* (Gray, 2015) – indeed it is already one of the top ten most media-cited climate change studies of recent years (McSweeney, 2015) – such that it has now become the standard reference point for all claims and reports on the subject. A further article by Francesca De Châtel (2014) is sometimes also cited in support of Syria-climate conflict arguments, but is overall quite critical of them and provides little backing for the claims made by Femia and Werrell, Gleick or Kelley et al. (hereafter FGK), let alone for subsequent political statements and media reportage on the subject.

All three studies, and most other discussions of the subject, in essence advance a three-step argument about the role of anthropogenic climate change in the Syrian civil war: firstly, that anthropogenic emissions were, or may have been, a contributory to the severe late 2000s drought experienced in Syria; second, that this drought led to large-scale internal migration; and third, that these internal migrants were an important contributory factor in the 2011 unrest which spiralled into Syria's civil war. It is sometimes also claimed that increases in the price of wheat resulting from climate change-related droughts in China and Russia were a contributory factor to the Arab spring, in Syria included (e.g. Sternberg, 2013) – but this 'externalist thesis' has received much less attention from commentators and policymakers, and is not discussed further here.

Before considering the various specific arguments made within these works, we need first to be clear what is meant when it is claimed that climate change and drought 'helped fuel' or 'sparked' or 'contributed to' or 'is implicated in' Syria's civil war. It needs emphasising, to begin with, that despite the odd extreme statement – such as the assertion that 'the Syria war began because of climate change' by the head of a leading political risk consultancy (Channel 4, 2015) – no one seriously believes that climate change and drought were the sole causes of Syria's civil war. Therefore simply pointing to the existence of other causes – of which there were of course many – does not invalidate the Syria-climate conflict thesis. Even allowing for this, however, four distinct causal claims could be and have been made about the role of climatic factors in the onset of Syria's civil war: (1) that they were the *final* cause or *spark* of conflict, as for instance in Friedman's rhetorical suggestion that 'if a drought is bad enough it can help push an already stressed society to the breaking point. Is that what happened in Syria?' (Showtime, 2014); (2) that they were the *primary* causal factor, as for instance in Al Gore's claim that climate change provides 'the underlying story of what caused the gates of hell to open in Syria' (Dinshaw, 2015a); (3) that they were a *significant* contributory factor; and (4) that they were a contributory factor of *unknown or unspecified significance*. All four types of causal claim can be found in the literature, even sometimes with a single report or study. For instance, Kelley et al. (2015: pp. 3241–2) simultaneously suggest that Syria's drought 'had a catalytic effect' in sparking unrest; that this drought may have been a 'primary factor' behind the civil war; alternatively, that it may have been a 'substantial factor', or may have 'contributed to the conflict'; and that climate change is 'implicated in' Syria's civil war. These claims are all subtly different.

For the purposes of our analysis here, such slippages also make it difficult to know by what standard the Syria-climate conflict thesis should be evaluated. Any critique of claim types 1, 2 and 3 would be vulnerable to the counter that claim type 4, and therefore the entire

Syria-climate conflict thesis, continues to hold. Yet conversely, it is impossible to demonstrate that climate change *was not a factor at all* in the onset of Syria's civil war, since claims of this type (claim type 4) are essentially unfalsifiable. Given this, instead of asking whether climate change was *actually* a causal factor, of whatever significance, in the Syrian civil war, our approach is to examine the quality of the *evidence* that has thus far been marshalled in support of this causal thesis. More specifically we ask: *is there clear and reliable evidence that climate change-related drought in Syria was a contributory factor in the onset of the country's civil war?*; and, *if and where yes, was it as significant a contributory factor as is claimed in the existing academic and expert literature?* We ask these questions in relation to both the overall Syria-climate conflict thesis, and each of its sub-theses. These questions place the burden of proof on the existing literature to demonstrate the existence of clear linkages between climate change, internal drought and Syria's civil war – rather than on us to undertake the impossible task of demonstrating their non-existence – whilst also leaving open the possibility that stronger evidence may at some point emerge.

In practice, this leads us to ask several types of question of the existing literature: about the accuracy of its data claims (e.g. was Syria's drought the most severe on record?); about geographical location and scale (e.g. was there a spatial correspondence between most drought-affected areas and areas of highest out-migration?); about temporality (e.g. to what extent did migration levels during the drought depart from long-term trends?); about human agency (e.g. did the conscious political demands of Syria's early demonstrators relate to drought?); and about other intersecting causes (e.g. were there other causes of migration in Syria besides drought?).

In exploring these questions, our methods are as follows. We focus primarily on the three key works introduced above, discussing other sources only where they introduce significant additional evidence. On the drought and its alleged links to climate change, we analyse both Kelley et al.'s data and statistical model and raw station rainfall data for Syria and its environs. On the alleged links between the drought and Syria's civil war, we both revisit FGK's sources, and draw upon evidence not considered in these studies. We also introduce evidence from interviews with Syrian refugees which were undertaken by one of the authors (Fröhlich) during 2014–15. Further details on our methods can be found in the [technical appendix](#).

3. Climate change and Syria's drought

FGK claim that prior to the civil war, Syria experienced a severe multi-year drought which was partly attributable to anthropogenic climate change. Both [Femia and Werrell \(2012: p. 1\)](#) and [Gleick \(2014: p. 332\)](#) refer to it as 'the worst long-term drought ... since agricultural civilizations began in the Fertile Crescent', while Kelley et al. call it 'the most severe drought in the instrumental record' (2015: 3241). All three studies refer to work by Martin [Hoerling et al. \(2012\)](#) to support their contentions that Syria's pre-civil war drought can be partly attributed to regional drying and thus to greenhouse gas emissions. In addition, Kelley et al. perform their own statistical modelling analysis, and conclude from this that there has been a long-term drying trend in the Eastern Mediterranean, that this trend is consistent with climate models, and that 'a drought of the severity and duration of the recent Syrian drought' has therefore 'become more than twice as likely as a consequence of human interference in the climate system' (2015: 3241).

Before interrogating these claims, two points of clarification are in order. It deserves stressing, firstly, that none of the three key studies above provide any data on rainfall patterns in Syria specifically. [Femia and Werrell \(2012\)](#) and [Gleick \(2014\)](#) provide no

rainfall data whatsoever. Kelley et al.'s analysis, moreover, is of a huge region labelled 'the Fertile Crescent' which includes, in addition to Syria, territory from 14 other countries ([Kelley et al., 2015: Fig. 2](#)). Though Kelley et al. repeatedly refer to 'the Syrian drought', none of their data or statistical findings are about Syria specifically; they are instead about this far larger Fertile Crescent region. Hoerling et al.'s findings are likewise not about Syria specifically, but the entire Mediterranean Basin: these authors state explicitly that 'the observational data are not adequate to assess centennial changes at local scales' (2012: 2160). Moreover, and secondly, the three studies above offer contradictory accounts of the duration of the rainfall shock in Syria. [Femia and Werrell \(2012\)](#) refer to it as lasting from 2006 to 11, as also does [Gleick \(2014: p. 332\)](#); while [Werrell et al. \(2015: p. 32\)](#) claim it lasted from 2007 to 12, and Kelley et al. describe it as covering, variously, 2007–10 (2015: 3243), 2005–08 (2015: 3245) and 2005–10 (2015: Figure S1). This confusion is reflected in policy and media statements, where the drought has been described as lasting anywhere up to six years (e.g. [Mills, 2015](#)). Greater clarity and specificity is evidently required on the spatial and temporal scale of Syria's late 2000s drought.

Did, then, Syria and its neighbours experience a particularly severe drought (i.e. negative rainfall shock) during the late 2000s, and if so during which years? According to the data presented by [Kelley et al. \(2015\)](#), which we have reanalysed, across the Fertile Crescent region as a whole 2007/08 was indeed the driest year in the instrumental record, with precipitation 35% below the 1961–90 average. Moreover, according to this same data 2006/07–2008/09 was the Fertile Crescent's driest three-year period on record, 22% below the long-term average. Station data for northeast Syria specifically indicates that a similar pattern applied there: in both Qamishli and Deir ez-Zor 2007/08 was the driest year on record (Qamishli received 25% of its 1961–90 average rainfall, Deir ez-Zor only 12%), while 2006/07–2008/09 was the driest three-year period on record (Qamishli received 46% of the three-year average rainfall, Deir ez-Zor 36%). The severity of this three-year drought was mainly a product of the extremely low rainfall in 2007/08, however: in both Qamishli and Deir ez-Zor 2006/07 and 2008/09 were dry years but no drier than many others experienced over the last 60 years. Moreover, in 2009/10 rainfall at both stations increased to close to average for Deir ez-Zor and above average for Qamishli (see [Figs. 2–3](#), and [Fig. 1](#) for locations). This mirrors the regional precipitation pattern: 2009/10 was an average-to-wet winter across the Fertile Crescent, and this was followed by a very dry winter (2010/11) and then a wet one (2011/12). These precipitation conclusions are corroborated by analysis of the Global Precipitation Climatology Centre's dataset conducted by [Becker et al. \(2013\)](#).

The rainfall pattern across Syria during this period was far from uniform, however. While northeast Syria witnessed extremely low rainfall during 2007/08 and during the three-year period 2006/07–2008/09, the same was not true in most of the rest of the country (see [Fig. 4](#)). During both of these periods, most of western Syria including its three largest cities, Aleppo, Damascus and Homs, all received above average rainfall (well above average in the case of Aleppo). And the town of Dara'a, near the Jordanian border – to which we return below, and which was supposedly 'especially hard hit', or even 'crippled', by the drought ([Femia & Werrell, 2012; Gleick, 2014: p. 336](#)) – received close to average rainfall. Moreover, it was not only Syria which experienced low rainfall during these years. Drought also affected southeast Turkey, albeit not as severely as northeast Syria (see e.g. data for Diyarbakir and Siirt in [Figs. 2 and 3](#)). And it affected much of northern Iraq. Indeed, during the two year period 2007/08–2008/09 the largest precipitation declines were found in northern Iraq, not Syria ([Trigo et al., 2010](#)).

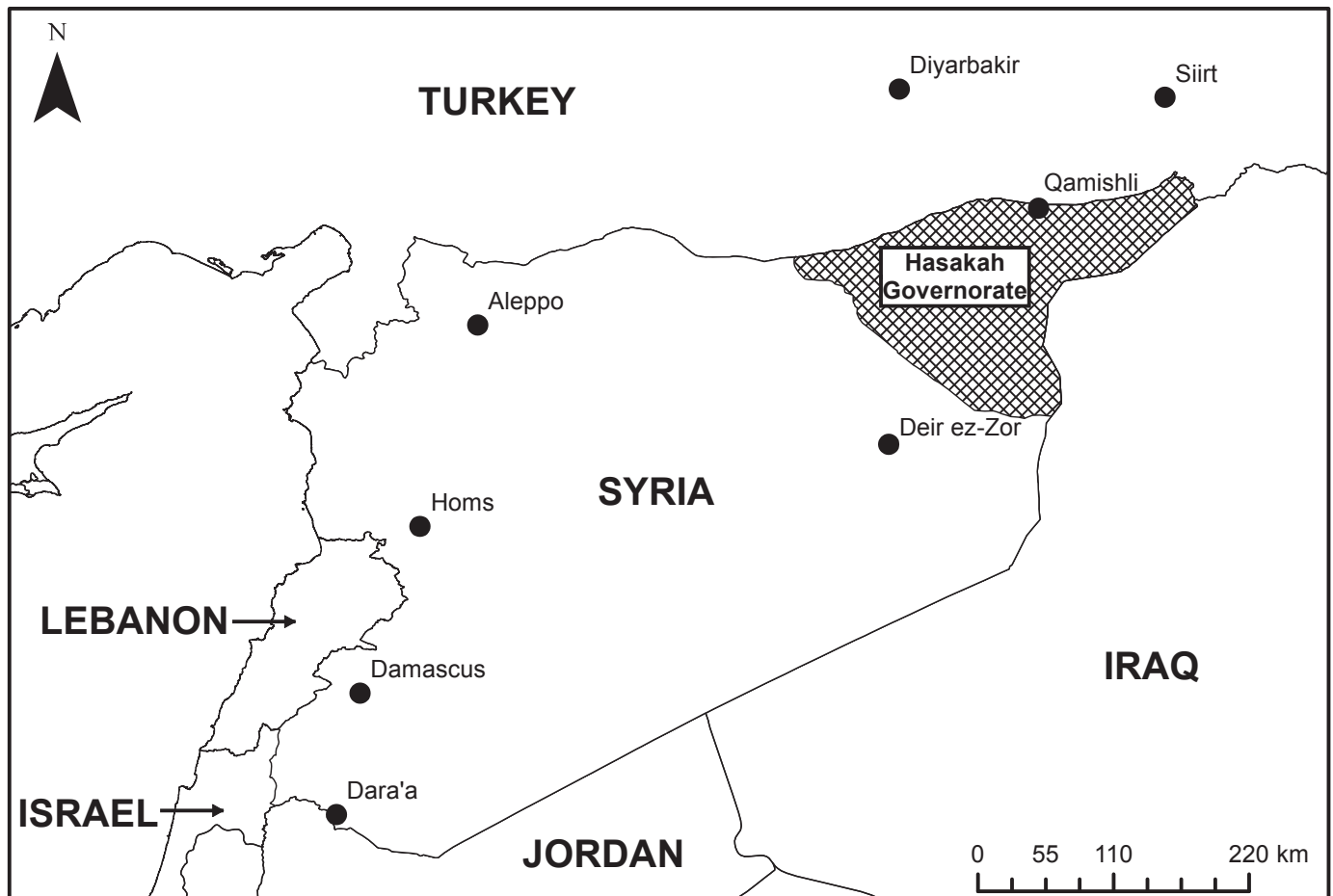


Fig. 1. Syria and its neighbours. The figure identifies all locations (cities, rainfall stations, governorates, and neighbouring states) discussed in the text.

We can now turn to the drought's causes. So, firstly, was the drought in northeast Syria part of a long-term drying trend? Kelley et al. claim that it was, identifying a significant regional drying trend over the period 1931–2009 (2015: 3244). Yet only 20% of the station series that they examine across the Fertile Crescent display significant negative rainfall trends. Moreover, Kelley et al. do nothing to establish why their Fertile Crescent rainfall time series is best modelled statistically as a linear trend, and nor do they present the sensitivity of their linear trend analysis to the choice of time period. Dryland rainfall is well known to exhibit very high natural inter-annual and inter- and multi-decadal variability (Hulme, 1996; Hulme et al., 2001), attributes not well modelled by linear trends. Using linear trends to model dryland rainfall in other regions such as the Sahel has been shown to be misleading (Dong & Sutton, 2015; Hulme, 2001). Indeed, the anomalous rainfall in the Kelley et al. (2015) Fertile Crescent region is very largely focused on the decade 1999–2008, which was 10% drier than the long-term average; while Hoerling's et al. (2012) analysis of the wider Mediterranean picks out the decade 1985 to 1995 as the driest. In both studies, the linear trend for the majority of the twentieth century is weak to non-existent. Rather than characterising rainfall in the Fertile Crescent as displaying a long-term drying trend, the observed rainfall series is better characterised as highly variable with an anomalous decade from 1999 to 2008, culminating in a severe drought (centred on 2007/08) after which rainfall returned to its pattern of high inter-annual variability (wet, dry, wet). Our analysis of raw station data from northeast Syria confirms this finding (see technical appendix). We conclude that there is no

evidence of progressive multi-decadal drying either in the Fertile Crescent region as a whole, or in northeast Syria specifically.

Last, can the drought be attributed to human influences on the global climate system? The science of extreme weather event attribution is still young and subject to competing methods and the constraints of limited observational data and imperfect models (Bellprat & Doblas-Reyes, 2016; Hulme, 2014). The attribution method used by Kelley et al. effectively involves three steps: identifying a long-term drying trend, as discussed above; estimating the increased likelihood of the drought occurring given this trend; and comparing the trend to results from climate model simulations. There are two problems here. On the one hand, given that there is no evidence of a long-term drying trend either in the Fertile Crescent region as a whole or, more importantly, in Syria specifically, as argued above, it follows that claims about the increased likelihood of severe droughts occurring because of a claimed trend are invalid. And on the other hand, the rainfall simulations on which Kelley et al. (and also Hoerling et al.) rely involve huge uncertainties (see technical appendix). It is also worth noting that, even if Kelley et al. were right that human influences had caused the frequency and severity of droughts in Syria to increase, it would still not follow that these human influences were causally 'implicated' in this particular drought (2006/07–2008/09): to claim thus, as Kelley et al. (2015: 3241) do, is to confuse probabilistic and deterministic claims (Solow, 2015).

In summary, northeast Syria did experience a severe drought during the three years 2006/07–2008/09, and unprecedentedly so during 2007/08. However, contrary to what Femia and Werrell,

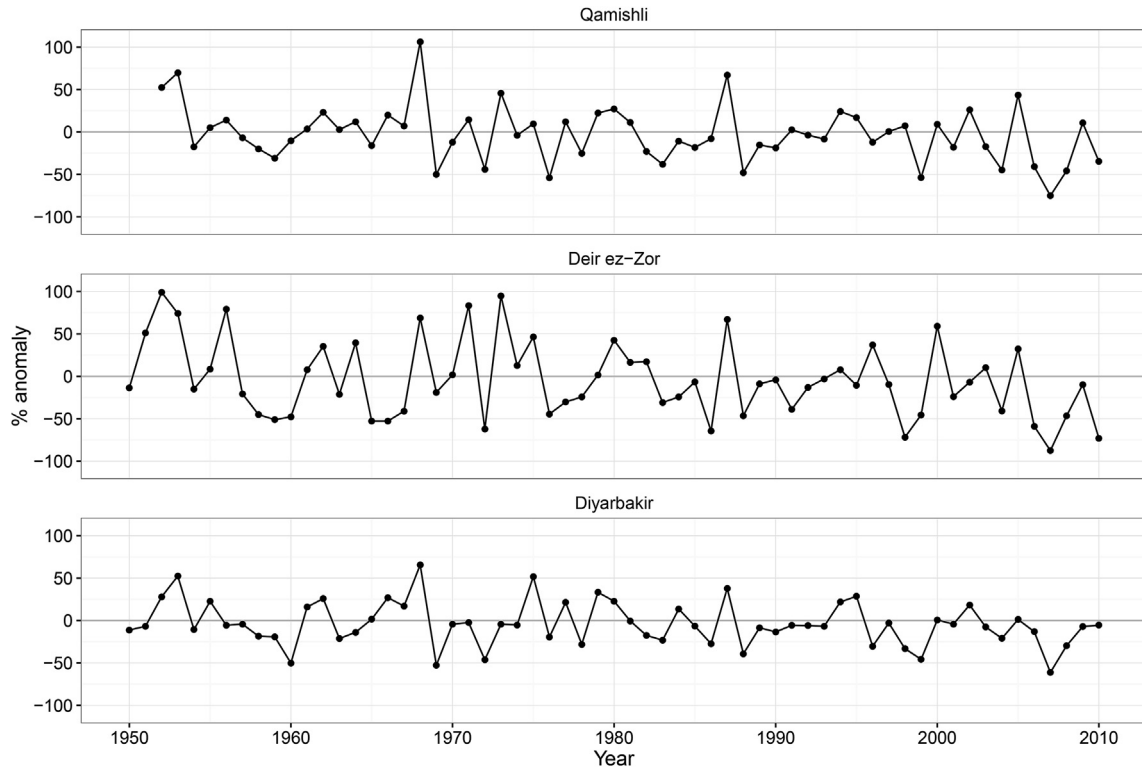


Fig. 2. Percentage anomalies of ‘annual’ November–April rains, relative to 1961–90 average, for Qamishli (Syrian/Turkey border), Deir ez-Zor (northeast Syria) and Diyarbakir (southern Turkey). Years are dated by the November of this winter rains period. The last year shown is for 2010/11. Data source: David Lister, Climatic Research Unit, University of East Anglia.

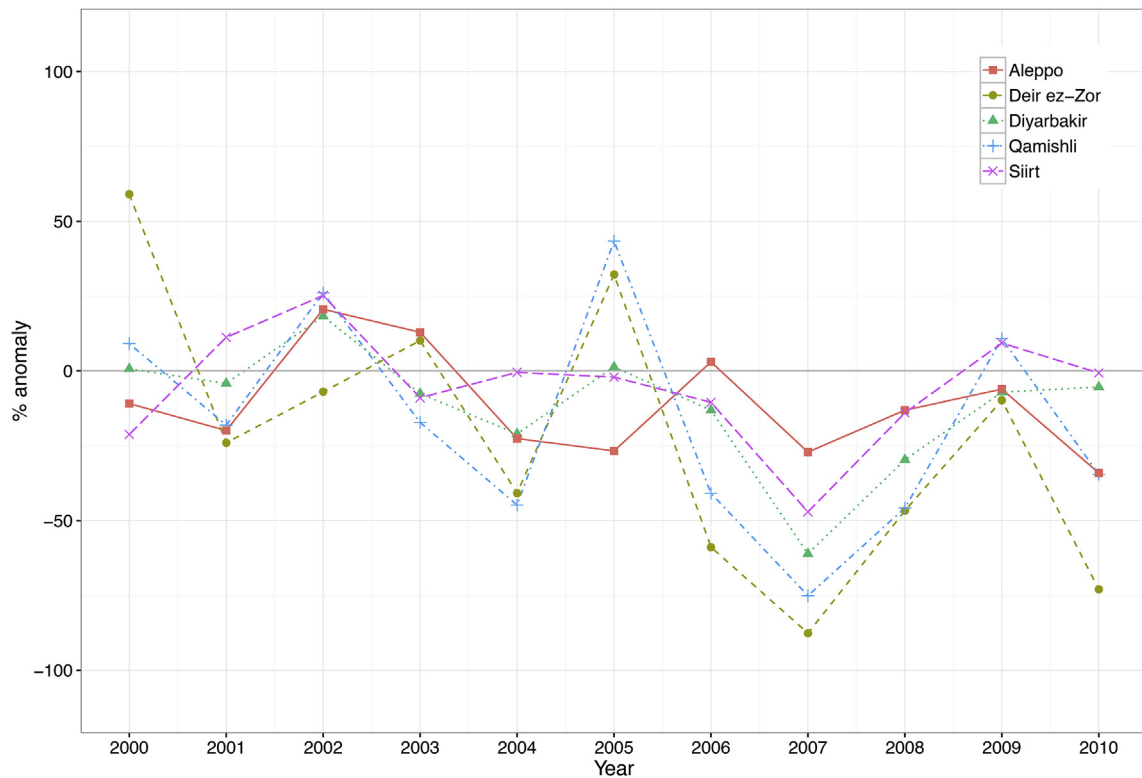


Fig. 3. Percentage anomalies of ‘annual’ November–April rains, relative to 1961–90 average, for the period 2000/01 to 2010/11 for five stations in Syria and Turkey. Data source: David Lister, Climatic Research Unit, University of East Anglia.

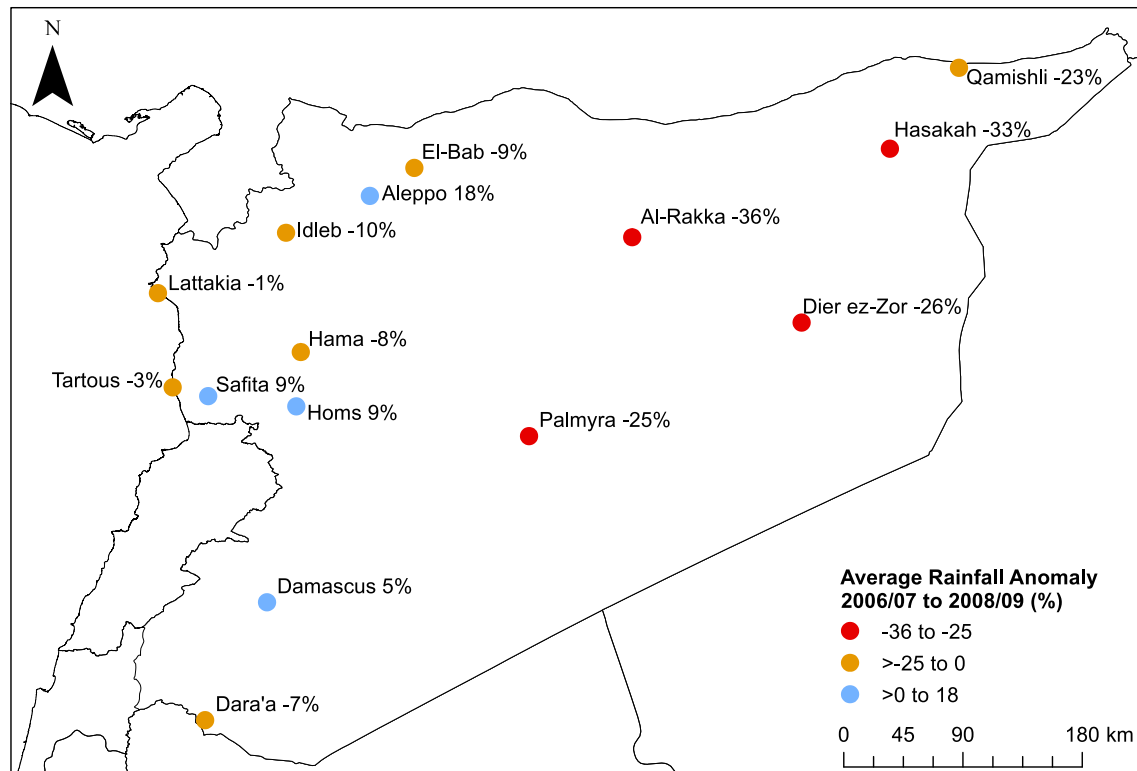


Fig. 4. Percentage anomalies of 'annual' rainfall for the three-year period 2006/07–2008/09 relative to the 1982/83–2009/10 average for Syrian stations. Blue is wetter than average; orange/red is drier. Data source: MAAR, 2016. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Gleick and others claim or imply, this was not a five-plus year drought, and did not affect the whole of Syria. Pace Kelley et al., our analysis also questions whether the historic pattern of rainfall in the Eastern Mediterranean is best described as a 'long-term drying trend'. In view of both this and the uncertainties in climate model simulations, we therefore conclude that there is no clear and reliable evidence that human influences on the climate system are implicated in northeast Syria's 2006/07–2008/09 drought.

4. Drought and migration

Step two of the Syria-climate conflict thesis involves the claim that Syria's drought led to 'total crop failure' (Femia & Werrell, 2012), 'agricultural failures' (Gleick, 2014: p. 334), and maybe even wholesale agricultural 'collapse' in the northeast governorate of Hasakah (Kelley et al., 2015: p. 3241), and that this in turn precipitated large-scale migration from the Syrian countryside, and from Hasakah in particular. Kelley et al., Gleick and Femia and Werrell all make this case, in only slightly different ways: thus Kelley et al. claim that 'as many as 1.5 million people' were 'internally displaced by the drought' (2015: 3241–2), Gleick that 'more than 1.5 million people' migrated (2014: 334), and Femia and Werrell (2012) that there was 'a massive exodus ... to the cities'. In subsequent media reports, this 1.5 million figure has often morphed into the claim that up to 2 million Syrians were displaced by the drought (including by Femia and Werrell: see e.g. Baker, 2015; Werrell & Femia, 2015).

In evaluating this sub-thesis, it is worth acknowledging from the outset that there is abundant evidence that Syria's 2006/07–2008/09 drought did have some significant agricultural, rural livelihood and migration effects, especially within the governorate of Hasakah. UN drought impact assessments, Syrian government statements, US diplomatic cables and international media reports all

corroborate this, as do the interviews used in the present study. There would not have been successive international drought appeals (UN-OCHA, 2009a, 2008) in the absence of significant drought impacts. Indeed, we know of no evidence and see no reason to think that exceptionally poor rains were *not* a contributory factor in internal migration during 2008–09. Hence the relevant analytical question becomes not whether there does exist evidence of a link between drought and migration – since there does – but whether this link was of the scale and significance that is claimed by FGK and others.

Here the obvious starter question is whether the claimed migration numbers are at all plausible. It is of course impossible to say precisely how many people migrated from northeast Syria during 2008–09, especially as no comprehensive survey of migrant numbers was ever undertaken. What can be said with confidence, however, is that there is no meaningful foundation for a 1.5 let alone 2 million figure. The sole source for the former was a short humanitarian news report, citing a single Syrian government officer as claiming that 1.25–1.5 million people had been displaced by the drought (IRIN, 2009b). Our best guess is that this figure was meant to refer to the number of people *affected* by – not *displaced* by – the drought, given the UN's estimate for numbers affected of 1.3 million (UN-OCHA, 2009a: 1). In any case, the 1.5 million figure claimed by Gleick and Kelley et al. is completely out of line with Syrian government and UN estimates, and all other sources of which we are aware. The first UN drought appeal, launched in September 2008 following the extreme 2007/08 drought, gave no figure at all, claiming only that migration from rural areas during 2007/08 was 20–30% higher than during previous years (UN-OCHA, 2008: p. 1). By summer 2009 the UN, using Syrian government figures, was estimating that 40–60,000 families had migrated because of the drought, including 36,000 families, or 200–300,000 people, from Hasakah (UN-OCHA, 2009a: p. 5; UN-OCHA, 2009b:

pp. 18–19). A subsequent UN report put total drought migration at 65,000 families (UN-OCHA, 2010: 6), plus the UN Special Rapporteur at one point claimed 600,000 people had migrated (De Schutter, 2010); but 40–60,000 families remained the most widely used figure (e.g. IRIN, 2009a; Massoud, 2010). Even the highest of these figures is far below the 1.5 or 2 million suggested by FGK.

Numbers aside, the other key question to ask is: was the 2006/07–2008/09 drought as significant a cause of migration from northeast Syria as is claimed within the existing literature? To be sure, FGK recognise that the pre-civil war out-migration from northeast Syria was not caused by poor rains alone, and to this extent none of them offers a mono-causal account of the link between drought and migration. Instead, they each emphasise that ‘agricultural collapse’ and the ensuing migration were caused by a ‘complex interplay of variables’, which included declining groundwater levels, inefficient irrigation, over-grazing, population growth, and poor governance (Femia & Werrell, 2012; 2015: p. 33; Gleick, 2014: pp. 334–6; Kelley et al., 2015: pp. 3241, 3243). These emphases are in keeping with research showing that vulnerability to environmental shocks is caused by a multiplicity of environmental, economic and governance factors (e.g. Adger, 2006), and that ‘environmental migration’ is never caused by environmental variables alone (e.g. Black et al., 2011). Nonetheless, it still needs asking whether FGK provide accurate accounts of the links between drought and other variables in the making of northeast Syria’s pre-civil war migration crisis. In our assessment, there are important respects in which they do not.

To start with, several crucial variables are neglected by FGK. Their accounts include barely any mention, most strikingly, of the dramatic economic transformations that Syria had been undergoing prior to and during the 2006/07–2008/09 drought (two short sentences in Kelley et al., [2015: p. 3242] excepted: we return to these below). For, starting in the 1990s and intensifying following Bashar al-Assad’s accession in 2000, Syria had made a decisive turn towards the market economy, including through the privatisation of state farms, trade liberalisation, and the removal of key subsidies – including, in May 2008, the removal of fuel subsidies (which led to an overnight 342% spike in fuel prices) and, in May 2009, the removal of fertilizer subsidies (which led to price increases of 200–450%: De Schutter, 2011: p. 16).

FGK also fail to note that large-scale migration from and within rural Syria, and especially from Hasakah, was occurring well before the 2006/07–2008/09 drought. There had long been a pattern of seasonal agricultural labour migration, involving men from northern and northeast Syria spending the summer working in the south, before returning to their families and landholdings in the autumn. Livestock herding had also long involved extensive migration, with herds typically spending their winters on the open steppe, before being transported as far as the Mediterranean in search of crop residues or greener pastures (Leybourne, 1998: pp. 201–2). More importantly, the liberalisation programme discussed above led to a sharp rise in rural-to-urban migration: between 2000 and 2005, an estimated 135,000 people were leaving rural for urban areas each year (estimated from al-Hindi, 2011: p. 25), and even prior to the drought the peri-urban areas and informal housing in and around Syria’s cities were growing rapidly (Goulden, 2011). Hasakah specifically was already witnessing net annual out-migration estimated at 1.7% during the late 1990s (Khawaja, 2002: p. 27), while farmland in Hasakah was already being extensively abandoned before the 2006/07–2008/09 drought (Hole, 2009).

This leads us to the key issue, which is that FGK’s inattention to Syria’s changing political economy leads them to systematically overstate the impacts, both direct and indirect, of the 2006/

07–2008/09 drought on migration. With respect to the indirect effects, firstly: FGK repeatedly misattribute important socio-economic changes within Syria – changes which, they imply, contributed to the migration from the northeast – to the drought, when in fact they were long-term corollaries of the country’s troubled liberalisation. For example, while Kelley et al. (2015: p. 3241) imply that it was drought which led to a sharp decline in agriculture’s contribution to Syrian GDP between 2003 and 2008, this decline in fact predated the 2006/07–2008/09 drought, and non-drought years, such as 2003 and 2004, experienced amongst the steepest declines (World Bank, 2016). Kelley et al. (2015: p. 3242) also claim that livestock feed and food price inflation in Syria prior to the civil war was mainly caused by drought; but this cannot have been more than a secondary factor given that the entire Syrian economy was plagued by high inflation during this period (during 2007/08, for instance, the cost of utilities rose by an estimated 87%: US Embassy Damascus, 2008c). Femia and Werrell (2012) and Gleick (2014: p. 334) claim that the drought drove two to three million people into food insecurity and extreme poverty; and yet the UNDP estimates on which these claims are based (El Laithy & Abu-Ismael, 2005; El Laithy & Abu-Ismael, 2009) were for pre-drought extreme poverty levels (2 million during 2003–04; 2.4 million during 2006–07). In the one place where these various authors make any mention of Syria’s experiment with liberalisation, it is to imply that Bashar al-Assad ‘shifted to liberalizing the economy’ in response to the drought (Kelley et al., 2015: p. 3242) – a suggestion completely at odds with the historical record. Indeed, contrary to what FGK imply, the steep decline in agricultural employment in Syria during the pre-civil war years was ‘clearly linked to major structural transformations of the sector, more than to drought and climatic conditions’ (Aita, 2009b: p. 76; see also; Ababsa, 2011). While the drought would no doubt have had socio-economic consequences, it is clear that many – perhaps even most – of FGK’s claims about these consequences are overstated and unreliable.

The same applies to FGK’s portrayals of the final causes of the 2008–09 migration from northeast Syria. FGK assume that, whatever the contextual factors that may have increased Syria’s vulnerability to shocks, it was an exceptionally severe drought which ultimately compelled people to migrate. And yet drought was not the only shock event to affect northeast Syria during 2007–09. As already noted, rural Syria was hit during both 2008 and 2009 by overnight triple-digit increases in the price of crucial agricultural inputs, following the removal of government subsidies. In addition, 2007 saw the implementation of a new agrarian relations law giving landowners the right to terminate tenant contracts with immediate effect, while 2008 saw the enactment of Presidential Decree No. 49, which restricted land sales across the whole of Hasakah governorate (Ababsa, 2015: pp. 210–11, 216–17). During 2008, Syria’s wheat crop was also hit by exceptionally severe late-winter frost. None of these other ‘shock factors’ can be dismissed as irrelevant. The view of the US Embassy in Damascus was that Hasakah’s poor wheat harvest during 2008 was ‘mostly due’ to the late frost, with drought having been merely one of several ‘contributing factors’ (US Embassy Damascus, 2008a). De Châtel, in her analysis of the Syria climate-conflict thesis, claims that ‘for many farmers in the Jazira and elsewhere’ the cancellation of subsidies ‘formed a greater burden than the successive years of drought and spurred their decision to abandon their land’ (2014: 526). And Decree No. 49 has been cited as a key factor in the increased Kurdish out-migration from northeast Syria pre-civil war (ACCORD and DIS, 2010). At the very least, it should not be assumed that drought was the only, or dominant, catalyst of migration.

Consideration of the economic structure of agriculture in northeast Syria suggests an even stronger conclusion, however. For,

except in the case of purely rain-fed crops such as barley, most agricultural production in the northeast, including in Hasakah, was not that dependent on good rains. The wheat and livestock sectors both illustrate this. For obvious reasons, wheat yields are strongly affected by drought when rainfed, but relatively stable when irrigated; and given that over 60% of Syria's wheat production and the vast majority of Hasakah's production was irrigated, it follows that yields should not have been highly susceptible to drought (Westlake, 2003: pp. 140–41). By contrast, as was observed prior to the price liberalisation, 'most wheat farmers ... would be unable to sustain production if the government were to withdraw its price support' (Westlake, 2003: p. 162). And similarly for livestock: because Syrian sheep flocks are primarily fed on artificial supplements and crop residues, including from irrigated areas, and obtain as little as 9% of their food requirements from natural fallow-land and range grazing, '[t]he stability of the system is far more dependent upon the availability of supplements and the price of feedstuffs than upon the availability of natural forage' (Jaubert & Bocco, 1998: p. 188). Assuming this is correct, then the sudden removal of fuel and fertilizer subsidies in 2008 and 2009 must have had greater immediate impacts on farmer livelihoods and migration than the drought. The fact that government- and UN-sponsored 'drought relief' efforts were concentrated, paradoxically, in an area of Hasakah where rainfall levels are so naturally low that wheat production is dependent on groundwater irrigation, and not in areas of rain-fed agriculture (UN-OCHA, 2010: p. 4; De Schutter, 2011: p. 12), lends further support to this conclusion.

Overall we conclude that, while there is no reason to doubt that the 2006/07–2008/09 drought did increase migration from northeast Syria during 2008–09, FGK significantly overstate both the scale of the migration, and the extent to which it was caused by drought. The official UN and Syrian government estimate was that 40–60,000 families migrated from northeast Syria during 2008–09, not the 1.5 or 2 million people that is often claimed. Moreover, given that large-scale migration from northeast Syria predated the drought, it follows that 'excess migration' (i.e. migration during 2008–09 minus average pre-drought migration numbers) must have been lower still. Numbers aside, we also find that FGK present a mistakenly environment- and drought-centric reading of the causes of northeast Syria's agrarian and migration crisis, and that other factors, most importantly Syria's experiment with economic liberalisation, were likely more important contexts for and catalysts of migration than the drought.

5. Migration and civil war

We can now turn to the final step of the Syria-climate conflict thesis, namely that migrants from the drought in northeast Syria were a contributory factor in the country's 2011 unrest. FGK claim essentially this: that the sudden presence of large numbers of rural poor 'placed significant strains on Syria's economically-depressed cities' and provincial towns, and became one 'driver' of unrest (Femia & Werrell, 2012); that drought-related migration 'contributed to urban unemployment and economic dislocations and social unrest' and 'spurred many Syrians to make their political grievances publicly known' (Gleick, 2014, pp. 333, 336, quoting; Saleeby, 2012); and that 'population shock' to Syria's urban peripheries 'exacerbated a number of the factors often cited as contributing to the unrest', including 'unemployment, corruption, and rampant inequality' (Kelley et al., 2015: p. 3242).

In considering the merits of this thesis, it is worth emphasising to start with just how meagre the evidence for it is. Femia and Werrell (2012) devote only one paragraph to the issue, Kelley et al. (2015: p. 3242) just two, and Gleick (2014: pp. 333–5), in the most extensive treatment of the links, just a couple of pages. No

attempt is made within these studies either to statistically correlate climatic and conflict variables or to make use of original interview or ethnographic research; instead all three studies rely exclusively on journalistic and policy advocacy sources. Moreover, none of them refers to the body of academic literature on the causes of Syria's civil war. Particularly striking in this regard is Kelley et al.'s analysis, which devotes considerable effort to establishing a connection between climate change and the Fertile Crescent drought, while relying on secondary and journalistic sources to establish a link between drought and Syria's conflict. Indeed, the little evidence that is provided by FGK and others in support of the drought migration-civil war thesis is essentially threefold, comprising: claims that drought-induced migration was a key element in the 'population pressures' within pre-civil war Syria; evidence on the timeline and geography of Syria's early unrest; and testimony from individual Syrians. We examine each of these types of evidence in turn.

Firstly, then, was drought-related migration a key element in the 'population pressures' within pre-civil war Syria (and should it be assumed that these pressures fed unrest)? Kelley et al. contend just so, implying that Syrians displaced by drought accounted for around half of Syria's 2003–10 urban growth (2014: Figure S1), and that the 'conflict literature supports the idea that rapid demographic change encourages instability' (Kelley et al., 2015: p. 3242). Yet neither contention is correct. The major (positive as well as negative) population changes in Syria during this period were: (1) natural population growth of up to 3% annually: around 3 million (Aita, 2009a: pp. 10–11); (2) the arrival of Iraqi refugees: 1.5 million (Kelley et al., 2015); (3) general rural-to-urban migration: around 1 million (extrapolated from al-Hindi, 2011: p. 25); (4) out-migration from Syria, estimated at 128,000 annually: 900,000 (Aita, 2009a: p. 47); (5) the end of circular migration to Lebanon in 2005: several hundred thousand (Chalcraft, 2009); and (6) 'excess migration' from Syria's northeast during 2008–09: a proportion of the estimated 40–60,000 families. Given, in addition, that this 'excess migration' is not wholly attributable to drought, as discussed above, it is evident that Kelley et al. significantly overstate the contribution of drought-related migration to Syria's pre-civil war urban growth (see technical appendix for further calculations).

In any case, it should not be assumed that these population changes contributed to unrest. Pace Kelley et al., while some studies do indeed find a link between demographic change and conflict (Goldstone, 2002), others have found to the contrary (e.g. Urdal, 2005; Buhaug and Urdal, 2013). Moreover, while some studies have found links between environmental migration and conflict (e.g. Reuveny, 2007), more have disputed this, including by finding that migration is a mechanism of adaptation and thus conflict mitigation (e.g. Black et al., 2011; Hartmann, 2010). The fact that there were significant demographic and migration changes in Syria prior to the civil war in itself lends no weight to the Syria climate conflict thesis. If such changes did play a causal role, then this needs to be demonstrated empirically.

Second, then, does the chronology and geography of Syria's early unrest support the drought migration-civil war thesis? FGK aver that it does, claiming that Syria's 'rapidly growing urban peripheries' (Kelley et al., 2015: p. 3242) as well as 'disaffected rural communities' (Femia & Werrell, 2012) were at the heart of the developing unrest; and that the provincial town of Dara'a, where by most accounts the civil war began, had been 'especially hard hit by five years of drought' (Femia & Werrell, 2012) and had witnessed 'a particularly large influx of farmers and young unemployed men displaced off their lands by crop failures' (Gleick, 2014: p. 335). Are these claims convincing?

It is indeed generally accepted within the literature on the Syria's 2011 uprising that its geography was much more 'rural and

urban' (De Châtel, 2014: p. 521) than in the parallel case of Egypt (see esp. Barout, 2011); and it is also widely accepted that Dara'a was 'where the Syrian uprising began' (Leenders & Heydemann, 2012: p. 140). In fact, the first post-Arab Spring protests in Syria took place, not in Dara'a, but on 17 February in the old commercial district of Al-Hariqa in central Damascus, following a police officer's assault on the son of a shop owner. The second protests also took place in Damascus, on 22 and 23 February, when a group of youths held a vigil outside the Libyan embassy in solidarity with opponents of Muammar Qadhafi. Protests were also ongoing in Kurdish areas of the northeast. Mass protests did not begin elsewhere, including in Dara'a and then other provincial towns, until mid-March 2011. None of this in question.

What is in question, however, is whether the undoubted centrality of Dara'a and other provincial areas to the uprising corroborates the drought migration-civil war thesis. There are two issues here. Firstly, it is not clear that the uprising took hold in rural and provincial areas for reasons of socio-economic determination. Though some have argued this (see esp. Barout, 2011: pp. 21–22), statistical evidence is contradictory, with some research finding, for instance, that Dara'a governorate experienced particularly acute increases in poverty pre-civil war (SCPR, 2013: p. 21), and other research characterising Dara'a as a 'low deprivation' region which had experienced 'significant improvement' in poverty levels (UNICEF, 2014: p. 41). Indeed, the most in-depth analyses of the origins of Syria's civil war suggest that the uprising took hold in rural and peripheral areas such as Dara'a, not for socio-economic reasons, but because of patterns of regime repression and political opportunity (Leenders, 2012; Leenders & Heydemann, 2012). Initially during early 2011, the regime focused its attention mostly on urban (and Kurdish) areas, where unrest was thought most likely; in consequence, security and police forces were redeployed away from peripheral areas, including Dara'a. The outbreak of mass protests in this supposedly quietist town thus caught the regime by surprise. It was within this context that, from 22 March, state security forces unleashed a level of violence against protesters in Dara'a which was beyond anything seen to that point, with regime repression providing the impetus for further local mobilisation (Leenders & Heydemann, 2012: pp. 142–3). Dara'a also benefitted from its location adjacent to Jordan, which enabled protesters to utilise established cross-border and migration networks for arms, funding and escape. Syria's civil war, by such interpretations, was not initially a 'rural and urban' uprising, but instead became one as a result of regime repression combined with the opportunities afforded by rural and peripheral location.

Moreover, even if economic marginalisation and grievances were a factor in the geography of the uprising, this would still not constitute evidence of the impact of drought-related migration specifically. There were, as discussed above, multiple sources of rural socio-economic grievance in pre-civil war Syria, besides drought – the long-term process of agricultural liberalisation, the ensuing long-term pattern of rural out-migration, and the sudden removal of input subsidies, most notably. And Dara'a had not been 'especially hard hit' by drought, as noted above. While this does not preclude the possibility that the presence of migrants from the northeast may have been a factor in anti-regime mobilisation in Dara'a – a possibility to which we return below – existing scholarly accounts do not mention or consider it (Barout, 2011; Leenders, 2012). In our assessment, then, the timeline and geography of Syria's early unrest does little to corroborate the drought migration-civil war thesis.

What, lastly, of testimony from individual Syrians? 'The drought and unemployment were important in pushing people towards revolution', says a Syrian farmer quoted by Kelley et al. (2015: p. 3245, following Friedman, 2013); 'the drought was beyond our

capacity as a country to deal with', claimed the Syrian Minister of Agriculture as quoted by Gleick (2014: p. 334, from US Embassy Damascus, 2008b). Clearly, such comments should not be dismissed as irrelevant, since subjective representations and reasoning are critical elements in the descent into war, as in any political process. That said, it is striking how little personal testimony is marshalled in support of the claim that drought-related migration was a factor in the Syrian uprising: Kelley et al. quote just one displaced Syrian farmer, Gleick and Femia and Werrell none at all.

In sum, the evidence marshalled by FGK on the link between drought migration and civil war is extremely weak. Even more striking than this, however, is what their accounts omit: namely, any consideration of whether migrants from northeast Syria were significantly involved, whether as mobilisers, participants or targets, in the early demonstrations which spiralled into civil war. Neither FGK, nor to our knowledge anyone else, has provided any evidence of this. And there are at least two reasons that suggest to the contrary.

First, the interviews with Syrian refugees conducted by one of this study's authors suggest that, in Dara'a at least, migrants from the northeast did not participate to any significant degree in the spring 2011 protests, were not targets of the demonstrations or subsequent repression, and left as soon as the protests started and went back to the northeast. 'They had nothing to do with politics. They went to work and back home' (interview Zaatari, 6 January 2015, interviewee from southern Dara'a). 'They had no opinion. Their life revolved solely around their work', said one (interview Zaatari, 6 October 2014a; interviewee from Dara'a). 'In the first year some of them stayed. But when the troubles grew, they left' (interview Ramtha, 10 October 2014; interviewee from Tafas, Dara'a). 'They left at the beginning of the demonstrations' (interview Zaatari, 7 January 2015, interviewee from Dara'a). Indeed, most of the migrants from the northeast seem not to have even lived in Dara'a city, where the uprising began, but rather in tents and small houses scattered throughout surrounding rural areas (Ababsa, 2015: p. 210; Fröhlich, 2016). Of the 32 interviews conducted on the subject, in only one did the interviewee claim that migrants from the northeast were at all involved in Syria's early unrest.

Second, none of the political demands made by Syria's early 2011 protest movements related directly to either drought or migration. If migrants from the northeast had been significantly involved in the early unrest, whether as subjects or objects, then this would have been reflected within political discourse and demands (e.g. in demands for them to be sent home, or for host communities to receive increased government support). Yet the February–March 2011 protests in Damascus focused on denouncing the security forces and the broader apparatus of authoritarianism, including demands for the release of political prisoners; and reflecting this, the two main slogans of the protest movement became '*al-sha'ab as-souri ma biyinthal*' ('the Syrian people will not be humiliated'), and '*yalli bi-eqtul sha'bo khayen*' ('he who kills his own people is a traitor'). In Dara'a, likewise, initial demands revolved around civil rights and political freedoms, plus economic liberalisation-related grievances. For example, the 13 demands presented in March 2011 by Dara'a notables and representatives of aggrieved families to the President's emissary, Major General Hesham Ikheteyar, included: removal from their offices of the head of the local Political Security branch and the town Governor; apologies to the families who had been offended by the Governor; political reform and greater political freedoms; a meeting with the President; the return of women teachers who had been expelled following introduction of a law banning them from wearing the niqab; the expulsion from the town of all companies owned by

Rami Makhlof (the President's cousin and country's leading business magnate); the removal of new laws regarding land sales; and the lowering of the price of fuel (Barout, 2011: pp. 186–7). The last three of these demands related to grievances arising from Syria's troubled economic liberalisation. By contrast, we know of no slogans, demands or chants made in Dara'a which can be directly or indirectly attributed to the presence of migrants.

In summary, the evidence marshalled by FGK and others in support of drought migration-civil war thesis is extremely weak: neither their assertions about population pressures, nor their claims about the chronology and geography of Syria's early unrest, nor indeed the testimonies they quote, provide any firm basis for concluding that migration from northeast Syria was a factor in civil war onset. To the contrary, our evidence suggests that migrants from the northeast were not significantly involved in the early 2011 unrest.

6. Conclusions

In light of the above we can now return to our main questions: *is there clear and reliable evidence that climate change-related drought in Syria was a contributory factor in the onset of the country's civil war?*; and, *if and where yes, was it as significant a contributory factor as is claimed in the existing academic and expert literature?* On each step of the claimed causal chain, our answers are no. We find that there is no clear and reliable evidence that anthropogenic climate change was a factor in northeast Syria's 2006/07–2008/09 drought; we find that, while the 2006/07–2008/09 drought in northeast Syria will have contributed to migration, this migration was not on the scale claimed in the existing literature, and was, in all probability, more caused by economic liberalisation than drought; and we find that there is no clear and reliable evidence that drought-related migration was a contributory factor in civil war onset. In our assessment, there is thus no good evidence to conclude that global climate change-related drought in Syria was a contributory causal factor in the country's civil war.

This finding, to be clear, does not prove that climate change and northeast Syria's drought were not factors in its civil war, only that the existing claims to this effect do not stand up to close scrutiny. It remains possible that additional and stronger evidence of a human-induced long-term drying trend in northeast Syria, or of linkages between drought migration and Syria's unrest, may emerge; plus it deserves stressing that nothing in the above refutes the 'externalist thesis' about the links between climate change and Syria's civil war.

Nonetheless, as in the case of Darfur, these findings suggest the need for far greater caution and rigour, and lend further weight to critiques of 'threat multiplier' climate conflict discourse (e.g. Hartmann, 2010; Selby and Hoffmann, 2014b). For, contrary to the claims of its advocates, 'threat multiplier' discourse is neither cautious nor rigorous, instead typically combining dystopian speculation and exaggerated accounts of the likely impacts of climate change (see esp. CNA Military Advisory Board, 2007), together with periodic, if contradictory, calls for the avoidance of over-simplification (e.g. Werrell & Femia, 2015). Given the urgency of the climate change challenge and the contestation around it, plus the mass media's preference for striking, overblown stories – as is clearly illustrated by the take-up of Kelley et al. (2015) – it is in our view incumbent on analysts not to exaggerate climate-conflict linkages, or to champion false but headline-friendly statistics. Equally, given the complexities involved in analysing the socio-economic and political impacts of climate change – as clearly demonstrated above – it is crucial that researchers working on these impacts draw upon cross-disciplinary expertise, and not, as Femia and Werrell, Gleick and Kelley and colleagues do, expound on the causes of migrations and conflicts without even drawing on

social scientific research on the subjects. The case for international action on climate change is strong enough without resort to dubious evidence of its impact on the Syrian civil war.

Conflict of interest statement

The authors of this manuscript have no conflicts of interest.

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Technical appendix

The geographical extent of Kelley's et al. and Hoerling's et al. analyses

Kelley et al. (2015) analyse rainfall trends across what they label the 'Fertile Crescent' region. They define this region as including, in addition to Syria, all of Armenia, Lebanon and the Palestinian territories; most of Azerbaijan, Cyprus, Iraq, Israel, Jordan; large parts of Iran and Turkey; and small areas of Egypt, Georgia, Russia, Saudi Arabia (Kelley et al., 2015: Fig. 2) Kelley et al. examine rainfall data from 25 stations across this Fertile Crescent region, of which only a small fraction are located in Syria. Hoerling et al. (2012) treat the entire Mediterranean Basin as their region of analysis; their analysis includes no stations from Syria (see their Fig. 2: p. 2149).

Rainfall data methodology

Kelley et al.'s rainfall data is measured by the important winter rains period, November–April, which delivers the vast majority of annual rainfall. It is for this reason that our analysis refers to rainfall years (e.g. 2007/08) rather than calendar years (e.g. 2007). 2008/09 is the last year analysed by Kelley et al., but we also draw on their data for 2009/10 and 2010/11 (data supplied by Colin Kelley to authors, 4 October 2015).

For Syria specifically, we analyse two sets of data: (1) monthly rainfall series for all Syrian stations contributing to Climatic Research Unit (CRU) gridded data products (Harris et al., 2014). There are 14 such data series in the CRU station archive, the longest (Damascus) commencing in 1911, seven more commencing in the inter-war years, and the remainder commencing only since 1945. Only seven of these series have archived data after 1998. Just two of these seven CRU station series are in the northeast of Syria, the area claimed as the source of Syria's pre-civil war migration: Qamishli on the border with Turkey (commencing 1952), and Deir ez-Zor on the Euphrates (commencing 1946). We analyse these two station series in the same way that Kelley et al. do for the aggregated series for the FC region. Both of these station series have several months of missing data (about 20% of the months in question) for the years 2004–2012. The missing data is estimated using percentage deviations from the 1961–90 average for the remaining months in

each respective rainy season (i.e. it was assumed that missing months' percentage total was identical to the percentage total of preceding and following months). We also analyse (2) annual rainfall year data from the Syrian Ministry of Agriculture and Agrarian Reform (MAAR, 2016). This data covers 54 stations for the period 1982/83–2009/10. Fig. 4 uses this data.

Analysis of rainfall trends

Of the 25 rainfall station series examined by Kelley et al., only five display significant linear drying trends (one displays a wetting trend). Moreover, these trends are of marginal significance ($p < 0.1$, rather than the more conventional $p < 0.05$). Only one of these five stations is in Syria (Deir ez-Zor).

For the Fertile Crescent as a whole, the linear drying trend is weak to non-existent for the majority of the twentieth century (1931–1998); it is far from being significant ($p = 0.27$).

Analysis of raw station data from northeast Syria confirms these findings. Subjecting the Qamishli and Deir ez-Zor time series to linear regression, as performed by Kelley et al., shows that although rainfall declined on average through their 60 (Qamishli) and 65 (Deir ez-Zor) year periods, this decline was nowhere near significant for the former station ($p = 0.72$) and only close to significant at the 5% level for the latter ($p = 0.06$). In line with our argument above, moreover, the trends over the twentieth century (up to 1998/99) are even less significant ($p = 0.30$ and $p = 0.34$ respectively). In short, there is no significant 'long-term drying trend' in northeast Syria over the recorded series as captured by linear regression. Rather, the behaviour of rainfall in this region – consistent with what is known about semi-arid rainfall regions elsewhere – is for high inter- and multi-annual variability, punctuated by occasional very severe droughts and dry decades, of which the 2000s was one.

Use of climate model simulations

The detection and attribution method used by Kelley et al. detrends the observed time series before applying a frequency analysis to the residual extremes and comparing this to results from climate model simulations. Specifically, they use an ensemble of CMIP5 models in simulating rainfall over the Fertile Crescent region. There are several problems with using such models, not least that individually they contain biases of up to 40% in both climatology and inter-annual variability (Kelley et al. Fig. S3). Physical understanding of regional rainfall responses to human influences remains incomplete. For example, recent analysis by He and Soden (2017) questions the reliability of the sub-tropical precipitation decline thesis, suggesting that in response to human influences on the atmosphere rainfall declines in the sub-tropics are more likely over ocean areas (e.g. over the Mediterranean Sea) than over land (e.g. northeast Syria). Moreover, the logic involved in using a model 'ensemble of opportunity' rather than an ensemble designed according to model independence criteria (Sanderson et al., 2015) is uncertain. Kelley et al. claim (2015: SI) that the CMIP5 ensemble of opportunity projects a reduction in future winter rainfall in the FC region. While true, the strength of 'agreement' within this ensemble is weak and not significant relative to the standard deviation of the model-estimated natural variability of 20 year means (Stocker et al., 2014: p. 1356, Figure AI.42).

The contribution of 'excess migration' from northeast Syria during 2008–09 to Syria's 2003–10 urban growth

As a very rough approximation, on the basis of figures in the main text we estimate Syria's urban population growth during

2003–10 at 3.9–4.2 million, as a result of: (1) natural urban population growth: +1.5 million (50% of Syria's total estimated population growth); (2) the arrival of Iraqi refugees: +1.5 million (100% of the Iraqi refugees); (3) general rural-to-urban migration: +1 million; (4) out-migration from Syria: –450,000 (50% of Syria's total estimated out-migrants); (5) the end of circular migration to Lebanon in 2005: +200,000; and (6) 'excess migration' from Syria's northeast during 2008–09: a proportion of the estimated 40–60,000 families (i.e. 200–500,000). These figures would suggest that 'excess migration' from northeast Syria during 2008–09 accounted for between 4 and 12% of Syria's 2003–10 urban growth. We wish to stress that this is only a rough calculation intended to illustrate the extent to which Kelley et al. overstate the contribution of drought to Syria's pre-civil war population pressures. Indeed, if anything, the above calculation may overstate the contribution of the 2006/07–2008/09 drought to Syria's urban growth, for four reasons. First, the 40–60,000 families figure is an estimate of absolute migration numbers during 2008–09, not an estimate of 'excess migration' above and beyond pre-2008 migration levels; whatever the correct absolute number, excess migration must have been considerably lower. Second, drought was not the only catalyst of 'excess migration' from northeast Syria during 2008–09, as discussed in the main text. Third, not all of the 'excess migration' would have contributed to Syria's urban growth given that many of those leaving northeast Syria during 2008–09 migrated overseas (there was a noticeable rise in Syrian Kurdish migration to Europe during these years: ACCORD and DIS, 2010). And third, not all of the internal migration from northeast Syria during 2008–09 was to urban or peri-urban areas; some of it was rural-to-rural migration, as discussed in the main text.

Interview method

Interviews with Syrian refugees in Jordan were undertaken by Fröhlich between September 2014 and January 2015. 32 interviews were undertaken in total (27 in Zaatari camp, three in Azraq camp, one in Irbid and one in Ramtha) lasting a total of 25 hours, 40 minutes. The interviewees were all Syrians who had worked full or part time in agriculture in pre-civil war Syria (specifically, in and around Dara'a, Homs, Idlib, Damascus, Deir ez-Zor and Raqqqa); they included both male and female respondents. The interviews were all semi-structured. Some of them were with a single respondent, while others took the form of focus group discussions in which more than one person responded to questions. All interviews were conducted in the respondents' homes in Arabic, and facilitated by a translator. In Zaatari the translator was Syrian; translators in Azraq, Irbid and Ramtha were Jordanian nationals.

Interviews focused mainly on respondents' experiences prior to the civil war, though some questions also addressed their experiences as refugees. Interviews addressed five areas: (1) interviewees' general profile, e.g. the size of their household, the extent of their agricultural income or land ownership; (2) their experiences of changes in the availability in agricultural inputs, e.g. water, seeds, and their impacts; (3) their experiences of internal migration; (4) their political involvement and attitudes; and (5) their experiences of being a refugee in Jordan.

Respondents were selected by dimensional sampling. The following characteristics were taken into account in building the sample (with everyone meeting the basic criteria of Syrian nationality and having worked in agriculture in Syria pre-2011): gender, geographical origin, status (migrant/non-migrant), protest participant/non-participant, landholder/non-landholder. Interviews were generally arranged with the help of an independent 'fixer' rather than through the UNHCR system, in order to avoid potential biases. Azraq was an exception: here Fröhlich was

accompanied by an UNHCR official at all times and, even though this person never actively interacted with respondents, this may have affected responses.

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