

Extended Appendix:

Conflict shapes in flux: Explaining spatial shift in conflict-related violence

1. Constructing the conflict shape

To determine the conflict shape—the area affected by conflict-related violence—we adopt a six-step logic supported by data from the Uppsala Conflict Data Program Georeferenced Event Dataset UCDP GED (Croicu and Sundberg, 2018; Sundberg and Melander, 2013), fieldwork interviews, the literature, and interviews with experts with fieldwork experience in the respective region.

1. We select an *anchor conflict*, that is, the conflict of interest driven by a particular contested issue, or issues, that typically includes multiple conflict actors. The contested issue determines which conflict actors form part of this anchor conflict. Contrary to other studies (see, e.g., Pettersson et al., 2019), we do not specify the types of main contested issues (e.g., over government or territory) as defining criteria since they can mutate over time, often resulting in the involvement of new conflict actors, and because the contested issue is a social construct that different conflict parties can perceive differently (Kriesberg and Gerard, 2018). Instead, we track the contested issue's evolution over time. This conceptualization is consistent with the concept “incompatibility” used by UCDP GED, thus making it possible to draw on this data source. The UCDP defines incompatibility as “stated (in writing or verbally) generally incompatible positions” and distinguishes between incompatibility over government or territory (*Uppsala Conflict Data Program*, 2022)—the concept “contested issue” comprises both of these subtypes.

We examine other, spatially connected conflicts in the region as well as preceding and succeeding conflicts in the same territory to determine whether they relate to the anchor conflict through one or both of the following mechanisms:

- a. Conflict mutation (connecting over time). The original contested issue changes or a new contested issue adds to the conflict. This can occur when actors involved in conflict seem to change but only regroup under a new name (e.g., elements of Iraqi insurgents and military transformed into the Islamic State of Iraq and Syria [ISIS]) or when a new conflict actor emerges (e.g., drug cartels joined Colombia's armed conflict).
- b. Conflict spread (connecting across space). An actor or actors involved in a conflict move(s) to a new location and triggers or escalates a new conflict there that can have the same or a different contested issue (e.g., the leaders of al-Qaeda and the Taliban escaped to the former Federally Administered Tribal Areas [FATA], triggering the area's militarization and radicalization).

If we detect any of these mechanisms, we add the conflicts to the anchor conflict, creating an umbrella conflict.

2. We identify the conflict actors involved. We identify the wider region that comprises countries where relevant conflicts occur, and their neighboring countries, to obtain the list of potentially involved actors from the UCDP GED (Croicu and Sundberg, 2018; Sundberg and Melander, 2013) based on the list of conflicts established in the first step (e.g., we include all countries adjacent to Colombia since violence related to this case often occurs near state borders). Then we filter out the actors who engage violently in the conflicts identified in the previous step.¹ We assess the actors' participation based on their connection to the contested issues. When a conflict mutates or spreads, new actors are likely to join the armed conflict.

3. We select all conflict events from the UCDP GED dataset in which the actors identified in the previous step were involved. We follow the Uppsala Conflict Data Program's (UCDP)'s definition of conflict events as "[a]n incident where armed force was used by an organised actor against another organized [sic] actor, or against civilians, resulting in at least 1 direct death at a specific location and a specific date" (Högbladh, 2020: 4). Hence, we exclude governments or non-state actors financing other actors involved in the conflict. An actor needs to have at least a limited level of organizational structure; civilians and community groups are not considered conflict actors. We select those relevant events for which we have relatively precise information about their locations to ensure that we do not distort the conflict shape. We select events with the precision of their location within the first-level administrative unit (one below the state level).² We exclude conflict events where organized actors deliberately attack civilians because "civilians" is a generic label and event descriptions often do not provide enough information to be assigned to a specific conflict.
4. Using the R package *Concaveman* (Gombin et al., 2017), based Park and Oh (2013)'s algorithm, we draw a concave hull from the selected events to denote the conflict shape's contours. We set the concavity level for all concave hulls to number two. Following Weidmann (2015), who points out the level of spatial error in data, we add a 50-km buffer to mitigate potential remaining spatial errors in the UCDP GED. A concave hull encloses points more compactly than a convex hull (Asaeedi et al., 2017). It permits internal angles larger than 180 degrees. These internal angles create dents, allowing the researcher to exclude large areas without any data points and hence facilitating more realistic information about the conflict shape's type of environment (see Figure 1). The UCDP family of datasets offers conflict polygons based on conflict dyads. These conflict polygons are convex hulls based on the location of the events allocated to given conflict dyads. Yet the resulting polygon does not allow for dents and consequently includes large regions without conflict events. Since a convex hull does not allow for external angles smaller than 180 degrees, the polygon also includes the red area without any events.
5. We identify any outliers (Croicu and Sundberg, 2012) and redraw the conflict shapes if outliers were removed. When events occur far away from the conflict setting, we exclude them from the conflict shape because they would unreasonably stretch the geographical scope. We consider an event an outlier if removing it would lead to a 15 percent contraction of the concave hull area. While Croicu and Sundberg (2012) use a 20 percent threshold for their convex hull-based polygons, we lower the cut-off point because the concave hull we use produces areas smaller than a convex one. The 15 percent rule does not apply if the event involves more than 10 percent of the total number of deaths in the polygon for a given year. In some situations, we consider a group of events to be potential outliers, i.e., when the events occur in the same or nearby location. We do not remove more than 5 percent of the total number of events that are outliers to keep a realistic shape and spatial pattern of each conflict.

To detect outliers for each year separately, we visually detect events—potential outliers—that seem to be located far away from most other events.³ We then calculate the total number of fatalities in the concave hull area. Subsequently, we calculate the concave hull area percentage that contracts after removing the potential outliers. If it contracts less than 15 percent, the event is not considered an outlier.⁴ If it contracts more than 15 percent, we calculate the percentage decrease in the total number of fatalities by removing the event. If the decrease is larger than 5 percent, the event is not considered an outlier. In assessing a group of events that are clustered close to each other, we calculate the percentage decrease in the total number of events. If the reduction is equal to or larger than 5 percent, the events are not considered outliers. Finally, if an event is identified as outlier, we exclude it from calculating the concave hull's new area and from the total number of fatalities. We select the next

closest outlier and repeat the calculations until all potential outliers are assessed, or the number of events removed reaches 5 percent of the total events.

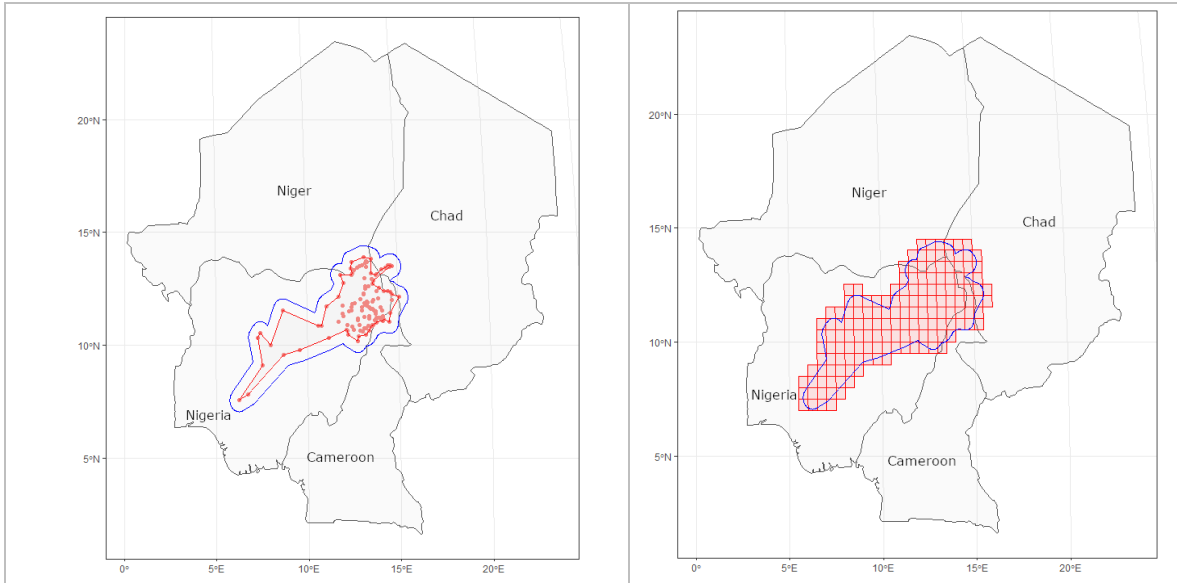


Figure 1: Lake Chad region conflict shape in 2014 overlayed with PRIO-GRIDs. Left: Dots and lines represent conflict events, a concave hull (red) and approximately 50-km buffer (blue), respectively. Right: PRIO-GRIDs (red) covering the conflict shape.

6. We check for what we call the friction mechanism: a conflict intersects substantively in time and space with the anchor conflict yet evolves around a different contested issue. We assume that such a conflict can affect the anchor conflict in the actors involved and in the impact the conflict has on civilians; hence, we add it to the anchor conflict and its relevant conflict events to the conflict shape (yet only in the year[s] in which we observe a substantial overlap). If actors were added via friction mechanism, we check again for outliers. The resulting polygon is the final conflict shape.

Figure 1 shows conflict events used to calculate the concave hull, and the 50km buffer. The red squares are PRIO-GRID, a spatio-temporal grid structure with socioeconomic and environmental information.

2. Analyzing spatial shift of conflict-related violence

Spatial hotspot analysis

We use the Getis-Ord algorithm that analyzes neighboring units to identify hotspots, i.e., spatial clusters of high and low values (Getis and Ord, 1992). Hotspots represent areas with a higher number of conflict events. The Getis-Ord algorithm identifies hotspots by comparing neighboring areas and selecting those with more conflict events. Contrary to other methods such as heatmaps based on kernel density, hotspots identified by the Getis-Ord algorithm are statistically different from their neighboring units rather than based on an arbitrary threshold.

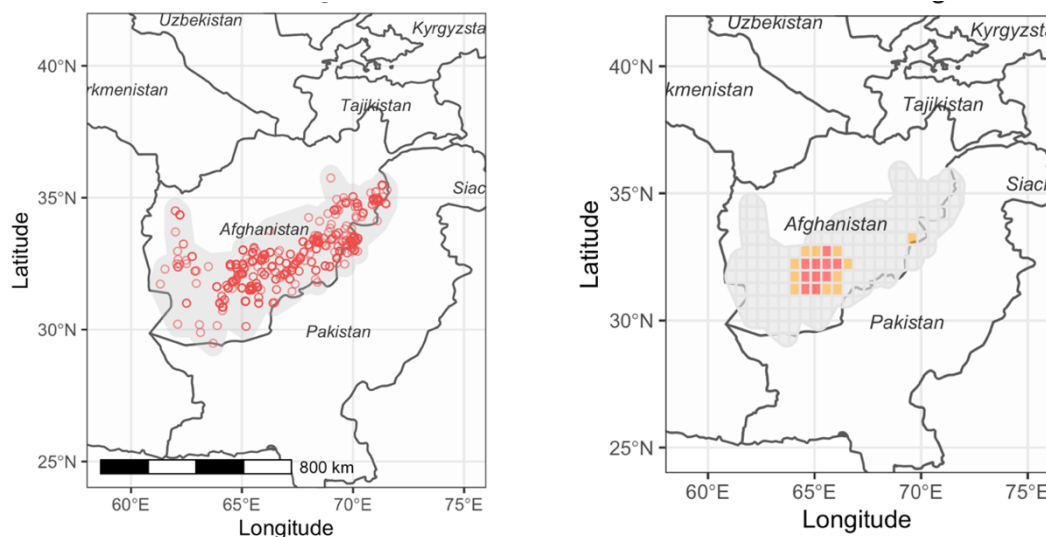


Figure 2: Conflict in the Afghan-Pakistani borderlands in 2006. Left: conflict events (red circles) and conflict shape (gray polygon). Right: Squares used for the calculation of G_i^* statistics. Hotspots with a z-score equal to or larger than 1.96 (yellow and red squares).

For the analysis, we build a list of neighboring units, defined as squares that share at least one side, by creating a fishnet with 50x50km squares. We calculate G_i^* statistics that return a z-score, a measure of statistical significance, for each square. The statistically significant positive high values of z-scores signal areas of conflict hotspots. We consider squares with a z-score equal to or greater than 1.96 to be a hotspot.

Process tracing

Process tracing helps evaluate whether the proposed relationship between the change in dominant actors and the conflict shape's shifting contraction/expansion is causal or spurious (George and Bennett, 2005: 9). In both probes, we choose two cases as pairs following a most-similar systems design (Gerring, 2017; Przeworski and Teune, 1970):⁵ the first probe features cases of expansion and the second probe features cases of contraction. The twin objectives of “(1) a representative sample and (2) useful variation on the dimensions of theoretical interest” guide our selection (Seawright and Gerring, 2008: 296). We selected these cases on the independent variable, ensuring in each pair variation in the presence/absence of new dominant actors (explanatory variable) while other characteristics of interest are similar. In both pairs, we conduct a within-case analysis of each case to evaluate the causal mechanism (low-risk/high-opportunity attraction) and a cross-case analysis to compare the two. The second probe includes cases that differ in the conflict duration and contested issues, allowing us to test scope conditions “through progressive pair comparison” (Tarrow, 2010: 251). The second pair thus helps to productively “build contrasts into the research design,” and to achieve “a more robust understanding and interpretation” of the first pair of cases (Mukhija, 2010: 423). The differences between the two pairs provide useful “contrast space” to the first pair.⁶ Even when comparing different armed multi-actor conflicts, the theoretical dimension—variation in the actor constellation—remains relevant and helps explain variation in the outcome (presence or absence of shift).

Interviews

To establish the causal mechanism that connects the change in dominant actors with spatial shift and to triangulate quantitative data on the conflict shapes, the dominant actors, and the spatial shifts of conflict-related violence, we drew on semi-structured interviews conducted by one of the authors in conflict-affected regions of one case in each probe: Colombia and Syria/Iraq. In Colombia: 59 interviews in Putumayo (2011, 2012), 20 interviews in Catatumbo (2012) and 16 interviews in Arauca (2012, 2016). In Syria/Iraq: 12 interviews in

northern Iraq, close to the Syrian border (2022). For security reasons, we refrain from providing the specific locations. The interviews were conducted in compliance with the authors' home institution's strict ethical and safety guidelines and only after obtaining approval by the institution's Central University Research Ethics Committee (CUREC), as per the reference numbers SSD/CUREC1A/11-240; R48604/RE001; R50663/RE004; CUREC 1A/ODID C1A_22_041. All interviewees provided informed consent. The interview questions evolved around the varying presence of armed actors and their relationship with the regions and the people residing there. The author selected questions from a long catalogue that were most suitable to the stakeholder group to which the interviewee belonged. Questions were adjusted when necessary: if the author established close trust relationships with the interviewees, she asked them more direct questions, whereas other interviews focused more on contextual information. The interviews generally ranged from 30 minutes to 2 hours. Interviews were conducted in spaces that minimized risks to the interviewees, the interviewer, and any other person involved, e.g. public places, offices, or homes. In all cases, the author only asked questions when interviewees felt comfortable about answering them and when she was confident that the interview would not cause any harm to anyone involved in or affected by the research process. Given the research's sensitive nature, all interviews were anonymous, and all data were treated with absolute confidentiality.

The author used snowball sampling to select interviewees, aiming for a relatively balanced distribution of interviewees across different stakeholder groups to maximize possibilities for triangulation and thus minimize biases in the data. For Colombia, the stakeholder groups comprised ex-combatants, police and military officers, civil society leaders, peasants, refugees, international organization staff, government officials, clerics, and others embedded in or with expert knowledge on conflict actors. For Iraq, the stakeholder groups comprised civil society leaders, youth (above 18 years), international organization staff, government officials, diplomats, and others embedded in or with expert knowledge on conflict actors. In addition to these interviews in challenging conflict settings, we interviewed experts with fieldwork experience in conflict-affected regions to gather additional context information.

3. Description of cases⁷

Armed conflict in Colombia

Anchor conflict: conflict between the Colombian government and left-wing guerrillas based on ideology, conflict actors and events added via mutation mechanism (illegal drug trade component added to the ideological conflict).⁸

Analysis start date: 1989. While the beginning of the Colombian conflict is a matter of debate among academics, the conflict is possible to trace back at least to the 1950s. The UCDP GED data are available only for the period starting in 1989.

Number of actors included: 11

Region used for the compilation of the list of the potentially involved actors: Colombia, Ecuador, Peru, Brazil, Venezuela, and Panama (in total 34 actors for the period 1989-2016).



Figure 3: Chart depicting the formation of the armed conflict in Colombia.

Colombia's armed conflict started as a left-wing guerrilla insurgency against Colombia's government in 1964, after bipartisan violence from 1948 to 1958. In the 1990s, the conflict mutated as the illicit drug trade became more central to the conflict. Left-wing guerrillas and paramilitary groups became involved in drug production and trafficking providing them with financial resources. Thus, control over the drug-related resources became a part of the contested issue that resulted in new actors such as drug cartels becoming intertwined with the Colombian conflict (Idler, 2019).

| UCDP GED ID | UCDP NAME | FULL/OTHER NAME ⁹ | CONFLICT- CONNECTING MECHANISM |
|----------------|---|--|--------------------------------------|
| 771 | AUC | United Self-Defense Forces of Colombia, Autodefensas Unidas de Colombia | Anchor conflict |
| 6506 | Bloque Central Bolívar | Central Bolívar Bloc | Anchor conflict |
| 810 | Cali Cartel | | Mutation |
| 744 | ELN | National Liberation Army, Ejército de Liberación Nacional | Anchor conflict |
| 746 | EPL | Popular Liberation Army, Ejército Popular de Liberación | Anchor conflict |
| 743 | FARC ¹⁰ | Revolutionary Armed Forces of Colombia—People's Army, Fuerzas Armadas Revolucionarias de Colombia—Ejército del Pueblo, FARC – EP | Anchor conflict |
| 7013 | FARC dissidents | | Anchor conflict |
| 17 | Government of Colombia ¹¹ | | Anchor conflict |
| 6579 | MAS | Death to Kidnappers, Muerte a Secuestradores | Anchor conflict |
| 774 | Medellin Cartel | | Mutation |
| 811 | PEPES | Persecuted by Pablo Escobar, Perseguidos por Pablo Escobar, Los Pepes | Anchor conflict |

Table 1: List of relevant actors for the armed conflict in Colombia

Actors added through friction mechanism for specific years only: NONE

Armed conflict in the Lake Chad region

Anchor conflict: Islamist insurgency led by Boko Haram, conflict actors and events added via spread mechanism (across Nigeria's borders) and friction mechanism (overlap with farmer-pastoralist conflict in central Nigeria).¹²

Analysis start date: 2009. While Boko Haram was founded in 2002 or 2003, they started using violence in 2009 (Hansen, 2017).

Number of actors included: 13

Region used to compile a list of potentially involved actors: Nigeria, Chad, Cameroon, Niger (in total 58 actors for the period 2009–2016).

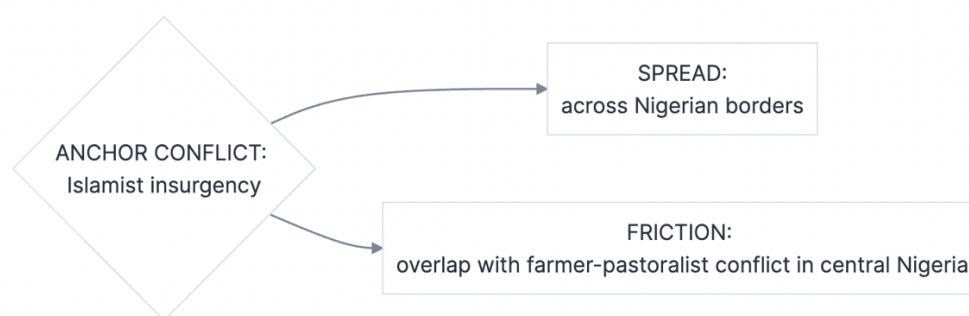


Figure 4: Chart depicting the formation of the armed conflict in the Lake Chad.

Boko Haram started to fight Nigeria's government in 2009 and over time more actors became involved. The military pressure from the Nigerian government and Yan Gora forced the Islamist groups to retreat to the Lake Chad region, and they then engaged in violent activities across Nigeria's borders in Chad, Cameroon, and Niger (Osumah, 2013). This *conflict spread* led the governments of Cameroon, Chad, and Niger to join Nigeria in the fight against the Islamists (Weeraratne, 2017). Ethno-religious violence in the Jos Plateau and throughout Nigeria is often seen as clashes between farmers and pastoralists. We do not consider the violence in Jos Plateau as a part of the armed conflict because it is not directly connected to the Islamist insurgency in northeast Nigeria. However, the activities of Boko Haram and the Islamic State (IS) spread to central Nigeria and contributed to the blurred distinction between the jihadists from northeast Nigeria and Muslims in central Nigeria. The Islamists' activities enhanced the conflict's narrative as being between Christians and Muslims while omitting the clashes' locally specific roots (Higazi, 2016). Since one of the cleavages between those communities is religion, it is reasonable to assume that increased activity of Boko Haram or Islamic State's West Africa Province (ISWAP) can increase the violent activity there too. Therefore, we include the farmer-pastoralist clashes only via the friction mechanism. Since the violence between Christians and Muslims is community-based rather than a conflict between two armed actors, we do not add the UCDP conflict "Christians-Muslims" to the armed conflict, even when there is substantial overlap in time and space. Thus, we treat the resulting events as instances of one-sided violence against civilians.

| UCDP GED ID | UCDP NAME | FULL/OTHER NAME ¹³ | CONFLICT- CONNECTING MECHANISM |
|-------------------|--|-------------------------------|--------------------------------------|
| 83 | Government of Cameroon | | Spread |
| 87 | Government of Chad | | Spread |
| 75 | Government of Niger | | Spread |
| 84 | Government of Nigeria¹⁴ | | Spread |
| 234 | IS¹⁵ | Islamic State, Daesh | Anchor conflict |
| 1051 | Jama'atu Ahlis Sunna Lidda'awati wal-Jihad¹⁶ | Boko Haram | Anchor conflict |
| 4000 | Yan Gora | | Anchor conflict |
| 4120 | Agatu | | Friction |
| 4022 | Atakar | | Friction |
| 589 | Birom | | Friction |
| 607 | Fulani | | Friction |
| 608 | Hausa | | Friction |
| 11040 | Sayawa | | Friction |

Table 2: List of relevant actors for the armed conflict in the Lake Chad region

Actors added through friction mechanism for specific years only:

- 2011: Birom, Fulani, Hausa, Sayawa
- 2014: Birom, Fulani
- 2015: Birom, Fulani, Agatu, Atakar

Armed conflict in the Afghan-Pakistani borderlands

Anchor conflict: Islamist insurgency led by the Taliban Movement of Pakistan (TTP) in FATA, conflict actors and events added via spread mechanisms (conflict in Afghanistan, Islamist violence in wider Pakistan) and friction mechanism (overlap with conflict in Baluchistan).¹⁷

Analysis start date: 2001. The US-led invasion of Afghanistan in 2001 is seen as one of the casual factors leading to the founding of TTP in 2007.

Number of actors included: 45

Region used to compile a list of potentially involved actors: Afghanistan and Pakistan (in total 67 actors for the period 2001–2016)

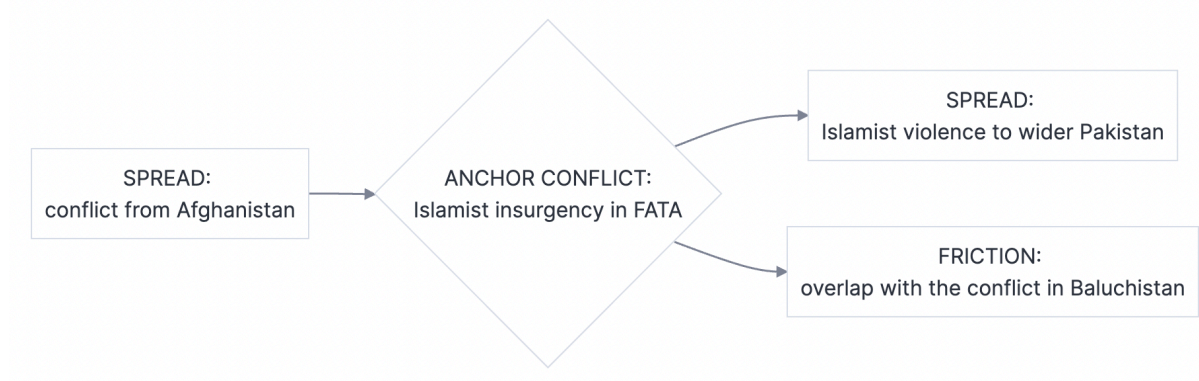


Figure 5: Chart depicting the formation of the armed conflict in the Afghan-Pakistani borderlands.

The TTP's existence and activities are closely connected to the US-led invasion of Afghanistan in 2001, after which high-ranking Taliban and al-Qaeda members fled to the former FATA.¹⁸ We consider the conflict between the Taliban and the US-led coalition connected to the insurgency led by TTP in FATA via the *spread mechanism* for two main reasons. First, the presence of the Taliban and al-Qaeda in FATA resulted in US drone strikes beyond the Afghan border (Aslam, 2011). Second, the presence of Islamists from Afghanistan and foreign fighters from other countries changed the local social fabric. Religious leaders and military commanders replaced the traditional authorities called maliks (Rais, 2019). This change, together with drone strikes that often caused civilian casualties, was conducive to FATA's militarization, the TTP's formation, and the subsequent spread of violence to wider Pakistan. The TTP soon clashed over territorial control with the local tribes and their militias, other armed groups operating in the area, and later also with its splinter groups. Therefore, we include in this armed conflict local militias and other clan-based armed groups that either fought against the TTP or their enemies. Due to their involvement with the TTP, we consider those actors as a part of the anchor conflict. After 2012, the *conflict spread* to wider Pakistan as the TTP carried out attacks in cities such as Karachi and Lahore.

| UCDP GED ID | UCDP NAME | FULL/OTHER NAME ¹⁹ | CONFLICT- CONNECTING MECHANISM |
|-------------------|---|-----------------------------------|--------------------------------------|
| 769 | al-Qaida | Al Qaeda | Spread from Afghanistan |
| 398 | Ansaar ul-Islam | | Anchor conflict |
| 790 | Bangesh | | Anchor conflict |
| 1046 | Fedayeen Islam | | Anchor conflict |
| 1100 | Forces of Momin Afridi | | Anchor conflict |
| 888 | Forces of Turkestan Bhittani | | Anchor conflict |
| 130 | Government of Afghanistan²⁰ | | Spread from Afghanistan |
| 142 | Government of Pakistan | | Spread to Pakistan |
| 3 | Government of United States of America | USA | Spread from Afghanistan |
| 359 | IMU | Islamic Movement of Uzbekistan | Anchor conflict |
| 234 | IS | Islamic State, Daesh | Spread from Afghanistan |
| 5928 | Jamaat-ul-Ahrar | | Anchor conflict |
| 399 | Lashkar-e-Islam | | Anchor conflict |
| 1177 | Lashkar of Akakhel tribe | | Anchor conflict |
| 1155 | Lashkar of Kukikhel clan | | Anchor conflict |
| 2987 | Lashkar of Mohmand tribe | | Anchor conflict |
| 887 | Lashkar of Orakzai tribe | | Anchor conflict |
| 796 | Lashkar of Salarzai tribe | | Anchor conflict |
| 787 | Lashkar of Wazir tribe | | Anchor conflict |
| 1142 | Lashkar of Zakakhel tribe | | Anchor conflict |
| 1143 | Laskhar of Masozai Qaumi tribe | | Anchor conflict |

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|------|---|---|-------------------------|
| 388 | LeJ | Lashkar-e-Jhangvi, Army of Jhangvi | Anchor conflict |
| 797 | Mangal | | Anchor conflict |
| 303 | Taleban ²¹ | Taliban | Spread from Afghanistan |
| 1178 | Tawheed ul-Islam | | Anchor conflict |
| 356 | TTP | The Taleban Movement of Pakistan, Tehrik-i-Taliban Pakistan | Anchor conflict |
| 3047 | TTP-Islahi | TTP - Fazal Saeed Haqqani faction | Anchor conflict |
| 5864 | TTP-KM | TTP - Khalid Mehsud faction, TTP - Khan Said Sajna faction | Anchor conflict |
| 5865 | TTP-SM | TTP - Shehryar Mehsud faction | Anchor conflict |
| 1102 | TTP - MR | TTP - Mulla Rafique faction | Anchor conflict |
| 1103 | TTP - MT | TTP - Mullah Toofan faction | Anchor conflict |
| 1101 | TTP - TA | TTP - Tariq Afridi faction, Asian Tigers | Anchor conflict |
| 791 | Turi | | Anchor conflict |
| 287 | BLA | The Balochistan Liberation Army | Friction |
| 289 | BRA | Baloch Republican Army | Friction |
| 375 | Forces of Abdul Rahman Khan | | Friction |
| 376 | Forces of Amanullah | | Friction |
| 378 | Forces of Arbab Basir | | Friction |
| 6356 | Government of United Kingdom, Government of United States | | Friction |
| 6252 | High Council of Afghanistan Islamic Emirate | Taleban - Faction of Mullah Mohammad Rasool Akhund and Mullah Mansoor Dadullah | Friction |
| 6318 | High Council of Afghanistan Islamic Emirate, IS | Taleban - Faction of Mullah Mohammad Rasool Akhund and Mullah Mansoor Dadullah, Islamic State | Friction |
| 299 | Hizb-i Islami-yi Afghanistan | | Friction |
| 292 | Jam'iyat-i Islami-yi Afghanistan | | Friction |
| 3192 | UBA | United Baloch Army | Friction |
| 304 | UIFSA | United Islamic Front for the Salvation of Afghanistan | Friction |

Table 3: List of the relevant actors involved in the armed conflict in the Afghan-Pakistani borderlands

Actors added through friction mechanism for specific years only:

- 2001: UIFSA, Government of United Kingdom and Government of United States
- 2003: Hizb-i Islami-yi Afghanistan, Forces of Abdul Rahman Khan, Forces of Amanullah
- 2006: Hizb-i Islami-yi Afghanistan, Forces of Abdul Rahman Khan, Forces of Arbab Basir
- 2007: Hizb-i Islami-yi Afghanistan, Jam'iyyat-i Islami-yi Afghanistan
- 2008: Hizb-i Islami-yi Afghanistan
- 2009: Hizb-i Islami-yi Afghanistan
- 2010: Hizb-i Islami-yi Afghanistan
- 2011: Hizb-i Islami-yi Afghanistan
- 2012: Hizb-i Islami-yi Afghanistan
- 2013: Hizb-i Islami-yi Afghanistan, BLA, UBA
- 2014: Hizb-i Islami-yi Afghanistan
- 2015: Hizb-i Islami-yi Afghanistan, High Council of Afghanistan Islamic Emirate, High Council of Afghanistan Islamic Emirate and IS
- 2016: Hizb-i Islami-yi Afghanistan, High Council of Afghanistan Islamic Emirate, BRA

Armed conflict in Syria/Iraq

Anchor conflict: Islamist insurgency led by IS, conflict actors and events added via spread mechanisms (conflict for Kurdish independence in Iraq, Syria and Turkey; civil war in Syria), mutation (conflict in Iraq after the US-led invasion), and friction mechanisms (conflict between the Iranian government and the Kurds in Iran; conflict between the Turkish government and left-wing groups).

Analysis start date: 2003.

Number of actors included in the analysis: 121

Region used to compile a list of potentially involved actors: Syria, Iraq, Turkey, Iran, Saudi Arabia, Jordan, Lebanon, and Israel (in total 142 actors for the period 2003–2019).

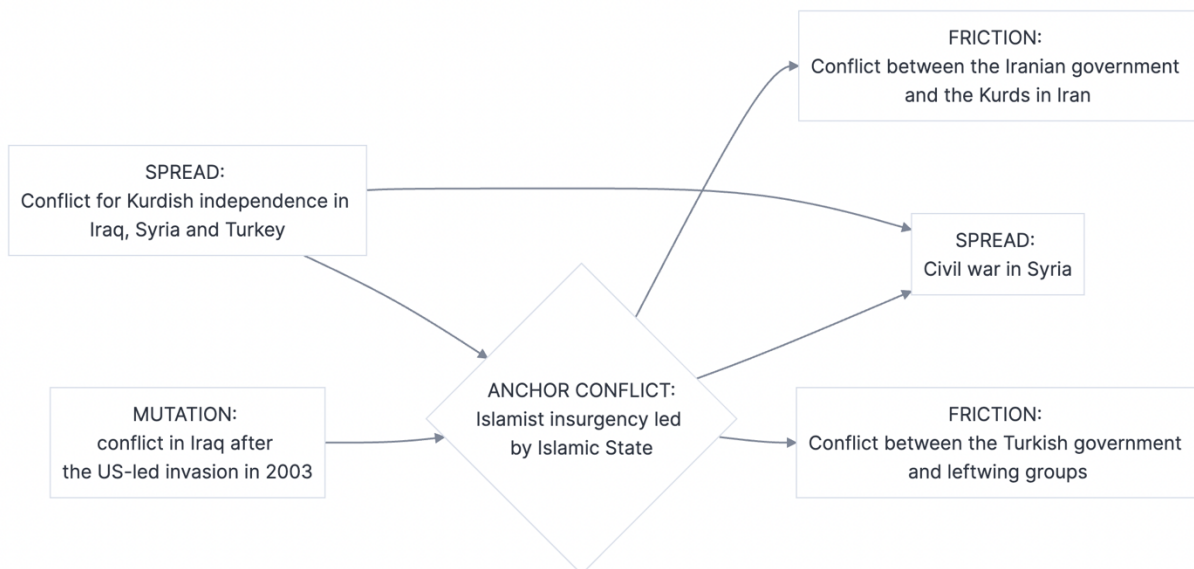


Figure 6: Chart depicting the formation of the armed conflict in Syria/Iraq.

The contemporary Iraqi armed conflict started in 2003 after the US-led invasion. In 2011, Syria's ongoing civil war started after the Syrian government's oppression of the Arab Spring uprising. The same year, the US forces withdrew from Iraq, leaving the Iraqi forces weakened. Al-Qaeda in Iraq (AQI)²² increased offenses on the

Iraqi forces and entered Syria (Brenner, 2019). The newly formed ISIS (Hashim, 2014), AQI's successor, gained positions in large parts of Syria and Iraq, taking advantage of the Sunni grievances bolstered by the Iraqi approach to the Sunni minority. Syrian rebel groups fighting against Syria's government progressed from Syria's peripheries in the north and east toward more central, and then more southern parts, benefiting from local support bases. When they captured Raqqa on March 4, 2013, for example, local inhabitants took down a statue of Assad's father, suggesting their support for the rebels rather than Assad's government (Harding, 2013). As the rebels moved further toward Damascus up to October 2013, they captured territory near Jordan and bombarded Central Damascus. Nonetheless, as the Syrian state forces' bombing of Raqqa shortly after the incident and many other subsequent government-led strikes show, the rebels failed to weaken the Syrian government's position. Syria's government and Syrian rebels are not the only new actors who joined the conflict. Following ISIS's human rights violations committed against Syrian Kurds in 2013, the People's Defense Units (PYD), a Syrian Kurdish armed non-state group, mobilized against the rising ISIS. Evidence of their violent engagements, however, suggests that they were not dominant actors; they did not influence the conflict shape and its hotspots as strongly as ISIS. We consider only those Kurdish armed groups that participated in the conflict in Syria or Iraq as part of this umbrella conflict, and hence the conflict shape. The instability in Iraq after the US-led invasion and the civil war in Syria intensified Kurdish efforts in Iraq and Syria to gain broader autonomy. They fought against other relevant conflict actors in those two conflicts and had their military bases located in or gained recruits from Syria and Iraq. For example, we include the Kurdistan Workers' Party (PKK), a Turkish armed non-state group, as it had several bases in Syria and Iraq and drew recruits from both countries. PKK's battles with the Turkish government took place in Turkey and Syria. In addition, PKK used its military bases in Iraq to launch attacks on the Turkish forces, and the Turkish forces attacked PKK camps in Iraq. We include the Kurdish Democratic Party of Iran (KDPI), an Iranian armed non-state group only for specific years via the friction mechanism because the group's focus was on regime change in Iran. Although, initially, the KDPI also drew recruits from Iraq, the Iraqi Kurds later formed their own branch.

Note on Syrian rebels

UCDP GED created the aggregated label "Syrian insurgents" because of difficulties identifying which specific groups were involved in individual conflict events. The label covers up to 1,200 groups whose aim was to topple Assad's regime. These include Jabhat al-Nusra, the Free Syrian Army, and many smaller groups—they do not include ISIS or Kurdish groups.²³ Given the composite character of the generic "Syrian insurgents" label, we consider ISIS to continue to be the dominant actor. Even though these groups' total number of engagements is highest (in total 10,551), we can reasonably assume the engagement of each group subsumed under this label to be lower than the total number of ISIS's engagement (412).

Note on Islamic State (IS)

IS is an umbrella identity for loosely connected armed groups across the world. In addition to the brand name, the groups often use the name of the region in which they operate, for example, Islamic State-Khorasan that is active in Afghanistan. We refer to several of these groups in the following way:

- Islamic State of Iraq and Syria (ISIS): armed conflict in Syria and Iraq.
- Islamic State's West Africa Province (ISWAP): armed conflict in the Lake Chad region.
- Islamic State-Khorasan (IS-K): armed conflict in the Afghan-Pakistani borderlands.

Since UCDP GED uses the abbreviation IS for all IS armed groups, we likewise use the abbreviation IS for the groups in the tables that list the conflict actors involved in our case studies and in the network graphs that depict the actors' engagements.

| UCDP GED ID | UCDP NAME²⁴ | FULL/OTHER NAME²⁵ | CONFLICT- CONNECTING MECHANISM²⁶ |
|----------------------------|--|---|--|
| 7443 | 16 th Division, Islamic Front, Jabhat Fateh al-Sham | | Spread (Syrian civil war) |
| 783 | 1920 Revolution Brigades | | Spread (Syrian civil war) |
| 7520 | 23 rd Division, Ahrar al-Sham, Jaysh al Nasr, Jaysh al-Nukhba, Nour al-Din al-Zenki, Sham Legion, SNA | | Spread (Syrian civil war) |
| 7524 | 23 rd Division, Jaysh al Nasr, Jaysh al-Nukhba, Sham Legion, SNA, Syrian Liberation Front | | Spread (Syrian civil war) |
| 886 | AAH | Asaib Ahl al-Haq | Spread (Syrian civil war) |
| 5563 | Ahfad al Rasoul Brigade | | Spread (Syrian civil war) |
| 7672 | Ahfad al Rasoul Brigade, Ahrar al-Sham, al-Farouq Brigades, Ghuraba al-Sham, IS, Jabhat Fateh al-Sham, Jazeera-Euphrates Liberation Front, Liwa al-Fateh | | Anchor conflict |
| 5565 | Ahfad al Rasoul Brigade, Ahrar al-Sham, IS, Islamic Kurdish Front, Jabhat Fateh al-Sham | | Anchor conflict |
| 5554 | Ahrar al-Sham | | Spread (Syrian civil war) |
| 7676 | Ahrar al-Sham, al-Tawhid Brigade, IS, Islamic Kurdish Front, Jabhat Fateh al-Sham | | Anchor conflict |
| 5567 | Ahrar al-Sham, al-Tawhid Brigade, IS, Jabhat Fateh al-Sham | | Anchor conflict |
| 7042 | Ahrar al-Sham, FSA, HTS, Jaysh al-Islam | FSA: Free Syrian Army, HTS: Hay'at Tahrir al Sham | Spread (Syrian civil war) |
| 6702 | Ahrar al-Sham, FSA, Jabhat Fateh al-Sham, Jaysh al-Islam | | Spread (Syrian civil war) |
| 6572 | Ahrar al-Sham, Furqan Brigades, Jabhat Fateh al-Sham, Jaysh al-Islam, Yarmouk Army | | Spread (Syrian civil war) |
| 7056 | Ahrar al-Sham, HTS, Southern Front | | Spread (Syrian civil war) |
| 6389 | Ahrar al-Sham, Jabhat Fateh al-Sham | | Spread (Syrian civil war) |

| | | | |
|------|--|--|---------------------------|
| 7498 | Ahrar al-Sham, Jabhat Fateh al-Sham, Jaysh al-Islam, Jaysh Asoud al-Sharqiya, Martyr Lieutenant Ahmed Abdou Brigades, Rahman Corps | | Spread (Syrian civil war) |
| 6532 | Ahrar al-Sham, Jabhat Fateh al-Sham, Southern Front | | Spread (Syrian civil war) |
| 7601 | Ahrar Ghurayan | | Spread (Syrian civil war) |
| 7155 | Aknaf Bait al-Maqdis, HTS, Jaysh al-Islam | | Spread (Syrian civil war) |
| 7492 | Aknaf Bait al-Maqdis, HTS, Jaysh al-Islam, Sons of Yarmouk Movement, Southern Front | | Spread (Syrian civil war) |
| 6378 | Aknaf Bait al-Maqdis, Jaysh al-Islam, PFLP-GC | PFLP-GC: Popular Front for the Liberation of Palestine-General Command | Spread (Syrian civil war) |
| 5659 | al-Mahdi Army | | Spread (Syrian civil war) |
| 7426 | al-Qa'qa Brigade, Army of Ahl al-Sunni wal Jamaa, Army of al-Ikhlās, Army of Maoata al-Islami, Authenticity and Development Front, Bayareq al-Shaaitat, Islamic Front, Jabhat Fateh al-Sham, Jaish al-Muhajireen wal-Ansar, Liwa al-Qadisiya | | Spread (Syrian civil war) |
| 769 | al-Qaida | | Mutation |
| 3232 | al-Tawhid Brigade | | Spread (Syrian civil war) |
| 233 | Ansar al-Islam | | Spread (Syrian civil war) |
| 6393 | Authenticity and Development Front | | Spread (Syrian civil war) |
| 7455 | Authenticity and Development Front, Islamic Front | | Spread (Syrian civil war) |
| 7612 | Authenticity and Development Front, Islamic Front, Jabhat Fateh al-Sham | | Spread (Syrian civil war) |
| 7662 | Baz al-Islamiya, Dawn of Freedom Brigades, Islamic Front, Jabhat al-Akrad, Jabhat Fateh al-Sham, Liwa al-Sultan Murad, Majd al-Sham | | Spread (Syrian civil war) |

| | | | |
|------|---|--|---------------------------|
| 7582 | Dawn of Freedom Brigades | | Spread (Syrian civil war) |
| 7646 | Dawn of Freedom Brigades, Euphrates Islamic Liberation Front, Islamic Front, Jabhat al-Akrad, Liwa Thuwar ar-Raqqa | | Spread (Syrian civil war) |
| 7663 | Dawn of Freedom Brigades, Harkat Hazm, Islamic Front, Jabhat al-Akrad, Jabhat Fateh al-Sham, Mujahideen Army, Nour al-Din al-Zenki, Sham Legion | | Spread (Syrian civil war) |
| 7650 | Dawn of Freedom Brigades, Jabhat al-Akrad, Northern Storm Brigade | | Spread (Syrian civil war) |
| 6410 | Eastern Ghouta Unified Military Command | | Spread (Syrian civil war) |
| 6390 | Eastern Qalamoun Operations Room | | Spread (Syrian civil war) |
| 7584 | Euphrates Islamic Liberation Front, Islamic Front, Jabhat Fateh al-Sham, Liwa Thuwar ar-Raqqa | | Spread (Syrian civil war) |
| 6419 | Euphrates Vulcano | | Spread (Syrian civil war) |
| 6436 | Fatah Halab | | Spread (Syrian civil war) |
| 6495 | Fatah Halab, Jabhat Fateh al-Sham | | Spread (Syrian civil war) |
| 367 | Forces of the Caucasus Emirate | | Spread (Syrian civil war) |
| 4168 | Ghuraba al-Sham, Jabhat Fateh al-Sham | | Spread (Syrian civil war) |
| 3822 | Government of Australia, Government of United Kingdom, Government of United States of America | | Mutation |
| 114 | Government of Iran | | Friction |
| 116 | Government of Iraq | | Anchor conflict |
| 121 | Government of Israel | | Spread (Syrian civil war) |
| 120 | Government of Jordan | | Spread (Syrian civil war) |
| 119 | Government of Lebanon | | Spread (Syrian civil war) |
| 57 | Government of Russia (Soviet Union) | | Spread (Syrian civil war) |

| | | | |
|------|--|--|---------------------------|
| 118 | Government of Syria | | Anchor conflict |
| 115 | Government of Turkey | | Spread |
| 3 | Government of United States of America | | Mutation |
| 6828 | Hamza Division, Liwa al-Sultan Murad | | Spread (Syrian civil war) |
| 6015 | Harkat Hazm | | Spread (Syrian civil war) |
| 6599 | Hawar Kilis Operations Room | | Spread (Syrian civil war) |
| 366 | Hezbollah | | Spread (Syrian civil war) |
| 6815 | HTS | Hay'at Tahrir al-Sham, Organization for the Liberation of the Levant | Spread (Syrian civil war) |
| 6825 | HTS, Rahman Corps | | Spread (Syrian civil war) |
| 6866 | HTS, Saraya Ahl al-Sham | | Spread (Syrian civil war) |
| 7036 | HTS, Southern Front | | Spread (Syrian civil war) |
| 234 | IS | Islamic State | Anchor conflict |
| 5540 | IS, Jabhat Fateh al-Sham | | Anchor conflict |
| 7669 | IS, Syrian insurgents | | Anchor conflict |
| 5575 | Islamic Front | | Spread (Syrian civil war) |
| 6030 | Islamic Front, Jabhat al-Akrad, Jabhat Fateh al-Sham, Mujahideen Army | | Spread (Syrian civil war) |
| 7437 | Islamic Front, Jabhat al-Akrad, Jabhat Fateh al-Sham, Mujahideen Army, SRF | | Spread (Syrian civil war) |
| 7649 | Islamic Front, Jabhat al-Akrad, Liwa Thuwar ar-Raqqa | | Spread (Syrian civil war) |
| 7468 | Islamic Front, Jabhat al-Akrad, Mujahideen Army, SRF | | Spread (Syrian civil war) |
| 6040 | Islamic Front, Jabhat Fateh al-Sham | | Spread (Syrian civil war) |
| 7666 | Islamic Front, Jabhat Fateh al-Sham, Liwa al-Jihad fi Sabeel Allah, Liwa Thuwar ar-Raqqa | | Spread (Syrian civil war) |
| 6069 | Islamic Front, Jabhat Fateh al-Sham, Mujahideen Army | | Spread (Syrian civil war) |
| 6014 | Islamic Front, Mujahideen Army, SRF | | Spread (Syrian civil war) |
| 7656 | Islamic Front, Northern Storm Brigade | | Spread (Syrian civil war) |

| | | | |
|------|---|--|---------------------------|
| 5541 | Jabhat al-Akrad | | Spread (Syrian civil war) |
| 1170 | Jabhat Fateh al-Sham | | Spread (Syrian civil war) |
| 6038 | Jabhat Fateh al-Sham, Liwa al-Aqsa | | Spread (Syrian civil war) |
| 7615 | Jabhat Fateh al-Sham, Liwa al-Qadisiya, Omar al-Mukhtar Battalion | | Spread (Syrian civil war) |
| 7461 | Jabhat Fateh al-Sham, Rahman Corps | | Spread (Syrian civil war) |
| 7674 | Jabhat Fateh al-Sham, Salahadin Brigade | | Spread (Syrian civil war) |
| 384 | Jamaat Jund al-Sahaba | | Spread (Syrian civil war) |
| 6380 | Jaysh al Fatah Idlib | | Spread (Syrian civil war) |
| 6605 | Jaysh al-Ashaer | | Spread (Syrian civil war) |
| 6377 | Jaysh al-Islam | | Spread (Syrian civil war) |
| 6600 | Jaysh al-Islam, Jaysh Asoud al-Sharqiya, Martyr Lieutenant Ahmed Abdou Brigades, Rahman Corps | | Spread (Syrian civil war) |
| 6302 | Jaysh al-Jihad (Saraya al- Jihad) | | Spread (Syrian civil war) |
| 4357 | Jaysh al-Mukhtar | | Spread (Syrian civil war) |
| 6367 | Jaysh al-Sanadid, Khabour Guards, MFS, PYD | MSF: military wing of Syriac Union Party | Spread (Syrian civil war) |
| 6370 | Jaysh al-Sanadid, MFS, PYD | | Spread (Syrian civil war) |
| 7150 | Jaysh al-Sanadid, PYD | | Spread (Syrian civil war) |
| 6626 | Jaysh Asoud al-Sharqiya, Martyr Lieutenant Ahmed Abdou Brigades | | Spread (Syrian civil war) |
| 4359 | JRTN | Army of the Men of the Naqshbandi Order, Naqshbandi Organization | Spread (Syrian civil war) |
| 6037 | Liwa al-Aqsa | | Spread (Syrian civil war) |
| 6564 | Mare' Operations Room | | Spread (Syrian civil war) |
| 308 | MEK | | Mutation |

| | | | |
|------|---|---|--|
| 6012 | Mujahideen Army | | Spread (Syrian civil war) |
| 7128 | National Front for Liberation | | Spread (Syrian civil war) |
| 7523 | National Front for Liberation, SNA | | Spread (Syrian civil war) |
| 7525 | National Front for Liberation, SNA, Syrian Liberation Front | | Spread (Syrian civil war) |
| 7631 | Northern Storm Brigade | | Spread (Syrian civil war) |
| 6434 | Nour al-Din al-Zenki | | Spread (Syrian civil war) |
| 7477 | Nour al-Din al-Zenki, Sham Legion | | Spread (Syrian civil war) |
| 6553 | NSA | | Spread (Syrian civil war) |
| 1144 | Opponents of al-Assad | | Spread (Syrian civil war) |
| 323 | PKK | Kurdistan Workers' Party | Spread (Kurdish conflict for autonomy) |
| 261 | PUK | Patriotic Union of Kurdistan | Spread (Kurdish conflict for autonomy) |
| 4163 | PYD | Partiya Yektiya Demokrat, Democratic Union Party | Spread (Kurdish conflict for autonomy) |
| 235 | RJF | Reform and Jihad Front | Spread (Syrian civil war) |
| 231 | SCIRI | The Supreme Council of the Islamic Revolution in Iraq | Mutation |
| 6288 | SDF | Syrian Democratic Forces | Spread (Syrian civil war) |
| 7514 | SNA | The Syrian National Army | Spread (Syrian civil war) |
| 6333 | Southern Front | | Spread (Syrian civil war) |
| 6011 | SRF | Syrian Revolutionaries' Front | Spread (Syrian civil war) |
| 1145 | Supporters of al-Assad | | Spread (Syrian civil war) |
| 7106 | Suqour al-Sham Brigades, Syrian Liberation Front | | Spread (Syrian civil war) |
| 4456 | Syrian insurgents | | Spread (Syrian civil war) |
| 6306 | Tahrir al- Sham Army | | Spread (Syrian civil war) |
| 7371 | Tajamu Shuhada al-Sharqiya | | Spread (Syrian civil war) |

| | | | |
|-----|------|----------------------------------|---|
| 335 | MKP | Maoist Communist Party | Friction (left-wing groups vs the Turkish government) |
| 309 | PJAK | Free Life Party of Kurdistan | Friction (Kurdish conflict in Iran) |
| 164 | KDPI | Kurdish Democratic Party of Iran | Friction (Kurdish conflict in Iran) |

Table 4: List of the relevant actors involved in the armed conflict in Syria/Iraq

Actors added through friction mechanism for specific years only:

- 2005: MKP
- 2016: PJAK, KDPI
- 2018: PJAK, KDPI
- 2019: PJAK, KDPI

4. Robustness checks

Alternative data: ACLED data for the armed conflict in the Lake Chad region

Out of our four case studies, only the armed conflict in the Lake Chad region has ACLED data (Raleigh et al., 2010) available for the periods under study. While both data sources provide information on the actors involved, geo-location, and the date of conflict events, ACLED does not impose the threshold of the minimum of 25 battle-related deaths per dyad per year to be included in the dataset. ACLED collects data on more types of conflict events than UCDP GED and consequently contains more data points. Thus, we need to ensure that we have two sets of events complying with the same rules to assess the similarity of the results. To mirror the type of events present in UCDP GED, we include only events that are classified as battles.²⁷

To build the conflict shape, we apply the same procedure we used for the UCDP GED data.²⁸ The resulting conflict shapes based on ACLED data are similar to those obtained from the UCDP GED data. The number of relevant actors and of conflict events is higher, given the threshold of 25 battle-related death required by the UCDP GED. The additional actors included in the ACLED data are typically communal or ethnic militia involved in less than five battles against Boko Haram or ISWAP. The original dominant actor Boko Haram was replaced by ISWAP while the government of Nigeria remained dominant also in 2016. Contrary to UCDP GED, ACLED data distinguish between police forces and military forces. To compare the results, we consider both military and police forces as representatives of the Nigerian government.

Relevant actors for the Islamist insurgency in Nigeria (2011-2016):

- Agzawayya Communal Militia (Cameroon)
- Attagara Communal Militia (Nigeria)
- Bakaresse Communal Militia (Cameroon)
- Boko Haram - Jamaatu Ahli is-Sunnah lid-Dawati wal-Jihad
- BVYG: Borno Vigilance Youths Group
- Civilian JTF: Civilian Joint Task Force
- Djakana Communal Militia (Cameroon)
- Dola Communal Militia (Cameroon)
- Double-Alagarno Communal Militia (Cameroon)
- Faa Communal Militia (Nigeria)

- Gaboua Communal Militia (Cameroon)
- Gangawa Communal Militia (Cameroon)
- Gogone Communal Militia (Niger)
- Islamic State (West Africa)
- Islamic State (West Africa) and/or Boko Haram - Jamaatu Ahli is-Sunnah lid-Dawati wal-Jihad
- Jitar Communal Militia (Nigeria)
- Kawuri Communal Militia (Nigeria)
- Kerawa Communal Militia (Cameroon)
- Kolofata Communal Militia (Cameroon)
- Lassa Communal Militia (Nigeria)
- Limani Communal Militia (Cameroon)
- Maiha Communal Militia (Nigeria)
- Maloumri Communal Militia (Cameroon)
- Military Forces of Cameroon (1982-)
- Military Forces of Cameroon (1982-) Rapid Intervention Battalion
- Military Forces of Chad (1990-2021)
- Military Forces of Niger (2011-2021)
- Military Forces of Nigeria (1999-2015)
- Military Forces of Nigeria (2015-)
- Military Forces of Nigeria (2015-) Joint Task Force
- Militia (Ali Kwara)
- Militia (Pro-Government)
- MNJTF: Multinational Joint Task Force
- Mora Communal Militia (Cameroon)
- Mozogo Communal Militia (Cameroon)
- Police Forces of Cameroon (1982-)
- Police Forces of Chad (1990-2021)
- Police Forces of Niger (2011-2021)
- Police Forces of Nigeria (1999-2015)
- Police Forces of Nigeria (2015-)
- Shawa Communal Militia (Nigeria)
- Shuwa Ethnic Militia (Nigeria)
- Tafawa-Balewa Communal Militia (Nigeria)
- Toumour Communal Militia (Niger)
- UN: United Nations
- VGN: Vigilante Group of Nigeria

Actors added through friction mechanism for specific years only:

- 2012: Berom Ethnic Militia (Nigeria)
- 2011, 2012: Christian Militia (Nigeria)
- 2013: Dadiya Ethnic Militia (Nigeria)
- 2014: Eggon Ethnic Militia (Nigeria)
- 2011, 2012, 2014, 2016: Fulani Ethnic Militia (Nigeria)
- 2014: Gbagyi Ethnic Militia (Nigeria)
- 2014: Gbajimba Communal Militia (Nigeria)
- 2012, 2014: Hausa Ethnic Militia (Nigeria)

- 2012: Igbo Ethnic Militia (Nigeria)
- 2014: Irigwe Ethnic Militia (Nigeria)
- 2014: Jukun Ethnic Militia (Nigeria)
- 2014: Kanberi Ethnic Militia (Nigeria)
- 2014: Kotoko Ethnic Militia (Cameroon)
- 2014: Marwa Ethnic Militia (Nigeria)
- 2014: Musgum Ethnic Militia (Cameroon)
- 2011, 2012: Muslim Militia (Nigeria)
- 2011: Muslim Youth Sect Militia (Nigeria)
- 2014: Pai Ethnic Militia (Nigeria)
- 2011: Private Security Forces (Nigeria)
- 2014: Rukuba Ethnic Militia (Nigeria)
- 2014: Shiite Muslim Militia (Nigeria)
- 2014: Tarok Ethnic Militia (Nigeria)
- 2013: Waja Ethnic Militia (Nigeria)

Change in dominant actors

As Table 5 shows, one of the dominant actors changes. The original dominant actor Boko Haram was replaced by ISWAP while the government of Nigeria also remained dominant in 2016. Contrary to UCDP GED, ACLED data distinguish between police forces and military forces. To compare the results, we consider both military and police forces as representatives of the Nigerian government.

| Year | ACLED name | Degree centrality |
|------|---|-------------------|
| 2011 | Boko Haram - Jamaatu Ahli is-Sunnah lid-Dawati wal-Jihad | 34 |
| | Police Forces of Nigeria (1999-2015) | 22 |
| | Military Forces of Nigeria (1999-2015) | 14 |
| | Christian Militia (Nigeria) | 8 |
| | Muslim Militia (Nigeria) | 4 |
| | Fulani Ethnic Militia (Nigeria) | 3 |
| | Muslim Youth Sect Militia (Nigeria) | 2 |
| | Private Security Forces (Nigeria) | 1 |
| 2016 | Islamic State (West Africa) | 180 |
| | Military Forces of Nigeria (2015-) | 171 |
| | Islamic State (West Africa) and/or Boko Haram - Jamaatu Ahli is-Sunnah lid-Dawati wal-Jihad | 83 |
| | Military Forces of Cameroon (1982-) | 46 |
| | Military Forces of Niger (2011-2021) | 13 |
| | Police Forces of Nigeria (2015-) | 4 |
| | Military Forces of Cameroon (1982-) Rapid Intervention Battalion | 4 |
| | Boko Haram - Jamaatu Ahli is-Sunnah lid-Dawati wal-Jihad | 3 |
| | Police Forces of Cameroon (1982-) | 3 |
| | Civilian JTF: Civilian Joint Task Force | 2 |
| | Military Forces of Chad (1990-2021) | 2 |
| | Limani Communal Militia (Cameroon) | 2 |
| | Kolofata Communal Militia (Cameroon) | 2 |
| | Shawa Communal Militia (Nigeria) | 1 |
| | Agzawaya Communal Militia (Cameroon) | 1 |
| | Military Forces of Nigeria (2015-) Joint Task Force | 1 |
| | UN: United Nations | 1 |
| | Mozogo Communal Militia (Cameroon) | 1 |
| | Fulani Ethnic Militia (Nigeria) | 1 |
| | Mora Communal Militia (Cameroon) | 1 |
| | Djakana Communal Militia (Cameroon) | 1 |
| | Bakaresse Communal Militia (Cameroon) | 1 |
| | Toumour Communal Militia (Niger) | 1 |
| | Double-Alagarno Communal Militia (Cameroon) | 1 |
| | Kerawa Communal Militia (Cameroon) | 1 |
| | Police Forces of Niger (2011-2021) | 1 |
| | Maloumri Communal Militia (Cameroon) | 1 |
| | Gangawa Communal Militia (Cameroon) | 1 |

Table 5: Degree centrality results based on the ACLED data.

Spatial shift results

Also according to ACLED data, the Lake Chad region conflict shape experienced a shifting contraction. It contracted by 46.7 percent (UCDP: 48.8 percent). It also shifted since the hotspots and conflict shapes overlapped by 25.9 percent (UCDP: 42.7 percent) and 48.3 percent (UCDP: 48.3 percent), respectively. The visual representation of the spatial shift is similar regardless of which conflict event data we use (see Figure 7).

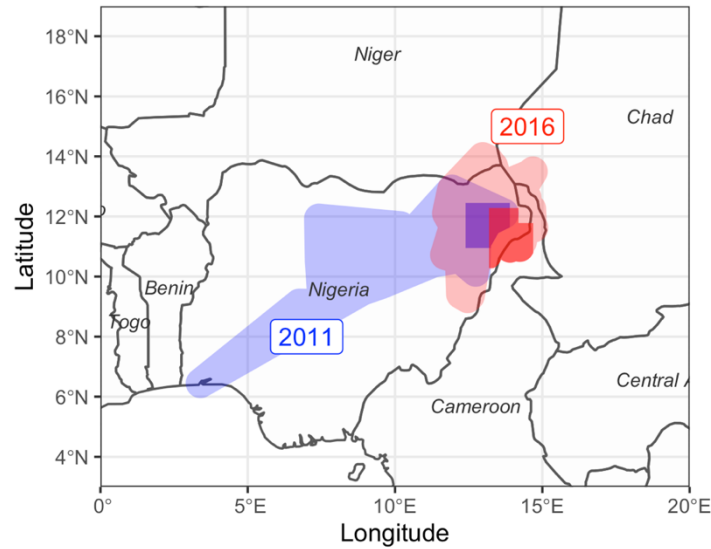


Figure 7: Shifting contraction of the Lake Chad region conflict shape, 2011–2016. Calculations based on ACLED data. Blue shading: conflict shape in 2011. Red shading: conflict shape in 2016. Darker blue and darker red shapes: hotspots.

Alternative operationalization of dominant actors

We use the degree centrality measure (that counts the total number of vertices) for the individual vertices to identify the dominant actors within an armed conflict. Nodes denote conflict actors, and vertices represent conflict events between the actors. Degree centrality thus counts the total number of conflict events in which a given conflict actor was involved. We assume that the most active conflict actors are also the dominant actors. We calculate three further network measures as alternative approaches to identifying the dominant actors (see Table 6).

First, we count the number of unique nodes connected to the given conflict actors. This measure assumes that the most important actors are those who fought many other conflict actors without considering the frequency of those violent encounters. This measure often assigns similar values to actors with a widely different frequency of engagement in conflict events. Consequently, this measure undervalues the importance of actors involved in a high number of conflict events if those events always involve only one other conflict actor. For instance, in 2008, the Taliban fought in 937 events against one conflict actor. The Lashkar-e-Islam militia was engaged in 13 conflict events battling two enemies, meaning that the Taliban is assigned a lower importance score than Lashkar-e-Islam based on the number of nodes. Given our definition of dominant actors, this measure is not suitable for identifying the dominant actors or their change.

| Armed conflict | | Conflict actors | | Centrality measures | | | | | | |
|--|------|-----------------|--|---------------------|------------|---------|-------------|---------|-------|---------|
| Name | Year | UCDP ID | Name | Degree | N of nodes | | Eigenvector | | Katz | |
| | | | | Value | Value | Same DA | Value | Same DA | Value | Same DA |
| Armed conflict in Colombia - period I | 2006 | 17 | Government of Colombia | 87 | 3 | Yes | 1 | Yes | 1.35 | Yes |
| | | 771 | AUC | 1 | 1 | | 0.01 | | 1.12 | |
| | | 744 | ELN | 8 | 1 | | 0.1 | | 1.14 | |
| | | 746 | EPL | 2 | 1 | | 0.03 | | 1.14 | |
| | | 743 | FARC | 78 | 2 | | 0.99 | | 1.25 | |
| | 2011 | 17 | Government of Colombia | 44 | 1 | Yes | 1 | Yes | 1.34 | Yes |
| | | 743 | FARC | 44 | 1 | | 1 | | 1.11 | |
| Armed conflict in Colombia - period II | 2012 | 17 | Government of Colombia | 27 | 1 | Yes | 1 | Yes | 1.11 | Yes |
| | | 743 | FARC | 27 | 1 | | 1 | | 1.11 | |
| | 2016 | 17 | Government of Colombia | 13 | 3 | Yes | 1 | Yes | 1.11 | No |
| | | 744 | ELN | 10 | 1 | | 0.98 | | 1.13 | |
| | | 746 | EPL | 1 | 1 | | 0.1 | | 1.13 | |
| | | 743 | FARC | 2 | 1 | | 0.2 | | 1.13 | |
| Armed conflict in the Laker Chad region | 2011 | 84 | Government of Nigeria | 55 | 1 | No | 1 | Yes | 1.11 | No |
| | | 608 | Hausa | 2 | 1 | | 0 | | 1.11 | |
| | | 589 | Birom | 13 | 1 | | 0 | | 1.11 | |
| | | 1051 | Boko Haram | 55 | 1 | | 1 | | 1.11 | |
| | | 1140 | Sayawa | 2 | 1 | | 0 | | 1.11 | |
| | | 607 | Fulani | 13 | 1 | | 0 | | 1.11 | |
| | 2016 | 75 | Government of Niger | 12 | 1 | No | 0.06 | Yes | 1.16 | Yes |
| | | 84 | Government of Nigeria | 217 | 2 | | 1 | | 1.29 | |
| | | 83 | Government of Cameroon | 32 | 2 | | 0.13 | | 1.29 | |
| | | 87 | Government of Chad | 3 | 1 | | 0.02 | | 1.16 | |
| | | 234 | IS | 234 | 5 | | 1 | | 1.61 | |
| | | 4000 | Yan Gora | 6 | 1 | | 0.03 | | 1.16 | |
| | | 1051 | Boko Haram | 36 | 2 | | 0.15 | | 1.26 | |
| Armed conflict in the broader Afghanistan-Pakistan border area | 2006 | 130 | Government of Afghanistan | 713 | 2 | No | 1 | Yes | 1.22 | Yes |
| | | 3 | Government of United States of America | 19 | 1 | | 0 | | 1.11 | |
| | | 303 | Taleban | 707 | 1 | | 1 | | 1.12 | |
| | | 299 | Hizb-i Islami-yi Afghanistan | 6 | 1 | | 0.01 | | 1.12 | |
| | | 769 | al-Qaida | 19 | 1 | | 0 | | 1.11 | |
| | 2008 | 790 | Bangesh | 29 | 2 | No | 0 | Yes | 1.25 | No |
| | | 142 | Government of Pakistan | 419 | 2 | | 0 | | 1.27 | |
| | | 796 | Lashkar of Salarzai tribe | 7 | 1 | | 0 | | 1.15 | |
| | | 797 | Mangal | 12 | 2 | | 0 | | 1.25 | |
| | | 398 | Ansaar ul-Islam | 11 | 1 | | 0 | | 1.12 | |
| | | 888 | Forces of Turkestan Bhattani | 1 | 1 | | 0 | | 1.15 | |
| | | 792 | Forces of Shah Sahib | 4 | 1 | | 0 | | 1.15 | |
| | | 3 | Government of United States of America | 31 | 1 | | 0 | | 1.11 | |
| | | 130 | Government of Afghanistan | 951 | 2 | | 1 | | 1.22 | |
| | | 791 | Turi | 39 | 2 | | 0 | | 1.25 | |
| | | 356 | TTP | 429 | 4 | | 0 | | 1.47 | |
| | | 399 | Lashkar-e-Islam | 13 | 2 | | 0 | | 1.24 | |
| | | 769 | al-Qaida | 31 | 1 | | 0 | | 1.11 | |
| | | 303 | Taleban | 937 | 1 | | 1 | | 1.12 | |
| | | 299 | Hizb-i Islami-yi Afghanistan | 14 | 1 | | 0.01 | | 1.12 | |

| Armed conflict | | Conflict actors | | Centrality measures | | | | | | |
|---|------|-----------------|--|---------------------|------------|---------|-------------|---------|-------|---------|
| Name | Year | UCDP ID | Name | Degree | N of nodes | | Eigenvector | | Katz | |
| | | | | Value | Value | Same DA | Value | Same DA | Value | Same DA |
| Armed conflict in Syria and Iraq - period I | 2010 | 114 | Government of Iran | 7 | 1 | No | 0 | Yes | 1.11 | No |
| | | 116 | Government of Iraq | 241 | 1 | | 1 | | 1.11 | |
| | | 115 | Government of Turkey | 59 | 1 | | 0 | | 1.11 | |
| | | 309 | PJAK | 7 | 1 | | 0 | | 1.11 | |
| | | 234 | IS | 241 | 1 | | 1 | | 1.11 | |
| | | 323 | PKK | 59 | 1 | | 0 | | 1.11 | |
| | 2013 | 114 | Government of Iran | 4 | 1 | No | 0 | Yes | 1.11 | No |
| | | 116 | Government of Iraq | 309 | 1 | | 0 | | 1.21 | |
| | | 115 | Government of Turkey | 7 | 1 | | 0 | | 1.11 | |
| | | 4357 | Jaysh al-Mukhtar | 3 | 1 | | 0 | | 1.11 | |
| | | 366 | Hezbollah | 2 | 1 | | 0 | | 1.13 | |
| | | 118 | Government of Syria | 10640 | 3 | | 1 | | 1.54 | |
| | | 5540 | IS, Jabhat Fateh al-Sham | 54 | 2 | | 0 | | 1.32 | |
| | | 3232 | al-Tawhid Brigade | 7 | 1 | | 0 | | 1.21 | |
| | | 5565 | Ahfad al Rasoul Brigade, Ahrar al-Sham, IS, Islamic Kurdish Front, Jabhat Fateh al-Sham | 9 | 1 | | 0 | | 1.21 | |
| | | 5567 | Ahrar al-Sham, al-Tawhid Brigade, IS, Jabhat Fateh al-Sham | 36 | 1 | | 0 | | 1.21 | |
| | | 234 | IS | 412 | 8 | | 0.01 | | 2.1 | |
| | | 5563 | Ahfad al Rasoul Brigade | 4 | 1 | | 0 | | 1.21 | |
| | | 7582 | Dawn of Freedom Brigades | 1 | 1 | | 0 | | 1.21 | |
| | | 7672 | Ahfad al Rasoul Brigade, Ahrar al-Sham, al-Farouq Brigades, Ghuraba al-Sham, IS, Jabhat Fateh al-Sham, Jazeera-Euphrates Liberation Front, Liwa al-Fateh | 14 | 1 | | 0 | | 1.21 | |
| | | 7676 | Ahrar al-Sham, al-Tawhid Brigade, IS, Islamic Kurdish Front, Jabhat Fateh al-Sham | 22 | 1 | | 0 | | 1.21 | |
| | | 309 | PJAK | 4 | 1 | | 0 | | 1.11 | |
| | | 323 | PKK | 7 | 1 | | 0 | | 1.11 | |
| | | 308 | MEK | 3 | 1 | | 0 | | 1.11 | |
| | | 1170 | Jabhat Fateh al-Sham | 5 | 2 | | 0 | | 1.32 | |
| | | 4456 | Syrian insurgents | 10551 | 1 | | 1 | | 1.15 | |
| | | 4163 | PYD | 160 | 8 | | 0 | | 2.1 | |
| | | 5575 | Islamic Front | 2 | 1 | | 0 | | 1.21 | |
| | | 7631 | Northern Storm Brigade | 10 | 1 | | 0 | | 1.21 | |
| | | 5541 | Jabhat al-Akrad | 4 | 1 | | 0 | | 1.13 | |

| Armed conflict | | Conflict actors | | Centrality measures | | | | | | | | | |
|--|--|-----------------|---|---------------------|------------|-------------|-------|---------|-------|---------|---|--|------|
| Name | Year | UCDP ID | Name | Degree | N of nodes | Eigenvector | Katz | | | | | | |
| | | | | Value | Value | Same DA | Value | Same DA | Value | Same DA | | | |
| Armed conflict in Syria and Iraq - period II | 2014 | 116 | Government of Iraq | 696 | 1 | No | 0 | Yes | 1.72 | No | | | |
| | | 234 | IS | 2749 | 35 | | 0.06 | | 7.23 | | | | |
| | | 118 | Government of Syria | 10211 | 3 | | 1 | | 2.06 | | | | |
| | | 366 | Hezbollah | 11 | 3 | | 0 | | 2.07 | | | | |
| | | 119 | Government of Lebanon | 8 | 1 | | 0 | | 1.72 | | | | |
| | | 3 | Government of United States of America | 7 | 1 | | 0 | | 1.11 | | | | |
| | | 121 | Government of Israel | 2 | 1 | | 0 | | 1.21 | | | | |
| | | 5540 | IS, Jabhat Fateh al-Sham | 6 | 1 | | 0 | | 1.22 | | | | |
| | | 1170 | Jabhat Fateh al-Sham | 36 | 4 | | 0 | | 2.26 | | | | |
| | | 6015 | Harkat Hazm | 4 | 1 | | 0 | | 1.23 | | | | |
| | | 6038 | Jabhat Fateh al-Sham, Liwa al-Aqsa | 10 | 1 | | 0 | | 1.21 | | | | |
| | | 6419 | Euphrates Vulcano | 144 | 1 | | 0 | | 1.72 | | | | |
| | | 6389 | Ahrar al-Sham, Jabhat Fateh al-Sham | 1 | 1 | | 0 | | 1.72 | | | | |
| | | 6564 | Mare Operations Room | 3 | 1 | | 0 | | 1.72 | | | | |
| | | 7443 | 16th Division, Islamic Front, Jabhat Fateh al-Sham | 1 | 1 | | 0 | | 1.72 | | | | |
| | | 7455 | Authenticity and Development Front, Islamic Front | 7 | 1 | | 0 | | 1.72 | | | | |
| | | | Euphrates Islamic Liberation Front, Islamic Front, Jabhat Fateh al-Sham, Liwa Thuwar ar-Raqqa | 33 | 1 | | 0 | | 1.72 | | | | |
| | | 7584 | Ahrar Ghurayan | 6 | 1 | | 0 | | 1.22 | | | | |
| | | 7601 | Authenticity and Development Front, Islamic Front, Jabhat Fateh al-Sham | 84 | 1 | | 0 | | 1.72 | | | | |
| | | | Dawn of Freedom Brigades, Euphrates Islamic Liberation Front, Islamic Front, Jabhat al-Akrad, Liwa Thuwar ar-Raqqa | 37 | 1 | | 0 | | 1.72 | | | | |
| | | 7646 | Dawn of Freedom Brigades, Jabhat al-Akrad, Northern Storm Brigade | 9 | 1 | | 0 | | 1.72 | | | | |
| | | | Baz al-Islamiya, Dawn of Freedom Brigades, Islamic Front, Jabhat al-Akrad, Jabhat Fateh al-Sham, Liwa al-Sultan Murad, Majd al-Sham | 49 | 1 | | 0 | | 1.72 | | | | |
| | | 7662 | | | | | | | | | | | |
| | | | Dawn of Freedom Brigades, Harkat Hazm, Islamic Front, Jabhat al-Akrad, Jabhat Fateh al-Sham, Mujahideen Army, Nour al-Din al-Zenki, Sham Legion | 14 | 1 | | | | | | | | |
| | | 7663 | Legion | 14 | 1 | | | | | | 0 | | 1.72 |
| | | 6393 | Authenticity and Development Front | 16 | 1 | | | | | | 0 | | 1.72 |
| | | 115 | Government of Turkey | 5 | 1 | | | | | | 0 | | 1.11 |
| | | 4359 | JRTN | 6 | 1 | | | | | | 0 | | 1.72 |
| | | 4456 | Syrian insurgents | 9586 | 1 | | | | | | 1 | | 1.21 |
| | | 769 | al-Qaida | 7 | 1 | | | | | | 0 | | 1.11 |
| | | 4163 | PYD | 313 | 4 | | | | | | 0 | | 2.17 |
| | | 5575 | Islamic Front | 71 | 1 | | | | | | 0 | | 1.72 |
| | | 6011 | SRF | 36 | 3 | | | | | | 0 | | 2.07 |
| | | 6012 | Mujahideen Army | 7 | 1 | | | | | | 0 | | 1.72 |
| | | 6014 | Islamic Front, Mujahideen Army, SRF | 246 | 1 | | | | | | 0 | | 1.72 |
| | | | Islamic Front, Jabhat al-Akrad, Jabhat Fateh al-Sham, Mujahideen Army | 2 | 1 | | | | | | 0 | | 1.72 |
| | | 6030 | Sham, Mujahideen Army | 2 | 1 | | | | | | 0 | | 1.72 |
| | | 6040 | Islamic Front, Jabhat Fateh al-Sham | 136 | 1 | | | | | | 0 | | 1.72 |
| | | | Islamic Front, Jabhat Fateh al-Sham, Mujahideen Army | 31 | 1 | | | | | | 0 | | 1.72 |
| | | 6069 | Army | 31 | 1 | | | | | | 0 | | 1.72 |
| 6333 | Southern Front | 1 | 1 | | | 0 | | 1.72 | | | | | |
| 7150 | Jaysh al-Sanadid, PYD | 25 | 1 | | | 0 | | 1.72 | | | | | |
| | al-Qa'qa Brigade, Army of Ahl al-Sunni wal Jamaa , Army of al-Ikhlās, Army of Maoata al-Islami, Authenticity and Development Front, Bayareq al-Shaaitat , Islamic Front, Jabhat Fateh al-Sham, Jaish al-Muhajireen wal-Ansar, Liwa al-Qadisiya | 99 | 1 | | | 0 | | 1.72 | | | | | |
| 7426 | al-Muhajireen wal-Ansar, Liwa al-Qadisiya | 99 | 1 | | | 0 | | 1.72 | | | | | |
| | Islamic Front, Jabhat al-Akrad, Jabhat Fateh al-Sham, Mujahideen Army, SRF | 2 | 1 | | | 0 | | 1.72 | | | | | |
| 7437 | Sham, Mujahideen Army, SRF | 2 | 1 | | | 0 | | 1.72 | | | | | |
| | Islamic Front, Jabhat al-Akrad, Mujahideen Army, SRF | 21 | 1 | | | 0 | | 1.72 | | | | | |
| 7468 | SRF | 21 | 1 | | | 0 | | 1.72 | | | | | |
| | Jabhat Fateh al-Sham, Liwa al-Qadisiya, Omar al-Mukhtar Battalion | 1 | 1 | | | 0 | | 1.72 | | | | | |
| 7615 | Mukhtar Battalion | 1 | 1 | | | 0 | | 1.72 | | | | | |
| | Islamic Front, Jabhat al-Akrad, Liwa Thuwar ar-Raqqa | 18 | 1 | | | 0 | | 1.72 | | | | | |
| 7649 | Raqqa | 18 | 1 | | | 0 | | 1.72 | | | | | |
| 7656 | Islamic Front, Northern Storm Brigade | 10 | 1 | | | 0 | | 1.72 | | | | | |
| | Islamic Front, Jabhat Fateh al-Sham, Liwa al-Jihad fi Sabeel Allah, Liwa Thuwar ar-Raqqa | 34 | 1 | | | 0 | | 1.72 | | | | | |
| 7666 | Sabeel Allah, Liwa Thuwar ar-Raqqa | 34 | 1 | | | 0 | | 1.72 | | | | | |
| 323 | PKK | 5 | 1 | | | 0 | | 1.11 | | | | | |

26

| Armed conflict | | Conflict actors | | Centrality measures | | | | | | |
|--|------|-----------------|--|---------------------|------------|-------------|-------|---------|-------|---------|
| Name | Year | UCDP ID | Name | Degree | N of nodes | Eigenvector | Katz | | | |
| | | | | Value | Value | Same DA | Value | Same DA | Value | Same DA |
| Armed conflict in Syria and Iraq - period II | 2016 | 114 | Government of Iran | 18 | 3 | No | 0 | Yes | 1.74 | No |
| | | 116 | Government of Iraq | 559 | 1 | | 0.04 | | 1.51 | |
| | | 115 | Government of Turkey | 261 | 2 | | 0.01 | | 1.62 | |
| | | 234 | IS | 2367 | 25 | | 0.26 | | 5.08 | |
| | | 120 | Government of Jordan | 4 | 1 | | 0 | | 1.51 | |
| | | 366 | Hezbollah | 3 | 3 | | 0 | | 1.8 | |
| | | 119 | Government of Lebanon | 4 | 1 | | 0 | | 1.51 | |
| | | 121 | Government of Israel | 1 | 1 | | 0 | | 1.18 | |
| | | 118 | Government of Syria | 4356 | 3 | | 1 | | 1.87 | |
| | | 6378 | Aknaf Bait al-Maqdis, Jaysh al-Islam, PFLP-GC | 3 | 1 | | 0 | | 1.51 | |
| | | 6436 | Fatah Halab | 61 | 2 | | 0 | | 1.75 | |
| | | 6495 | Fatah Halab, Jabhat Fateh al-Sham | 28 | 2 | | 0 | | 1.75 | |
| | | 6389 | Ahrar al-Sham, Jabhat Fateh al-Sham | 13 | 2 | | 0 | | 1.75 | |
| | | 6532 | Ahrar al-Sham, Jabhat Fateh al-Sham, Southern Front | 62 | 1 | | 0 | | 1.51 | |
| | | 5554 | Ahrar al-Sham | 17 | 1 | | 0 | | 1.11 | |
| | | 6564 | Mare,Ã Operations Room | 14 | 1 | | 0 | | 1.51 | |
| | | 6599 | Hawar Kilis Operations Room | 150 | 2 | | 0.01 | | 1.75 | |
| | | 6600 | Jaysh al-Islam, Jaysh Asoud al-Sharqiya, Martyr Lieutenant Ahmed Abdou Brigades, Rahman Corps | 15 | 1 | | 0 | | 1.11 | |
| | | 6702 | Ahrar al-Sham, FSA, Jabhat Fateh al-Sham, Jaysh al-Islam | 5 | 1 | | 0 | | 1.51 | |
| | | 7461 | Jabhat Fateh al-Sham, Rahman Corps | 22 | 1 | | 0 | | 1.16 | |
| | | 7498 | Ahrar al-Sham, Jabhat Fateh al-Sham, Jaysh al-Islam, Jaysh Asoud al-Sharqiya, Martyr Lieutenant Ahmed Abdou Brigades, Rahman Corps | 15 | 1 | | 0 | | 1.51 | |
| | | 164 | KDPI | 10 | 1 | | 0 | | 1.17 | |
| | | 309 | PJAK | 5 | 1 | | 0 | | 1.17 | |
| | | 323 | PKK | 191 | 1 | | 0 | | 1.16 | |
| | | 6333 | Southern Front | 4 | 1 | | 0 | | 1.51 | |
| | | 1170 | Jabhat Fateh al-Sham | 29 | 2 | | 0 | | 1.69 | |
| | | 4456 | Syrian insurgents | 3449 | 1 | | 0.97 | | 1.19 | |
| | | 5575 | Islamic Front | 1 | 1 | | 0 | | 1.51 | |
| | | 6014 | Islamic Front, Mujahideen Army, SRF | 4 | 1 | | 0 | | 1.51 | |
| | | 6288 | SDF | 685 | 6 | | 0.05 | | 2.39 | |
| | | 6377 | Jaysh al-Islam | 27 | 2 | | 0 | | 1.62 | |
| | | 6553 | NSA | 8 | 1 | | 0 | | 1.51 | |
| | | 6037 | Liwa al-Aqsa | 17 | 1 | | 0 | | 1.11 | |
| | | 6306 | Tahrir al- Sham Army | 15 | 1 | | 0 | | 1.11 | |
| | | 6626 | Jaysh Asoud al-Sharqiya, Martyr Lieutenant Ahmed Abdou Brigades | 2 | 1 | | 0 | | 1.51 | |
| | | 7477 | Nour al-Din al-Zenki, Sham Legion | 1 | 1 | | 0 | | 1.51 | |

Table 6: Comparison of the results of the centrality measures used to identify dominant actors. Dominant actors in blue (beginning of the observed period) and red (end of the observed period). *DA means dominant actors.

Second, we calculate eigenvector centrality. As with the degree centrality, this measure considers the number of connected nodes and the total number of conflict events in which a given conflict actor was involved. In addition, eigenvector centrality assigns a higher score to nodes with well-connected neighbors. In our case, conflict actors fighting other conflict actors with a higher centrality score also receive more points for such connections. In an undirected network of n nodes, the eigenvector centrality x_i of node i is proportional to the sum of the centralities of i 's neighbor. Thus, the eigenvector centrality is defined as

$$x_i = \kappa^{-1} \sum_{j=1}^n A_{ij} x_j , \quad (1)$$

where the adjacency matrix is denoted as A_{ij} and the constant of proportionality κ^{-1} is equal to the largest eigenvalue of the adjacency matrix (Newman, 2018: 159–161). Using eigenvector centrality leads to identifying the same dominant actors as in the case of degree centrality.

Third, we compute Katz centrality, which adds a small value to all nodes regardless of their connections and thus is a convenient measure for less connected networks. We define Katz centrality x_i in a network with n nodes as

$$x_i = \alpha \sum_j^n A_{ij} x_j + \beta \quad (2)$$

where α is the eigenvector centrality term summing all centralities of the nodes that point to node i and β is the constant adding extra value to each node in the network (Newman, 2018: 163).

Our results suggest that Katz centrality often assigns the same value to many conflict actors and identifies as important those that are connected to at least two other conflict actors. For instance, in 2008, the measure assigns higher importance to the Mangal tribe, which was involved in 12 conflict events with two other conflict actors, namely Turi and Bangesh tribes, than to the Afghan government, which was involved in 951 conflict events with two other conflict actors. This measure, mainly due to its use of constant β , undervalues less connected actors with high frequency involvement. Katz measure provides similar results as degree centrality and eigenvector centrality if used in less connected networks, such as the armed conflict in Colombia.

In general, network centrality measures identify the most important nodes within the network. They differ based on the applied assumptions of what constitutes an important node within a network. Given how we conceptualize dominant actors, the centrality measures that adequately represent our conceptualization of dominant actors are degree centrality, eigenvector centrality, and to some extent Katz centrality.

Alternative spatial shift explanation

As an alternative explanation of spatial shift, we further consider the change in the proportion of how many actors are fighting the main state actors in relation to the overall number of actors involved in a given conflict. We also consider the change in the proportion conflict events that the state actor was engaged in, in relation to the total number of conflict events assigned to a given conflict. The results do not explain spatial shift, as there is no substantive difference between spatial change (such as contraction or expansion) with or without shift (see Table 7).

| Armed conflict | | | Actors | | | Conflict events | | |
|--|---------------------------|------|--------------------------------|-------------------|----------------------|----------------------------------|--------------------------|-----------------------------|
| Name | State actor | Year | N of actors inv. with the gov. | Total N of actors | Proportion of actors | N of confl. events with the gov. | Total N of confl. Events | Proportion of confl. Events |
| Armed conflict in Colombia (2006 - 2011) | Government of Colombia | 2006 | 3 | 5 | 0.6 | 87 | 88 | 1 |
| | | 2007 | 3 | 4 | 0.8 | 77 | 77 | 1 |
| | | 2008 | 2 | 3 | 0.7 | 54 | 54 | 1 |
| | | 2009 | 2 | 3 | 0.7 | 65 | 65 | 1 |
| | | 2010 | 2 | 3 | 0.7 | 75 | 75 | 1 |
| | | 2011 | 1 | 2 | 0.5 | 44 | 44 | 1 |
| Armed conflict in Colombia (2012 - 2016) | Government of Colombia | 2012 | 1 | 2 | 0.5 | 27 | 27 | 1 |
| | | 2013 | 2 | 3 | 0.7 | 21 | 21 | 1 |
| | | 2014 | 2 | 3 | 0.7 | 35 | 35 | 1 |
| | | 2015 | 3 | 4 | 0.8 | 28 | 28 | 1 |
| | | 2016 | 3 | 4 | 0.8 | 13 | 13 | 1 |
| Armed conflict in the Lake Chad region (2011 - 2016) | Government of Nigeria | 2011 | 1 | 6 | 0.2 | 55 | 70 | 0.8 |
| | | 2012 | 1 | 2 | 0.5 | 120 | 120 | 1 |
| | | 2013 | 1 | 3 | 0.3 | 92 | 103 | 0.9 |
| | | 2014 | 1 | 5 | 0.2 | 169 | 184 | 0.9 |
| | | 2015 | 2 | 11 | 0.2 | 166 | 251 | 0.7 |
| | | 2016 | 2 | 7 | 0.3 | 217 | 270 | 0.8 |
| Armed conflict in the wider Afghanistan-Pakistan border area (2006 - 2008) | Government of Afghanistan | 2006 | 2 | 5 | 0.4 | 713 | 732 | 1 |
| | | 2007 | 1 | 14 | 0.1 | 849 | 956 | 0.9 |
| | | 2008 | 2 | 15 | 0.1 | 951 | 1464 | 0.6 |
| Armed conflict in Syria and Iraq (2010 - 2013) | Government of Iraq | 2010 | 1 | 6 | 0.2 | 241 | 307 | 0.8 |
| | | 2011 | 2 | 12 | 0.2 | 141 | 465 | 0.3 |
| | | 2012 | 1 | 11 | 0.1 | 145 | 8346 | 0 |
| | | 2013 | 1 | 24 | 0 | 309 | 11135 | 0 |
| Armed conflict in Syria and Iraq (2010 - 2013) | Government of Syria | 2010 | NA | NA | NA | NA | NA | NA |
| | | 2011 | 2 | 12 | 0.2 | 208 | 465 | 0.4 |
| | | 2012 | 2 | 11 | 0.2 | 8073 | 8346 | 1 |
| | | 2013 | 3 | 24 | 0.1 | 10640 | 11135 | 1 |
| Armed conflict in Syria and Iraq (2014 - 2016) | Government of Iraq | 2014 | 1 | 46 | 0 | 696 | 12403 | 0.1 |
| | | 2015 | 1 | 38 | 0 | 589 | 7585 | 0.1 |
| | | 2016 | 1 | 36 | 0 | 559 | 6213 | 0.1 |
| Armed conflict in Syria and Iraq (2014 - 2016) | Government of Syria | 2014 | 3 | 46 | 0.1 | 10211 | 12403 | 0.8 |
| | | 2015 | 4 | 38 | 0.1 | 5994 | 7585 | 0.8 |
| | | 2016 | 3 | 36 | 0.1 | 4356 | 6213 | 0.7 |

Table 7: Proportion of the actors involved with the main state actor and proportion of conflict events with the involvement of the main state actor.

Alternative hotspot operationalization

We use the Getis-Ord algorithm to identify hotspot locations (Getis and Ord, 1992). We create squared grids to obtain the list of neighboring units and calculate z-scores for all units. In the article, we rely on the size of the grids, 50x50 km at the equator. Given the potential spatial error in the UCDP GED data estimated by Weidmann (2015), we believe that smaller grids would be inappropriate.²⁹ To test our method's robustness for identifying spatial shift, we calculate Getis-Ord hotspots with larger grids, namely 75x75 km and 100x100 km at the equator (see Table 8). Our results show that even though larger-sized grids tend to produce smaller overlaps, all three grid sizes identify the same type of spatial change. Thus, we are confident that spatial change is not affected by our choice of grid size.

| Armed conflict | Hotspot overlap | | | | |
|--|-----------------|-----------------|----------|------------------|----------|
| | Grid size 50 km | Grid size 75 km | | Grid size 100 km | |
| | % | % | Same SC* | % | Same SC* |
| Armed conflict in Colombia (2006 - 2011) | 78.7 | 65.5 | Yes | 56.8 | Yes |
| Armed conflict in Colombia (2012 - 2016) | 0.0 | 0.0 | Yes | 0.0 | Yes |
| Armed conflict in the Lake Chad region (2011 - 2016) | 42.7 | 51.9 | No | 23.6 | Yes |
| Armed conflict in the broader Afghanistan-Pakistan border area (2006 - 2008) | 56.1 | 51.9 | Yes | 28.6 | Yes |
| Armed conflict in Syria and Iraq (2010 - 2013) | 0.0 | 0.0 | Yes | 0.0 | Yes |
| Armed conflict in Syria and Iraq (2014 - 2016) | 74.2 | 86.4 | Yes | 68.0 | Yes |

Table 8: Results of the alternative grid specification. *SC means spatial change.

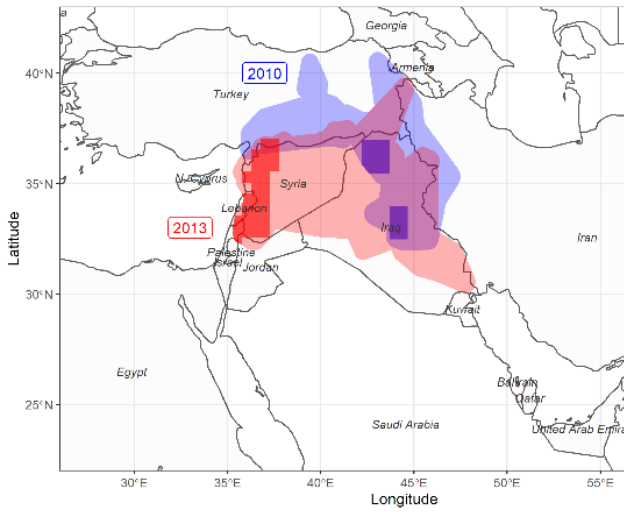
Alternative conflict shape operationalization

How we form the buffer for the final conflict shape polygons might affect the type of identified spatial change. We use a 50 km buffer to mitigate potential spatial errors in the UCDP GED estimated by Weidmann (2015). We also build conflict shapes with buffers of 75 km and 100 km to test our results' stability. We identify the same spatial shifts regardless of the buffer sizes, the only exception being Colombia in 2012–2016, where the buffer size affected the location of hotspots resulting in the hotspot overlap of 12.2 percent.

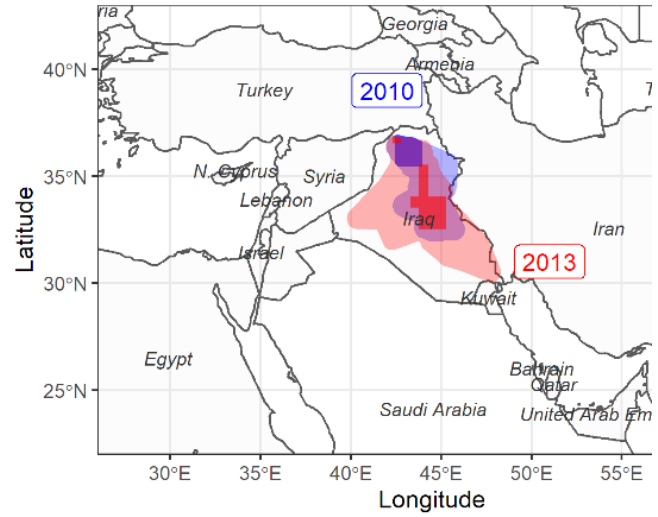
We further assess the results of building the conflict shape based on conflict dyads, i.e., pairs of conflict actors, as reflected in georeferenced event datasets, such as UCDP GED (Sundberg and Melander, 2013). Figure 8 shows the difference between our approach and the dyadic one in the conflict in Syria/Iraq. In map 8.1, the conflict shape is based on conceptualizing conflict as a fluid multi-actor phenomenon. In map 8.2, the conflict shape is based on conceptualizing it as a dyad. The conflict in Iraq's dyadic representation as a conflict between Iraq's government and ISIS ignores ISIS battles with other conflict actors across Kurdish territories in Syria, Iraq, Turkey, and Iran. It omits the emergence of a new dominant actor, Syria's government. The conflict shape's shifting expansion into Syria remains an analytical blind spot.

| Armed conflict | Conflict overlap | | | | |
|--|-------------------|-------------------|----------|--------------------|----------|
| | Buffer size 50 km | Buffer size 75 km | | Buffer size 100 km | |
| | % | % | Same SC* | % | Same SC* |
| Armed conflict in Colombia (2006 - 2011) | 88.8 | 89.5 | Yes | 90.2 | Yes |
| Armed conflict in Colombia (2012 - 2016) | 91.3 | 92.0 | No | 92.8 | Yes |
| Armed conflict in the Lake Chad region (2011 - 2016) | 48.3 | 53.3 | Yes | 57.5 | Yes |
| Armed conflict in the broader Afghanistan-Pakistan border area (2006 - 2008) | 96.4 | 97.0 | Yes | 97.6 | Yes |
| Armed conflict in Syria and Iraq (2010 - 2013) | 58.9 | 64.3 | Yes | 68.3 | Yes |
| Armed conflict in Syria and Iraq (2014 - 2016) | 93.1 | 93.4 | Yes | 93.8 | Yes |

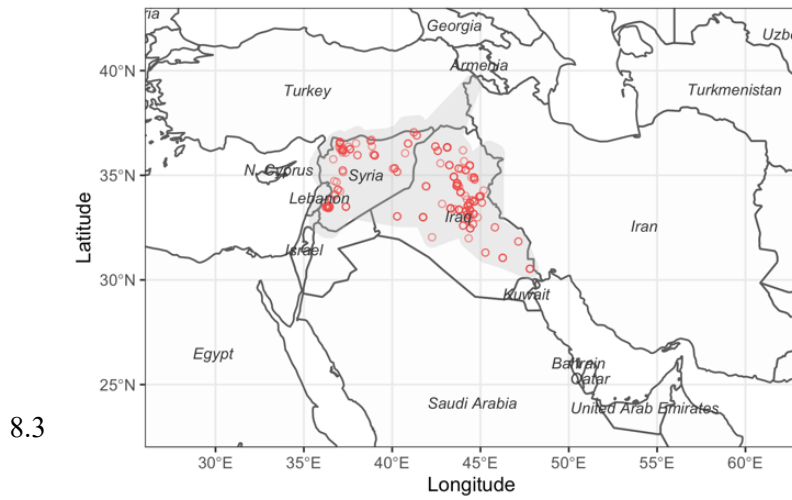
Table 9: Results of the alternative buffer specification. *SC means spatial change.



8.1



8.2

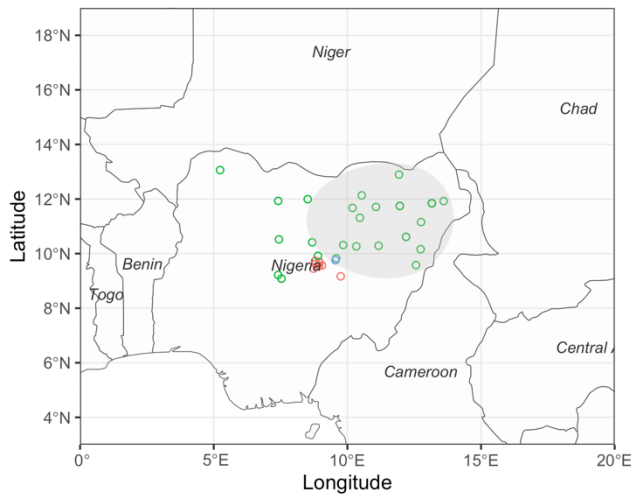


8.3

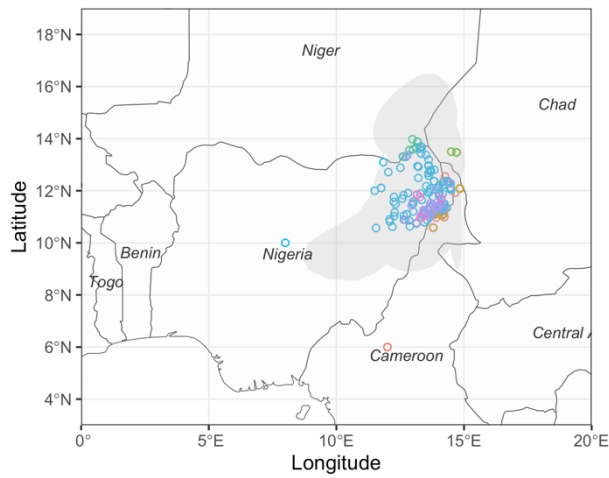
Figure 8: Multi-actor conceptualization of the conflict (8.1) and dyad Government of Iraq and ISIS (8.2), with the conflict shape in light and conflict hotspots in dark color, respectively. Conflict events with the involvement of ISIS in 2013 (8.3). Gray polygon and red circles represent the conflict shape and conflict events, respectively, per the multi-actor conceptualization proposed in this article.

Alternative operationalization of the conflict shape: Wzone dataset

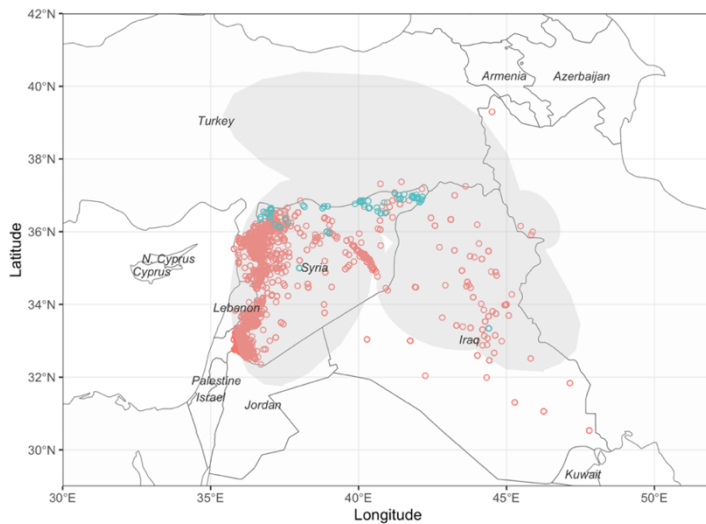
We construct polygons from Kikuta's (2022) Wzone dataset as an alternative to the conflict shapes. The Wzone Dataset relies on UCDP GED data and provides daily polygons for conflict dyads and armed conflicts. Unlike conflict shapes, Wzone polygons apply weights to conflict events based on the number of casualties assigned to a given conflict event. Figure 9 shows Wzone polygons with respect to the conflict events relevant to the armed conflict in the Lake Chad region in 2011 (9.1) and 2016 (9.2). The Wzone polygon for 2011 does not overlap with some of the conflict events. There are no Wzone polygons for the Hausa-Fulani and Hausa-Sayawa dyads. The Wzone polygon for 2016 covers a large area without conflict event.



9.1



9.2



9.3

Figure 9: Wzone polygons (gray polygons) and conflict events (circles). Lake Chad region conflict shape in 2011 (9.1) and 2016 (9.2); Syria/Iraq conflict shape in 2013 (9.3).

We replicate the spatial analysis of cases and present the results for all cases. We select the conflict dyads based on the list of actors involved in each case study. Per Kikuta's (2022) recommendation, we create Wzone polygons for individual dyads and aggregate them into a final polygon for the umbrella conflict. We calculate

hotspots based on the Getis-Ord algorithm. WzoneData miss some of the dyads we included in our original analysis, such as Government of Afghanistan-Hizb-i Islami-yi Afghanistan (armed conflict in the Afghan-Pakistani borderlands, 2008) and AUC-FARC (armed conflict in Colombia, 2006). Dyads without Wzone polygons typically represent few conflict events except for the dyad Government of Syria-IS in 2010. However, if spatially clustered, they may affect the hotspot location or the final polygon shape. Figure 9.3 shows how conflict events of dyads without Wzone polygons cluster in the Syria-Turkey border area in 2013.

The replication using the Wzone dataset differs from the results obtained with the methodology to construct conflict shapes. It missed one of the three spatial shifts we demonstrated in the article: it suggests expansion rather than shifting contraction for the conflict shape in the Lake Chad region (2011-2016). We also include non-dominant actors in the analysis to probe our claim's relevance and not bias our empirical analysis against non-dominant actors.

Colombia conflict shape (2006–2011)

Overlap: 95.02 percent (shape: 100 percent, hotspots: 90.04 percent)

Spatial change: no shift

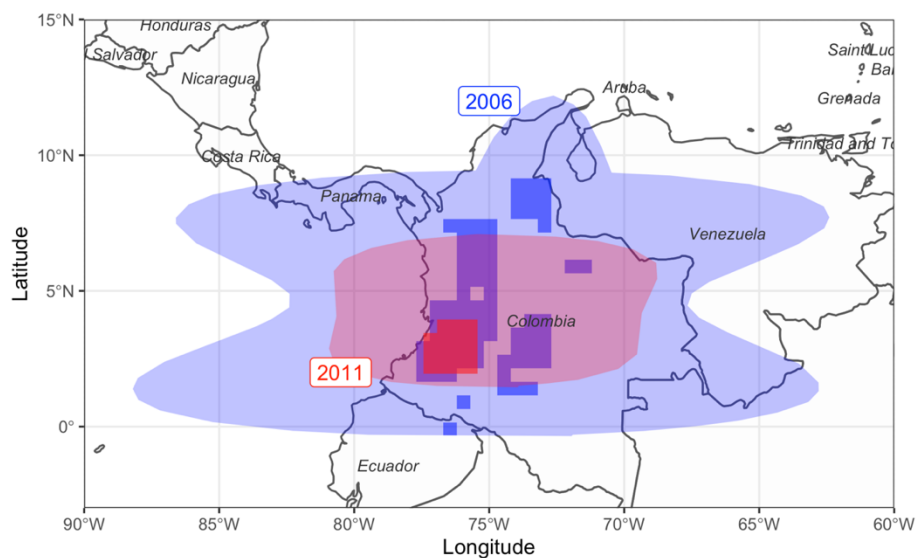


Figure 10: Spatial change in the Colombia conflict shape (2006 - 2011) based on wzoneData (Kikuta, 2022). The hotspots are the darker blue and red shapes.

Colombia conflict shape (2012–2016)

Overlap: 32.55 percent (shape: 65.10 percent, hotspots: 0 percent)

Spatial change: shift

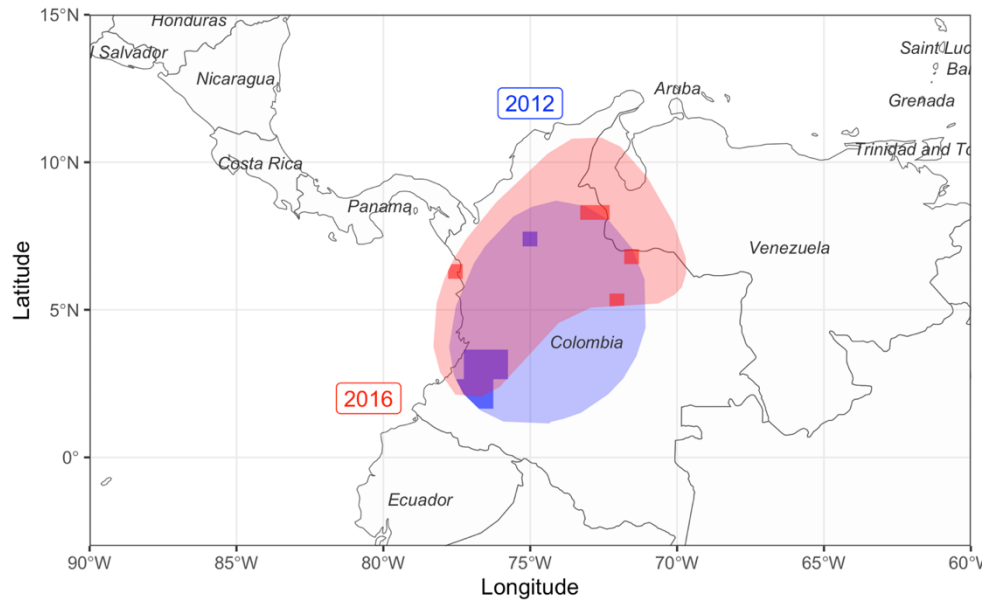


Figure 11: Spatial change in the Colombia conflict shape (2012 - 2016) based on wzoneData (Kikuta, 2022). The hotspots are the darker blue and red shapes.

Lake Chad region conflict shape (2011–2016)

Overlap: 50.56 percent (shape: 65.30 percent, hotspots: 35.81 percent)

Spatial change: no shift

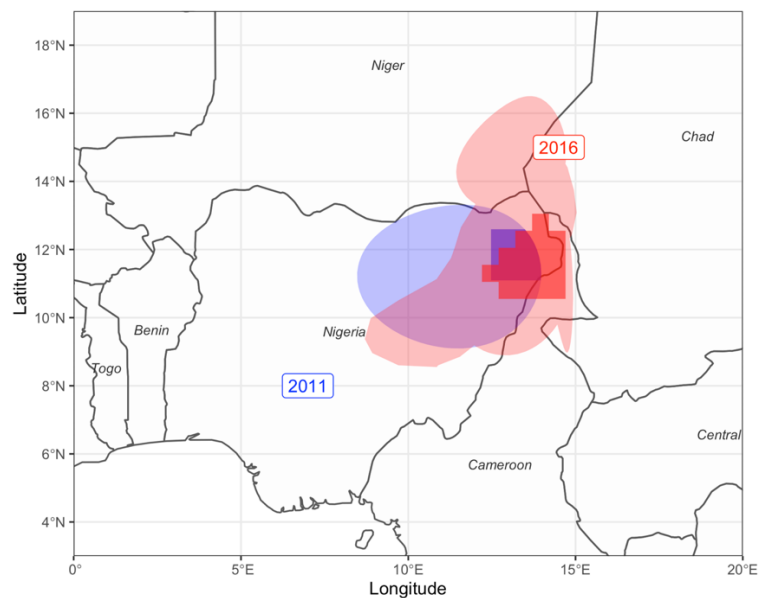


Figure 12: Spatial change in the Lake Chad region conflict shape (2011 – 2016) based on WzoneData (Kikuta, 2022). The hotspots are the darker blue and red shapes.

Afghan-Pakistani conflict shape (2006 – 2008)

For our calculations, we remove the United States-al-Qaeda dyad because not all of the conflict events assigned to this dyad are part of the armed conflict in the Afghan-Pakistani borderlands.

Overlap: 71.48 percent (shape: 100 percent, hotspots: 42.96 percent)

Spatial change: no shift

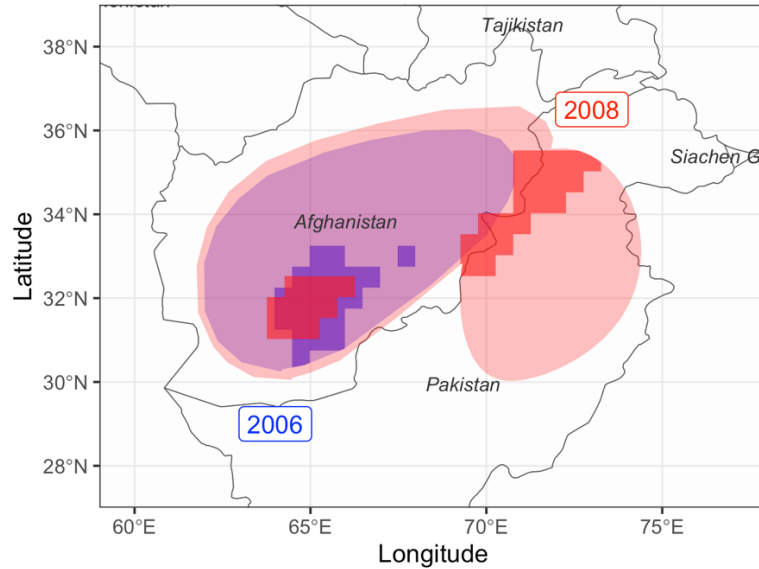


Figure 13: Spatial change in the Afghan-Pakistani conflict shape (2006 – 2008) based on WzoneData (Kikuta, 2022). The hotspots are the darker blue and red shapes.

Syria/Iraq conflict shape (2010–2013)

We remove the United States-al-Qaeda dyad because not all of the conflict events assigned to this dyad are part of the armed conflict in Syria/Iraq.

Overlap: 37.54 percent (shape: 75.09 percent, hotspots: 0 percent)

Spatial change: shift

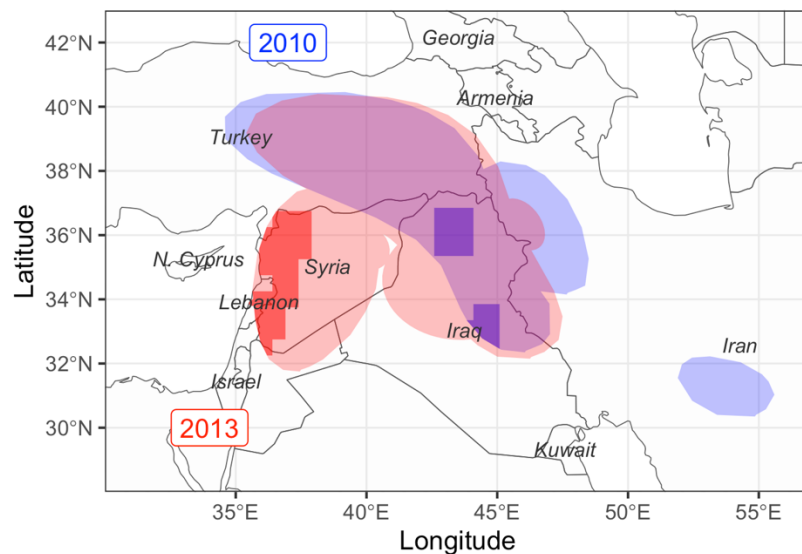


Figure 14: Spatial change in the Syria/Iraq conflict shape (2010 - 2013) based on WzoneData (Kikuta, 2022). The hotspots are the darker blue and red shape

Syria/Iraq conflict shape (2014–2016)

We remove the United States-al Qaeda dyad because not all of the conflict events assigned to this dyad are part of the armed conflict in Syria/Iraq.

Overlap: 54.04 percent (shape: 87.61 percent, hotspots: 20.46 percent)

Spatial change: no shift

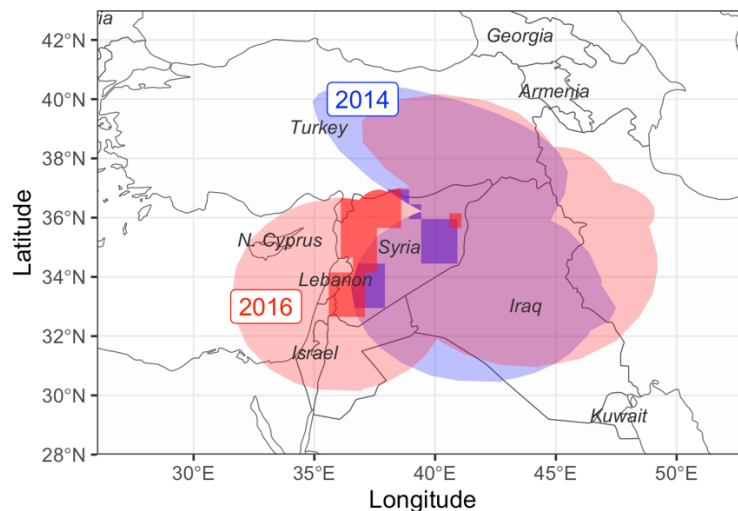


Figure 15: *Spatial change in the Syria/Iraq conflict shape (2014 - 2016) based on WzoneData (Kikuta, 2022). The hotspots are the darker blue and red shapes.*

Software

We used R software version 4.1.2 “Bird Hippie” for all calculations. List of the key R packages: Tidyverse (Wickham et al., 2019), Concaveman (Gombin et al., 2017), Igraph (Csardi and Nepusz, 2006), Network (Butts, 2008), Rnaturalearth (South, 2017), Sf (Pebesma, 2018), Ggplot2 (Wickham, 2016).

Data availability

Data are available on the journal website as well as on GitHub, together with the relevant R code: <https://github.com/Global-Security-Programme/Conflict-shapes-in-flux>

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¹ The authors and trained research assistants collected the data; the authors double-blind coded a random sample of coded data for each case to ensure the quality and consistency of coding.

² To filter out the events from the UCDP GED we use their variable where_prec and include all events with values equal or smaller than four.

³ The first potential outlier is the most detached event. We select the rest of the possible outliers by moving systematically in a counter-clockwise spiral until all potential outliers are examined.

⁴ The percentage is loosely guided by the methodology for the convex hull of the UCDP polygon, which uses 20 percent.

⁵ We follow George (1979) and consider a case to be ‘an instance of a class of events of interest to the investigator,’ quoted in Bennett (2004: 20–21).

⁶ For a discussion of ‘contrast space,’ see Collier and Mahoney (1996: 88).

⁷ Data for the cases were collected by the authors and research assistants.

⁸ For more detailed discussions of the Colombian armed conflict see, e.g., (Gray, 2008; McDougall, 2009; Safford and Palacios, 2002; Sanín, 2008).

⁹ For instances when widely used terms or abbreviations are different than the ones in UCDP GED.

¹⁰ Dominant actor in the studied period 2006–2011.

¹¹ Dominant actor in the studied period 2006–2011.

¹² For more detailed discussions on Boko Haram insurgency see, e.g., (Aghedo and Osumah, 2015; Foyou et al., 2018; Iyekekpola, 2016).

¹³ For instances when widely used terms or abbreviations are different than the ones in UCDP GED.

¹⁴ Dominant actor in the studied period 2011–2016.

¹⁵ Dominant actor in the studied period 2015–2016.

¹⁶ Dominant actor in the studied period 2011–2015.

¹⁷ For more detailed discussions on armed conflict in FATA and its historical context, see, e.g., (Haroon, 2011; Nojumi, 2002; Rehman, 2017; Schofield, 2010; Shinwari, 2010).

¹⁸ In 2018, FATA merged with the neighboring province Khyber Pakhtunkhwa.

¹⁹ For instances when widely used terms or abbreviations differ from those used in UCDP GED.

²⁰ Dominant actor in the studied period 2006–2008.

²¹ Dominant actor in the studied period 2006–2008.

²² AQI changed its name to Islamic State in Iraq in 2012 and later to Islamic State in Iraq and Syria (ISIS).

²⁴ Actors often joining forces to fight a common enemy are listed together with their own ID in UCDP GED.

²⁵ For instances when widely used terms or abbreviations differ from those used in UCDP GED.

²⁶ Some of the conflict actors are involved in more than one conflict depicted in Figure 6. If this is the case, the column gives preference to the conflict in which the actor was most involved.

²⁷ ACLED defines battles as ‘a violent interaction between two politically organized armed groups at a particular time and location.’ (ACLED, 2022: 8).

²⁸ ACLED contains many actors with generic names such as unidentified armed group, unidentified militia, or rioters. Given the lack of information about these actors, we do not include them.

²⁹ See, for example, PRIO GRID (Tollefsen et al., 2012) that uses also grids 50 kmx50 km.