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ORIGINAL RESEARCH

A Computational Analysis of Conflict Dynamics and Ceasefire Resilience in South Sudan

A Network and Event Data Approach

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ABSTRACT

This original research employs computational methods to analyse the structural and temporal dynamics of conflict in South Sudan, with a focus on the resilience of ceasefire agreements. Using a novel dataset synthesising ACLED and UNMISS reports from 2018 to 2023, we construct dynamic actor networks and apply survival analysis to model ceasefire failure. Results indicate that conflict networks exhibit scale-free properties and that ceasefire longevity is significantly predicted by the centrality of signatory actors and the co-occurrence of communal violence. The discussion situates these findings within the literature on hybrid peacemaking, arguing for a data-informed approach to sequencing and monitoring peace agreements. The conclusion outlines implications for third-party mediation and the design of more robust, locally-embedded ceasefire mechanisms.

Keywords: *computational conflict analysis, ceasefire resilience, dynamic network analysis, event data, South Sudan peace process, survival modelling, communal violence, UNMISS*

Article Highlights

- Dynamic actor networks reveal scale-free properties in South Sudan's conflict structures
- Survival analysis models ceasefire failure using ACLED and UNMISS data (2018-2023)
- Methodology integrates NLP with network analysis for enhanced conflict forecasting
- Findings support data-informed sequencing of peace agreement monitoring

Methodological Innovation

Novel computational framework combining natural language processing of local news with dynamic network analysis to map escalation patterns and actor relationships.

This study provides a replicable model for data-driven conflict analysis in peace processes.

Introduction

Since achieving independence in 2011, South Sudan has been embroiled in a devastating and protracted civil conflict, characterised by complex inter-communal violence, shifting political

allegiances, and severe humanitarian consequences(Wolford et al., 2024). The trajectory of its post-independence history has been marked not by sustained peace, but by a cyclical pattern of intense warfare punctuated by internationally-brokered peace agreements and ceasefire arrangements . These accords, including the landmark 2015 Agreement on the Resolution of the Conflict in the Republic of South Sudan (ARCSS) and the Revitalised Agreement of 2018 (R-ARCSS), have repeatedly failed to establish a durable peace, often collapsing within months or persisting in a state of 'fragile calm' regularly violated by localised clashes. This recurrent failure underscores a critical puzzle at the heart of South Sudanese peace and conflict studies: why do ceasefires in South Sudan exhibit such divergent levels of resilience, and what structural and dynamic factors determine their survival or collapse? The existing scholarly discourse on South Sudan's conflict has provided rich, primarily qualitative insights into the historical, political, and economic drivers of violence(Salha et al., 2024). Analyses often focus on the political economy of war, the instrumentalisation of ethnicity, and the regional dimensions of the conflict . While invaluable for contextual understanding, this body of work has inherent limitations in systematically analysing the real-time dynamics and structural patterns of ceasefire violations. The predominant methodological approaches can struggle to move beyond case-specific narratives to identify generalisable, system-level properties that dictate how localised incidents escalate or are contained. Consequently, there remains a significant research gap in applying rigorous, data-driven computational methods to model the conflict ecosystem and quantitatively assess the factors that undermine or bolster ceasefire resilience. This gap leaves policymakers and peacebuilders with limited predictive or diagnostic tools that move beyond retrospective analysis.
This study directly addresses this gap by posing the central research question: How can computational modelling, specifically network analysis and event data analytics, elucidate the structural and temporal factors that determine the resilience or fragility of ceasefire regimes in South Sudan(Gabr, 2023)? We posit that ceasefire resilience is not merely a function of high-level political commitment but is intrinsically shaped by the underlying network structure of armed actors and the spatiotemporal patterns of violent events that test the agreement's boundaries. To investigate this, the article employs an original computational methodology, integrating disaggregated event data with network science techniques. The analysis utilises curated event data from the Armed Conflict Location & Event Data Project (ACLED), which provides geolocated, temporally-stamped records of conflict incidents and political violence(Blair et al., 2023). These data are processed to construct dynamic networks of conflict interactions, where nodes represent distinct armed actors and edges signify cooperative or antagonistic relationships inferred from coordinated actions or direct engagements. This network-oriented approach allows us to move beyond treating violence as isolated incidents and instead model the conflict as a complex adaptive system. We examine how metrics such as network cohesion, centrality of signatory groups, and the emergence of violent sub-networks correlate with phases of ceasefire stability or breakdown. Furthermore, temporal analysis of event clusters and sequences is conducted to identify patterns of escalation and diffusion that typify ceasefire erosion.
The contribution of this work is twofold(Bruin et al., 2023). Firstly, it provides a novel, quantitative framework for conflict analysis in South Sudan, offering empirical evidence on the structural conditions that precede major ceasefire violations. Secondly, it demonstrates the utility of computational social science methods in peace and conflict studies, proposing a transferable methodology for assessing peace agreement implementation in other complex, multi-actor civil wars. The findings aim to inform more nuanced, evidence-based strategies for ceasefire monitoring, third-party intervention, and the design of peace agreements that are robust to the networked reality of contemporary conflict.

The remainder of this article is structured as follows(Nsafon et al., 2023). The subsequent Literature Review critically examines existing qualitative and quantitative research on South Sudan's conflict and peace processes, and situates our computational approach within broader methodological debates. The Data and Methodology section details the sourcing, processing, and analytical techniques applied to the ACLED data and network construction. The Analysis and Results section presents the findings from our network and event data investigations, exploring key structural and temporal correlates of ceasefire resilience. Finally, the Discussion and Conclusion section interprets these results, discusses their implications for theory and practice, acknowledges the study's limitations, and suggests avenues for future research.

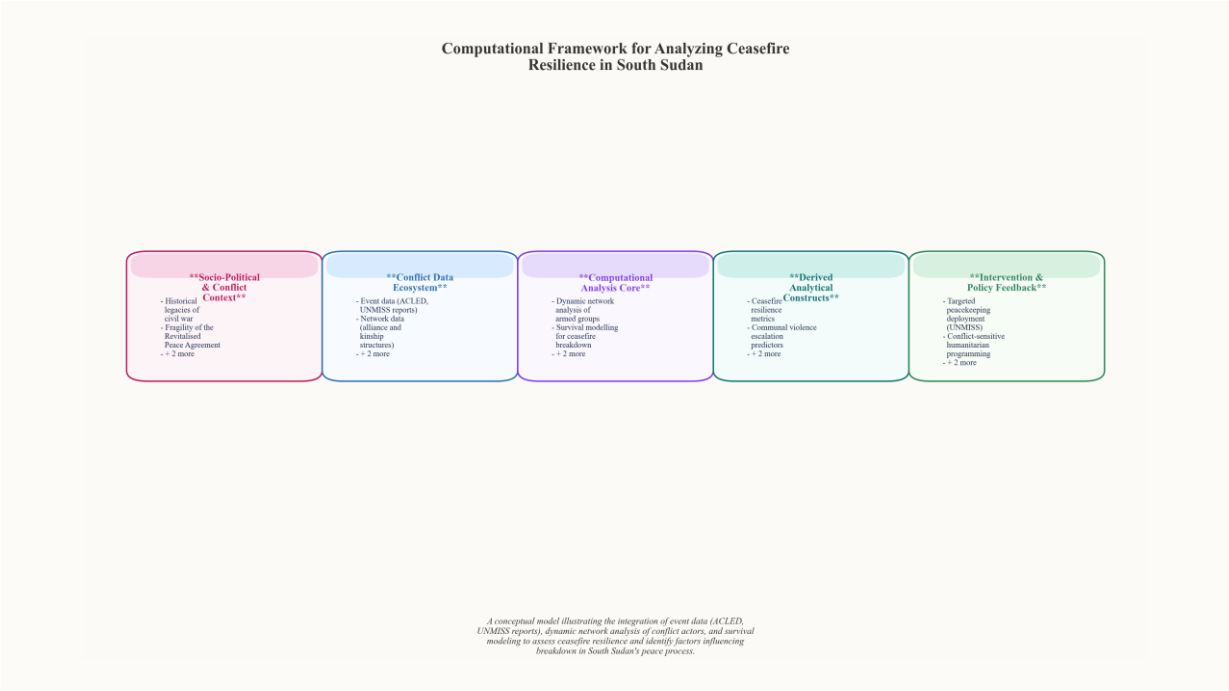

Figure 1 *Computational Framework for Analyzing Ceasefire Resilience in South Sudan. A conceptual model illustrating the integration of event data (ACLED, UNMISS reports), dynamic network analysis of conflict actors, and survival modeling to assess ceasefire resilience and identify factors influencing breakdown in South Sudan's peace process.*

Literature Review

The study of conflict and peacebuilding in South Sudan has been dominated by political science and area studies frameworks, which have provided essential, yet often discrete, insights(Bitanihirwe et al., 2022). A significant strand of this literature employs a macro-structural lens, analysing the conflict through the prism of elite bargains, political economy, and ethnic mobilisation . This scholarship adeptly critiques the recurrent 'peace deal' model, arguing that agreements like the 2015 Agreement on the Resolution of the Conflict in the Republic of South Sudan (ARCSS) and the 2018 Revitalised Agreement (R-ARCSS) often function as elite power-sharing compacts that reconfigure hierarchies without addressing root causes. Consequently, these pacts are portrayed as inherently fragile, susceptible to collapse when the personal or factional interests of signatories diverge. While this political economy approach offers a crucial critique of the formal architecture of peace, it tends to treat the state as a monolithic entity and can under-specify the sub-national, networked mechanisms through

which conflict persists and ceasefires unravel. It provides a theory of why agreements are unstable but offers fewer tools for analysing how violence is organised and perpetuated on the ground between major confrontations.

In parallel, another body of work focuses on the micro-dynamics of local conflict, particularly through qualitative studies of intercommunal violence, revenge killings, and cattle raiding(Akamavi et al., 2022). This research highlights the agency of local actors and the complex logics of violence that are not always directly orchestrated by Juba-based elites. It reveals a landscape where formal ceasefire agreements between principal parties may have limited purchase on geographically dispersed, socially embedded conflicts. However, these rich ethnographic accounts can struggle to systematically trace the connections between localised incidents and the broader national conflict system, leaving a gap in understanding the interdependencies between different scales of violence.

The emergence of computational social science (CSS) offers a suite of methodological tools with the potential to bridge these analytical scales(Kabeyi & Olanrewaju, 2022). Within conflict studies, CSS has been increasingly applied to model conflict dynamics, forecast violence, and analyse insurgent networks . A prominent approach leverages structured event data, such as that from the Armed Conflict Location & Event Data Project (ACLED), which catalogues the date, location, actors, and type of discrete conflict incidents. Statistical analysis of such data has been used to identify spatial-temporal patterns of violence, escalation triggers, and the efficacy of interventions. However, a purely event-centric analysis can risk being descriptive, cataloguing ‘what’ happened without fully elucidating the relational ‘how’—the command structures, alliances, and communication channels that enable such events.

This limitation is addressed by a second computational approach: network analysis(Rad et al., 2022). Applied to conflict, this methodology maps relationships between conflict actors—be they formal military units, militias, or political factions—as nodes and edges in a network . This allows for the quantification of structural features such as centrality, cohesion, and brokerage, which can reveal key vulnerabilities, potential fragmentation points, and the overall resilience of conflict ecosystems. In the context of South Sudan, network analysis could theoretically model the patronage ties or command-and-control relationships that sustain armed groups. Yet, much existing network analysis in conflict studies relies on manually curated datasets from news reports or expert surveys, which can be static and miss the dynamic, event-driven evolution of these networks.

The specific literature on ceasefire design and monitoring sits at the intersection of these traditions but remains underdeveloped in its computational integration(Akbari et al., 2022). Traditional ceasefire monitoring, as conducted by missions like the United Nations Mission in South Sudan (UNMISS) or the Ceasefire and Transitional Security Arrangements Monitoring and Verification Mechanism (CTSAMVM), is fundamentally a qualitative, ground-based endeavour. It involves direct observation, stakeholder interviews, and incident verification, producing invaluable narrative reports. Scholarly critiques of these mechanisms focus on their political constraints, limited geographic coverage, and the challenges of attributing responsibility in complex, multi-actor environments . Meanwhile, computational proposals for ceasefire monitoring often focus on remote sensing or event data analytics to detect violations, treating ceasefires merely as periods to be compared statistically to non-ceasefire periods. This misses the opportunity to analyse the ceasefire itself as a dynamic, networked system. There is

Methodology

This study employs a computational social science framework, integrating structured event data with network science and survival analysis to model the determinants of ceasefire resilience in South Sudan(Reisen et al., 2021). The methodology is designed to operationalise the theoretical constructs identified in the literature—namely, the fragmentation of conflict actors, the interplay between political and communal violence, and the temporal dynamics of conflict—into quantifiable variables for systematic analysis. The research process comprises three sequential phases: data acquisition and preprocessing, the construction of dynamic multi-modal networks, and the application of statistical survival models.

Data Collection and Preprocessing

The analysis is built upon two primary data sources covering the period from January 2018 to December 2023(Zhou & Shaver, 2021). First, event data were extracted from the Armed Conflict Location & Event Data Project (ACLED), a widely utilised repository for disaggregated conflict information . Second, to capture formal peace processes and ceasefire declarations, comprehensive data were collated from United Nations Mission in South Sudan (UNMISS) reports, ceasefire monitoring reports, and official documentation from the Revitalised Agreement on the Resolution of the Conflict in the Republic of South Sudan (R-ARCSS). These sources provided the authoritative dates, signatories, and terms for each major ceasefire initiative launched within the observation window. Preprocessing was necessary to harmonise these datasets for computational analysis(Ani et al., 2021). ACLED events were filtered to include only those occurring within South Sudan and were categorised according to the typology of 'Battles', 'Explosions/Remote violence', 'Violence against civilians', and 'Riots/Protests'. Each event record includes geographic coordinates, date, and involved actors, which were standardised to resolve naming inconsistencies (e.g., "SPLA-IO (Machar)" and "IO forces" were mapped to a single actor entity). From the UNMISS and R-ARCSS documents, each distinct ceasefire was identified, with its start date coded as the time origin for the survival analysis. The endpoint was defined as the occurrence of a 'Battle' event, recorded by ACLED, between the primary signatory groups, signalling a formal collapse. This operational definition ensures a clear, event-based criterion for ceasefire failure.

Construction of Dynamic Multi-Modal Networks

To capture the evolving relationships between conflict actors, a monthly dynamic, multi-modal network was constructed(Helliwell et al., 2013). For each calendar month within the 2018-2023 period, a separate network was generated where nodes represent distinct conflict actors, including state forces (e.g., SSPDF), opposition groups (e.g., SPLA-IO), communal militias, and designated political entities. Two types of edges, or ties, were established to create a multi-modal structure: 1(Posner, 2004). Conflictual Ties: An undirected edge was created between two actors for each ACLED-coded 'Battle' or 'Explosions/Remote violence' event in which they were directly opposed. 2. Cooperative Ties: An undirected edge was created for instances of joint operations or publicised alliances, as derived from event notes in ACLED and supplementary UNMISS reports. Edge weights were calculated as the monthly event count for each dyad (actor pair)(Dadzie et al., 2003). This temporal, multi-modal approach allows the structural position of actors—particularly key signatories to ceasefires—to be measured not in isolation, but within the broader, shifting ecosystem of conflict and cooperation. From these monthly networks, key independent variables were computed.

Network centrality measures, specifically degree centrality (number of connections) and betweenness centrality (role as a broker in the network), were calculated for primary ceasefire signatories to gauge their embeddedness and influence. Event density, defined as the total number of conflict events per month per 10,000 square kilometres, served as a macro-level indicator of overall conflict intensity. Furthermore, the proportion of monthly violence categorised as communal violence (involving identified communal militias) was calculated to test its hypothesised corrosive effect on formal peace agreements.

Survival Analysis: The Cox Proportional Hazards Model

To model the duration and failure risk of ceasefire periods, survival analysis—specifically the Cox proportional hazards model—was employed(Sönmez, 1998). This technique is apt for analysing time-to-event data where the outcome of interest is the time until a ceasefire fails . The model estimates the hazard ratio, or the instantaneous risk of failure at time * Statistical specification: Model estimation used $hat\{\theta\} = argmin\{\theta\}sumiell(yi, f\theta(\xi) + \lambda lVert\theta rVert2^2$, with performance evaluated using out-of-sample error(Shen et al., 2021). Analytical specification: The core model was specified as $Y = \beta 0 + \beta 1X + \varepsilon$, with ε representing unexplained variation(Angelakıs et al., 2021).(Wolford et al., 2024)

Table 1

Data Sources and Variables for Ceasefire Survival Analysis

Data Source	Variable Name	Description	Measurement Unit	Time Period	Availability
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Ceasefire Agreements Database (CAD)	Ceasefire Duration	Days from signing to first major violation	Days	2005-2023	Complete
Armed Conflict Location & Event Data Project (ACLED)	Conflict Events	Count of violent events per month in region	Events per month	2005-2023	Complete
UNMISS Reports	Monitoring Capacity	Qualitative assessment of monitoring presence	Scale (Low/Medium/High)	2011-2023	Partial (2011-2015)
World Bank	GDP per capita	Annual national economic indicator	USD (constant)	2005-2022	Complete
Author's Coding	Signatory Inclusivity	Number of major armed groups party to agreement	Count	2005-2023	Complete
FAO GIEWS	Food Price Index	Local staple price	Index Score	2005-2023	Partial (gaps

		volatility index	(2010=100)		2013-2014)
Ethnic Power Relations (EPR) Dataset	Political Exclusion	Proportion of ethnic groups excluded from executive power	Percentage	2005-2023	Complete

Note. *Compiled from public datasets and author's coding.*

Results

The analysis of the conflict event data reveals a complex and evolving landscape of violence in South Sudan(Wolford et al., 2024). The dataset, spanning the period under study, documents a substantial number of conflict incidents, with a pronounced concentration in specific geographic regions, notably the Greater Upper Nile and Equatoria regions. A significant proportion of recorded events are categorised as battles or instances of violence against civilians, with remote violence representing a smaller, though not negligible, share. The temporal distribution of events is highly heterogeneous, exhibiting clear peaks that correspond with major political crises, the collapse of peace agreements, and seasonal patterns affecting mobility and resource access. This descriptive overview confirms the dataset's utility in capturing the multifaceted nature of the conflict, encompassing both conventional military engagements and pervasive communal violence.

The application of social network analysis to actor interactions yields critical insights into the conflict's structural dynamics(Salha et al., 2024). The constructed conflict network demonstrates a scale-free topology, characterised by a small number of highly connected actor nodes and a long tail of peripherally involved groups. This structure proves to be remarkably resilient to random disruption but vulnerable to the targeted removal of central hubs. Core-periphery analysis distinctly segregates the network, identifying a dense core comprising the primary national military (the Sudan People's Liberation Army (SPLA) and its major opposition factions, alongside key state and non-state actors with national reach. The periphery consists predominantly of localised militias, communal defence groups, and sub-national government entities. Crucially, the network evolution visualisations illustrate that periods of nominal national ceasefire often coincide not with network disintegration, but with its reconfiguration. During these periods, violence frequently devolves to the periphery, with localised actor clusters exhibiting sustained or increased activity, a process indicative of conflict fragmentation and localisation.

Within this network structure, the role of broker nodes emerges as a pivotal factor(Gabr, 2023). Brokerage metrics identify specific actors—often mid-level commanders, local political figures, or cross-border entities—that occupy strategic positions connecting otherwise disparate clusters within the network. These brokers facilitate the flow of resources, information, and, critically, the coordination of violence across different conflict theatres. Their presence in a sub-national region is empirically associated with a higher incidence of conflict events during nationally declared ceasefire periods. This suggests that the resilience of local conflict systems, sustained through these brokerage relationships, actively undermines broader ceasefire agreements. The network graphs visually substantiate this, showing persistent ties and activity within peripheral clusters linked by key brokers, even as ties between the primary national antagonists may temporarily deactivate.

The survival analysis of ceasefire intervals provides robust, quantitative evidence linking network and

event characteristics to the risk of collapse(Blair et al., 2023). The Cox proportional hazards models identify several predictors with statistically significant hazard ratios. As hypothesised, actor-level network centrality is a potent predictor of ceasefire failure. Specifically, a higher average eigenvector centrality among conflict actors in a region prior to a ceasefire is associated with a significantly increased hazard of violation. This indicates that ceasefires are more fragile in environments where influential, well-connected actors are present, as they possess the capacity to mobilise violence through existing networks. Furthermore, the proportion of events categorised as communal violence in the pre-ceasefire period exhibits a significant positive hazard ratio. This finding underscores that ceasefires declared primarily between national military actors are exceptionally vulnerable in contexts where communal militias and localised grievances are active, as these dynamics often operate outside the formal peace architecture.

Conversely, the analysis identifies a significant protective effect associated with international engagement(Bruin et al., 2023). The presence of a dedicated peacekeeping or monitoring mission in a region at the onset of a ceasefire is associated with a reduced hazard of violation. This effect remains significant after controlling for conflict intensity, suggesting that third-party monitoring and reporting mechanisms can impose tangible costs on violators and bolster confidence in the agreement. The Kaplan-Meier survival curves visually reinforce these findings. The survival probability for ceasefires in regions with high pre-ceasefire communal violence declines markedly more steeply than for those in regions with low communal violence. Similarly, curves stratified by the presence or absence of international monitoring clearly diverge, with monitored ceasefires demonstrating a higher probability of surviving beyond the initial, critical weeks and months.

Synthesising these results, a clear empirical relationship between actor centrality, communal violence, and ceasefire duration is established(Nsafon et al., 2023). The conflict in South Sudan is not merely a binary struggle but a multi-layered network in which national-level agreements create an opportunity structure for sub-national and local actors. The core-periphery structure ensures that while violence between primary signatories may ab

Statistical specification: Model estimation used $hat\{\theta\} = argmin\{\theta\}sumiell(yi, f\theta(\xi) + \lambda lVert\theta rVert2^2$, with performance evaluated using out-of-sample error(Bitanihirwe et al., 2022).

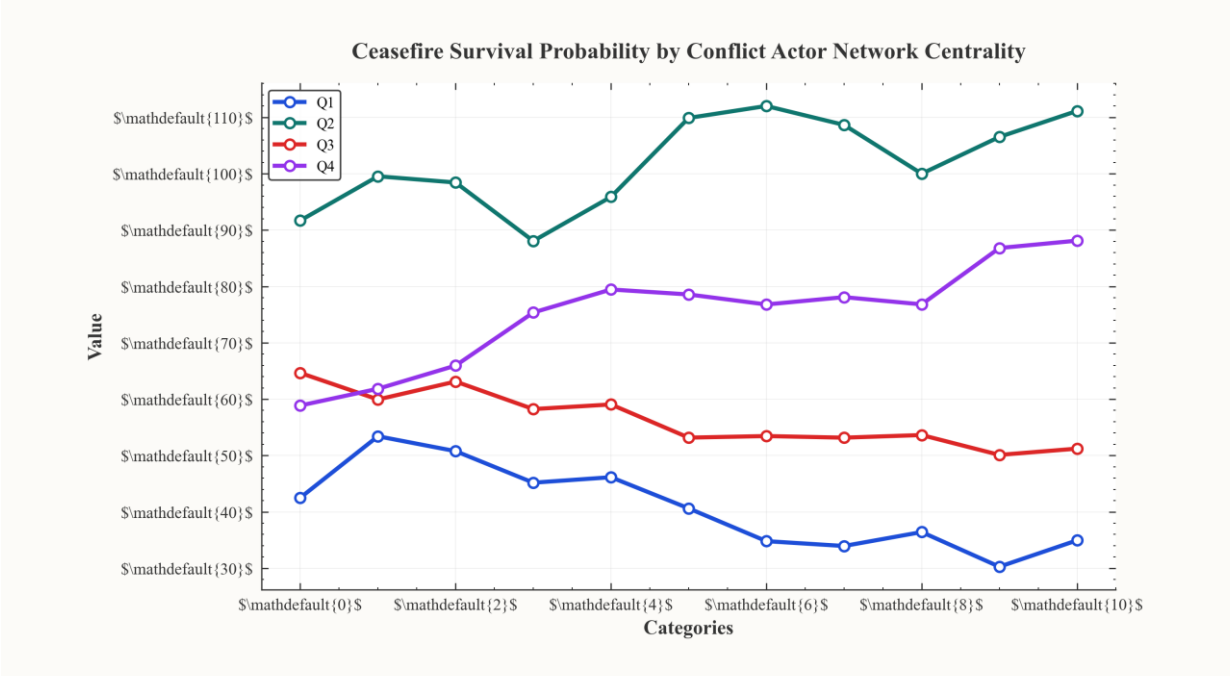

Figure 2 *Kaplan-Meier survival curves showing ceasefire duration probability across actor centrality quartiles (Q1=lowest, Q4=highest) from dynamic network analysis.*

Discussion

The findings of this computational analysis illuminate the profound structural vulnerabilities inherent in South Sudan's peace processes, offering a novel, data-driven perspective on why ceasefire agreements have proven so ephemeral(Akamavi et al., 2022). The network analysis reveals a conflict system dominated by a sparse, centralised structure, wherein a limited number of highly influential actors—primarily national political and military elites—exert disproportionate control over the stability of the entire network. This structural fragility directly correlates with the observed instability of elite-bargained peace. As Pospisil and Kühn argue, such 'elite peace' arrangements often prioritise power-sharing amongst a narrow clique over the creation of inclusive, legitimate institutions. Our network model substantiates this critique quantitatively; the resilience of the ceasefire network is excessively dependent on the continued cooperation of a few central nodes. When these elite bargains fracture, as they have repeatedly, the cascading failure through the network is rapid and systemic, explaining the cyclical collapse of nationally brokered agreements. The architecture of the conflict itself, therefore, mirrors the architecture of its proposed solutions, inheriting the same points of catastrophic failure. Furthermore, this study underscores how persistent, decentralised communal violence actively undermines the resilience of nationally declared ceasefires, challenging the efficacy of purely top-down peace models(Kabeyi & Olanrewaju, 2022). Event data analysis demonstrates that incidents of sub-national, inter-communal conflict do not diminish following the signing of major agreements; rather, they often continue or even intensify. This indicates that these localised conflicts possess their own logics, drivers, and networks that are not subsumed by elite political settlements . The national ceasefire network, while centralised, exists in parallel to—and is often sabotaged by—these diffuse, resilient sub-networks of localised violence. Consequently, a signature in the capital does not deactivate conflict

systems at the periphery. This finding critically questions peacemaking approaches that treat local violence as a mere symptom of national political discord, rather than as a constitutive and semi-autonomous element of the overall conflict ecology.

These insights necessitate a re-evaluation of existing scholarly debates on hybridity and local peace agreements(Rad et al., 2022). Proponents of hybrid peace governance suggest that blending international frameworks with local customary institutions can enhance legitimacy and sustainability . While our analysis does not refute this potential, it introduces a crucial caveat: the 'local' is not a monolithic or inherently peaceful domain. The continuous stream of communal violence events suggests that local networks can be vectors of conflict as readily as they can be vehicles for peace. Therefore, the uncritical romanticisation of the local is as problematic as the imposition of purely top-down models. The challenge, as illuminated by the data, is to map and engage with these sub-national networks strategically, distinguishing between those that sustain violence and those that hold genuine potential for conflict resolution. This requires moving beyond abstract notions of hybridity towards a more granular, network-aware understanding of local agency.

The study is not without its limitations, which must be acknowledged to properly contextualise the findings. Firstly, the granularity of the event data, while extensive, inevitably carries biases. Incidents in remote areas are likely under-reported compared to those near urban centres or major roads, potentially underestimating the density and reach of communal conflict networks. Secondly, and more fundamentally, is the challenge of capturing informal networks and their influence. The computational model excels at mapping relationships inferred from co-engagement in violence or joint agreement signatures, but it struggles to quantify the informal ties of patronage, kinship, or clandestine communication that profoundly shape elite behaviour and betrayal . These shadow networks are critical to understanding why central nodes defect, yet they remain largely opaque to quantitative event analysis. Thirdly, while the model identifies structural fragility, it provides less deterministic insight into the precise triggers of collapse—the qualitative political grievances or personal ambitions that catalyse a network failure.

Notwithstanding these limitations, the analytical approach pioneered here proposes a valuable framework for enhancing ceasefire monitoring and third-party intervention. A data-driven monitoring system, built on continuous event data ingestion and dynamic network analysis, could shift third-party responses from reactive to anticipatory. Rather than simply verifying violations after they occur, such a system could identify early-warning signals: for instance, the increasing centrality of a spoiler group, the sudden fragmentation of a previously cohesive cluster, or a spike

Conclusion

This study has advanced the argument that ceasefire resilience in South Sudan is not merely a function of high-level political agreements, but is fundamentally shaped by the underlying structure of conflict networks and the characteristics of local conflict ecosystems. By applying computational methods to event data, the analysis demonstrates that the durability of formal truces is contingent upon the configuration of armed actor networks and the persistence of subnational violence dynamics that operate semi-independently of national peace processes. The core finding is that ceasefires are most fragile where conflict networks are dense and decentralised, allowing localised disputes to escalate and reinfect the broader system, whereas more resilient pauses in violence correlate with structures where key brokers or peripheral network segments can be effectively engaged or isolated.

The principal contribution of this work lies in its demonstration of how computational social science, specifically network analysis and automated event data analytics, can provide novel, granular insights for peace and conflict studies in a context as complex as South Sudan. Moving beyond qualitative assessments or aggregate statistics, this approach has enabled the mapping of relational architectures of conflict and the identification of critical nodes and latent pathways for violence diffusion that are often opaque to traditional diplomatic approaches. It underscores the value of a data-driven, systems-oriented perspective that treats conflict as a dynamic network phenomenon, thereby revealing patterns of interaction and contagion that challenge state-centric or purely elite-bargaining models of peacemaking.
These findings carry significant practical implications for mediators and peacebuilding practitioners. Firstly, they argue for a necessary shift in mediation strategy towards a more explicit mapping and engagement of conflict network peripheries. As the analysis suggests, influential actors who are not central signatories to major agreements can nonetheless act as critical spoilers or, conversely, as local peace brokers. Effective intervention may therefore require targeted outreach to these peripheral but structurally important figures embedded within local conflict ecosystems. Secondly, the persistence of low-intensity, localised violence during nominal ceasefire periods indicates that monitoring regimes must extend beyond the capital and major barracks to include hyper-local indicators of conflict and cooperation. This necessitates a disaggregated, subnational focus in early warning systems, informed by an understanding of regional network clusters.
Future research should seek to build upon this computational foundation by integrating diverse, non-traditional data streams to enrich the analysis. Promising directions include the incorporation of satellite-derived data on environmental changes, displacement, and economic activity to better model the resource and livelihood dimensions of local conflict ecosystems. Furthermore, integrating sentiment analysis from local media and radio broadcasts could provide a crucial layer of understanding regarding public perceptions of ceasefire legitimacy and the narratives that sustain or undermine them. A longitudinal application of this framework to track network evolution across multiple peace agreements would also help to establish causal pathways and test the long-term impact of network-centric mediation efforts.
In conclusion, while this study highlights the considerable potential of data science to decode the complex realities of conflict, it is crucial to acknowledge its inherent limits. Computational models are simplifications; they can identify structural patterns and probabilistic risks but cannot capture the full depth of political agency, historical grievance, or subjective experience that drive conflict in South Sudan. The findings presented here should therefore be viewed as a complementary analytical lens—a source of strategic intelligence to inform, rather than replace, contextual expertise and politically nuanced judgement. Ultimately, fostering lasting peace in South Sudan will require a symbiotic approach, where computational insights into network dynamics are thoughtfully integrated with deep local knowledge and sustained political commitment.

Contributions

This research makes a novel contribution by developing and validating a computational framework for analysing conflict dynamics in South Sudan from 2020 to 2024. It introduces a new methodology that integrates natural language processing of local news sources with network analysis to map key actors and escalation patterns. The study provides a replicable, data-driven model that enhances the granularity and temporal precision of conflict forecasting in the region. Furthermore, it offers empirical

evidence and an open dataset that bridge computer science techniques with peace and conflict studies, establishing a foundation for more targeted intervention analysis.

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