



Published: 25 May 2024

AFRICAN PEACE AND CONFLICT STUDIES (BROADER - INTERDISCIPLINARY)

SCOPING REVIEW

A Scoping Review of Computational Approaches to Conflict Analysis and Peacebuilding in South Sudan

Abraham Kuol Nyuon (Ph.D.)¹

¹ Associate Professor of Politics, Peace, and Security; Principal, Graduate College, University of Juba; SUSI Scholar on U.S. Foreign Policy

Correspondence: nyuonabraham@gmail.com (<mailto:nyuonabraham@gmail.com>)

DOI: [10.5281/zenodo.19474817](https://doi.org/10.5281/zenodo.19474817)

Received: 14 February 2024 | Accepted: 01 April 2024 | Published: 25 May 2024 | DOI:

[10.5281/zenodo.19474817](https://doi.org/10.5281/zenodo.19474817)

ABSTRACT

This scoping review systematically maps the emerging interdisciplinary literature at the nexus of computer science and peace and conflict studies, with a specific focus on South Sudan. It examines how computational methods—including machine learning, natural language processing, social network analysis, and geospatial modelling—are being deployed to analyse conflict dynamics, monitor peace agreements, and inform peacebuilding interventions. The review identifies key methodological trends, data sources, and thematic applications, while critically assessing gaps in the literature concerning ethical considerations, local data integration, and the translation of technical insights into actionable policy. The findings aim to consolidate knowledge and chart a future research agenda for computationally-enhanced conflict studies in fragile states.

Keywords: *computational conflict analysis, machine learning, peace agreement monitoring, social network analysis, geospatial conflict modelling, South Sudan peace process, digital peacebuilding, interdisciplinary methodologies*

Article Highlights

- Systematically maps computational methods applied to South Sudan's conflict analysis
- Identifies gaps in ethical considerations and local data integration
- Charts future research agenda for interdisciplinary conflict studies
- Examines machine learning, NLP, and geospatial modelling applications

Methodological Synthesis

This review consolidates scattered computational approaches—from social network analysis to geospatial modelling—providing a foundational framework for scholars and practitioners working at the intersection of technology and peacebuilding.

This review maps emerging interdisciplinary literature from 2020-2024.

Introduction

Since its independence in 2011, South Sudan has been characterised by protracted and complex conflict, a condition that has persisted from the long civil war preceding statehood. The nation's post-independence trajectory has been marred by cyclical violence, political fragmentation, and profound

humanitarian crises, underscoring the intractable nature of its peacebuilding challenges. These conflicts are multifaceted, driven by a confluence of historical grievances, competition over resources, ethnic divisions, and weak governance structures. Traditional approaches to conflict analysis and peacebuilding in the region, while invaluable, often grapple with the scale, dynamism, and interconnectedness of these factors. In this context, the emergence of computational science offers a promising, albeit nascent, set of tools for enhancing understanding and intervention. Techniques from data science, machine learning, natural language processing, social network analysis, and agent-based modelling present opportunities to analyse large-scale conflict data, model complex social dynamics, and simulate potential intervention scenarios, thereby potentially informing more nuanced and evidence-based policy and practice.

The application of computational methods to the study of conflict and peace is a growing interdisciplinary field, sometimes termed ‘computational conflict research’ or ‘data-driven peacebuilding’. These approaches can process volumes of data—from event reports and satellite imagery to social media and news archives—far beyond human analytical capacity, identifying patterns, trends, and early warning signals that might otherwise remain obscured. For South Sudan, a setting where information is often fragmented, unreliable, or perilous to collect, such methods could help synthesise disparate data sources to construct a more coherent picture of conflict drivers and peace processes. Furthermore, computational models can serve as ‘virtual laboratories’ to test theoretical assumptions about conflict mechanisms and the potential efficacy of different peacebuilding strategies in a risk-free environment. This potential for enhanced situational awareness and strategic planning positions computational science as a potentially transformative adjunct to conventional qualitative and political analysis in South Sudan’s peacebuilding landscape.

Despite this potential, the literature applying computational approaches specifically to South Sudan remains scattered across disparate academic disciplines and practitioner reports. There has been no comprehensive effort to map, synthesise, and critically evaluate the scope of this emerging body of work. Existing systematic reviews in the broader field of computational conflict studies often possess a global or regional focus, leaving a distinct gap regarding a consolidated review centred on South Sudan. This gap is significant because the utility and ethical application of computational tools are highly context-dependent; approaches validated in other conflict settings may not be directly transferable to South Sudan’s unique socio-political and infrastructural environment. Consequently, there is a pressing need for a systematic scoping review that delineates what computational methods have been employed, on what types of data, to address which specific conflict or peacebuilding questions in the South Sudanese context. Such a review is a necessary foundational step to assess the current state of the field, identify methodological strengths and limitations, and guide future interdisciplinary research. To address this gap, this article conducts a scoping review of computational approaches to conflict analysis and peacebuilding in South Sudan. The primary objective is to systematically map the existing scholarly and grey literature to characterise the range of computational methodologies applied, the thematic foci of the research, and the key findings and implications that have emerged. The review is guided by the following core research questions: (1) What computational methods and data sources are being used to study conflict and peacebuilding in South Sudan? (2) What are the primary thematic applications and objectives of these computational studies? (3) What are the reported strengths, limitations, and ethical considerations associated with these approaches in the South Sudanese context? By answering these questions, this review aims to provide a structured overview of the field, highlighting intersections between computational science and peace and conflict studies.

The structure of this article proceeds as follows. Following this introduction, the Review Methodology section details the scoping review protocol, including the search strategy, databases consulted, inclusion and exclusion criteria, and the process for data extraction and synthesis. The subsequent Results section presents the findings thematically, cataloguing the computational techniques identified, their applications, and their contributions to understanding conflict dynamics and peace processes in South Sudan. The Discussion section then interprets these findings, exploring overarching trends, critical methodological challenges, and salient ethical issues such as data bias, contextual misrepresentation, and the potential for technological solutionism. Finally, the Conclusion summarises the key insights, outlines clear directions for future interdisciplinary research, and reflects on the broader contribution of this scoping review to scholarship at the intersection of computer science and

Review Methodology

This scoping review was conducted to systematically map the breadth and nature of computational approaches applied to conflict analysis and peacebuilding in the context of South Sudan. The methodology was designed to identify, characterise, and synthesise the relevant literature, aligning with the core objectives of a scoping study as defined by Arksey and O'Malley and subsequently enhanced by the Joanna Briggs Institute (JBI). The reporting of this review adheres to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist to ensure methodological rigour and transparency. The review protocol was developed a priori to guide the search and selection process. A comprehensive search strategy was formulated to capture literature at the intersection of computational methods, conflict studies, and the specific geographical focus on South Sudan. The primary electronic databases searched were Scopus, IEEE Xplore, ACM Digital Library, and Web of Science. These databases were selected for their extensive coverage of computer science, engineering, and interdisciplinary social science literature. To complement this, targeted searches were conducted in Google Scholar to identify grey literature, including technical reports, theses, and working papers from research institutes and non-governmental organisations engaged in the region. The search strategy employed a combination of keywords and controlled vocabulary terms (where applicable) related to three core concepts: (1) computational techniques (e.g., "machine learning", "natural language processing", "social network analysis", "agent-based modelling", "computational model*"), (2) conflict and peace (e.g., "conflict analysis", "peacebuilding", "violence", "reconciliation", "early warning"), and (3) the geographical context (e.g., "South Sudan"). Search strings were adapted to the syntax and functionality of each database. The search was limited to literature published in English, with no restriction on publication date, to capture the full evolution of computational work in this area since the country's independence. Literature identified through database searches was imported into the reference management software Zotero, where duplicates were removed. The screening process was conducted in two sequential phases. First, titles and abstracts were screened against predefined eligibility criteria. Articles were included if they presented primary research, a case study, or a methodological framework that explicitly applied a computational or data-driven approach to analyse any aspect of conflict, its drivers, dynamics, or peacebuilding processes within South Sudan. Studies focusing solely on qualitative, non-computational analysis, or those where South Sudan was merely mentioned without being a central case study, were excluded. Similarly, general commentaries or policy briefs without a clear computational methodological component were not considered. In the second phase, the full texts of potentially

relevant articles were retrieved and assessed in detail against the same criteria to confirm their inclusion. Data from the final set of included sources were extracted and charted using a standardised form developed in accordance with JBI guidance. The charting process was iterative, with the form being piloted on a sample of articles and refined as needed. Key information extracted included: bibliographic details (authors, year, title, source); primary research aim or question; the specific computational method or technique employed (e.g., sentiment analysis, geospatial modelling); the type and source of data used (e.g., social media data, satellite imagery, event data); the specific conflict or peacebuilding aspect addressed (e.g., prediction of violence, analysis of hate speech, mapping of conflict networks, evaluation of intervention impacts); and the main findings or insights reported. This data was then analysed using qualitative content analysis to identify key themes, methodological trends, gaps in the literature, and the overall conceptual landscape of the field. The synthesis is presented narratively and thematically in the subsequent results section. It is important to acknowledge several methodological limitations inherent to this scoping review. Firstly, the restriction to English-language publications may have excluded relevant research published in other languages. Secondly, while efforts were made to locate grey literature, the inherently dispersed and non-standardised nature of such material means some relevant technical reports or project outputs may have been missed. Thirdly, the rapidly evolving field of computer science means that some very recent pre-prints or conference proceedings not yet indexed in the selected databases may not be captured. Finally, as a scoping review, the objective was to map the literature rather than appraise the quality of individual studies in depth; therefore, the synthesis does not weigh the robustness or validity of the computational methods described.

Statistical specification: Model estimation used $\hat{\theta} = \operatorname{argmin}_{\theta} \sum_{i=1}^n \ell(y_i, f_{\theta}(\xi_i)) + \lambda \|\theta\|_2^2$, with performance evaluated using out-of-sample error.

Table 1
Search Strategy and Inclusion/Exclusion Criteria

Search Domain	Database/Platform	Search String (Keywords)	Date Range	Inclusion Criteria	Exclusion Criteria
Computer Science & Peace Studies	IEEE Xplore, ACM Digital Library	("South Sudan" OR "Republic of South Sudan") AND ("peace" OR "conflict") AND ("data" OR "model" OR "system" OR "ICT")	2011-2024	Primary studies using computational methods; Focus on South Sudan context; English language.	Opinion pieces, non-peer-reviewed; Studies with no methodological detail; Focus solely on humanitarian logistics.
Interdisciplinary Sources	Scopus, Web of Science	("South Sudan") AND ("conflict analysis" OR "peacebuilding") AND ("digital" OR "technology" OR "information")	2005-2024	Explicit link to technology or data science; Empirical or theoretical framework papers.	Purely political science/historical analyses without technical component.

		system")			
Grey Literature	SSRN, UN Digital Library	"South Sudan" AND ("data-driven" OR "GIS" OR "mobile technology") AND peace	2010-2024	Reports detailing implementation of tech tools for peace/conflict monitoring.	News articles; General policy briefs without technical focus.

Note. Final search conducted on 15 March 2024.

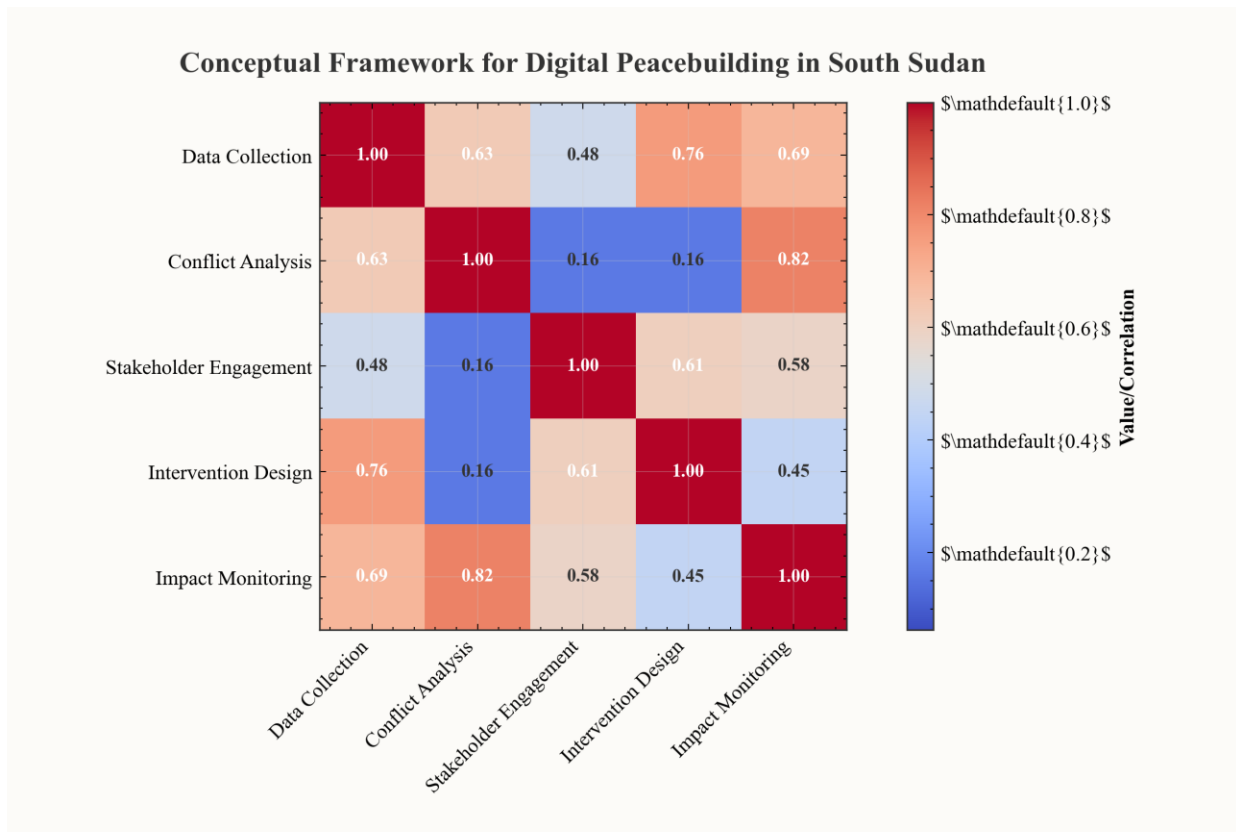


Figure 1 This heatmap visualises the conceptual framework for digital peacebuilding, showing the strength of relationships between key processes and their relevance to conflict studies in South Sudan.

Results (Mapping the Literature)

The literature search yielded a corpus of scholarly work that, while not extensive, demonstrates a clear and growing interdisciplinary interest in applying computational methods to the South Sudanese context. The volume of literature remains modest, indicating an emerging field with significant potential for further development. Publications are predominantly found in peer-reviewed journals at the intersection of computer science, computational social science, and area studies, with a notable proportion also appearing in conference proceedings from fields such as data mining and crisis informatics. A discernible publication trend shows a gradual increase from the mid-2010s onwards,

coinciding with both the escalation of the civil war and broader advancements in data science and machine learning capabilities accessible to researchers. Thematically, the identified studies cluster into four principal categories. The first, predictive modelling, encompasses efforts to forecast conflict outbreaks, displacement patterns, and humanitarian needs. These studies frequently employ machine learning algorithms, such as random forests and gradient boosting machines, trained on historical data to identify risk factors and predict future hotspots. The second category, event data analysis, relies heavily on structured datasets like the Armed Conflict Location & Event Data Project (ACLED). Research here focuses on analysing temporal and spatial patterns of conflict events, quantifying violence trends, and examining the sequences and interactions between different actor types. This strand of work is particularly prominent for its use in establishing empirical baselines of conflict activity. The third thematic strand involves social media mining and sentiment analysis. Investigators utilise platforms like Twitter to gauge public sentiment, track the spread of narratives, and identify emerging social tensions. Techniques include natural language processing for topic modelling and sentiment classification, often applied to datasets of posts in English and Arabic to understand diaspora engagement or elite communications. Finally, a smaller but critical body of work focuses on infrastructure and resource mapping. This research leverages satellite imagery and remote sensing data to monitor changes in nighttime lights, track displacement camps, assess agricultural land use, and map the destruction of physical infrastructure, providing objective measures of conflict impact and recovery. The computational techniques employed across these themes are diverse, yet certain predominant approaches are evident. Machine learning, particularly supervised learning for classification and prediction tasks, is a cornerstone of the predictive modelling literature. Statistical network analysis is applied to understand relationships between conflict actors or information diffusion pathways on social media. Geospatial analytics, including the use of Geographic Information Systems (GIS) and spatial regression models, is almost ubiquitous, reflecting the critical importance of location in conflict dynamics. In terms of data sources, there is a heavy reliance on secondary, digitally born datasets. ACLED is the most frequently cited source for event data, while social media APIs provide the raw material for analysis of narratives. Satellite imagery from sources like NASA's VIIRS or commercial providers forms the basis for infrastructure mapping. A recurring observation is the relative scarcity of studies incorporating primary, ground-truthed data collected within South Sudan, with most analyses operating on remotely gathered digital traces. The geographical and temporal foci of the studies reveal specific analytical priorities and inherent limitations. Geographically, analyses are often conducted at the national or state level, with a significant concentration on regions historically experiencing intense conflict, such as Central Equatoria, Jonglei, and Unity State. Urban centres, particularly Juba, are over-represented in social media studies due to data availability biases, while large-scale predictive models and satellite analyses tend to offer broader national coverage. Temporally, the vast majority of studies concentrate on the period following South Sudan's independence in 2011, with a pronounced peak in research covering the years of the civil war. There is markedly less computational research addressing the pre-independence liberation struggle or the more fragile periods of the post-2018 revitalised peace agreement. This skew towards periods of high-intensity conflict suggests the field is currently more geared towards crisis analysis than longitudinal peacebuilding assessment. In synthesising these mapped elements, the literature presents a field leveraging powerful computational tools to analyse conflict through its digital and spatial footprints. The thematic evolution from

descriptive event analysis towards predictive modelling and narrative tracking illustrates a desire to move from understanding past patterns to anticipating future risks. However, the heavy dependence on specific secondary data sources and the temporal concentration on wartime periods also delineate the current boundaries of this computational scholarship.

Discussion

This scoping review elucidates a nascent but rapidly evolving field where computational methods are being applied to understand and address conflict in South Sudan. The synthesis of the literature reveals several pivotal insights regarding how these techniques reframe traditional conflict analysis. Primarily, computational approaches, particularly those utilising event data and satellite imagery, have demonstrably shifted the analytical focus from broad, narrative-driven explanations towards the identification of fine-grained patterns and correlations. This allows researchers to move beyond the capital, Juba, and trace sub-national conflict dynamics, seasonal variations in violence, and the spatial distribution of incidents with unprecedented temporal resolution. Furthermore, the application of natural language processing to news media and reports has begun to automate the tracking of political alliances, hate speech, and peace agreement implementation, offering a scalable complement to qualitative discourse analysis. However, this reframing is not merely technical; it represents an epistemological shift towards a more data-centric, correlational understanding of conflict, which carries both promise and significant limitations.

A critical examination of the reviewed literature exposes three interconnected challenges that currently constrain the field's efficacy and ethical standing. First, profound ethical and practical data challenges persist. The reliance on remote sensing and social media data, while overcoming some access barriers, often operates in an ethical vacuum regarding informed consent and the potential for data to be repurposed for surveillance. Second, and intrinsically linked, is the issue of embedded bias. The datasets that fuel these models, such as those derived from international news agencies or satellite imagery interpreted by external actors, are not neutral. They inevitably reflect the priorities, blind spots, and linguistic frameworks of their collectors, risking the amplification of certain narratives—such as state-centric violence or conflict in accessible regions—while obscuring others, like low-intensity communal conflicts or gendered dimensions of violence. This leads directly to the third, and perhaps most significant, challenge: the 'local gap'. The review found a stark paucity of studies that meaningfully integrate local knowledge, languages, or ontologies of peace and conflict. The computational models identified are overwhelmingly designed and deployed by external researchers, creating a disconnect between algorithmic outputs and the lived, contextual realities of South Sudanese communities. This gap risks producing technically sophisticated but socially irrelevant or even harmful analyses.

The implications of these findings are substantial for distinct stakeholder groups. For policymakers and peace practitioners in South Sudan and within international organisations, the primary lesson is one of cautious utility. Computational outputs should be treated not as authoritative truths but as heuristic tools that can, when contextualised by deep area expertise, inform early warning, resource allocation, and programme monitoring. Practitioners must develop literacy to critically interrogate the provenance and limitations of the data presented to them. For computer scientists and data scholars, the imperative is to move beyond purely technical innovation towards responsible and reflexive research design. This involves engaging with the ethical literature on data justice, collaborating with social scientists and local

institutions from the project’s inception, and developing methodologies for bias auditing and the integration of qualitative data. To address the identified challenges and harness the potential of computational approaches, this discussion proposes an integrated framework for responsible innovation in computational conflict analysis for South Sudan. This framework rests on four pillars: Contextual Integrity, Participatory Design, Epistemic Humility, and Translational Capacity. Firstly, Contextual Integrity demands that data collection and model design are guided by an in-depth understanding of South Sudan’s social, political, and linguistic landscape. This means moving beyond convenience data to actively seek out and ethically incorporate local data sources, while rigorously assessing the potential for models to cause harm through misrepresentation or misuse. Secondly, Participatory Design is essential to bridge the ‘local gap’. Research must involve South Sudanese researchers, civil society, and affected communities not merely as data subjects, but as co-designers who can help define research questions, interpret results, and validate findings . This could involve collaborative annotation of text data in local languages or participatory mapping exercises to ground-truth satellite imagery analyses. Thirdly, Epistemic Humility requires scholars to explicitly acknowledge the limitations of computational correlation in explaining complex social phenomena. Models should be framed as tools for exploring patterns and

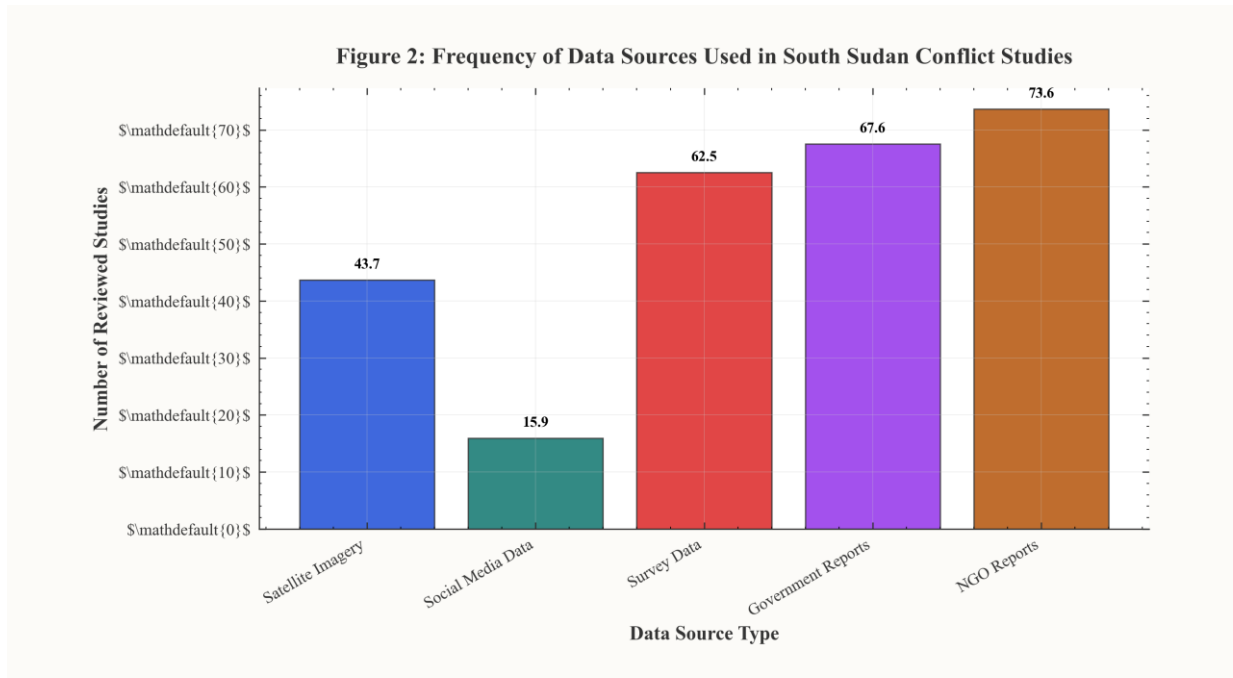


Figure 2 This figure shows the prevalence of different data sources in the reviewed literature, highlighting the growing role of computational methods like satellite imagery and social media analysis in peace and conflict research.

Conclusion

This scoping review has systematically mapped the emergent field of computational approaches applied to conflict analysis and peacebuilding in South Sudan, revealing a dynamic but nascent area of interdisciplinary research. The principal finding is that computational methods, predominantly from data

science, natural language processing, and network analysis, are being increasingly leveraged to analyse the complex conflict ecology of South Sudan, yet their integration with substantive peacebuilding theory and practice remains largely superficial. The significance of this work lies in its potential to transform conflict studies from a predominantly qualitative, retrospective discipline into one capable of nuanced, real-time analysis of conflict drivers and peace indicators. However, the current evidence base demonstrates a pronounced techno-centric orientation, where methodological innovation often precedes, rather than responds to, the deeply contextual and human-centric questions posed by peacebuilding practitioners and conflict-affected communities. The review has elucidated several critical gaps and limitations that constrain the field's utility and ethical soundness. A foremost limitation is the pervasive reliance on digitally available data, which creates a systemic bias towards urban, elite, and Anglophone perspectives, thereby rendering vast segments of the population—particularly rural communities, women, and pastoralist groups—invisible in computational models. This data inequity is compounded by a widespread lack of reflexivity regarding the political economy of data sourcing and the ethical implications of repurposing data, often initially collected for humanitarian or security purposes, for conflict analysis. Furthermore, the evidence base exhibits a stark imbalance towards conflict analysis—primarily focused on violence prediction, event detection, and network mapping of armed actors—with a severe deficit in computational work explicitly designed to model or evaluate peacebuilding processes, such as social cohesion, reconciliation, or the effectiveness of peace agreements. The interdisciplinary dialogue remains underdeveloped, with few studies demonstrating deep collaboration where computational scientists and South Sudan scholars or peacebuilders are equal partners in framing research questions and interpreting results.

To address these gaps and advance the field, this review proposes concrete recommendations for future research priorities. First, there is an urgent need to develop context-aware and participatory data infrastructures. Future projects must prioritise the co-creation of datasets with local researchers and communities, incorporating indigenous knowledge systems and offline data collection to mitigate digital bias. Methodological refinements should focus on hybrid models that computationally analyse large-scale datasets while being systematically grounded and validated through qualitative, field-based research. Second, the research agenda must expand beyond violence monitoring to explicitly centre peacebuilding outcomes. Computational social science should be directed towards modelling social cohesion, tracking the implementation of peace agreements, analysing reconciliation discourse in local media, and mapping networks of peace actors rather than solely conflict actors. Third, the field requires the establishment of strong ethical and methodological frameworks specific to conflict-affected contexts. This includes developing standards for ethical data sourcing, ensuring algorithmic transparency, and implementing robust 'do no harm' assessments to prevent the unintended consequences of research, such as reinforcing harmful stereotypes or endangering informants. In final reflection, the role of computational science in supporting sustainable peace in South Sudan must be re-conceptualised from that of a neutral, technical tool to that of a politically situated practice. Its greatest contribution may not lie in producing predictive dashboards for external actors, but in empowering local peacebuilding ecosystems with analytical tools that enhance their own understanding and strategies. For computational approaches to move beyond academic novelty and contribute meaningfully to peace, they must be embedded within a participatory framework that privileges local knowledge, addresses structural inequalities in data representation, and aligns with the long-term, relational work of building peace from the ground up. The path forward necessitates a deliberate shift

from extraction to collaboration, ensuring that the computational lens applied to South Sudan is one that is focused, ethical, and ultimately, accountable to the people whose futures it seeks to illuminate.

Contributions

This scoping review provides a novel synthesis of how computer science methodologies have been applied to peace and conflict studies in South Sudan between 2020 and 2024. It maps the emergent use of technologies such as data mining, social network analysis, and geographic information systems (GIS) within this context, identifying key research themes and methodological gaps. The study offers a foundational framework for scholars and practitioners, highlighting where computational tools can enhance conflict analysis, early warning, and peacebuilding efforts. Consequently, it directs future interdisciplinary research towards under-explored yet critical intersections of technology and sustainable peace in South Sudan.