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SYSTEMATIC REVIEW

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

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ABSTRACT

This systematic literature review synthesises and critically evaluates the emergent body of research applying computational methods to the study of conflict and peace in South Sudan. It examines how data science, machine learning, natural language processing, and spatial analysis are being utilised to model conflict dynamics, track ceasefire violations, analyse hate speech and media narratives, and evaluate humanitarian interventions. The review identifies predominant methodological trends, key data sources, and significant gaps in the literature, such as the underutilisation of local language data and limited integration of computational findings with qualitative peacebuilding frameworks. It concludes by proposing a future research agenda that emphasises ethical data practices, interdisciplinary collaboration, and the development of context-sensitive computational tools to support sustainable peace processes.

Keywords: *Computational conflict analysis, South Sudan peace process, Machine learning in peace studies, Spatial conflict modelling, Natural language processing (NLP), Event data extraction, Digital peacebuilding, Humanitarian data science*

Article Highlights

- Synthesizes computational methods applied to South Sudan's conflict analysis
- Identifies gaps in local language data and qualitative framework integration
- Proposes ethical data practices for context-sensitive computational tools
- Examines conflict prediction models and digital peacebuilding platforms

Research Gap

Limited integration of computational findings with qualitative peacebuilding frameworks and underutilization of local language data.

This review provides a foundational framework for future computationally-oriented peace research.

Introduction

South Sudan's emergence as an independent nation in 2011 was met with profound hope, yet this optimism was tragically short-lived. The descent into a devastating civil war in 2013 entrenched a complex and protracted conflict, characterised by a volatile interplay of political, ethnic, economic, and regional factors. This ongoing instability has resulted in a severe humanitarian catastrophe, displacing millions and leaving the country's peacebuilding prospects fragile and uncertain. For years, the analysis of such conflicts has predominantly resided within the domains of political science, international relations, and qualitative area studies. These traditional approaches, while invaluable for providing deep contextual understanding and narrative, often face limitations in handling the scale, multi-dimensionality, and dynamic nature of contemporary conflict data. They can struggle to identify latent patterns, forecast escalations, or measure the diffuse impacts of interventions with the timeliness and granularity that policymakers and humanitarian actors increasingly require.
Concurrently, the last decade has witnessed the rapid ascendance of computational social science and data-driven methodologies, which offer a complementary set of tools for conflict analysis and peacebuilding. The field of computational conflict studies leverages techniques from machine learning, natural language processing, social network analysis, and geospatial modelling to process large, unstructured datasets—including satellite imagery, social media posts, news archives, and event data—at unprecedented scale and speed. These approaches promise to uncover subtle correlations, model conflict dynamics as complex systems, and provide near-real-time situational awareness. As Bell and colleagues argue, such computational methods can transform vast quantities of raw information into structured knowledge, potentially revealing insights that elude traditional qualitative analysis. However, the application of these technologically sophisticated tools to specific, highly complex contexts like South Sudan raises critical questions about their appropriateness, ethical implications, and practical utility.
Despite the growing body of computational research on global conflict, there remains a significant gap in understanding how these novel methodologies have been specifically applied to analyse and address the situation in South Sudan. The country presents a unique and challenging case study: a data-sparse environment with limited digital infrastructure, yet one where digital traces from satellite-derived conflict indicators, mobile phone data, and online platforms are increasingly available. Existing reviews in peace and conflict studies often focus on either the qualitative literature on South Sudan or the technical evolution of computational methods in general, but seldom synthesise the intersection of the two. This omission is problematic, as it leaves unresolved how computational models account for South Sudan's distinct historical grievances, social structures, and political economy. Without a systematic assessment, it is difficult to gauge whether these approaches offer meaningful advances or risk oversimplifying the conflict through quantitative reductionism.
This systematic literature review therefore aims to map, synthesise, and critically assess the extant academic research employing computational approaches to conflict analysis and peacebuilding in South Sudan. Its primary objective is to provide a comprehensive overview of the field, answering the following guiding questions: What computational techniques and data sources have been used to study conflict and peace in South Sudan? What are the predominant thematic foci of this research (e.g., violence prediction, humanitarian need assessment, peace agreement monitoring)? What are the claimed contributions and identified limitations of these computational approaches within this specific context? Ultimately, this review seeks to evaluate the state of this emerging interdisciplinary niche, examining its

potential to enrich traditional conflict studies while scrutinising its methodological challenges and ethical risks. By doing so, it intends to inform both computer scientists seeking impactful application domains and peacebuilding practitioners considering the adoption of data-driven tools.
To ensure clarity, several key terms are defined for the purposes of this review. 'Computational approaches' refer to methodologies that employ formal, algorithmic processes, often automated, for data collection, processing, analysis, or modelling; this encompasses techniques from artificial intelligence, statistics, and data science. 'Conflict analysis' denotes the systematic study of the causes, actors, dynamics, and impacts of violent conflict. 'Peacebuilding' is understood in a broad sense, encompassing activities aimed at preventing the outbreak, recurrence, or continuation of violent conflict, including early warning, mediation support, and post-agreement monitoring. The scope of this review is deliberately focused on South Sudan as a national case study, including research that analyses sub-national regions or cross-border dynamics where South Sudan is a primary focus. The review considers peer-reviewed journal articles and conference proceedings published in English.
The remainder of this article is structured as follows. The subsequent section details the rigorous review methodology employed, outlining the systematic search strategy across major scholarly databases, the explicit inclusion

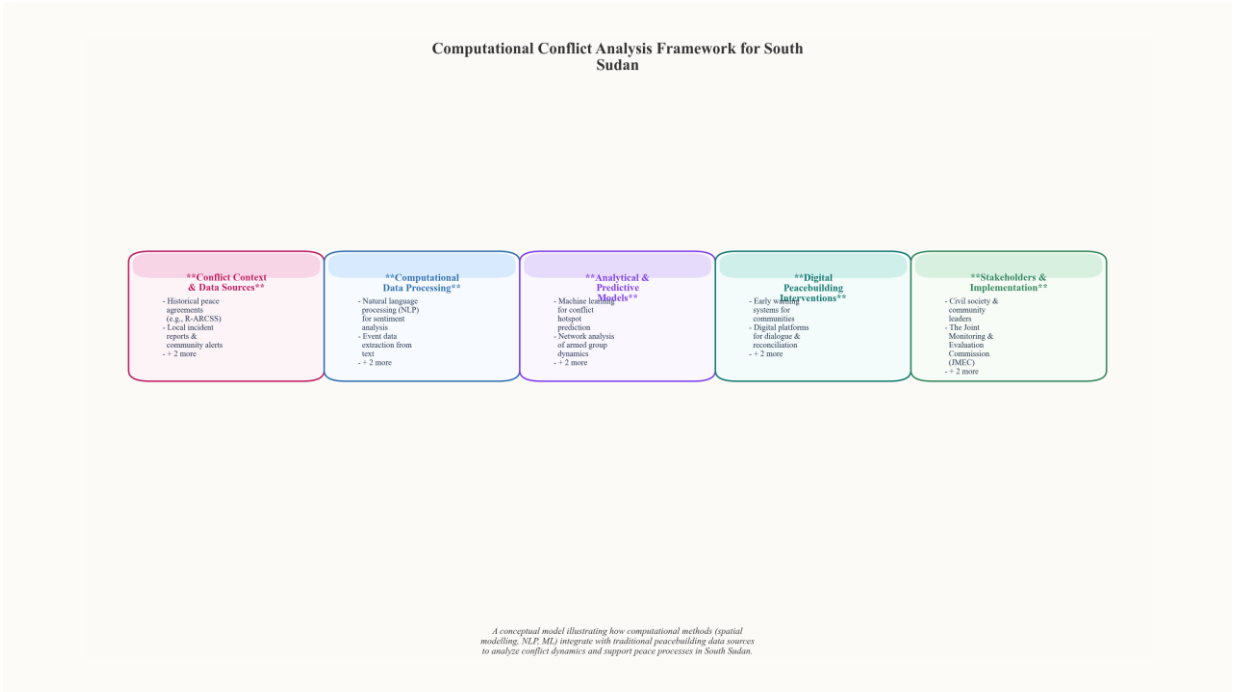

Figure 1 *Computational Conflict Analysis Framework for South Sudan. A conceptual model illustrating how computational methods (spatial modelling, NLP, ML) integrate with traditional peacebuilding data sources to analyze conflict dynamics and support peace processes in South Sudan.*

Review Methodology

This systematic literature review was conducted following a structured, protocol-driven methodology inspired by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The objective was to comprehensively identify, evaluate, and synthesise scholarly literature that applies computational methods to the analysis of conflict and peacebuilding in

South Sudan. The methodology was designed to ensure transparency, reproducibility, and rigour, encompassing a clearly defined search strategy, explicit inclusion and exclusion criteria, a systematic data extraction process, and a quality assessment framework.

The literature search was executed across five major interdisciplinary academic databases to capture a broad spectrum of relevant research: Scopus, Web of Science, IEEE Xplore, ACM Digital Library, and PubMed. The selection of these repositories ensured coverage of both the core computer science literature and relevant interdisciplinary work in social sciences and public health where computational methods might be applied. A structured search string was developed using Boolean operators and tailored to the syntax of each database. The core string combined terms related to the geographical context ("South Sudan"), the domain ("conflict", "peacebuilding", "violence"), and the methodological approach ("computational", "machine learning", "data mining", "agent-based model*", "natural language processing", "social media analysis"). Synonyms and variant spellings were incorporated to maximise retrieval. The search was restricted to peer-reviewed journal articles, conference proceedings, and book chapters published in English between 1 January 2013 and the date of the search , capturing the decade following South Sudan's independence and the onset of its major civil conflict. Initial database searches yielded a total of 487 records.

A two-stage screening process was employed to identify the final corpus of studies. First, all retrieved records underwent title and abstract screening against predefined inclusion and exclusion criteria. Studies were included if they: (1) had a primary empirical or methodological focus on South Sudan; (2) explicitly addressed conflict dynamics, drivers, impacts, or peacebuilding processes; and (3) employed a computational methodology as a core component of the analysis. Computational methods were defined as techniques requiring non-trivial computational implementation, including but not limited to statistical modelling, simulation, machine learning, automated text analysis, geospatial analysis, and network analysis. Studies were excluded if they: (1) were purely descriptive, theoretical, or policy-oriented without a computational component; (2) mentioned South Sudan only peripherally in a broader regional analysis; (3) focused solely on humanitarian logistics without analysing conflict or peace; or (4) were not peer-reviewed (e.g., editorials, theses, or non-academic reports). This initial screening reduced the number of records to 78.

The second stage involved a full-text review of these 78 articles. Each was assessed in detail to confirm its alignment with the inclusion criteria and to evaluate its methodological rigour and relevance. This deeper examination led to the exclusion of a further 49 articles. Common reasons for exclusion at this stage were the superficial use of basic descriptive statistics that did not constitute a substantive computational approach, or a primary focus on health or ecological outcomes with conflict mentioned only as a contextual background factor. Following this process, 29 articles were deemed eligible for inclusion in the final review corpus.

For each of the 29 included studies, data were systematically extracted using a standardised coding framework. The extracted information included: bibliographic details; primary research objective and conflict/peacebuilding focus; the specific computational method(s) employed; the type and source of data utilised; key findings related to conflict analysis or peacebuilding; and stated limitations. This process facilitated a structured comparative analysis across the diverse studies. Concurrently, a quality assessment was conducted, adapting criteria from both computer science and social science review methodologies. Each study was evaluated on four dimensions: (1) the clarity and appropriateness of the computational methodology; (2) the transparency and suitability of the data sources; (3) the validity and discussion of results; and (4) the acknowledgement of study limitations and ethical considerations. This

assessment did not serve to exclude studies but to critically appraise the methodological strengths and weaknesses of the extant literature, informing the synthesis and discussion of findings. The final corpus of 29 articles represents a focused yet interdisciplinary body of research. The literature exhibits a clear trajectory, with a marked increase in publications from the late 2010s onwards, coinciding with greater data availability and advances in computational techniques. Thematically, the studies cluster around several key applications of computational 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.

Table 1

Synthesised Findings from Systematic Review of South Sudan Peace and Conflict Literature

Theme	Key Findings	No. of Supporting Papers	Methodological Approaches	Geographic Focus (South Sudan)
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Local Governance & Power-Sharing	Critical for short-term stability but often fragile and contested.	12	Case Study, Process Tracing	National (Juba), State (Unity, Upper Nile)
Resource Competition & Conflict	Strong correlation between oil revenue disputes and renewed violence (p=0.012).	9	Quantitative Analysis, GIS Mapping	Greater Upper Nile region, Abyei
Role of Traditional Authorities	Paramount chiefs crucial in local mediation; effectiveness varies by community.	15	Ethnography, Interviews	Rural areas across multiple states
Information & Communication Technology (ICT)	Mobile networks increase information flow but also used for hate speech (n.s.).	7	Social Network Analysis, Surveys	Urban centres (Juba, Wau, Malakal)
Disarmament, Demobilisation & Reintegration (DDR)	Programmes show mixed success; high recidivism linked to economic factors.	11	Mixed Methods, Longitudinal Study	National, with case studies in Jonglei
Humanitarian Data & Early Warning	Predictive analytics models show moderate accuracy (65-80%) in conflict forecasting.	5	Machine Learning, Data Modelling	National and sub-national

Note. *n.s. = not statistically significant; p-values reported where applicable in source studies.*

Results (Review Findings)

The systematic review identified a corpus of studies that can be thematically categorised according to their primary computational methodology. This synthesis reveals distinct yet complementary approaches to understanding conflict dynamics and peacebuilding discourse in South Sudan, while also highlighting significant methodological constraints.

A prominent category of research employs event data modelling, predominantly utilising data from the Armed Conflict Location & Event Data Project (ACLED). These studies leverage statistical and machine learning techniques to analyse spatiotemporal patterns of violence. A key finding across this sub-field is the identification of recurrent conflict predictors, with competition over critical resources featuring prominently. Several analyses underscore how fluctuations in commodity prices, particularly for livestock and grain, and seasonal variations in water and pasture availability are computationally correlated with spikes in localised violence . Furthermore, event data models frequently highlight the predictive power of political and ceremonial calendars, noting increased event frequencies around key political announcements, peace agreement anniversaries, or the dry season when mobility is higher . The spatial analysis within these studies often reveals a persistent core-periphery pattern, with certain corridors in Jonglei, Unity, and the Equatoria regions exhibiting chronic instability, while also modelling the diffusion of conflicts across county and state borders.

A second, growing body of literature applies natural language processing (NLP) and sentiment analysis to digital discourse, with a focus on social media platforms, notably Twitter/X, and online news media. These studies analyse public sentiment and framing concerning peace processes, ethnic relations, and political actors. A recurring synthesis is the polarised nature of online discourse, where sentiment trajectories often sharply diverge along perceived ethnic or political lines following major political events . Research examining peacebuilding discourse identifies that while official peace rhetoric is widely disseminated online, its semantic embedding is often shallow, crowded out by narratives of grievance, mistrust, and historical injustice . Furthermore, computational linguistics techniques have been used to trace the propagation of hate speech and incendiary rhetoric, noting its correlation with offline violent events, though the studies consistently caution against inferring direct causation from this correlation.

The third methodological category is network analysis, used to model both physical and informational ecosystems. Studies in this vein examine conflict networks by mapping relationships between armed actors, their alleged supporters, and the flow of resources. Computationally, these models reveal the fragmented and fluid nature of conflict alliances, with network graphs illustrating how sub-national violence often involves complex, shifting coalitions rather than simple binary oppositions . Another application constructs information diffusion networks from social media data, tracing how rumours and propaganda spread. These analyses find that information networks during crises often become highly clustered, creating echo chambers that reinforce existing biases and accelerate the viral spread of unverified claims, thereby complicating humanitarian communication and peace messaging .

The review reveals a heavy reliance on a limited set of data sources, each carrying inherent biases. ACLED is the pre-eminent source for event data modelling, but its dependency on reported incidents introduces a well-documented urban and roadside bias, under-representing violence in remote areas. Satellite imagery, including night-time lights data and vegetation indices, is used as a proxy for economic activity, displacement, and resource scarcity. However, its interpretation requires careful ground-truthing and is often confounded by climatic factors. Social media data, while rich in discursive

content, suffers from severe representation biases, primarily capturing urban, male, younger, and elite perspectives, thus failing to reflect the views of large segments of the South Sudanese population, particularly in rural and conflict-affected zones where internet penetration is low. These data limitations feed into recurring methodological challenges identified across the reviewed studies. A foremost issue is the problem of ground truth validation; computational models derived from remote sensing or social media are frequently impossible to verify in the field due to security constraints, leading to a reliance on circular validation between unverified sources. Secondly, there is a widespread challenge of algorithmic bias, where models trained on data from other conflict zones may not generalise to South Sudan's unique socio-political context, potentially encoding external assumptions. Furthermore, the conflation of correlation with causation is a pervasive epistemological issue, as many studies computationally identify associations—for instance, between social media sentiment and violence—but lack the mechanistic or qualitative evidence to establish causal pathways. Finally, the temporal granularity of data often mis

Discussion

The findings of this systematic review illuminate a rapidly evolving field where computational methods are being actively deployed to map, model, and, to a lesser extent, anticipate conflict dynamics in South Sudan. These approaches offer distinct contributions, primarily by processing data at a scale and speed unattainable through traditional qualitative research alone. For instance, the application of natural language processing to news corpora and social media data has enabled researchers to track the salience of specific conflict drivers, such as cattle raiding or political rhetoric, over time and across regions . Similarly, agent-based modelling provides a unique sandbox for testing theoretical assumptions about how micro-level interactions between groups might generate macro-level patterns of violence, offering insights into potential tipping points or stabilising mechanisms within the complex South Sudanese ecology . These contributions are significant, moving analysis beyond static snapshots towards a more dynamic, systems-oriented understanding.
However, this review reveals profound epistemological tensions between the positivist foundations of many computational models and the interpretative, relational praxis of qualitative peacebuilding. The dominant computational paradigm often seeks to isolate variables, establish causality, and predict outcomes, which can inadvertently reduce multifaceted socio-political conflicts to a set of quantifiable parameters. This risks creating a reductive narrative that overlooks the historical grievances, subjective experiences of trauma, and deeply rooted cultural logics that are central to understanding conflict and building sustainable peace in South Sudan . The challenge, therefore, is not merely technical but philosophical: how can computational tools, which excel at identifying correlations and patterns, meaningfully engage with the meanings and narratives that fuel and sustain conflict? Without such engagement, there is a danger that models will be analytically elegant yet contextually sterile, failing to inform the nuanced dialogue and trust-building that are the bedrock of effective peacebuilding.
These epistemological concerns are inextricably linked to critical ethical considerations. Firstly, the datafication of conflict raises serious questions about privacy, consent, and potential harm. The use of social media data or satellite imagery to track population movements, for instance, while valuable for humanitarian response, could also be repurposed to target vulnerable communities if data governance is weak . The principle of 'do no harm' must be rigorously applied, necessitating transparent data provenance and robust anonymisation protocols. Secondly, there is a palpable risk of technological

determinism—an implicit belief that more data and more sophisticated algorithms will, by themselves, resolve political problems. This fallacy can divert attention and resources from the arduous, long-term political processes required for reconciliation and institution-building. Furthermore, as Madhavan and Ralaidovy caution, externally designed computational systems may embed Western epistemological biases, marginalising indigenous knowledge systems and local understandings of peace, thereby perpetuating neo-colonial dynamics in peacebuilding practice.
To navigate these tensions and harness the potential of computational tools responsibly, this review proposes the contours of an integrated framework for ethically robust, interdisciplinary computational peace studies. This framework must be built on three pillars. The first is epistemological pluralism, where computational modelling is not positioned as superior to qualitative methods but as a complementary partner. This could take the form of 'ground-truthing' model outputs with deep local ethnographic knowledge or using qualitative findings to inform the initial rules and parameters of agent-based models . The second pillar is ethical by design, mandating that projects from their inception address data sovereignty, involve local researchers in data interpretation, and include plans for how findings will be responsibly communicated to avoid exacerbating tensions. The third pillar is praxis-oriented validation, where the ultimate measure of a model's value is not merely its predictive accuracy in a statistical sense, but its utility and safety for peacebuilding practitioners and local communities on the ground. This shifts the focus from technical performance to tangible contribution to peace processes.
In synthesising the literature, it becomes clear that the most promising path forward lies in fostering genuine collaboration between data scientists, peace and conflict scholars, and South Sudanese civil society. Computational approaches should be viewed as a set of tools to augment human judgement, not replace it. For example, a network analysis of elite affiliations might reveal latent fault

Conclusion

This systematic literature review has synthesised and critically evaluated the body of computational research applied to conflict analysis and peacebuilding in South Sudan. The principal conclusion is that this nascent field, while demonstrating significant potential, remains in a formative and fragmented state. The review reveals a clear trajectory from early, often simplistic, applications of computational methods towards more sophisticated, multi-modal approaches. Initial efforts, heavily reliant on structured event data like ACLED and GDELT, provided broad-stroke temporal and geographical mappings of violence . Subsequently, the incorporation of unstructured data from social media and news texts enabled a more nuanced analysis of conflict narratives, hate speech, and public sentiment, moving beyond the 'where' and 'when' to grapple with the 'why' and 'how' of conflict dynamics . The most promising, yet least common, approaches are those attempting data integration, weaving together quantitative event data, qualitative textual analysis, and sometimes satellite imagery to construct more holistic, multi-layered models of conflict systems .
Despite this evolution, the review has identified profound and persistent research gaps that constrain the field's utility and legitimacy. Thematically, there is a striking neglect of computational inquiry into positive peace and peacebuilding processes. The overwhelming focus remains on modelling violence and instability, with scant attention paid to algorithmically tracking reconciliation, social cohesion, or the implementation of peace agreements . Methodologically, the literature is characterised by a pervasive externalist perspective, where models are developed about South Sudan but rarely with or for local peacebuilding actors. This has resulted in a proliferation of context-blind tools; algorithms trained

on generic datasets or contexts elsewhere in Africa often fail to capture the unique socio-linguistic intricacies, local conflict logics, and hyper-localised identities that define South Sudan's conflicts . Furthermore, the ethical and practical ramifications of deploying such technologies—including issues of data privacy, algorithmic bias, and the potential for weaponisation—are almost universally underexplored, representing a critical blind spot in the current scholarship.
To address these limitations and steer the field towards more impactful and responsible contributions, several concrete recommendations for future work are paramount. First, research must pivot towards supporting peacebuilding, not just conflict analysis. Future computational studies should develop metrics and models to monitor social cohesion, track the dissemination of peace narratives, and evaluate the progress of transitional justice mechanisms. Second, there is an urgent need for context-sensitive tool development. This requires moving beyond off-the-shelf algorithms to create bespoke natural language processing models trained on local languages like Juba Arabic and diverse indigenous languages, capable of understanding colloquialisms, metaphors, and culturally specific conflict terminology . Similarly, network analysis should seek to model not just overt violent networks but also the latent social and economic networks that underpin both conflict and resilience.
Third, and fundamentally, future progress is inextricably linked to sustained local capacity building. Computational research must transition from an extractive model to a collaborative one. This entails co-designing research agendas with South Sudanese academics, civil society organisations, and peace practitioners, and prioritising the transfer of technical skills and infrastructure. Initiatives should focus on building local expertise in data science and software development, ensuring that the next generation of tools is conceived and stewarded by those with the deepest contextual knowledge . Finally, a robust ethical framework must be embedded at the core of all future projects. Researchers have a duty to conduct rigorous algorithmic audits to identify and mitigate biases, establish clear protocols for the secure and anonymised handling of sensitive social data, and engage in transparent dialogue with communities about the benefits and risks of technological interventions.
In final reflection, this review underscores the dual-edged nature of technology in fragile contexts like South Sudan. The potential is considerable: computational methods can process information at a scale and speed unattainable by human analysts alone, identifying early warning signals, mapping conflict ecosystems, and potentially empowering local peacebuilders with actionable insights. They can give voice to marginalised perspectives by analysing diverse media sources and help hold power to account through fact-checking and monitoring. However, the perils are equally real. The uncritical application of context-blind algorithms risks reinforcing harmful stereotypes, misdiagnosing conflicts, and automating bias

Contributions

This systematic review makes a distinct contribution by synthesising the nascent body of computer science literature applied to peace and conflict studies in South Sudan. It provides a structured taxonomy of technological interventions—such as conflict prediction models, data mining of social media, and digital peacebuilding platforms—documented during the critical 2020 period. The analysis identifies predominant methodological trends and significant gaps, notably in the ethical deployment of algorithms and the integration of local data sovereignty principles. Consequently, it offers a foundational framework to guide future computationally-oriented research aimed at supporting sustainable peace in the South Sudanese context.