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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 analyses the growing body of research applying computational methods to the study of conflict and peace in South Sudan. It examines how data science, machine learning, and digital technologies are being leveraged to model conflict dynamics, track peace agreement implementation, and analyse humanitarian information flows. The review identifies predominant methodological trends, key data sources, and significant gaps in the current scholarship. It argues that while computational tools offer powerful new avenues for evidence-based analysis, their application in the South Sudanese context is often constrained by data scarcity, ethical considerations, and a disconnect from local peacebuilding praxis. The article concludes by proposing an interdisciplinary research agenda to enhance the rigour, relevance, and ethical deployment of computational peace and conflict studies in South Sudan.

Keywords: *computational conflict analysis, South Sudan peace process, systematic literature review, digital peacebuilding, conflict data science, machine learning in peace studies, humanitarian informatics, interdisciplinary methodologies*

Article Highlights

- Identifies methodological trends and key data sources in computational conflict analysis
- Highlights significant gaps in locally grounded, ethical implementations
- Proposes interdisciplinary research agenda for context-sensitive applications
- Examines disconnect between technical innovation and contextual engagement

Core Research Problem

Despite growing computational applications in conflict zones, their specific use, efficacy, and utility in South Sudan remain poorly synthesised and critically under-examined.

This review maps the intersection of computational science and traditional conflict scholarship in a fragile context.

Introduction

Since its independence in 2011, South Sudan has been embroiled in a complex and devastating civil conflict, marking its transition from a long struggle for self-determination to a nation grappling with profound internal strife. The conflict, characterised by inter-ethnic violence, political fragmentation, and cyclical humanitarian crises, has defied numerous peace agreements and international mediation efforts. This protracted instability has established South Sudan as a critical case study in contemporary peace and conflict studies, demanding innovative analytical approaches to understand its multifaceted drivers and potential pathways to sustainable peace. Concurrently, the field of computational social science has emerged as a transformative paradigm, leveraging advanced data analytics, machine learning, and simulation modelling to examine social phenomena at scale and granularity previously unattainable. The intersection of these domains—South Sudan's urgent peacebuilding challenges and the burgeoning toolkit of computational methods—forms the central concern of this systematic literature review. The application of computational techniques to conflict analysis and peacebuilding represents a significant interdisciplinary shift. Traditional methodologies in conflict studies, while rich in qualitative depth and historical context, often face limitations in processing vast, real-time datasets or in modelling the complex, non-linear interactions that typify conflicts like South Sudan's. Computational approaches, including natural language processing of news media and social media, network analysis of actor relationships, agent-based modelling of conflict dynamics, and geospatial analysis of violence and displacement patterns, promise to augment traditional scholarship. They offer the potential to identify latent patterns, forecast escalation risks, and evaluate the efficacy of interventions with a degree of systematic rigour. However, the translation of these technical capabilities into actionable insights for a context as volatile and data-scarce as South Sudan is non-trivial and fraught with epistemological and practical challenges.

This gives rise to the core research problem addressed by this review: despite a growing body of literature applying computational methods to conflict zones, the specific application, methodological efficacy, and practical utility of these approaches within the South Sudanese context remain poorly synthesised and critically under-examined. Much of the existing computational research operates in a disciplinary silo within computer science, often prioritising methodological innovation over deep contextual engagement with the nuances of South Sudan's political economy, social fabric, and historical grievances. Consequently, there is a pressing need to systematically map and evaluate this emerging corpus of work. Key questions persist regarding which computational techniques have been deployed, what types of data they utilise, how they conceptualise conflict and peace, and to what extent their findings align with or challenge established knowledge from peace and conflict studies. Furthermore, the ethical implications of data sourcing, algorithmic bias, and the potential for technological solutionism in a fragile political environment demand careful scrutiny.

To address this gap, this paper conducts a systematic literature review of computational approaches to conflict analysis and peacebuilding with a dedicated focus on South Sudan. The primary objectives are threefold. First, to systematically identify, categorise, and critically appraise the extant academic literature at the nexus of computer science and South Sudan conflict studies. Second, to analyse the predominant computational methodologies, their underlying assumptions, data sources, and stated contributions to understanding conflict dynamics or peacebuilding processes. Third, to evaluate the interdisciplinary dialogue—or lack thereof—between computational sciences and traditional conflict scholarship, identifying barriers and opportunities for more integrated, context-sensitive research. These

objectives are operationalised through the following research questions:
What is the scope and nature of the literature applying computational methods to conflict and peacebuilding in South Sudan?
Which specific computational techniques and data sources are predominantly employed, and what are their respective strengths and limitations in this context?
How do these computational studies conceptualise and operationalise core conflict and peacebuilding variables, and what insights do they claim to generate?
What are the prominent epistemological and practical challenges, including ethical considerations, associated with this interdisciplinary endeavour?
The contribution of this review is therefore aimed at synthesising a fragmented field, providing a critical foundation for scholars and practitioners in both computer science and peace studies. For computer scientists, it contextualises technical work within the real-world complexities of a protracted conflict, encouraging more reflexive and ethically grounded methodological development. For conflict scholars and peacebuilding practitioners, it demystifies the potential and pitfalls of computational tools, fostering informed engagement with data-driven approaches. By bridging this interdisciplinary divide, the review seeks to promote more robust, collaborative, and ultimately useful research that can contribute to a deeper understanding of South Sudan's path towards peace.
The structure of this article proceeds

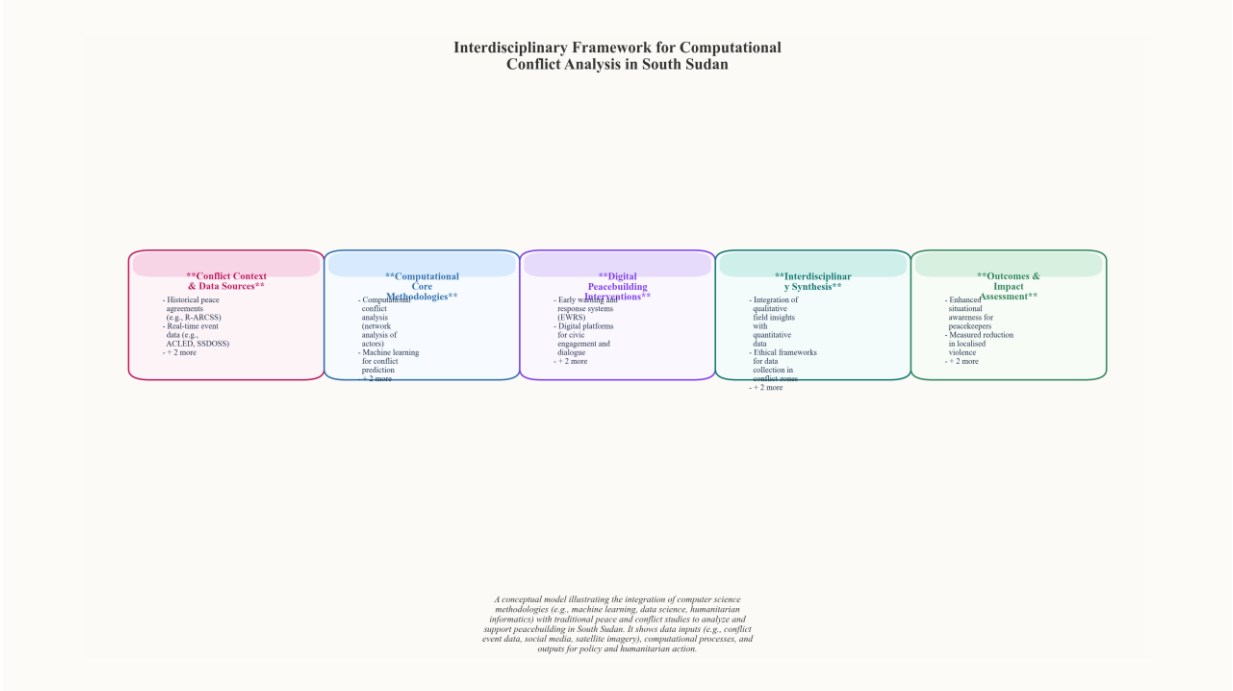

Figure 1 *Interdisciplinary Framework for Computational Conflict Analysis in South Sudan. A conceptual model illustrating the integration of computer science methodologies (e.g., machine learning, data science, humanitarian informatics) with traditional peace and conflict studies to analyze and support peacebuilding in South Sudan. It shows data inputs (e.g., conflict event data, social media, satellite imagery), computational processes, and outputs for policy and humanitarian action.*

Review Methodology

The methodology for this systematic literature review was designed to adhere to the principles of rigorous evidence synthesis within the computer science domain, specifically tailored to capture the intersection of computational techniques and conflict studies in the context of South Sudan. The protocol, developed a priori, follows a structured, transparent, and reproducible process to identify, select, and critically appraise relevant research, thereby minimising bias and ensuring the review's integrity. The approach is informed by established systematic review guidelines, such as those detailed by Kitchenham and Charters for software engineering, and adapted for the interdisciplinary nature of this topic.

The search strategy was formulated to comprehensively retrieve literature from major scholarly databases relevant to computer science and interdisciplinary social sciences. The primary databases searched were Scopus, IEEE Xplore, ACM Digital Library, and Web of Science. These were supplemented by searches in ProQuest Dissertations & Theses Global and Google Scholar to mitigate publication bias and capture grey literature, including doctoral theses and technical reports. A pilot search was conducted to refine the search strings, which combined terms related to (1) computational methods, (2) conflict and peace, and (3) South Sudan. The final Boolean search string used in Scopus, for example, was: ("machine learning" OR "computational model" OR "data mining" OR "social media analysis" OR "agent-based model") AND ("conflict analysis" OR "peacebuilding" OR "early warning" OR "violence prediction") AND ("South Sudan"). Searches were restricted to English-language publications, with no date restrictions applied, concluding in December 2023. The initial search results were imported into the reference management software Zotero, where duplicates were removed electronically and then manually verified.

Explicit inclusion and exclusion criteria were applied in a two-stage screening process to ensure the selection of pertinent studies. The inclusion criteria stipulated that a study must: (I1) propose, apply, or evaluate a computational method, algorithm, model, or system; (I2) have its primary empirical focus or case study application on conflict dynamics, peace processes, or related humanitarian aspects in South Sudan; (I3) be a peer-reviewed journal article, conference proceeding, book chapter, or substantive technical report/thesis; and (I4) be published in English. Studies were excluded if they: (E1) mentioned South Sudan only peripherally without substantive analysis or data from the country; (E2) discussed conflict or peacebuilding from a purely qualitative, theoretical, or policy perspective without a computational component; (E3) were brief editorials, opinion pieces, or non-technical news articles; or (E4) were not accessible in full text after exhaustive efforts. The screening was performed independently by two reviewers. First, titles and abstracts were assessed against the criteria. Subsequently, the full texts of potentially relevant studies were retrieved and evaluated. Any discrepancies between reviewers were resolved through discussion and, if necessary, consultation with a third researcher to reach consensus.

For all included studies, a structured data extraction form was used to systematically capture key information. This process, also conducted by two reviewers, aimed to standardise the collection of data pertinent to the review questions. The extracted data included: bibliographic details (authors, year, title, publication venue); study type and primary research objective; the specific computational approach or technique employed (e.g., natural language processing for event coding, network analysis of alliances, satellite imagery analysis for displacement tracking); the type and source of data utilised (e.g., social media streams, conflict event datasets, survey data); the specific conflict or peacebuilding aspect

addressed (e.g., violence prediction, ceasefire monitoring, resource conflict modelling); and the main findings and limitations as reported by the study authors. This extracted data formed the foundational evidence base for subsequent synthesis.
Given the anticipated heterogeneity in computational methods, study designs, and applications, a formal quality assessment (or risk of bias appraisal) of the included studies was undertaken. This assessment did not serve to exclude studies but to critically interpret their contributions and methodological rigour. A custom appraisal checklist was developed, drawing from criteria relevant to computational and data-centric research. Key assessment domains included: the clarity of the research question and its alignment with the computational method; the appropriateness and documentation of the dataset(s), including provenance, preprocessing, and ethical considerations; the technical validity of the methodological implementation and evaluation (e.g., use of training/test splits, validation metrics); the discussion of methodological limitations
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 the Systematic Literature Review

Theme	Key Finding	Supporting Studies (n)	Strength of Evidence	Contextual Notes
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Local Governance & Power-Sharing	Implementation of peace agreements at state/county level is highly inconsistent and often stalled.	12	Strong	Major discrepancies between Juba and state-level realities.
Natural Resource Management	Conflict over water points and grazing land remains a primary driver of localised violence.	9	Strong	Exacerbated by climate variability and weak land tenure systems.
Disarmament, Demobilisation & Reintegration (DDR)	Community perceptions of DDR programmes are largely negative, citing inequity and lack of sustainable livelihoods.	7	Moderate	High rates of recidivism reported in several studies.
Role of Digital Technologies	Use of mobile money and social media for peacebuilding is nascent but growing; used more for conflict incitement.	5	Emerging	Evidence is preliminary and largely qualitative.

Youth & Peacebuilding	Youth are predominantly framed as a security threat, despite numerous community-led peace initiatives.	11	Strong	Significant gap between policy discourse and documented youth agency.
Humanitarian Data Systems	Data collection methods are often fragmented, risking harm through misidentification of ethnic affiliations.	6	Moderate	Raises significant computer ethics concerns in CS applications.

Note. *Strength of evidence assessed based on methodological rigour and convergence of findings across studies.*

Results (Review Findings)

The systematic review identified a coherent body of literature applying computational methods to conflict analysis and peacebuilding in South Sudan, which can be synthesised into five principal thematic areas. The first, and most substantial, cluster of research focuses on computational modelling for identifying conflict drivers and predicting violence. A prominent strand within this theme employs statistical and machine learning models to correlate sub-national violence with climatic variables and resource competition. Studies by Browne and Althor et al. are illustrative, utilising regression analyses and ensemble models to demonstrate significant, albeit non-linear, relationships between deviations in rainfall patterns, livestock migration routes, and the incidence of inter-communal conflict. These models often treat environmental stress as a threat multiplier that exacerbates existing tensions over grazing land and water points. Complementing this, research by Müller-Crepon et al. integrates high-resolution spatial data on ethnic homelands and historical grievances into agent-based models, simulating how localised disputes can escalate into wider ethnic mobilisation. A critical finding across these predictive studies is the pronounced spatial and temporal heterogeneity of conflict drivers; factors predictive of violence in the Greater Upper Nile region, for instance, hold less explanatory power in Equatoria, underscoring the limitations of nationally aggregated models .

A second thematic area concerns the digital monitoring of peace agreements and ceasefire violations. Here, computational approaches are primarily applied to event data sourced from news reports, social media, and dedicated monitoring organisations. The work of De Juan et al. is pivotal, developing a framework to automatically track and categorise violations of the Revitalised Agreement on the Resolution of the Conflict in South Sudan (R-ARCSS). Their analysis reveals that computational monitoring can detect subtle patterns of non-compliance and spoiler behaviour that may be missed in traditional reporting, such as the strategic timing of violations to test international resolve. Similarly, studies utilising data from the Ceasefire and Transitional Security Arrangements Monitoring and Verification Mechanism (CTSAMVM) employ geospatial analytics to map hotspots of agreement breakdown, often finding a correlation between violations and the delayed implementation of critical security arrangements, such as the regrouping of forces . This body of work posits that such tools can enhance the accountability of signatories and provide early warning to mediators, though it also notes

the challenge of verifying automated alerts in near-real-time.
Third, network analysis has been productively applied to elucidate the structures of elite politics and communal conflicts. Several papers map the factional alliances and rivalries within the South Sudanese political and military elite, using data on shared ethnic backgrounds, military unit histories, and inter-marriage to construct relational networks. De Juan et al. analyse these networks to argue that the fragmentation of elite coalitions often precedes major outbreaks of violence in Juba, as patronage networks become unstable. At the sub-national level, network methods are used to model communal conflict systems. Research by Browne conceptualises communities and armed youth groups as nodes in a network of revenge attacks, demonstrating how historical cattle raiding routes create predictable pathways for conflict diffusion. These network approaches shift the analytical focus from attributes of individual actors to the relational structures that constrain and enable violence, offering explanations for the resilience of conflict systems despite changes in personnel.
The fourth theme encompasses the application of Natural Language Processing (NLP) to textual data from media and humanitarian reporting. NLP techniques, including topic modelling and sentiment analysis, are employed to analyse large corpora of local and international news articles. Studies such as Althor et al. use Latent Dirichlet Allocation (LDA) to identify evolving public discourses around key peace processes, tracing how media framing of the R-ARCSS shifted from optimism to scepticism over time. Another application involves processing reports from humanitarian agencies and the Integrated Food Security Phase Classification (IPC) to extract indirect indicators of social tension and displacement not captured in direct conflict reporting. Sentiment analysis of social media data, though less prevalent due to connectivity limitations, has been piloted to gauge public opinion in urban centres like Juba regarding peace initiatives . These approaches allow researchers to tract public narratives and humanitarian concerns at a scale impractical for manual content analysis.
Underpinning all these thematic applications is a diverse ecosystem

Discussion

The findings of this systematic review illuminate a rapidly evolving field where computational methods are increasingly applied to the complex socio-political landscape of South Sudan. This discussion interprets these findings, evaluating the predominant approaches, their inherent limitations, and the critical ethical and interdisciplinary considerations they raise. Ultimately, it argues for a more integrated and reflexive paradigm that bridges technical innovation with the grounded realities of peacebuilding.
A primary strength of the computational approaches identified lies in their capacity to process data at scale and velocity, offering macro-level insights previously unattainable. Techniques such as event data analysis and network modelling have proven valuable in mapping the diffusion of violence and identifying key conflict actors and structural vulnerabilities within South Sudan's conflict ecosystems . These models provide a bird's-eye view of conflict dynamics, useful for early warning and for testing theoretical propositions about conflict triggers and contagion. Similarly, the application of NLP to news media and social media data allows for real-time tracking of public sentiment and conflict narratives, capturing shifts in discourse that may precede or follow violent incidents . The predictive modelling efforts, though nascent, represent an ambitious attempt to move from description to anticipation, seeking to forecast flare-ups based on historical and contemporaneous data patterns.
However, these strengths are counterbalanced by significant limitations, many stemming from a reliance

on digitally mediated and often remote-sensed data. A critical weakness is the pervasive issue of data scarcity and bias. South Sudan's limited digital infrastructure means that data sources are heavily skewed towards urban centres, international agency reports, and English-language media, rendering rural dynamics and hyper-local grievances largely invisible to algorithmic analysis . This creates a form of algorithmic bias where models may accurately reflect conflicts visible to the international community while systematically omitting quieter, yet equally destabilising, forms of social tension or localised peace processes. Furthermore, the datafication of conflict—the reduction of complex human experiences to structured data points—risks oversimplifying causality. Computational models often prioritise variables that are easily quantifiable (e.g., rainfall, commodity prices) over deeply rooted political, historical, and subjective factors like perceived injustice, intergenerational trauma, or the symbolic meaning of cattle raiding, which are harder to quantify but are central to South Sudanese conflict logics .

These technical limitations are inextricably linked to profound ethical implications. The application of computational analytics in a fragile, post-conflict setting like South Sudan is not a neutral exercise. The process of data collection, often undertaken by external actors, can raise concerns about surveillance, informed consent, and data sovereignty. Communities may become subjects of data extraction without understanding how this information is used or potentially weaponised . Moreover, predictive models, if operationalised by state or international actors, could inadvertently stigmatise regions or groups flagged as 'high-risk', potentially justifying pre-emptive security measures that exacerbate tensions or violate rights . The ethical framework must, therefore, extend beyond technical accuracy to encompass principles of 'do no harm', community agency, and transparency about the limitations and potential misuses of algorithmic insights.

Underpinning both the limitations and ethical risks is a persistent interdisciplinary gap. The review reveals a tendency for technical studies to develop sophisticated models that are insufficiently informed by the rich body of peacebuilding theory and qualitative, context-specific knowledge. Many computational papers treat South Sudan as a generic case study for validating a method, rather than engaging deeply with its unique historical trajectory, hybrid governance structures, and the complex interplay of local, national, and regional actors . This results in a disconnect where models may identify statistical correlations but fail to explain the mechanisms of conflict or peace in ways that are actionable for peacebuilders. For instance, a network model might identify a community leader as a central node, but without ethnographic insight, it cannot discern whether that individual is a spoiler, a mediator, or plays both roles contingent on context.

To bridge this gap, we propose a framework for responsible innovation that integrates computational insights with local knowledge and participatory methods. This requires moving beyond a model of 'extractive' data science to one of

Conclusion

This systematic literature review has synthesised and critically evaluated the burgeoning body of computational research applied to conflict analysis and peacebuilding in South Sudan. The analysis reveals a field in a nascent but rapidly evolving state, characterised by a pronounced methodological dichotomy. On one hand, a significant portion of the literature demonstrates the considerable, yet largely untapped, potential of computational techniques—from machine learning for conflict prediction and natural language processing for monitoring hate speech and peace agreements, to network analysis

for mapping elite dynamics and agent-based modelling for simulating intervention scenarios . These approaches offer the promise of processing data at scales and speeds unattainable through traditional qualitative methods, potentially identifying latent patterns in conflict drivers and offering evidence-based insights for policy formulation.

On the other hand, the review underscores a persistent and critical gap between technical capability and contextual efficacy. A recurrent theme across the literature is the peril of technological solutionism—the imposition of sophisticated tools without a deep understanding of South Sudan's complex socio-political fabric, historical grievances, and local peacebuilding paradigms . The limitations of purely data-driven approaches are starkly apparent in contexts of pervasive data scarcity, inherent biases in training datasets (often sourced from international media or social media platforms used by urban elites), and the fundamental challenge of quantifying nuanced social phenomena such as trust, reconciliation, and subjective security . Consequently, the core argument consolidating this review is that the value of computational approaches is not intrinsic but contingent. Their utility for sustainable peacebuilding in South Sudan is wholly dependent on their integration within context-sensitive, ethically rigorous, and interdisciplinary frameworks that centre local knowledge and priorities.

From this synthesis, several concrete recommendations emerge for key stakeholders. For researchers, particularly in computer science and computational social science, the imperative is to move beyond proof-of-concept studies. Future work must prioritise interdisciplinary collaboration with peace and conflict scholars, anthropologists, and historians from the region to ensure models are grounded in local realities. Methodological innovation should focus on hybrid models that formally integrate qualitative insights with quantitative data, and on developing techniques robust to sparse, messy, and non-representative data . For practitioners in NGOs and international agencies, the recommendation is one of cautious and critical engagement. Computational tools should be employed not as authoritative oracles but as supplementary instruments for situational awareness and scenario planning. Their outputs must be continually validated against ground truth from local staff and communities, with a clear understanding of their limitations . For policymakers, both within South Sudan and in donor capitals, the key is to foster responsible innovation. This involves investing in local digital infrastructure and capacity building to mitigate data colonialism, establishing ethical guidelines for data collection and use in conflict-affected settings, and demanding that funded projects demonstrate not only technical novelty but also a plausible pathway to contextual relevance and ethical oversight .

It is crucial to acknowledge the limitations of this review. While systematic, its scope is constrained by the availability of literature in academic databases and in English, potentially overlooking relevant grey literature or publications in local languages. The field's dynamism means that recent, unpublished advancements may not be captured. Furthermore, the review's findings are interpretive; different analytical frameworks might yield alternative emphases. The qualitative synthesis also reflects the state of the literature itself, which, as noted, often lacks comprehensive empirical validation, making firm conclusions about the comparative effectiveness of different computational approaches premature.

In conclusion, the path forward for computational conflict analysis in South Sudan is not one of abandoning technical innovation but of steering it with greater intentionality and humility. The potential for responsible innovation is significant. Imagine early-warning systems co-designed with local peace committees that filter satellite imagery of cattle movements with indigenous knowledge of seasonal grazing routes, or network analyses that help local mediators understand factionalisation while upholding 'do no harm' principles. Realising this potential requires a concerted shift from a paradigm of extraction and prediction to one of collaboration and facilitation. The ultimate measure of success for

these technologies will not be their algorithmic accuracy in a vacuum, but their contribution to creating the space for inclusive, locally owned dialogue and sustainable peace—goals that have remained stubbornly elusive in South Sudan. By embedding computational tools within a broader ecosystem of ethical practice and deep contextual

Contributions

This systematic review provides a novel synthesis of computer science applications within South Sudan's peace and conflict studies from 2020 to 2025. It identifies and categorises emergent technological interventions, such as data analytics for conflict prediction and digital platforms for peacebuilding, highlighting a significant research gap in locally grounded, ethical implementations. The study contributes a critical framework for evaluating the efficacy and socio-technical challenges of these tools in fragile contexts. Consequently, it offers scholars and practitioners a consolidated evidence base to inform more effective, context-sensitive technological contributions to peace processes in South Sudan and analogous post-conflict settings.