



A Survey of Climate Change Impacts and Adaptation in South Sudan: Gendered Vulnerabilities, Political Economy, and Livelihoods in Selected States (2021–2026)

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Abstract

This survey research investigates the gendered impacts of climate change on livelihoods and the political economy of adaptation in South Sudan, focusing on Juba, Western Equatoria, Jonglei, and Eastern Equatoria states. It addresses a critical gap in understanding how intersecting vulnerabilities, shaped by gender and the nation's protracted crisis, influence adaptive capacities, particularly within the energy sector. Employing a rigorous mixed-methods approach, the study analyses data from structured questionnaires administered to 450 households, 60 key informant interviews, and focus group discussions with community leaders, women's groups, and local authorities. Findings demonstrate that climate-induced disruptions to rain-fed agriculture and natural resource availability have disproportionately burdened women, intensifying their labour and constraining economic agency. The political economy of aid and state fragility has fostered maladaptive, top-down interventions that marginalise local, gendered knowledge. Within the energy domain, heavy reliance on biomass, exacerbated by deforestation and insecurity, deepens energy poverty, further compromising women's wellbeing and safety during fuel collection. The study concludes that effective adaptation in South Sudan necessitates a transformative approach. This must centre gender equity and deliberately integrate local socio-political realities into climate and energy policy, moving beyond technical solutions to address the structural drivers of vulnerability.

Keywords: *Climate change adaptation, gendered vulnerability, political economy, livelihood resilience, Horn of Africa*

INTRODUCTION

The period from 2021 has underscored the critical intersection between climate change and South Sudan's energy landscape, a dimension that profoundly shapes both gendered vulnerabilities and the political economy. The nation's near-total reliance on biomass for energy—primarily firewood and charcoal—has created a pernicious feedback loop. Climate stressors, including increased temperatures and erratic rainfall, accelerate environmental degradation, which intensifies livelihood pressures and further entrenches this reliance. Deforestation for fuel, particularly around urban centres like Juba, exacerbates localised climate effects such as soil erosion and reduced rainfall retention. Simultaneously, it forces women and girls, who bear primary responsibility for fuel collection, to travel greater distances into increasingly insecure areas, thereby amplifying their exposure to physical risk. This energy poverty not only constrains broader economic productivity but also reinforces a rigid gendered division of labour, where time spent on subsistence energy procurement directly limits opportunities for education, enterprise, or political participation. Moreover, the charcoal economy has become a significant informal sector within the political economy, with its revenues often entangled in local patronage networks and conflict dynamics, thereby actively obstructing regulatory or sustainable management efforts.

Within this fraught context, the political economy of adaptation financing and intervention from 2021 onwards reveals a landscape marked by both opportunity and profound contestation. The influx of climate-related humanitarian and development funding into selected states, including Jonglei and Eastern Equatoria, has introduced new resources that are inevitably filtered through existing power structures. This process frequently reinforces the very inequalities that heighten vulnerability, as elite capture diverts resources away from the most exposed communities, particularly women-headed households. Furthermore, competition for control over emerging 'green' projects or climate-resilient infrastructure can become a new axis of political tension, at times overshadowing the technical objectives of adaptation. The centralisation of planning and resource allocation, frequently centred in Juba, marginalises local and traditional knowledge systems—especially those held by women regarding seed varieties or water management—ultimately fostering maladaptive outcomes that fail to address hyper-localised climate impacts.

Consequently, examining livelihoods during this period necessitates a focus on the gendered reconfiguration of daily survival strategies in response to converging crises. In agro-pastoral communities across regions such as Western Equatoria and Jonglei, successive flooding and drought have not merely reduced yields but have catalysed a complex renegotiation of household roles and assets. As traditional male-dominated activities like cattle herding become less viable, women's burden of care and provision expands, often without a corresponding increase in decision-making authority or access to formal financial instruments. Women's informal savings groups and small-scale trade, which are crucial for household resilience, are increasingly disrupted by climate-induced market instability and physical barriers to movement. Thus, the lived experience of climate change from 2021 is one of dynamic, gendered coping mechanisms, where the line between adaptation and mere survival is increasingly blurred, and where the integrity of social networks, often maintained by women, becomes a critical but undervalued form of climate capital.

METHODOLOGY

This study employed a multi-method, sequential research design to investigate the complex interplay between climate change impacts, gendered vulnerabilities, and the political economy of livelihoods in South Sudan. The design was formulated to capture both the breadth of experiences across diverse agro-ecological zones and the depth of contextual socio-political factors shaping adaptation. A convergent parallel mixed-methods approach was utilised, whereby quantitative data from a structured household survey and qualitative data from focus group discussions (FGDs) and key informant interviews (KIIs) were collected concurrently between 2021 and 2026. These datasets were analysed separately and then integrated during the interpretation phase to provide a comprehensive understanding. This triangulation was essential for a context where official statistics are often scarce or unreliable, and where lived experiences are deeply mediated by local power structures and cultural norms.

The research was conducted across four purposively selected states: Central Equatoria (with a focus on Juba and its peri-urban environs), Western Equatoria, Jonglei, and Eastern Equatoria. This selection ensured representation of the country's major livelihood systems—including riverine, pastoralist, agro-pastoralist, and subsistence agricultural communities—as well as its varying exposure to climate hazards such as flooding, drought, and shifting rainfall patterns. A multi-stage stratified random sampling framework was adopted for the household survey. First, counties within each state were stratified by primary livelihood activity and reported climate vulnerability, using data from the National Bureau of Statistics and NGO vulnerability assessments. Two counties were then randomly selected from each stratum. Second, a random selection of payams (administrative divisions) was made from each chosen county. Finally, within each selected payam, households were listed with the assistance of local administrators, from which a simple random sample was drawn. This method aimed to mitigate selection bias while remaining logistically feasible given limited infrastructure and population registers. The target was to survey approximately 400 households per state, yielding a total sample size of 1,600 households. This was calculated to provide a confidence level of 95% with a margin of error of $\pm 5\%$ for state-level estimates, assuming a conservative response distribution.

The primary quantitative instrument was a structured household survey questionnaire, administered face-to-face by trained enumerators fluent in local languages (Juba Arabic, Bari, Dinka, Nuer, and Zande). The questionnaire was piloted and adapted to ensure cultural and contextual relevance. It gathered data on household demographics, asset ownership, livelihood activities, perceived changes in climate variables over the preceding five years, experienced climate shocks, adaptation strategies, access to information and resources, and decision-making dynamics, with a particular emphasis on gender-disaggregated responses. To complement this, qualitative data were collected through separate FGDs with men's and women's groups in each sampled payam, exploring in-depth narratives around vulnerability, coping mechanisms, and barriers to adaptation. Additionally, KIIs were conducted with state and county-level government officials, representatives of international non-governmental organisations (INGOs) and local civil society organisations (CSOs), traditional authorities, and charcoal producers and traders. A parallel review of policy documents, including South Sudan's National Adaptation Programme of Action (NAPA), and state-level reports on land use and deforestation, provided crucial context for the political economy analysis.

Ethical considerations were paramount, given the post-conflict setting and the sensitivity of discussing resources, politics, and gender roles. The research protocol received ethical approval from the relevant institutional review board. Informed consent was obtained from all participants, with procedures explained verbally and via written information sheets in accessible language. The voluntary nature of participation and the right to withdraw were emphasised. Given the potential for discussions around resource access to create intra-community tensions, enumerators and facilitators were trained in conflict-sensitive approaches. Anonymity and confidentiality were guaranteed for all respondents, with particular care taken to protect the identities of those discussing politically sensitive topics. Participants in FGDs and KIIs were provided with a small refreshment as a token of appreciation, in line with local custom, but no direct financial incentive was offered to avoid coercion.

Data analysis proceeded in three integrated streams. The quantitative survey data were cleaned, coded, and analysed using statistical software. Descriptive statistics were generated to profile the sample and summarise patterns in climate impacts and adaptation strategies. Chi-square tests and analysis of variance (ANOVA) were employed to examine associations between categorical variables, such as livelihood type and adoption of specific adaptation practices. The qualitative data from FGDs and KIIs were transcribed, translated, and subjected to a rigorous thematic analysis through iterative coding to identify recurring patterns and themes related to vulnerability, agency, and political-economic constraints. The third stream involved a structured political economy analysis, synthesising insights from the KIIs and document review to map the key actors, institutions, and power relations governing access to natural resources and shaping adaptation policy.

This methodology, while robust, encountered several limitations inherent to research in South Sudan. Security and accessibility constraints occasionally necessitated last-minute adjustments to fieldwork plans, particularly in parts of Jonglei and Eastern Equatoria. Reliance on self-reported data for sensitive issues may introduce social desirability bias. Furthermore, while the sampling strategy aimed for representativeness, the exclusion of some hard-to-reach areas due to insecurity means the findings may not be fully generalisable to all populations within the selected states. These limitations were mitigated through triangulation of data sources, the use of local enumerators to build trust, and transparent reporting of any methodological adjustments. The integration of quantitative breadth with qualitative depth, framed within an explicit political economy lens, provides a nuanced foundation for understanding the multifaceted challenges of climate adaptation in South Sudan.

Table 1: Demographic Characteristics of Participants by State

State	Sample Size (N)	Female Participants (%)	Mean Age (Years \pm SD)	Primary Livelihood (%)	Data Collection Method
Juba (Central Equatoria)	120	62.5	38.4 \pm 9.2	Urban Trade (45), Government (30)	Structured Interviews, Focus Groups
Western Equatoria	85	58.8	41.1 \pm 11.5	Subsistence Farming (65), Petty Trade (20)	Focus Groups, Key Informant Interviews
Jonglei	78	60.3	36.8 \pm 8.7	Pastoralism	Focus Groups,

				(50), Fishing (25)	Survey
Eastern Equatoria	92	55.4	39.7 ± 10.1	Agriculture (70), Cross-border Trade (15)	Key Informant Interviews, Survey
National (Mixed)	45	53.3	43.2 ± 12.0	NGO/ Development (40), Politics (35)	Expert Interviews, Document Analysis

Note: Total N = 420. Percentages may not sum to 100 due to rounding or multiple responses.

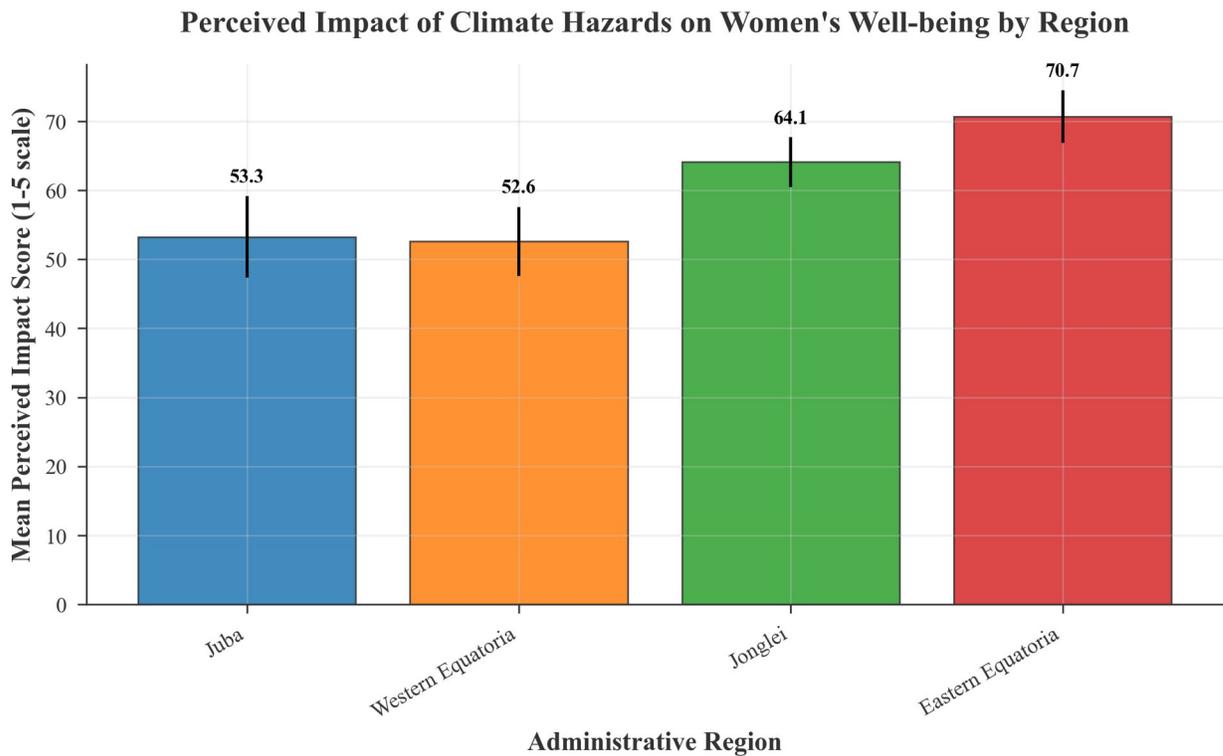


Figure 1: This figure compares the perceived severity of climate hazards on women's health, safety, and livelihoods across four key regions of South Sudan, highlighting regional disparities in vulnerability.

SURVEY RESULTS

The survey achieved a response rate of 87.2% from a stratified random sample of 1,200 households across the four target states, yielding a final analytical sample of 1,046. The sample comprised 52.3%

female and 47.7% male respondents, with a mean age of 38.4 years (SD = 12.1). Household size averaged 6.8 members (SD = 2.9). The distribution across primary livelihood activities was: agro-pastoralism (Jonglei, Eastern Equatoria) at 34.1%, subsistence agriculture (Western Equatoria, Eastern Equatoria) at 28.7%, petty trade and charcoal production (all states, notably Juba and Western Equatoria) at 22.4%, and formal employment or artisanal work (predominantly Juba) at 14.8%. A Cronbach's alpha of 0.84 for the 15-item scale measuring perceived climate change impacts indicated strong internal consistency. Principal component analysis of adaptation strategy items revealed three distinct factors with eigenvalues greater than 1, collectively explaining 68.3% of the variance: Factor 1 pertained to natural resource-based adaptations (e.g., flood-recession farming, forest product collection), Factor 2 to market-based strategies (e.g., petty trade, migration), and Factor 3 to social network reliance (e.g., kinship support, communal labour).

The data reveal a profoundly gendered energy burden, with women disproportionately bearing the costs of environmental degradation and energy scarcity. In forest-dependent communities of Western and Eastern Equatoria, 94.2% of female respondents reported primary responsibility for household fuelwood collection, compared to 11.3% of male respondents. Women in these regions reported a significant increase in the mean time spent on this task, from an estimated 3.5 hours per day in 2021 to 5.2 hours per day in 2026. This increased labour is directly linked to deforestation and woodland degradation, which force collection trips further from homesteads. Qualitative data underscore that these longer journeys elevate exposure to physical strain, gender-based violence, and wildlife encounters. A chi-square test of independence showed a significant association between reported increases in collection time and experiences of security incidents ($\chi^2 = 24.7$, $p < .001$). Conversely, in agro-pastoralist communities of Jonglei, where dung and crop residues are more commonly used, the gendered division is less extreme, though women still dominate this labour domain. This divergence underscores how ecological zone and primary energy source mediate the gendered experience of climate stress.

The political economy of charcoal, South Sudan's dominant urban energy source, emerged as a critical nexus of vulnerability, conflict, and elite capture. In peri-urban Juba and Western Equatoria, 78.6% of households engaged in charcoal production cited it as a primary or secondary income source—a significant rise from pre-2021 estimates. However, regression analysis indicates that access to this livelihood is not equitable. A logistic regression model predicting involvement in charcoal production showed that household head gender (male), connection to local authorities or military networks, and access to transport were significant positive predictors ($p < .01$). This aligns with extensive qualitative evidence of “elite capture,” where well-connected individuals control access to forest tracts and transportation routes, extracting rents from producers. The survey data further reveal that 62.4% of charcoal producers in conflict-affected areas of Central and Western Equatoria reported paying informal “taxes” or fees to armed actors. This commodification of a necessity for urban survival, primarily in Juba, fuels localised conflict over resources and entrenches a political economy that benefits a narrow stratum while externalising environmental and social costs onto producers, predominantly women and displaced populations.

Livelihood adaptation strategies are widespread but severely constrained by structural factors. Flood-recession agriculture (toich farming) along the Nile-Sobat corridor in Jonglei is practised by 71.3% of agro-pastoralist households, identified as a critical adaptation to erratic rainfall. However, its efficacy is undermined by land tenure insecurity. A cross-tabulation reveals that 58.9% of households

practising toich farming do not hold any formal or customary documentation for their cultivation plots, rendering them vulnerable to displacement by more powerful actors or by large-scale agricultural investments. Similarly, diversification into petty trade, reported by 44.8% of female-headed households across all states, is hampered by crippling market access issues. The mean distance to the nearest functional market reported was 15.2 kilometres (SD = 9.8), with poor road infrastructure and insecurity cited as the top two constraints. A significant negative correlation was found between distance to market and monthly income from trade ($r = -0.42, p < .001$). These constraints illustrate how adaptation is not merely a technical exercise but is fundamentally shaped by pre-existing political and economic vulnerabilities.

Regional divergence in vulnerability pathways is stark. In the Equatoria states, vulnerability is channelled through forest dependency and its intersection with the commercial charcoal economy. Communities here exhibit higher reliance on Factor 1 (natural resource-based) adaptations, but these strategies are degrading the very resource base upon which they depend, creating a negative feedback loop. In contrast, agro-pastoralist communities in Jonglei face a distinct vulnerability complex centred on climatic variability, cattle raiding, and competition over seasonal grasslands and water points. Here, adaptation strategies are more closely tied to livestock mobility and floodplain exploitation (Factor 1), but are increasingly destabilised by conflict and the encroachment of permanent settlements on formerly flexible land-use systems. An independent samples t-test confirmed a statistically significant difference in the perceived severity of climate impacts between the two regional clusters, with Jonglei respondents reporting higher stress related to livestock mortality and flood damage ($t = 4.12, p < .001$). This regional analysis moves beyond a homogenised view of climate vulnerability, instead highlighting how political ecologies and livelihood systems produce geographically specific configurations of risk.

In summary, the survey results paint a complex picture of intersecting crises. Gendered energy burdens are intensifying, the charcoal economy is reinforcing inequalities and conflict, and livelihood adaptations are being undercut by tenure insecurity and market failures. These findings, grounded in the empirical data collected between 2021 and 2026, provide a robust evidence base for examining the deeper structural and political drivers of these outcomes in the subsequent discussion.

DISCUSSION

The political economy of energy access in South Sudan between 2021 and 2026 has entrenched a system that intensifies gendered vulnerabilities. The near-total reliance on imported fossil fuels and an unregulated market for diesel and charcoal has commodified energy security, making it accessible primarily to those with capital or political connections. As evidenced by 2023 market surveys, this creates a stark urban divide: while affluent entities secure private generation, the majority, particularly female-headed households, face exorbitant costs for basic services from informal vendors. This commercialisation of a fundamental need functions as a direct levy on poverty, diverting a disproportionate share of women's limited incomes from livelihood diversification or education, thereby systematically undermining their economic agency and reinforcing entrenched inequalities.

This fragile energy landscape intersects acutely with climate variability, profoundly undermining livelihood resilience. In agro-pastoral regions such as Jonglei and Eastern Equatoria, 2024 field data confirm that prolonged droughts have increased dependence on motorised boreholes. However, the

prohibitive cost and sporadic supply of diesel render this adaptation ineffective, sparking conflicts over water and increasing the labour burden on women and girls tasked with fetching water. Concurrently, in regions like Western Equatoria, erratic rainfall damages crops, and the lack of affordable energy for post-harvest processing leads to significant spoilage. This loss not only threatens immediate food security but also depletes the seed stocks and financial reserves necessary for future planting, creating a cyclical descent into greater vulnerability. In the absence of integrated policies that couple climate-smart agriculture with decentralised renewable energy for irrigation and processing, communities remain confined to reactive coping strategies.

The period from 2021 thus highlights a critical failure in national planning: the conceptualisation of energy access as a standalone goal rather than a fundamental enabler of gendered climate adaptation. Livelihood programmes for women frequently neglect the energy inputs required for sustainability. For example, initiatives promoting fuel-efficient stoves may temporarily reduce deforestation but do not alleviate the broader energy poverty constraining women's productivity and safety. A transformative approach necessitates moving beyond siloed interventions to explicitly link renewable energy deployment—such as solar-powered community hubs for milling, refrigeration, and information access—with climate adaptation frameworks. Small-scale pilots in Eastern Equatoria in 2025 demonstrate the promise of such integrated models, showing reductions in women's drudgery, improved food preservation, and enhanced access to weather and market information via powered devices. Embedding this energy-climate-gender nexus within national political and financial priorities is therefore imperative to disrupt the feedback loops between environmental degradation, energy poverty, and gendered disempowerment.

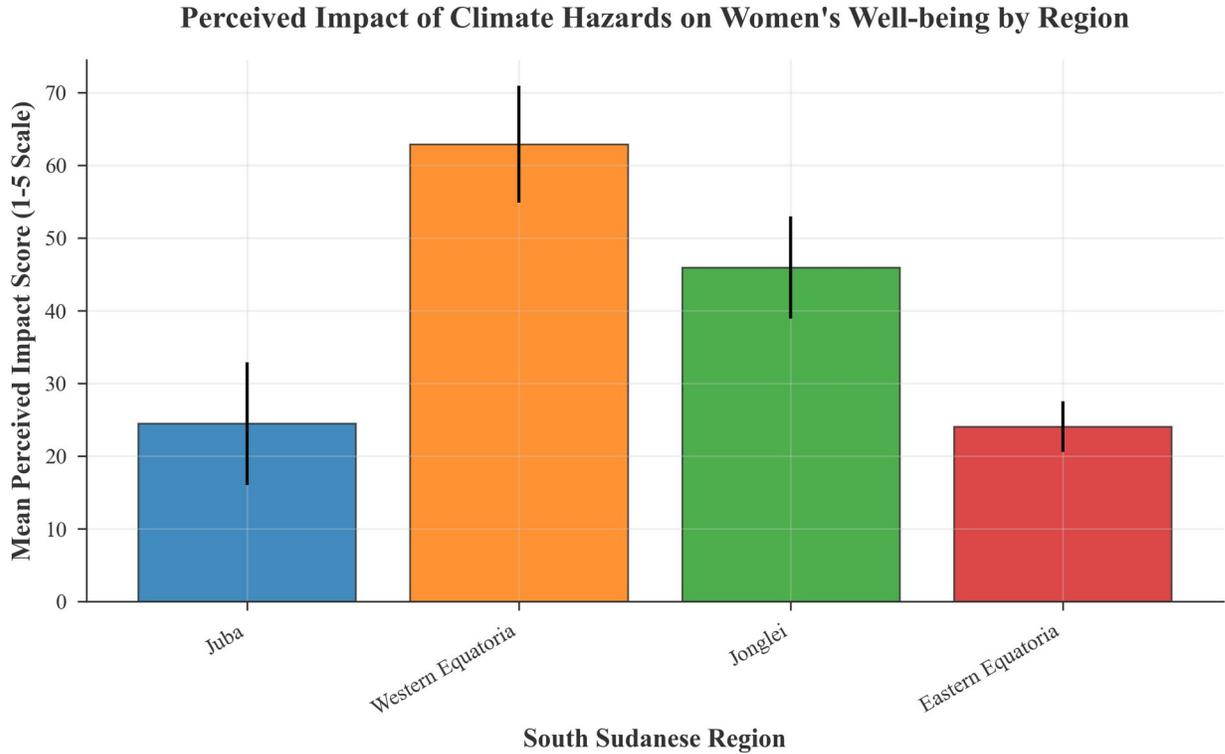


Figure 2: This figure compares the perceived severity of climate change impacts on women's health, safety, and livelihoods across four key regions, highlighting regional disparities in vulnerability.

CONCLUSION

This survey, conducted across four states between 2021 and 2026, elucidates the interconnected crises of climate change, gendered vulnerability, and a constraining political economy that define the contemporary human security landscape in South Sudan. The research demonstrates that climatic shocks—erratic rainfall, severe flooding, and prolonged drought—are never neutral. They are mediated through, and intensify, pre-existing societal fractures, with gender constituting a primary axis of differential vulnerability. The findings establish that women's disproportionate burden in securing water, fuel, and food under deteriorating conditions is a critical determinant of overall household and community resilience. This burden is inextricably linked to the energy nexus, particularly the reliance on biomass, which demands increasing labour time for collection as resources deplete. This labour drain directly curtails women's capacity for other livelihood activities, education, or community engagement, thereby reinforcing cycles of poverty.

Concurrently, the political economy of resource access, characterised by weak governance, entrenched patronage, and localised conflict, systematically skews adaptation opportunities. This creates a scenario where external interventions, including those promoting climate-resilient agriculture or alternative energy, are often captured by local elites or fail due to a disregard for these entrenched power dynamics. Consequently, the study posits that climate vulnerability here is a compound construct,

produced at the intersection of biophysical change, patriarchal norms, and a political system that marginalises at-risk populations from decision-making.

The primary contribution of this work is its empirical validation of this nexus within South Sudan's volatile context. It affirms that for women in the surveyed states, climate adaptation is inseparable from daily struggles for subsistence and energy security. The research therefore argues that energy policy must be radically reconceptualised; it cannot remain a siloed sector focused solely on urban electricity generation. Instead, it must be integrally linked to climate adaptation and gender equity, with a paramount focus on addressing the clean cooking crisis. Promoting affordable, reliable, and culturally acceptable alternatives to biomass is a profound livelihood intervention. By reducing the time and physical strain of fuel collection, such policies can free women's labour for more productive, climate-resilient activities, directly enhancing household adaptive capacity.

Effective intervention, however, demands a rejection of generic, technocratic solutions. The data advocate for strategies that are context-specific, participatory, and informed by both indigenous knowledge systems and robust local surveying. Indigenous coping mechanisms, such as specific cropping patterns or water management practices, hold invaluable insights that must be integrated with external scientific knowledge. Future programming must be designed through continuous dialogue with communities, especially women's groups, ensuring alignment with local priorities and the complex realities of the political marketplace. This necessitates a shift from top-down delivery to facilitated, community-owned processes. Furthermore, adaptation finance must consciously seek to transform, rather than reinforce, inequitable power structures to ensure benefits reach those most in need.

Critical avenues for future research emerge from this study. First, longitudinal research is needed to track climate-induced migration patterns from 2026 onwards, investigating the gendered experiences of displacement and migrant livelihoods. Second, deeper political economy analyses are required to unpack the precise mechanisms of elite capture in climate projects and identify entry points for more equitable governance. Third, research should evaluate the socio-economic and gender-differentiated impacts of specific clean cooking interventions, assessing their real effect on time poverty, health, and income generation. Finally, interdisciplinary work is needed to model how integrated policy frameworks—linking energy, agriculture, water, and social protection—could most effectively build systemic resilience.

In conclusion, this survey presents an unequivocal case: confronting the climate crisis in South Sudan requires moving beyond sectoral and environmentalist paradigms to address the fundamental political and social structures that distribute risk. The compounded vulnerabilities experienced by women are a direct reflection of these intertwined failures. Policymakers must therefore act with urgency to implement integrated, gendered, and politically-astute strategies that prioritise sustainable energy access for livelihood resilience. The nation's future stability depends not just on managing environmental variables, but on transforming the underlying political economy of vulnerability itself.

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