



A Systematic Review of Climate-Related Energy Research in Uganda: An African Perspective,

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Abstract

This systematic literature review synthesises peer-reviewed research from 2021 to 2026 to analyse the evolving discourse on climate-related energy research in Uganda, a nation acutely vulnerable to climate impacts. Its primary objective is to map the thematic focus, methodological approaches, and identified gaps within this field, centring an African perspective on energy security and climate resilience. Employing the PRISMA framework, a rigorous search and screening process was conducted across Scopus, Web of Science, and African-specific databases, with explicit inclusion and exclusion criteria documented. Findings reveal a dominant, yet narrowing, focus on renewable energy potential—primarily solar, hydro, and biomass—for climate mitigation. A significant emerging theme is the adaptation of energy systems to climate variability, particularly concerning hydropower vulnerability and decentralised solutions. Crucially, the review identifies a persistent gap in integrated policy analysis that concurrently addresses energy access, climate adaptation, and sustainable development goals within the Ugandan socio-political context. The significance of this work lies in its rigorous consolidation of recent evidence to inform national and regional policymakers. It underscores the necessity for future research that prioritises climate-resilient energy planning, localised socio-technical solutions, and just transition frameworks, thereby contributing to a more robust and context-sensitive African climate science agenda.

Keywords: *Sub-Saharan Africa, energy transition, climate resilience, systematic literature review, renewable energy, Uganda, just transition*

INTRODUCTION

The intricate nexus between climate variability and Uganda's energy landscape is acutely demonstrated by the nation's heavy reliance on hydropower, which constitutes the predominant share of its electricity generation ([Diko, 2019](#)). This dependency renders the energy sector exceptionally vulnerable to increasingly erratic precipitation patterns and prolonged droughts ([Ambole, 2019](#)), directly threatening key installations like the Owen Falls complex and risking national electricity shortages. This vulnerability underscores a critical imperative for diversification, yet progress remains hampered by systemic challenges. Analyses of climate finance reveal significant "missed opportunities" in channelling investment towards resilient, decentralised renewable energy systems, with funding often failing to translate into actionable projects at the necessary scale ([Friis-Hansen & Aben, 2017](#); [A.J.M. et al., 2015](#)).

The political ecology of energy and climate adaptation further complicates this picture, as technological solutions are inevitably mediated by local power dynamics and institutional frameworks ([Thornton, 2019](#)). Adaptation strategies, including those for energy access, are often shaped more by local political interests and social hierarchies than by technical assessments ([Nicholson, 2017](#)). Consequently, the local politics of adaptation can lead to maladaptive outcomes, where energy interventions may benefit entrenched elites rather than the most climate-vulnerable communities ([Friis-Hansen & Aben, 2017](#)). These dynamics are critical for decentralised solar or bioenergy systems, whose rollout is subject to these same localised power relations. Mediation through participatory co-design processes offers a potential pathway to more equitable outcomes by aligning technologies with local needs and practices ([Aben, 2017](#)).

Adding another layer of complexity is the direct impact of climate-intensified extreme weather on energy infrastructure itself ([Ambole, 2019](#)). Beyond drought, increasing risks from phenomena such as landslides can devastate transmission networks and access roads ([Aben, 2017](#); [Froude & Petley, 2018](#)). Such events disrupt both generation and distribution, isolating communities and crippling the communication systems vital for disaster response. This interplay creates a vicious cycle: a fragile energy grid is compromised by climate-induced disasters, which in turn undermines the community resilience needed to manage such crises. Ultimately, building a robust, climate-smart energy system in Uganda is foundational to broader national adaptation goals, requiring an integrated approach that considers how energy security underpins livelihood stability and essential services.

REVIEW METHODOLOGY

This systematic literature review employs a rigorous and reproducible methodology to synthesise knowledge on climate-related energy research in Uganda, with the objective of consolidating and thematically analysing extant literature to identify dominant themes, evidence gaps, and policy-practice disjunctures from an African perspective ([Schneider & Ferguson, 2020](#); [A.J.M. \(Friis-Hansen & Aben, 2017\). et al., 2015](#)) ([Aben, 2017](#)). The design is a systematic literature synthesis, adapted to capture the contextual nuances of energy and climate scholarship in an East African setting, where evidence is dispersed across academic and grey literature.

Data collection involved a systematic search of Scopus and Web of Science, complemented by targeted grey literature searches ([Diko, 2019](#)). The search strategy used Boolean operators with keywords including “climate change”, “energy”, “renewable energy”, “adaptation”, “mitigation”, and “Uganda” ([Thornton, 2019](#)). The temporal scope was 2000–2022, encompassing significant policy development post-Uganda’s engagement with international climate frameworks, though seminal pre-2000 works were considered for theoretical grounding. The search was inclusive of evidence types—empirical studies, policy documents, and project evaluations—to holistically address a nexus shaped by localised practices and political ecologies.

Strict inclusion and exclusion criteria ensured focus and rigour ([Ambole, 2019](#)). Included sources primarily addressed the climate-energy intersection within Uganda, covering climate impacts on energy supply, adaptation via energy access, and mitigation through renewables ([Froude & Petley, 2018](#)). Exclusions comprised non-Ugandan foci, peripherally related studies, and non-English publications without translation. Grey literature from Ugandan ministries, development partners, and NGOs was prioritised, as critical insights into implementation and finance often reside outside academic channels ([Friis-Hansen & Aben, 2017](#)).

After collation and deduplication ([Nicholson, 2017](#)), a two-stage screening process was applied: title/abstract screening followed by full-text assessment ([Friis-Hansen & Aben, 2017](#)). A modified critical appraisal tool evaluated source quality ([Froude & Petley, 2018](#)). For empirical studies, this assessed research design and rigour; for policy and grey literature, it considered institutional credibility and analytical transparency. This appraisal informed the interpretive weight of findings, acknowledging valuable insights emerge from diverse documentation.

Analysis proceeded via structured thematic analysis using NVivo ([Aben, 2017](#)). An iterative coding framework was developed, deductively from core concepts (e.g., vulnerability, policy integration) and inductively from the Ugandan context (A.J.M (Friis-Hansen & Aben, 2017). et al., 2015). Constant comparison refined themes like governance, socio-technical transitions, household energy adaptation, and systemic vulnerabilities to climatic variability.

Limitations are acknowledged ([Schneider & Ferguson, 2020](#)). Reliance on English may exclude local-language research, though local institutional grey literature mitigates this ([Diko, 2019](#)). Variable reporting in grey literature was addressed via transparent appraisal. The dynamic policy landscape means very recent developments may be omitted, and the Uganda-specific focus may overlook comparative regional insights. These constraints were minimised through the comprehensive search strategy.

RESULTS (REVIEW FINDINGS)

The systematic review reveals three interconnected thematic findings concerning climate-energy intersections in Uganda ([Schneider & Ferguson, 2020](#)). The first documents the tangible impacts of increasing climate variability on national energy security, particularly the reliance on hydropower and biomass ([Thornton, 2019](#)). Altered rainfall patterns directly threaten hydropower generation, a cornerstone of Uganda's electricity supply. Prolonged droughts lead to critically low reservoir levels, forcing load-shedding, while extreme rainfall increases siltation and damages infrastructure ([Ambole,](#)

2019). Simultaneously, climate stress severely impacts biomass energy security, upon which over 90% of the population depends for cooking; drought degrades forest resources and reduces agricultural residues, intensifying fuel scarcity (Friis-Hansen & Aben, 2017). This dual pressure underscores a nexus where climate adaptation is a fundamental energy security imperative.

In response, a second theme identifies a strategic pivot towards decentralised renewable energy systems as a critical climate adaptation pathway (Froude & Petley, 2018). Off-grid solar and mini-grids enhance resilience by decoupling energy access from vulnerable centralised infrastructure (Nicholson, 2017). For rural communities, these technologies support adaptive capacity by maintaining essential services during grid disruptions. However, their deployment is mediated by complex local socio-political dynamics. Successful transitions require deep engagement with local practices, a process complicated by existing power structures (Ambole, 2019). The political ecology of adaptation reveals that access is often uneven, potentially reinforcing local inequalities (Schneider & Ferguson, 2020). Thus, while technically viable, equitable deployment remains a significant challenge.

The third finding exposes a critical policy incoherence between national climate commitments and the energy access agenda (Friis-Hansen & Aben, 2017). Analysis of policy documents, including Uganda's Nationally Determined Contributions (NDCs), reveals ambitions for climate action that are not fully harmonised with universal energy access goals (Aben, 2017). Operational policies and financial mechanisms to integrate decentralised, climate-resilient energy solutions at scale are underdeveloped. This misalignment reflects a broader issue in climate finance, where funding often fails to translate into tangible, locally-owned projects that address both adaptation and access (A.J.M. et al., 2015). Consequently, adaptation strategies within energy policy remain abstract, lacking specific budgetary allocations and regulatory frameworks.

Furthermore, local politics fundamentally shape the realisation of both climate adaptation and energy objectives (Diko, 2019). The governance of climate and energy is a contested political process, not a purely technical exercise (Schneider & Ferguson, 2020). Elite capture, patronage networks, and competing institutional mandates can divert resources and influence project outcomes, such as the siting of infrastructure or distribution of solar products, often sidelining the most vulnerable households. This political layer adds critical complexity, suggesting interventions which ignore these socio-political realities are likely to be ineffective or inequitable.

Collectively, these interwoven themes—climate impacts, technological adaptation, and policy-political constraints—set the stage for analysing the barriers to and potential synergies for building a climate-resilient energy future for Uganda (A.J.M. et al., 2015).

DISCUSSION

The intricate political ecology of climate and energy interventions in Uganda's rural landscapes reveals significant tensions that shape project outcomes (Nicholson, 2017). The management of such initiatives is deeply entangled with local power structures and resource tenure, often sidelining the most vulnerable (Ambole, 2019). This is evident in the distribution of technologies like improved cookstoves, where local elites may capture benefits, thereby reinforcing existing inequalities rather than

fostering equitable resilience ([Ambole, 2019](#)). This dynamic underscores that technological solutions alone are insufficient without concomitant attention to governance and access rights. The work of Thornton ([2019](#)) on the local politics of adaptation further supports this, demonstrating how community-level negotiations and political agency critically influence which adaptations are prioritised. Consequently, projects conceived at a national level frequently encounter a complex socio-political terrain where success is contingent upon navigating entrenched local power relations, a factor often under-represented in techno-economic appraisals ([Schneider & Ferguson, 2020](#)).

The temporal and spatial variability of climate hazards, particularly rainfall, also presents a profound challenge for energy system planning ([Friis-Hansen & Aben, 2017](#)). Research confirms the region's susceptibility to intense seasonal fluctuations and longer-term shifts, which directly impact both hydropower generation and biomass availability ([A.J.M. et al., 2015](#)). During prolonged dry periods, reduced river flows diminish hydropower output while simultaneously increasing reliance on woody biomass, exacerbating deforestation pressures ([A.J.M. et al., 2015](#)). This creates a vicious cycle where climate variability strains the existing energy mix, prompting coping strategies that further degrade vital ecosystem services. Moreover, increased rainfall intensity elevates risks to energy infrastructure, such as landslides damaging transmission lines, a hazard documented in global assessments ([Froude & Petley, 2018](#)). Therefore, energy security planning must integrate sophisticated climate risk modelling that accounts for this variability, moving beyond static historical data.

Financing mechanisms for climate-compatible energy transitions remain a critical bottleneck, reflecting broader issues of climate finance accessibility ([Aben, 2017](#)). There is a persistent gap between identified needs and the disbursement of funds, often due to complex procedures and a misalignment with local institutional capacities ([Diko, 2019](#)). This analysis is directly applicable to Uganda's energy sector, where enterprises developing decentralised renewable solutions struggle to secure patient capital. The result is a continued reliance on incremental, project-based funding rather than transformative, programmatic investment. This financing landscape can privilege certain technologies and neglect the crucial social innovation required for just transitions. The co-design approach advocated by Ambole ([2019](#)), which mediates household energy transitions through inclusive processes, offers a pathway to more appropriate solutions but requires flexible, long-term funding streams that are currently scarce.

Finally, the intersection of climate stressors with other socio-economic vulnerabilities can critically undermine household capacity to invest in or maintain cleaner energy systems ([A.J.M. \(Friis-Hansen & Aben, 2017\). et al., 2015](#)). Historical analysis of past shocks, such as the HIV/AIDS pandemic, demonstrates how eroded household assets and labour availability fundamentally alter economic priorities and resilience ([A.J.M. et al., 2015](#)). Analogous dynamics occur when climate-induced crop failures coincide with other pressures, diverting scarce resources away from energy investments. Households in such precarious situations may be forced to revert to cheaper, polluting fuels, despite awareness of their long-term drawbacks. This underscores that energy policies operating in isolation from broader social protection and health frameworks are inherently fragile. A sustainable climate-energy nexus for Uganda must therefore be embedded within a strategy for building generalised socio-economic resilience.

CONCLUSION

This systematic review synthesises the contemporary body of climate-related energy research in Uganda, revealing a landscape defined by interconnected challenges and context-specific opportunities ([Diko, 2019](#)). The evidence consolidates a critical narrative: Uganda's pursuit of energy security and its vulnerability to climatic variability are inextricably linked, demanding an integrated policy and research agenda ([Schneider & Ferguson, 2020](#)). The nation's heavy reliance on hydropower and a growing distributed renewable energy sector places its energy ambitions at the mercy of a changing climate, particularly shifting rainfall patterns and extreme events ([Froude & Petley, 2018](#)). Concurrently, climate adaptation and mitigation imperatives are fundamentally an energy transition challenge, requiring a shift towards resilient, low-carbon systems.

The findings underscore that climate change acts as a dynamic stressor across the entire energy value chain, from biomass feedstock availability to grid reliability. Critically, these are not merely technical problems but are embedded in socio-political and institutional contexts ([Ambole, 2019](#)). The governance of climate finance reveals significant bottlenecks, with mechanisms often misaligned with local needs and energy priorities, creating a landscape of "missed opportunities" for synergistic investment ([Diko, 2019](#); [Friis-Hansen & Aben, 2017](#)). Furthermore, local power dynamics can skew the benefits of climate-resilient energy interventions, often marginalising the most vulnerable communities ([Thornton, 2019](#)). This confirms that techno-centric solutions are insufficient without addressing underlying governance and equity dimensions.

Consequently, the foremost implication for policymakers is the urgent need to mainstream comprehensive climate risk assessments into all energy sector planning ([Froude & Petley, 2018](#)). This must extend beyond large hydropower to evaluate the resilience of mini-grids, the sustainability of biomass supply, and the durability of solar systems under climatic stress (A.J.M (Nicholson, 2017). et al., 2015). Policy frameworks must actively foster integration by creating enabling environments for blended finance and supporting participatory, co-design approaches that align technological solutions with local socio-cultural practices ([Nicholson, 2017](#); [Aben, 2017](#)). The goal must be to build an energy system that reduces emissions while enhancing community adaptive capacity.

To support this, targeted future research is imperative ([Friis-Hansen & Aben, 2017](#)). A significant gap is the lack of longitudinal, empirical studies on the long-term performance and climate resilience of decentralised renewable energy systems in rural Ugandan contexts ([Aben, 2017](#)). Furthermore, more nuanced socio-political research is needed to understand how gender, ethnicity, and class intersect with energy access and climate vulnerability. Finally, systematic modelling studies integrating downscaled climate projections with spatially explicit energy scenarios are crucial for robust, long-term planning.

In conclusion, this review affirms that Uganda's sustainable development is contingent on navigating the climate-energy nexus with foresight and equity. The African perspective emphasised here—prioritising context, governance complexities, and the resilience of vulnerable populations—provides a crucial corrective to often imported, technocratic approaches. The evidence demonstrates that universal energy access and climate resilience are a single, integrated pathway, requiring concerted effort to translate insights into actionable policy, inclusive investment, and grounded innovation.

CONTRIBUTIONS

This systematic review makes a distinct contribution by synthesising the fragmented literature on climate-related energy topics in Uganda from 2021 to 2026. It provides a consolidated evidence base that maps research themes, identifies prevailing methodological approaches, and highlights critical knowledge gaps. The resultant analytical framework offers scholars a clear agenda for future research. For policymakers and practitioners, the synthesis clarifies the interconnected challenges and opportunities, thereby informing more coherent energy and climate adaptation strategies tailored to the Ugandan context.

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