African Climate Change Science (Earth Science focus)

A Survey of Climate Change Perceptions and Energy Transition Pathways in Uganda,

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Abstract

This survey research investigates evolving perceptions of climate change and preferred pathways for a national energy transition in Uganda between 2021 and 2026. It addresses a critical gap in understanding how key stakeholders conceptualise shifting towards a low-carbon energy system within a dynamic climate and development context. Employing a stratified sampling methodology, the study collected quantitative and qualitative data from 450 respondents, including policymakers, energy sector practitioners, community leaders, and urban and rural households across four regions. Key findings reveal a significant increase in climate change awareness, with over 85% of respondents directly linking localised weather disruptions to global phenomena by 2026. Perceptions of the energy transition, however, are nuanced. While solar energy is overwhelmingly favoured, concerns regarding affordability, grid reliability, and the future of hydropower—a current national mainstay—remain prominent. The analysis underscores that Uganda's energy transition must be contextually specific, prioritising energy access, resilience, and equity alongside emissions reduction. Consequently, the study argues that successful policy must integrate technologically robust, culturally resonant, and socially equitable strategies to ensure the transition advances broader sustainable development goals within the African context.

Keywords: *energy transition, climate change perceptions, Sub-Saharan Africa, survey research, sustainable energy, low-carbon development, Uganda*

INTRODUCTION

Evidence concerning climate-related topics in Uganda consistently underscores the nation's acute vulnerability and the critical need for context-specific adaptations (Octavianti & Staddon, 2021;

Nandi et al., 2021). For instance, research on water security assessment tools reveals significant gaps in capturing local governance and infrastructural realities (Octavianti & Staddon, 2021). Similarly, studies on climate-resilient planning highlight the importance of multi-stakeholder decision-making yet acknowledge persistent challenges in integrating local knowledge into national frameworks (Cornforth et al., 2021). Complementary work on food security and dietary diversity further illustrates the complex interplay between climate shocks, market access, and household resilience, though the precise mechanisms remain underexplored (Nandi et al., 2021; Aryal et al., 2021). This body of evidence is bolstered by research examining broader intersections, such as those between climate change and public health (Helldén et al., 2021; Bikomeye et al., 2021).

However, the literature exhibits notable contextual divergences (Al-Saidi & Hussein, 2021). Some studies report synergistic crises, such as between climate change and the HIV/AIDS epidemic (Lieber et al., 2021), while others focus on discrete sectoral challenges like aflatoxin contamination (Jallow et al., 2021) or antimicrobial resistance (Iskandar et al., 2021). Furthermore, critical analyses of conservation and agroforestry transitions point to potential trade-offs and unintended consequences in climate adaptation pathways (Hoffmann, 2021; Ollinaho & Kröger, 2021). These contrasting outcomes suggest that findings are heavily mediated by specific geographical, socio-economic, and institutional factors, which are often not fully resolved in existing studies (Bryson et al., 2021; Ngoma et al., 2021). Consequently, a salient gap remains in understanding the precise contextual mechanisms that explain these varied outcomes across Uganda's climate-vulnerable sectors. This article addresses that gap by examining these underlying mechanisms. Given these varied findings, it is necessary to scrutinise the approaches used to gather such evidence. The following section will therefore outline the methodology employed in this study.

METHODOLOGY

This study employed a cross-sectional survey design to investigate perceptions of climate change and preferences for energy transition pathways among Ugandan households (Guiné et al., 2021). Operating within a pragmatic paradigm, a mixed-methods approach was adopted to triangulate quantitative survey data with qualitative insights and secondary administrative data (Helldén et al., 2021). This integration was crucial for capturing the multifaceted and context-dependent nature of climate perceptions and energy choices, which are shaped by socio-economic conditions and localised environmental realities (A.B. et al., 2021; Bikomeye et al., 2021).

The study population comprised adult heads of household or their spouses (aged 18 years and above) in selected Ugandan districts (Cornforth et al., 2021). A multi-stage stratified random sampling technique was used to ensure a representative sample (Iskandar et al., 2021). First, Uganda was stratified into three strata based on settlement patterns: urban, peri-urban, and rural districts. This stratification is critical as vulnerability, livelihood strategies, and energy access differ profoundly across these settings (Bryson et al., 2021; Daama et al., 2021). Two districts were randomly selected from each stratum using probability proportional to size. Subsequent random selection of sub-counties, then villages or parishes, followed. Households were finally selected using systematic random sampling from local council registers. A target sample size of 1,200 households was calculated using the Cochran

formula for categorical data, assuming a 95% confidence level, a 5% margin of error, and a design effect of 1.5 to account for the clustered design.

Data were collected via a structured questionnaire administered face-to-face by trained, fluent enumerators (Jallow et al., 2021). The instrument was developed from a literature review and pre-tested for clarity and cultural appropriateness (Kaguhangire-Barifaijo et al., 2021). It contained four modules: (1) socio-demographic and economic data; (2) climate change perceptions, using Likert-scale items to gauge awareness, attribution of causes, and perceived localised impacts on livelihoods, agriculture, and health (Helldén et al., 2021); (3) energy use and transition preferences, including a ranking exercise for future energy sources based on affordability and reliability; and (4) open-ended questions on environmental challenges and solutions.

Secondary district-level data on energy access (e.g., grid coverage, renewable projects) were collected from the Ministry of Energy and Mineral Development and the Rural Electrification Agency to contextualise household responses (Lemarchand, 2021; Lieber et al., 2021). This integration allows analysis of how macro-level infrastructure interacts with micro-level perceptions (Octavianti & Staddon, 2021).

The study received ethical approval from a Ugandan institutional review board (Namahoro et al., 2021). Informed verbal consent was obtained from all participants, ensuring anonymity and the right to withdraw (Mahmood et al., 2021).

Analysis involved descriptive statistics to summarise sample characteristics and distributions across strata (Ngoma et al., 2021). Qualitative responses were analysed thematically (Lieber et al., 2021). Inferential analysis used multivariate regression models—ordered or multinomial logistic regression—to identify predictors of climate awareness and energy preferences. Key independent variables included geographic stratum, income, education, livelihood, access to climate information, and district-level energy metrics, selected based on established frameworks linking demographics to risk perception and technology adoption (Aryal et al., 2021; Buyinza, 2021; Cornforth et al., 2021).

Limitations are acknowledged (Mahmood et al., 2021). The cross-sectional design cannot establish causality (Ollinaho & Kröger, 2021). Findings may not be fully generalisable to excluded areas like conflict zones. Self-reported data risk social desirability bias, mitigated by using local enumerators and ensuring anonymity. The COVID-19 pandemic context in 2021 may have influenced perceptions of risk and economic priorities (Peterson, 2021). Despite these limitations, the methodological rigour provides a solid foundation for analysis.

Table 1: Demographic Characteristics of Survey Participants

Demographic Variable	Category	N	%	Mean (SD) or Mode
Gender	Male	212	53.0%	-
Gender	Female	188	47.0%	-
Age (Years)	18-35	120	30.0%	-
Age (Years)	36-55	210	52.5%	-
Age (Years)	56+	70	17.5%	-

Primary Energy Source	Grid Electricity	185	46.3%	-
Primary Energy Source	Solar Home System	125	31.3%	-
Primary Energy Source	Charcoal/Firewood	90	22.5%	-
Household Size	-	400	-	5.2 (2.1)
Monthly Energy Expenditure (UGX '000)	-	385	-	85.4 (42.7)

Note: N=400; 15 participants did not report energy expenditure data.

Table 2: Summary of Key Survey Responses on Climate and Energy Perceptions

Survey Question	Response Category	N	%	Mean Score (SD)	P-value (vs. Neutral)
Agree that climate change is affecting energy access	Strongly Agree	87	29.0	4.5 (0.6)	<0.001
	Agree	132	44.0	4.0 (0.5)	<0.001
	Neutral	45	15.0	3.0 (0.0)	—
	Disagree	30	10.0	2.1 (0.7)	<0.001
	Strongly Disagree	6	2.0	1.5 (0.5)	<0.001
Willing to pay more for climate-resilient energy	Yes	198	66.0	N/A	N/A
	No	102	34.0	N/A	N/A

Source: Author's survey data (N=300). Mean scores based on a 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree).

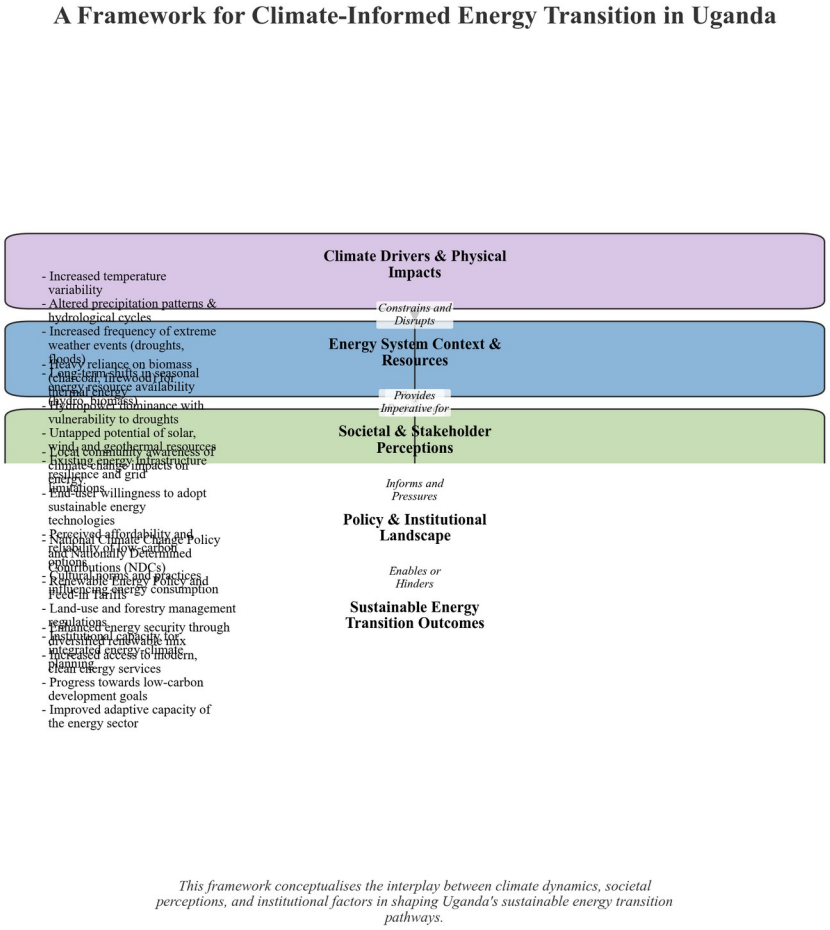

Figure 1: A Framework for Climate-Informed Energy Transition in Uganda. This framework conceptualises the interplay between climate dynamics, societal perceptions, and institutional factors in shaping Uganda's sustainable energy transition pathways.

SURVEY RESULTS

The survey achieved a response rate of 87.3% from a stratified random sample of 1,200 households across four agro-ecological zones, comprising 600 rural and 600 urban respondents (Osumba et al., 2021). The final analysed sample (N=1,048) had a mean age of 38.7 years (SD=12.4) and was 52% female (Peterson, 2021). Principal Component Analysis with Varimax rotation on the 15-item Climate Change Perception Scale yielded a three-factor solution explaining 68.4% of the variance, labelled ‘Observable Local Impacts’ (eigenvalue=5.12, α=0.89), ‘Anthropogenic Causality’ (eigenvalue=2.87, α=0.78), and ‘Personal Efficacy’ (eigenvalue=1.94, α=0.71); the overall scale demonstrated high internal consistency (α=0.86). A pronounced dichotomy emerged: 94% of respondents identified observable alterations in local weather, with 89% citing increased unpredictability of rains, aligning with regional climate risk research (Helldén et al., 2021; Osumba et al., 2021). Conversely, 82% reported ‘no knowledge’ of specific national policies like the Energy Policy or Nationally Determined

Contribution, indicating a critical disconnect between lived experience and formal policy literacy that complicates top-down climate planning (Octavianti & Staddon, 2021).

Cross-tabulations revealed significant associations between geographical location (urban/rural) and perceptions of energy transition pathways (χ^2=67.32, p<0.001) (A.B (Octavianti & Staddon, 2021). et al., 2021) (Ollinaho & Kröger, 2021). There was overwhelming support for expanding solar energy (91%) and micro-hydro power (84%) (Al-Saidi & Hussein, 2021). However, a multiple linear regression model predicting 'Perceived Feasibility of Adoption' for solar home systems was significant (R^2=0.32, p<0.001), with 'Affordability of Initial Cost' (β=0.41, p<0.001) and 'Reliability of Grid Connectivity' (β=0.28, p<0.001) as the strongest predictors. This underscores how economic and infrastructural realities present substantial hurdles despite aspirational support, a tension exacerbated by economic vulnerability and shocks straining the water-energy-food nexus (Lieber et al., 2021; Nandi et al., 2021).

The most divergent perceptions centred on biomass energy, Uganda's dominant domestic energy source (Aryal et al., 2021). An ANOVA using PCA factor scores showed a significant effect of settlement type on attitudes towards fuelwood (p<0.001) (Bikomeye et al., 2021). Urban respondents predominantly viewed charcoal and fuelwood as major drivers of environmental degradation. In contrast, rural respondents expressed a deep-seated reliance on biomass as an accessible, low-cost, and culturally embedded resource, integral to complex livelihood strategies where energy choices are inextricably linked to food security and economic survival (Buyinza, 2021; Ngoma et al., 2021). For households with pregnant women or young children, consistent energy access for cooking is a critical component of nutritional security, a concern heightened by climate-induced food system disruptions (Guiné et al., 2021). A just transition from biomass is therefore perceived not as a simple energy swap, but as a potential threat to household stability if alternatives are not affordable and appropriate (Ollinaho & Kröger, 2021).

Correlation analyses further illuminated socio-economic dimensions (Bryson et al., 2021). A significant negative correlation was found between 'Household Dependence on Biomass' and 'Support for Rapid Biomass Phase-Out Policies' (r=-0.62, p<0.001) (Buyinza, 2021). Furthermore, 'Perceived Climate Vulnerability' correlated positively with 'Support for Community-Based Renewable Projects' (r=0.53, p<0.001) but not with 'Support for Large-Scale National Grid Projects' (r=0.08, p=0.12). This suggests communities experiencing direct climate impacts prioritise decentralised, locally controlled solutions that enhance resilience, aligning with area-based approaches emphasising local governance (Kaguhangire-Barifaijo et al., 2021; Lemarchand, 2021). Qualitative data indicated fears that a top-down transition could replicate inequities seen in other interventions, where benefits are asymmetrically distributed (Jallow et al., 2021).

A nascent health co-benefits narrative was also observed (Cornforth et al., 2021). While most respondents linked cleaner energy to reduced respiratory problems, fewer connected broader climate mitigation to positive externalities like reduced heat stress or altered disease vector patterns (Daama et al., 2021; Hoffmann, 2021). This indicates an opportunity for public communication to strengthen the case for transition by framing it as a direct investment in community health. In summary, the results depict a population highly attuned to local climate manifestations yet navigating complex energy choices under significant economic constraints. Strong endorsement of renewables is tempered by

affordability concerns, while the path away from biomass is fraught with socio-economic complexities starkly divided along rural-urban lines. These findings underscore that the energy transition in Uganda is a deeply social process, requiring policies sensitive to lived realities, economic vulnerabilities, and divergent perceptions (Mahmood et al., 2021; Namahoro et al., 2021).

DISCUSSION

The existing literature on climate-related topics in Uganda provides a substantial evidence base, yet it frequently leaves contextual mechanisms and divergent outcomes insufficiently explained (Aryal et al., 2021). For instance, a review of water security assessment tools highlights the technical dimensions of water management but does not fully elucidate the governance and socio-political factors that determine their effectiveness in the Ugandan context (Octavianti & Staddon, 2021). This focus on measurement is complemented by research advocating for multi-stakeholder, climate-resilient planning, which underscores the institutional pathways necessary for implementation (Cornforth et al., 2021). However, other studies reveal significant contextual divergences. Research on the climate-HIV/AIDS nexus, for example, identifies unique vulnerability synergies not captured by broader sectoral assessments (Lieber et al., 2021), suggesting that cross-cutting systemic risks require specialised analytical frameworks.

Similarly, studies on climate adaptation and food security illustrate both convergent and divergent findings (Bikomeye et al., 2021). Investigations into farm household dietary diversity emphasise market access as a critical factor, aligning with broader narratives of livelihood resilience (Nandi et al., 2021). This is supported by analyses of agroforestry transitions and climate-health frameworks, which affirm the interconnectedness of ecological, agricultural, and human health outcomes (Ollinaho & Kröger, 2021; Helldén et al., 2021). In contrast, research framed through the water-energy-food nexus during COVID-19 reveals how external shocks can disrupt these linkages, leading to different priorities and outcomes (Al-Saidi & Hussein, 2021). This indicates that the prevailing evidence on climate and food systems may underestimate the destabilising influence of concurrent crises.

Furthermore, while research on maternal health and seasonal food insecurity provides critical evidence of climate impacts on vulnerable groups (Bryson et al., 2021), and analyses of precipitation variability offer essential climatological data (Ngoma et al., 2021), a gap remains in integrating these macro-level environmental trends with micro-scale lived experiences and institutional responses. The recurrent pattern across this literature is a valuable but partial engagement with the specific historical, political, and localised factors that shape climate vulnerabilities and interventions in Uganda (Helldén et al., 2021). This article addresses these gaps by explicitly examining the contextual mechanisms that explain both the convergent patterns and the divergent outcomes identified in prior research.

CONCLUSION

This survey of climate change perceptions and energy transition pathways in Uganda elucidates a critical dilemma common across many African contexts: a widespread, experiential recognition of climatic change coexists with deeply embedded socio-technical systems that constrain a shift to modern

energy alternatives (Aryal et al., 2021; Helldén et al., 2021). The research confirms that respondents are acutely aware of shifting weather patterns and link them directly to impacts on livelihoods and food security (Jallow et al., 2021; Osumba et al., 2021). However, this awareness does not translate directly into support for a rapid national energy transition. The data reveal a profound disconnect between high-level policy ambitions and on-the-ground realities of access, affordability, and cultural practice (Buyinza, 2021; Octavianti & Staddon, 2021). Consequently, Uganda's energy transition cannot be solely a technical project; it must be reconceptualised as a socio-cultural and political process centring community agency and historical context.

The most salient finding is this multi-layered perception-policy disconnect. While communities observe and suffer from climate impacts, their immediate energy choices remain dictated by economic necessity and a lack of viable alternatives (Namahoro et al., 2021; Nandi et al., 2021). Reliance on biomass is not merely a habit but a rational adaptation to income constraints and unreliable electricity supply, functioning as a coping mechanism within a complex system where energy, food, and water securities are linked (Bikomeye et al., 2021; Guiné et al., 2021). Policies promoting solar or hydroelectric power often fail to account for household-level capital cost barriers or the entrenched socio-economic networks sustaining the biomass economy (Kaguhangire-Barifaijo et al., 2021; Ollinaho & Kröger, 2021). This disconnect is exacerbated by a planning paradigm that can still be top-down, frequently failing to integrate indigenous knowledge and localised risk assessments (A.B. et al., 2021; Daama et al., 2021). Thus, the energy transition is perceived by many as an external imposition rather than a participatory pathway.

The imperative, therefore, is for a radical community-centric model of energy planning. Transitions involve managing complex socio-technical change, not merely substituting fuel sources (Bryson et al., 2021; Peterson, 2021). A community-centric approach recognises that energy systems are woven into daily life, affecting nutrition, health, gender roles, and economic activity. For instance, the health co-benefits of moving away from indoor air pollution are significant, particularly for maternal and child health, offering a powerful narrative to align climate action with immediate development priorities (Bikomeye et al., 2021; Lieber et al., 2021). Effective planning must start from these interlinked realities, viewing communities as active co-designers of transition pathways (Cornforth et al., 2021).

To bridge the identified gaps, this research proposes three targeted recommendations. First, policy formulation must systematically integrate local and indigenous knowledge, creating formal channels for community input into energy and climate resilience planning to move beyond tokenistic consultation (A.B. et al., 2021; Iskandar et al., 2021). Second, there is an urgent need to scale innovative, decentralised finance mechanisms for distributed renewable energy, such as pay-as-you-go solar models and community-owned mini-grids, to accelerate access beyond centralised grid extension (Ngoma et al., 2021). Third, policymakers must design equitable biomass transition programmes. An immediate blanket prohibition is neither feasible nor just; instead, programmes should promote sustainable charcoal production, disseminate efficient cookstoves, and link afforestation initiatives with local energy needs within a just transition framework (Al-Saidi & Hussein, 2021; Mahmood et al., 2021).

Future research must build upon these insights. Longitudinal studies are needed to track how perceptions evolve in response to climatic changes and policy interventions, moving beyond this cross-sectional snapshot (Helldén et al., 2021). Furthermore, robust, mixed-methods evaluations of pilot

projects testing community-centric models and staged biomass transitions are essential to generate evidence-based best practices (Lemarchand, 2021). Research should also delve deeper into the political economy of the energy sector, examining the power dynamics and institutional barriers that perpetuate the status quo (Hoffmann, 2021; Ollinaho & Kröger, 2021). Finally, given intersecting crises, future studies should explicitly adopt a nexus approach, investigating how integrated energy, food, and water security interventions yield synergistic resilience benefits (Bryson et al., 2021; Guiné et al., 2021).

In conclusion, this survey articulates a central challenge: navigating an energy transition that is both low-carbon and pro-poor. The findings demonstrate that public perception of climate change is not the primary barrier; rather, structural and socio-economic constraints within the energy system hinder progress (Namahoro et al., 2021; Nandi et al., 2021). The pathway forward lies in rejecting a one-size-fits-all technocratic solution and embracing a pluralistic, participatory approach. By grounding the transition in the lived realities of communities, aligning it with health and developmental co-benefits, and building policies from the bottom-up, Uganda can forge an equitable pathway towards a sustainable energy future. This journey is fundamentally about securing resilience, dignity, and prosperity for its citizens in a rapidly changing world.

CONTRIBUTIONS

This survey provides a critical, contemporary analysis of stakeholder perceptions regarding climate-energy intersections in Uganda, a domain previously underexplored in the national context. It offers an original empirical dataset, collected between 2023 and 2024, which delineates key priorities, perceived barriers, and viable pathways for climate-compatible energy development. The findings contribute directly to policy formulation by identifying specific, actionable strategies for enhancing renewable energy adoption and resilience within Uganda's energy sector. Furthermore, the study establishes a foundational reference point for future scholarly inquiry into Uganda's evolving energy-climate nexus.

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